80 Years
Building Our Nation Together

CONSTRUCTION PRODUCTIVITY IN SINGAPORE:

EFFECTIVE MEASUREMENT TO FACILITATE IMPROVEMENT

The Singapore Contractors Association Ltd

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EFFECTIVE MEASUREMENT TO FACILITATE IMPROVEMENT

A study by:

The Singapore Contractors Association Ltd

Singapore Chinese Chamber of Commerce and Industry

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Construction productivity in SIngapore: Effective measurement to facilitate improvement

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FOREWORD FROM THE SINGAPORE CONTRACTORS ASSOCIATION LIMITED

Since its establishment dating back 1937, the Singapore Contractors Association Ltd (SCAL) has been the voice of the construction industry, working with other stakeholders including the government towards win-win advancements for the industry.

As the industry champion, SCAL undertook this study on construction productivity with the objective to dive deep into the key drivers to unearth new and valuable dimensions for productivity improvements. It aims to provide practical recommendations for construction firms, government and stakeholders across the construction value chain to raise productivity.

The study involved a questionnaire-based survey of members of SCAL, interviews and focus group discussions with industry leaders and international experts, and research and literature review on construction productivity both in Singapore and overseas.

In one of the key findings, the study recognises the importance on the need for measurements and tracking of productivity at the company level to implement self-driven and sustainable continuous productivity improvement

SCAL would like to thank Professor George Ofori formerly from the National University of Singapore (NUS) for conducting this study. We would also like to express our appreciation to members who have participated in the surveys and interviews and contributed their knowledge, expertise and time to make this publication possible. We also acknowledge the partnership with the Singapore Chinese Chamber of Commerce and Industry (SCCCI) in this project.

With this commemorative publication celebrating SCAL's 80th Anniversary, we hope to provide new and fresh insights for more effective practices, measures and policies towards higher productivity as the construction sector prepares to build for Singapore's future economy.

Mr Kenneth Loo

President

The Singapore Contractors Association Limited

Mr Dominic Choy

Chairman, Productivity and Technology Sub-Committee

The Singapore Contractors Association Limited

FOREWORD FROM SINGAPORE CHINESE CHAMBER OF COMMERCE & INDUSTRY

The Committee on the Future Economy has encouraged trade associations to play an active role in industry development. The Singapore Chinese Chamber of Commerce and Industry (SCCCI) is happy to have worked together and supported the Singapore Contractors Association Ltd (SCAL) to undertake this joint study to look into the productivity efforts of Singapore contractors, and offer recommendations relating to productivity improvement of the construction sector. One of the recommendations from this study is for SCAL to take ownership and leadership to drive productivity improvement of the construction sector. In fact, this study on construction productivity is a good example of industry leadership by SCAL to address an industry issue.

Following the conclusion of this study, we hope that the findings would provide a better understanding of the key factors to help improve productivity in the construction sector. Last but not least, 2017 marks the 80th Anniversary of SCAL. I congratulate SCAL on attaining this significant milestone!

Mr Roland Ng

President

Singapore Chinese Chamber of Commerce & Industry

Executive Summary

The Study

The study was initiated by the Singapore Contractors Association (SCAL) and Singapore Chinese Chamber of Commerce and Industry (SCCCI). The theme of the study was "effective measurement of construction productivity in Singapore". The aim was to find and recommend ways to help the industry to improve productivity and enable the government to devise better policies and programmes. The scope was to understand factors underlying construction productivity in Singapore; ascertain how agencies and construction firms measure it; and explore the best way of measurement that would help the government to draw up policies to enable firms to improve their productivity performance. The study also considers current measures by government and industry, makes international comparisons and studies what more can be done.

Productivity

Productivity, the economy and construction

The aim of the Economic Strategies Committee (ESC) for Singapore's economy in 2010 was to:[1] "… make skills, innovation and productivity the basis for sustaining Singapore's economic growth". In order to stay competitive, the nation must achieve GDP growth by expanding productivity, upgrading the quality of jobs and raising incomes. The ESC set a productivity growth target of two to three per cent per year over the next ten years. Attaining it would involve all sectors and firms.

The bar was to be raised even higher. In October 2015, the government set up the Committee on the Future Economy (CFE) to develop strategies to position Singapore well for the future. The focus of the CFE was "the challenge of moving the Singapore economy up the innovation ladder, from being one that is 'value-adding' to a 'value-creating' one".[2]

Where is the place of construction in this new productivity-driven and value-creating economy? How important will it be for the construction industry to improve its productivity performance? How relevant is it to measure construction productivity?

Productivity is considered to be a key source of economic growth and national competitiveness. It is of strategic importance to organisations—it helps to ensure their profitability and growth.

Construction plays a key role in every country's economy. It is a significant contributor to gross domestic product (GDP) and a main component of gross fixed capital formation (GFCF). It stimulates activities in many sectors. All sectors rely on its products. Countries see an important role for construction in national development and recognise the need to improve it, including its productivity.

Importance of productivity in construction

The role of construction in the economy and its development indicates the need for continuous improvement of productivity performance in the industry. The economy, construction firms, clients and employees will benefit from a productive industry that uses resources efficiently, saves costs, is competitive and is able to contribute strongly to the country's growth.

Productivity in construction and influencing factors

Productivity is the relationship between the volume of output and the volume of one or more of the inputs used in the production process. Owing to the nature and inherent features of construction, it is difficult to define, understand, measure, interpret and compare construction productivity indicators.

To formulate and implement measures to improve construction productivity performance, the factors influencing it should be understood.

1 Economic Strategies Committee (2010) *Economic Strategies Committee Report: High Skilled People, Innovative Economy, Distinctive Global City*. Ministry of Trade and Industry, Singapore, p. 3.

2 Lee, M. (2015) Five future challenges for Singapore economy. *The Straits Times*, 29 October; http://www.straitstimes.com/singapore/five-future-challenges-for-singapore-economy

Construction is undertaken in response to expressed demand: the contractor usually has no control over the type or volume of items it will build, where they will be built, and what inputs will be required. Thus, it is difficult for firms to invest ahead to enhance productivity. The uniqueness of projects means that solutions must be found to new challenges on every project. Much of the work is labour-intensive and difficult to mechanise or standardise. Construction is location-specific, and is subject to peculiar conditions in each location.

Productivity in construction is also influenced by inadequacies within the industry including design issues, management practices, human resource and technologies. Other factors of influence in construction firms' operating environment include subcontractor and supplier performance and extensive regulation.

What is to be done?

Proposed measures for enhancing construction productivity can be categorised under: (a) Project management; (b) Technology adoption; (c) Human resource management; and (d) Management at firm level. Broader level proposals include: government leadership; regulatory reform; government-industry partnership; and industry collaboration.

Approaches in other countries

In many countries, such as Australia, Hong Kong, the Netherlands, Singapore, and the UK, the main thrust of initiatives to increase the competitiveness of the construction industries in the early 2000s was that productivity growth needed to be improved.

Productivity features prominently in recent major reviews of construction industries. Weaknesses in the UK industry were found to be:[3] low vertical integration in the supply chain with high reliance on sub-contracting; low investment in R&D and intangible assets; lack of collaboration and limited knowledge sharing; low technology transfer; and high costs compared with foreign competitors. The vision for the UK construction industry is: "Construction in 2025 is no longer characterised, …by late delivery, cost overruns, …friction, late payment, accidents, unfavourable workplaces, a workforce unrepresentative of society or as an industry slow to embrace change" (p. 18). Among its many ambitions was that by 2015, time from inception to completion would be reduced by 50 per cent for all projects.

Ireland's vision is: "…a competitive, innovative, dynamic, safe and sustainable construction sector; one that makes its full and proper contribution to the economy and to job creation, and one that is based on best practice and capable of delivering the economic and social infrastructure we need to build to sustain a prosperous future"[4] (p. 6). The report noted: "Increased productivity through improved training and skills and …adoption of technology can make significant cost, building performance and project delivery differences" (p. 56).

By 2020, Malaysia aims to have:[5] "a modern, highly productive and sustainable industry that is able to enjoy continued growth and enable Malaysian companies to compete with international players". Its main thrusts were: internationalisation; productivity; sustainability; quality; safety; and professionalism. The target is to raise productivity by 2.5 times its 2011 value to US$16,500 per worker.

Singapore's productivity programme since 2010

Following the ESC's proposals for a productivity-driven economy, a $250 million fund was launched to help construction to prepare for impending changes. Incentives were to be given for technology adoption; workforce development and capability development.

In 2010, the Construction Productivity Roadmap was launched. Its vision was: "a highly integrated

3 HM Government (2013) *Construction 2025 – Industrial Strategy: Government and industry in partnership*. London.
4 Government of Ireland (2014) *Construction 2020: A Strategy for a Renewed Construction Sector*. Stationery Office, Dublin.
5 Construction Industry Development Board (2015) *Construction Industry Transformation Programme (CITP) 2016-20.* Kuala Lumpur.

and technologically advanced construction sector led by progressive firms and supported by a skilled and competent workforce in 2020".[6] The key thrusts were: Regulating the demand and supply of low cost, lower skilled foreign workforce; enhancing the quality of the construction workforce; imposing requirements and minimum standards to drive adoption of labour-saving technology; and offering incentives to encourage manpower development, technology adoption and capability building.

The Second Construction Productivity Roadmap's aim is to enable the industry to meet the national target of a 2-3 per cent average annual growth by 2020. The areas of focus are: a higher quality workforce; higher capital investment; and a better integrated construction value chain.

Regulation has been a key part of the productivity programme. Regulations are continually revised, fine-tuned and made increasingly more stringent.

Incentives have been a major driver in the productivity enhancement programme. They are increasingly enhanced. In 2015, an additional S$450 million was provided to help firms invest in "impactful productive technologies" and improve the quality of their workforce[7] from 2015 to 2018.

Procurement has been used to help firms to raise productivity. The BCA promoted integrative approaches such as the design-build scheme. Since January 2016, firms with good records in productivity, technology adoption and workforce development are preferred when tendering for government projects.[8]

Productivity performance is a criterion in BCA awards. Construction Productivity Award (CPA) – Advocates and CPA – Projects were launched in 2010. The Construction Productivity Award (CPA) for Advocates was launched in 2013.

Information on productivity policies and initiatives is disseminated by BCA, SCAL and others and via the interactive Construction Productivity Gallery.

SCAL's productivity objectives and activities

SCAL is committed to leading its members to attain superior performance. The Productivity and Technology Committee is entrusted with guiding members to fulfil this objective with respect to productivity. It undertakes studies on productivity, encourages members to adopt measures to improve productivity, educates them on technologies and informs them on government schemes. SCAL's initiatives include: liaising with agencies on regulations and schemes; organising information sessions on regulations and policies; organising seminars, courses and clinics; and holding productivity competitions among workers. SCAL's Foreign Construction Worker Directory System enables the industry to retain experienced foreign workers, hence enhancing productivity.

Measuring Productivity

Need for measurement and challenges

At the industry level, governments want a productivity indicator that assesses performance in the industry and which allows comparison of the assessment across other sectors and with industries abroad. Firms prefer measures which are relevant to them in their operations.

Productivity indicators enable firms and project managers to plan activities, control costs, motivate workers, evaluate performance, and guide company policy and action, and also those of their partners, to attain continuous improvement. Clients benefit from earlier project completion and lower costs.

The features of a good productivity indicator include clarity, relevance to strategic goals, ease

6 BCA (2011) Background: Construction Productivity Roadmap; http://www.bca.gov.sg/newsroom/others/pr03032011_CPA.pdf

7 BCA (2015) Media Release – About 7,000 firms to benefit from s$450 million boost for construction productivity; http://www.bca.gov.sg/newsroom/others/BCA_Media_Release_COS_2015_100315.pdf

8 BCA (2015) Media Release -- Productive builders will have an advantage when tendering for public projects; http://www.bca.gov.sg/Newsroom/others/Media_Release_SCPW_2015_131015.pdf

in training of skills to measure and apply, low cost of data collection and analysis, reliability and comparability of data, and a high likelihood of its application.

Construction productivity can be studied at four levels: trade, project, company and industry levels. Difficulties are faced in attempts to measure construction productivity at each of these levels.

Challenges in measuring project-level productivity include: uniqueness of constructed items; difficulty of determining the effect of technology, innovation, and improvements in the quality of materials on productivity; and that each project comprises many activities by different groups at different stages with a complex movement of workers to and from the site, making it difficult to measure time.

Issues at industry level are: business cycles that affect data on output and inputs, making it difficult to find suitable deflators to adjust the data; and aggregation issues, as in any given period, many types of items are produced. Also, countries define the industry, standards, and items differently.

Thus, problems arise when comparing productivity data from different projects, firms or countries owing to the differences in definition, assumptions, conditions and measurement methods. Guides and standards for measuring productivity must be prepared.

Productivity metrics

Productivity can be measured in terms of level and rate of change. Single productivity measures include Labour Productivity (LP), Capital Productivity (CP) and Intermediate Productivity which measure the relationship between output and labour input, capital input, and intermediate inputs, respectively. Other measures include: Multi-Factor Productivity (MFP) which considers the contribution of capital and labour inputs to output and is expressed in terms of the growth rate; and Total Factor Productivity (TFP) which measures the contribution of labour, capital and intermediate inputs to output.

The main productivity indicator for Singapore's economy is the value-added per worker. In future, the government's focus will be on value-add per paid hour worked,[9] which is considered more accurate than value-added per worker, as it represents better the changes in economic conditions and employment patterns. It gives higher productivity figures for all sectors, including construction.

In construction, trade-level labour productivity data [expressed as (a) units of output per dollar; (b) units of output per work-hour or (c) units of output per man-day) can be used by firms to calculate project cost, set targets and monitor site activity. The physical data can be used in planning the schedule and both the physical and monetary data can be used in evaluating subcontractors' bids.

At project level, LP is a composite measure such as square-metres of built-up floor area per man-day (used in Singapore) or square-metres per dollar. At industry level, LP, CP, MFP and TFP are used. As MFP and TFP are difficult to estimate, LP is the most common construction productivity indicator.

Disparity between economic and physical indicators

The appropriate way to measure industry-level construction productivity has long been debated. The main issues are challenges in finding accurate data and agreeing on measurement approaches.

A disparity between the trends in the monetary and physical measures of construction productivity is observed in many countries. A New Zealand study concluded that traditional measures of productivity suggest that con struction productivity has declined for over a decade.[10] Possible explanations are: the inability of the industry to pass on price increases; the nature of the items the industry builds (mainly housing which is subject to large fluctuations in demand, and has low labour productivity); how the industry responds to demand; the uncertainty over construction workload; and stagnant labour quality.

Other fundamental factors include: the high volume of small projects and non-new work (repairs and

9 Soon, W.L. (2015) Shift to 'more accurate' productivity measure, but challenges remain. *Business Times*, November 26. http://www.businesstimes.com.sg/government-economy/shift-to-more-accurate-productivity-measure-but-challenges-remain

10 Page, I. and Norman, D. (2014) *Measuring Construction Industry Productivity and Performance*, Study Report SR 310. Branz, Wellington.

retrofitting) which are more labour-intensive, and the low barriers to entry into the industry resulting in a fragmented industry with a huge majority of small firms with limited ability to invest in productivity-enhancing methods and skills. The practice of price-based tendering often leads to a race for the bottom, resulting in low margins on projects.

Need for range of productivity indicators

It is suggested that construction firms adopt a basket of measures of productivity rather than a single indicator. A recent study in Singapore[11] cites studies in many countries which advocate the use of multiple indicators of productivity.

Construction productivity measures in Singapore

BCA's guide on trade-level productivity "sets out the best practices on how to measure the productivity for 12 trades which are commonly found in most construction projects".[12] Productivity Monitoring Forms for each trade guides firms on what they should monitor and measure.

BCA has also provided a template for calculating value-added per worker at the company level for use by construction firms.

Problems facing measurement of productivity with value-added per person highlighted in a recent work in Singapore[13] include: difficulty in understanding the concept, and difficulty and cost in collecting sufficient data to obtain an accurate figure owing to the diversity, complexity and dispersal of projects. It was recently noted that value-added per worker, on its own, is insufficient as a way of "sizing up what is really happening on the ground".[14] The industry's poor productivity reputation was not merited if other industry-specific indicators such as constructed floor area per man-day were used. This issue has been discussed in Singapore for decades; studies in 1992 and 1998 highlighted similar problems with value-added per person data.[15]

To BCA, productivity is defined as "the amount of floor area completed per man-day". It is measured as square metres of gross floor area completed per man-day. A study declares: BCA's measurement based on the Electronic Productivity Submission System (ePSS) is "a reliable and realistic … industry-specific productivity indicator" (p. 29).

Productivity measurement: international examples

In the US, trade productivity data are published in the annual *R.S. Means Building Construction Cost Data Book*. In 2011, the American Society of Testing and Materials International (ASTM)[16] issued a new guide for measuring construction productivity at task, project, industry levels called Job Productivity Measurement (JPM). The Bureau of Labor Standards publishes data on labour productivity for all sectors except construction (owing to a lack of data).

UK trade productivity data are published in *Spon's Architect's and Builder's Price Book*. The UK Office for National Statistics[17] halted the publication of industry-level construction labour productivity data in 2001 because of data difficulties. Productivity is one of the annually published key performance indicators (KPIs) of the UK construction industry.[18] Value-added per full-time employee for UK construction was £48,900 in 2010, rising progressively to £61,300 in 2015.

In Malaysia, productivity is measured by "the average value in RM contributed by each worker".[19]

11 Low, S.P. (2015) A review of construction productivity indicators in Singapore. *The Singapore Engineer*, August, pp. 24-30.
12 BCA (2012) *Builders' Guide on Measuring Productivity: A guide to help builders measure productivity of various trades*. Singapore.
13 Low, S.P. (2015) A review of construction productivity indicators in Singapore. *The Singapore Engineer*, August, pp. 24-30.
14 Lee, M. (2016) Value-added 'falls short as measure of productivity'. *Business Times*, January 14; http://www.businesstimes.com.sg/government-economy/value-added-falls-short-as-measure-of-productivity
15 Task Force on Construction Productivity (1992) *Raising Singapore's Construction Productivity*. CIDB, Singapore.
16 American Society of Testing and Materials International (2011) *ASTM E2691-11, Standard Practice for Job Productivity Measurement*, ASTM International, West Conshohocken, PA.
17 Office for National Statistics (2002) Labour productivity measures for the non-production industries. *Economic Trends*, No 579.
18 KPI Team (2015) *UK Industry Performance Report: Based on the UK Construction Industry Key Performance Indicators*. Glenigan, CITB, Constructing Excellence, Department for Business, Innovation and Skills and BRE SMARTWaste, London.
19 Construction Industry Development Board (2015) *Construction Industry Transformation Programme (CITP) 2016-20*. Kuala Lumpur.

International comparison

LP is the most commonly used indicator for international comparisons (value-added per hour worked and/or value-added per employee). A study[20] outlines issues in comparisons: unreliable and inadequate data in many countries; differences in construction cycles in countries at the same time; exchange difficulties; differences in materials and methods among countries; and wage differences.

Despite the difficulties, comparisons are still made. CIDB noted that year 2005 figures for construction productivity data were:[21] Australia, US$66,000; Japan, US$47,000; Singapore, US$17,000; Turkey, US$16,000; and Malaysia, US$7,000.

Negative annual construction productivity growth is common in industrialised countries. Average annual percentage change in labour productivity (in value-added per paid hour worked) and MFP over 1990-2009 for OECD countries show that in all the countries, figures for construction were lower than for manufacturin, and for the whole economy. In seven of the nineteen countries, the average productivity growth for construction was negative. The figures for MFP were worse: twelve of the nineteen countries recorded negative figures.

Conclusion from literature review

The review of literature shows that the issues concerning construction productivity discussed are not just peculiar to Singapore. These issues include: a perceived lack of focus on productivity in the industry; appropriate ways to measure productivity; a perceived low productivity growth despite evidence of use of new technologies and systems to deliver large and complex projects; an interest in international comparison; and the intent of governments to act to enhance productivity.

What is the situation in Singapore? What are the industry's views? What has been done? What else needs to be done? This field study sought answers to these questions.

Method for the study

The research method for the study comprised: interviews of senior practitioners; a focus group meeting with some industry leaders; an online questionnaire-based survey of members of SCAL and SCCCI; and a survey of international experts.

Sections of the questionnaire were: views on industry-level productivity; causes of low productivity; productivity measurement; practices on productivity improvement; possible future improvement; and profile of firm and respondent.

Interview questions were on: (a) level of productivity; (b) ways in which productivity is measured; (c) whether interviewee's firm has a policy on productivity; (d) how the firm measures productivity on projects; (e) what the firm uses its productivity data for; (f) obstacles to productivity measurement and improvement; (g) main enablers and drivers of productivity improvement; (h) views on the government's productivity development programme; (i) what the firm and the industry had done to enhance productivity since 2010; and (j) proposals on how productivity could be improved.

Results of field study and discussion

Electronic mail messages were sent to all the 3032 members of SCAL and contractor members of SCCCI to complete the questionnaire. Telephone calls were made to remind some members' leaders.

Response rate; profile of respondents and firms

Some 110 responses were received, giving a response rate of 3.62 per cent, based on the total membership of SCAL.

20 Low, S.P. (2015) A review of construction productivity indicators in Singapore. *The Singapore Engineer*, August, pp. 24-30.
21 Construction Industry Development Board (2015) *Construction Industry Transformation Programme (CITP) 2016-20*. Kuala Lumpur.


ASSESSMENT
PLANNING
RESULT
GOAL
PROGRESS
EVALUATION
AUDIT
MEASURE
ANALYSIS

Over half of the 44 firms whose registration grades were indicated by respondents (26) were in the top grade (A1). Of the 66 companies whose origins were given, 53 were local firms, and 13 were foreign. Nearly one quarter of firms earned up to S$10 million; another quarter earned S$10-50 million, and one quarter earned over S$200 million in 2014.

Respondents held senior positions; nearly half held posts ranging from General Manager to Managing Director.

Thus, despite the small number of responses, the profile of the respondents and their firms indicate that the survey results give a good indication of the views of Singapore construction firms.

Views on industry-level productivity

To over two-thirds of respondents, 'productivity' meant "output per person employed". A significant portion of respondents thought it meant time saved and unit cost of work. The former shows the importance of setting reasonable project schedules, and the latter, the need to consider cost as a key productivity indicator. The results show that firms could use more than one productivity indicator.

Respondents ranked indicators of productivity in terms of usefulness to their firms as: (1) "Gross Output per Worker"; (2) "Value-added per worker"; (3) "square metre per man-day"; and "Gross Output per Month". These operationally useful indicators were deemed to be worth tracking by the firms.

The respondents' views on productivity growth in segments of the industry were in line with BCA's data: public housing topped the list, followed by institutional buildings.

The majority of respondents (54 per cent) indicated that construction industry productivity increased from 2010 to 2015, compared to 33 per cent who perceived a decrease. The majority of respondents (52 percent) felt that productivity will increase from 2016 to 2020, but a fair number (37 per cent) expected no change. The slim majority in both cases, especially on future increase, is instructive. Few respondents expected a decline.

The government, followed by contractors, was considered by the majority of respondents to be paying adequate attention to productivity. Under half of respondents considered consultants to be paying adequate attention to productivity and even fewer thought that clients did so.

A higher proportion of respondents (55 per cent) did not agree with official data which indicate that in most years, construction productivity growth is the lowest for all sectors but the difference between the those who agreed and those who did not was small.

Respondents who did not agree with the statistics indicating low construction productivity growth gave the following reasons for their views: the construction industry comprises many segments which would be best considered separately; productivity can be measured in many ways; and construction should not be treated like other sectors of the economy.

Causes of low productivity

The leading factors causing low construction productivity which were related to firms' policies and practices were: (1) poor skills of workers; (2) inadequate pre-project planning and pre-work planning; (3) inappropriate working methods; (4) poor motivation of workers; (5) communication difficulties between workers and supervisors, and among workers; and (6) reworks to rectify defects.

Respondents perceived the main contractor as the most important party in terms of influence on productivity, followed by specialist subcontractors, suppliers of materials, and labour subcontractors. Thus, a whole value chain approach to productivity improvement would be of merit.

Respondents rated all the entities and professionals highly in terms of their influence on productivity. The ranking, in descending order of importance, was: architect, client, structural engineer, approving authority, and mechanical and electrical (M&E) engineer.

The top five factors outside the companies' control which cause low productivity were: delays in providing information to contractors; delays caused by compliance with regulations; changes in

design; priority given to other project parameters such as cost, quality and safety; and complexity of the project. This underlines the importance of the roles of the client, consultants and regulatory authorities in the productivity improvement drive.

Corporate practices on productivity measurement

Less than half of respondents reported that their firms had written policies on productivity improvement on their projects; 57 per cent indicated that their firms did not have productivity policies. Thus, while many contractors have environmental, and health and safety policies, and some have quality policies, most lacked policies on productivity.

Respondents whose firms had productivity policies reported that the policies had the following main components: company's aims and objectives with respect to productivity; company's productivity targets; company's vision for its productivity; and company's productivity measurement approach.

Two-thirds of respondents reported that their firms measure productivity of their projects (at various levels). However, a significant proportion of firms do not measure it at any level. As bidders' productivity record becomes more important in procurement, firms will have to measure it.

Respondents who indicated that their firms measure productivity at project level reported what the results were used for. Over two-thirds of firms used them to monitor progress on their sites. One-third used the data to monitor progress of subcontractors' work; one-quarter used them to meet government requirements, and another one-quarter used the data for benchmarking themselves against competitors. Thus, productivity data help firms to administer projects and to meet business and regulatory needs.

Respondents ranked the top five obstacles to productivity measurement as: lack of direct benefit from productivity measurements to firms; lack of clear definition of productivity; cost of measurement process; uncertainty about what is to be measured; and requirement of personnel to measure productivity. These obstacles were similar to what were noted in the literature, and by Singapore administrators and practitioners. Factors given low scores were: "because government measures productivity" and the fact that firms make submissions to the ePSS.

The five leading methods used by respondents' firms to measure productivity on their projects are: by considering output per person-hour on key trades; by considering total revenue per month; by estimating square metres per man-day; by value-added per worker; and by the Constructability Score. The high ranking of total revenue per month and value-added per worker underline the importance of financial issues in productivity assessment to firms.

Nearly 60 per cent of respondents reported that their companies set targets of productivity on their projects. It is noted above that two-thirds of firms measure productivity, and 70 per cent use the productivity data to monitor progress on projects.

Corporate practices on productivity improvement

Respondents' firms have taken many measures to enhance productivity on their projects since 2010. Measures respondents' firms have not used are revealing. They include: applying ICT; monitoring Buildability and Constructability Scores; adopting prefabrication; and measuring productivity. Top five measures adopted were: training of workers; better project planning and monitoring; investment in mechanisation; re-engineering designs; and introduction of incentive schemes for workers.

The top five of the productivity-related incentive schemes that firms have used were: Workforce Training and Upgrading Scheme; Mechanisation Credit; Productivity and Innovation Credit; Construction Productivity and Capability Fund; and BIM Fund.

The top factors which motivate respondents' firms to improve productivity were: deliver projects on time; increase profitability; enhance firms' competitiveness; and enhance corporate image. Reducing the number of foreign workers and keeping within MYE quotas were not priorities.

The relative importance of factors which help respondents' firms to improve productivity was

ascertained. The top five were: support of clients; government incentive schemes; competition within the industry; support of subcontractors; and support of consulting teams. All of the factors had a mean score below 4.0 (out of 5.0), indicating that the productivity drivers were weak. The Clerk of Works (COW) and Resident Engineer (RE) were mentioned repeatedly as having an important influence on productivity improvement.

The top five hindrances to firms' efforts to improve productivity were: excessive regulation of construction activity; insufficient time to plan and execute work properly; lack of support from clients; delays in payments by clients; and restrictions on employment of foreign workers. Two other main obstacles were: restrictions on employment of foreign workers; and lack of competent Professional, Management, Executive and Technical (PMET) personnel.

Levels and trends of subcontracting in construction were ascertained. The results showed that the extent of subcontracting remained similar during 2010 to 2015.

The structural profile of the construction workforce and its changing trends were ascertained. Respondents indicated the breakdown of their firms' employees in 2010 and 2015 (in terms of professionals, supervisors and skilled workers). The results showed that the workforce structure did not change much between 2010 and 2015.

The level of investment by respondents' firms in mechanisation and ICT (in 2010 and 2015) was ascertained. Investments in both items increased over the period. The level of investment made by the firms in training in 2010 and 2015 was also analysed. The data showed that investment in training increased significantly during the period.

Possible future improvement

The respondents expressed views on productivity-enhancing factors and actions often proposed in Singapore. The top seven were: more complete and firmed-up design; standardisation of components; training of workers; prompt payment from clients; greater attention to productivity by firm's leaders; review of relevant government regulations; and involvement of contractor in design. Factors and measures given the lowest scores were (in ascending order of scores): reduction of MYE; reduction of extent of subcontracting; input by contractors of accurate data to ePSS; and mandatory requirement for contractors to pay attention to productivity.

Respondents' proposals for action

The respondents were given an opportunity to propose measures that various stakeholders can take.

On actions the authorities can take, the suggestions can be categorised under: Incentives (simplify application process; provide more funds for incentives, increase the caps on grants; increase recognition for firms' productivity record in procurement); Regulations and policies (review, reduce regulations; review, streamline approval processes. There were also calls for more stringent regulations and enforcement on project schedules and modular design); Relationship with industry (greater consultation and adoption of feedback; productivity awareness building); and Attitudes and approach (flexibility in enforcing regulations and processing applications for incentives; better understanding of construction).

Proposed actions by contractors may be grouped under: Involvement in design; Training (train workers, supervisors and managers, and assess effectiveness of training); Planning, organisation, and project management (ensure efficiency, improve planning, work preparation, organisation, project management, co-ordination;); Construction methods (adopt prefabrication, more constructable methods, mechanisation); Resource and value chain management; Measurement and improvement of productivity; Project performance (win tenders with "workable prices"; perform well, deliver on time; recognise sub-contractors for early completion or adoption of productive technologies); and Attitudes and mindset (comply with regulations, be creative, be proactive, be willing to collaborate).

Suggested actions clients can take were: Procurement (insist on efficient, cost-effective design; press for standardisation, constructability, buildability in design; practise systematic selection of consultants and contractors; adopt design and build and ECI; give preference to bidders proposing productive methods; insist on productivity during procurement and set targets; provide incentives for productivity improvements); Project and contract administration (minimise design changes; enforce and adhere to project's main contract; ensure prompt payment to contractors; allow design and construction teams a reasonable time period to work; expedite approval process); Attitudinal and behavioural factors (be open; support productivity initiatives; be less cost-driven; "maintain better communications and effective decision making").

Proposals for actions by consultants included: General approach to design (aim for efficiency and effectiveness in design; provide complete, co-ordinated and integrated design before construction; allow flexibility in design such as being receptive to new, productive technologies; incorporate details of interfacing in drawings instead of leaving it to contractors); Design for productivity (consider prefabrication and DfMA; provide standardised components such as PBU; make designs modular; pay attention to DfS; speed up designs and ensure early approval of design work; share information and drawings; set requirements and targets on productivity; promote ECI; work with contractors to achieve buildable designs); Project administration (work closely with site team; reduce response and action time; "be in the constructor's shoes").

Suggestions of actions by subcontractors included: Project management (support main contractors and comply with necessary instructions; be involved with main contractors in planning the work; adhering and meeting schedules; provide better supervision; adopt "constructable work methods"; invest in and use equipment); Project delivery and performance (set productivity improvement targets; act to increase firm's own productivity; produce good quality work, reduce cost, achieve timely delivery; eliminate accidents); Communication and co-operation (have close links, and share resources with main contractors); Training (provide continuous training; give incentives to workers); Attitudes and general approach (accept change; take pride in own work; be willing to co-operate; be committed and disciplined; adopt orientation of competitiveness; "show professionalism").

Summary of interviews

Views on productivity growth since 2010

There was agreement among the interviewees that construction productivity had improved since 2010. This is evident when one considers the huge jump in the technologies used: massive mechanisation; use of prefabrication; use of systems formwork. One interviewee believed that, in terms of physical work, Singapore's productivity might be on par with some industrialised countries. Value-added per worker for construction grew from 2008 to 2009 when many large projects were built, and firms made large profits, but it has been stagnant since 2010.

Various views were expressed regarding data on the growth of value-added per person industry-level indicator. It was noted that the depiction of the construction industry as a laggard in productivity improvement was tarnishing the industry's image.

It was highlighted that increases in productivity were the result of conscious action. The increase in productivity in the construction sector in Singapore was mainly attributed to the government's push for precast and prefabricated construction. It was agreed that there is still scope for improvement, the industry being still labour-intensive. The progress has to be pushed by many factors, including the authorities. It is also important to improve worker, supervisor and manager skills.

A hazard in measuring productivity and making international comparisons was differences among countries in expectations in terms of quality of work and standard provisions in the same type of built item.

Views on ways in which productivity is measured

It was agreed that measuring productivity at trade level is relatively simple. However, there remains a challenge in measuring and maintaining data because a trade task can be undertaken in many ways, and the methods change over time. Also, the industry should focus on useful aspects where change can be realised. Trade productivity can be measured just once in five years, as it does not improve overall productivity significantly.

Some firms measure productivity and compile data, however, no industry-wide information is published. For example, a specialist firm uses the following measures: the time it takes to set up the equipment and system; number of workers; and floor-by-floor cycle time.

Cost, and its relationship with productivity, was raised by many interviewees. For example, it was noted that if labour costs are relatively high, it will be better to mechanise.

Interviewees differed in their views on the usefulness of productivity measurement at project and industry levels. The number of activities the project comprises, and the variety of items the industry constructs were seen as problems in attempts to measure productivity.

The value-added per worker indicator is not well understood. However, one interviewee was positive about it; his company measures it at firm level, and sets a target of annual-growth rate. He urged the industry to focus on it.

Corporate policy on construction productivity

None of the interviewees' firms had a written policy on productivity, although most of them had safety and environmental policies. However, the firms do consider productivity in relevant policies and practices. One firm considers it in its integrated management system. In another firm, during design, safety considerations are made with regard to productivity as well. Another firm has no formal policy on it, but uses a procedure for attaining and applying productivity norms on projects.

Measures firms use to measure productivity

The companies assess productivity in many ways: One focuses on total manpower for the project; one measures productivity from floor to floor; another, an infrastructure firm, measures day-inches for labour for pipework; and yet another firm monitors revenue. In one firm, at project level, output is tracked; at company level, the indicator used is value-added productivity.

Although some companies systematically collect data, knowledge on general industry practice is patchy. One interviewee whose firm does not measure productivity believed no company in the industry did so; he knew a firm measuring productivity because it had a grant from BCA.

The merits of productivity measurement are not convincing to all interviewees. One extreme view taken by an interviewee was that productivity measurement did not make any sense. Another interviewee noted that value-added productivity targets at project level change with tendering margins which also depend on market conditions.

It was suggested that main contractors should show interest in, and take responsibility for the approach of their subcontractors to productivity, as their poor performance would have an impact on progress on the project, and on the main contractor. It was highlighted that this practice is prevalent in Korea, where such monitoring is provided for in the subcontract.

Uses of productivity measurements to firms

Interviewees reported that subcontractors have trade productivity data, and they use them to draft their quotations and control their work. One specialist subcontractor uses targets on costs, materials and productivity to plan and manage its work, and promote its services. The objective of one interviewee's firm is "to reduce headcount"; thus, it prefers to use total manpower per project.

A firm which focuses on revenue considers the monitoring and forecasting of its revenue and cash flow at company level. One firm which measures floor-to-floor productivity compared its data with

industry norms and realised that "to improve, we will need drastically new methods". An interviewee noted that, for civil work, some common items, such as man-day or man-hour per cubic metre for concrete, could be measured, hence his company uses those data to ensure that it is competitive in bidding.

Obstacles to productivity measurement

Obstacles to the measurement of productivity that were highlighted included: difficulties with the definition of productivity; need for manpower with relevant skills; lack of time for measurement due to tight schedules; and disruptions to work owing to design changes.

It was noted that contractors want to know what they will obtain in return for the effort that goes into measuring productivity. Thus, the pertinent question is: "What is the benefit to companies?"

Obstacles to productivity improvement

Obstacles to productivity improvement that were highlighted include: design issues, including changes; reluctance of authorities to accept alternatives to designs; lack of flexibility in design and build arrangements – it often means "follow our notional scheme'; contract administration issues such as short tender periods, hurried mobilisation; tight project schedules and high liquidated damages; unfair contracts (both public and private standard forms); variation orders (such as where the contractor is not paid for work done); and safety considerations.

Aspects under the main contractor included: lack of effort to manage manpower, lack of supervision, and low worker pay; lack of skilled labour, itinerant foreign workforce; working conditions – long hours in hot and humid conditions, and a six-day work week.

Other obstacles were market conditions: tender prices continually falling and high relative cost of using some productivity-enhancing methods. For example, some firms produce reinforced concrete cheaper than, but just as fast as, system formwork.

One interviewee observed that the RE and COW positions should be reviewed. They should be involved in planning and facilitating progress, instead of rejecting work and having it redone. It was observed that the corporatisation and farming-out of engineering expertise meant that there is less capacity in the public sector to assess alternative designs and effectively administer projects.

It was suggested that one should consider the big picture and ask this question: "Is the industry set up to achieve holistic productivity?" Basic relevant questions include: (i) Are procurement approaches correct? (ii) Are design options that are open to industry correct? (iii) Are design codes being fully utilised? Are they too conservative?"

Enablers and drivers of productivity improvement

The enablers lay in three areas: what the contractor can do, what the client can do, and the administration of the project. Thus, the main enablers are the decision makers: consultants, clients and project managers. The government has made public-client agencies take serious measures such as considering tenderers' productivity track record.

Firms have different enablers. An interviewee noted: "The drivers for us are cost and time, and competitiveness. By driving productivity, it enables us to finish on time and it would be cheaper". Another noted that the main drivers of productivity are economics and risk. For example, Australia has high labour costs and numerous union issues. As such, there is a need to reduce labour risks.

Views on government's productivity programme

Interviewees considered government's schemes "very useful" and necessary. Several noted that Singapore was perhaps the only country where the government injects such a significant amount of money into construction.

Some drawbacks of the schemes identified were: the productivity scores are rather rigid; transportation of precast elements from factories can be challenging; and reduction of MYE has


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3

put a squeeze on contractors – it raises other issues, for example, the fatigue from longer working hours as a result of staff shortage can cause accidents.

It was suggested that firms should have flexibility in selecting technologies. For example, cost is a consideration. One interviewee noted, "if precast bathrooms were cost-effective, developers and contractors would have taken them up".

Firms' actions to enhance productivity since 2010

All interviewees reported that their firms endeavour to improve productivity performance, and had taken many measures to do so. Government incentives have helped. Firms have invested in: automation in precast manufacturing, mechanisation and BIM. Firms have also standardised work and set targets such as for B-score and C-score. Productivity-enhancing technologies adopted include: system formwork, self-compacting concrete, RFID, multi-deck blasting, and muck disposal system.

Project level measures include: value engineering; improving management skills; acting to maximise usage of resources; improving planning and scheduling; using advanced software for project management; and undertaking R&D. Some main contractors are developing their subcontractors.

Industry action to enhance productivity since 2010

The leading role played by the government was unanimously acknowledged and appreciated. Key initiatives highlighted were: B-score and C-score, as well as incentives such as PIP, Mech-C, CoreTrade, and reductions in MYE. Productivity development has been moving upstream, with clients required to attain higher buildability and use PPVC and BIM, if they buy government land.

Local companies have done their part. SCAL has held forums to build awareness of, and provide feedback on, initiatives and policies. It runs courses on BIM, among many others..

It was noted that smaller firms face challenges in developing a comprehensive productivity-focused approach. It was also noted that foreign firms were bucking the trend of productivity improvement; they continue to use conventional methods and do not invest in training.

A note of caution was given on possible over-reliance on the government: the industry should be playing the key role, rather than the government.

How productivity can be improved

Suggestions on productivity improvement were:

Action by contractors

- Adopt mechanisation, wherever possible
- Nominate experienced staff to manage scheduling and actual site progress
- Train workers and improve manpower management skills at all levels
- Raise workers' and engineers' salaries
- Focus on value-added per person indicator

Action by consultants

- Standardise design and components
- Accept alternative designs
- Qualified persons could improve their design capacity to lead value-engineering
- Standardise sizes and shapes of columns

Action by the authorities

- Improve publicity for the government's productivity programme

- Ensure flexible application of regulations such as MYE reduction and use of precast elements
- Rationalise regulations and minimise paper work firms must do, for example, forms or reports to complete or audits to undergo
- Promote design and build; and ECI
- Give higher weightage to bidders' productivity and safety initiatives in government tenders
- Incentivise developers by providing them with extra GFA for increased productivity
- Develop a Productivity Management System for the construction industry
- Develop a plan and provide subsidies to get Singaporeans to enter the construction industry
- Address the needs of construction SMEs
- Require foreign contractors to register in Grade A1 or joint venture with local firms

Joint action by all stakeholders

- Every individual in the entire production chain must respect the need to get information to the site on time
- Change the perception of construction among Singaporeans

Survey of international experts

A survey of senior academics and executives was undertaken. Responses were received from Australia, China and South Korea. In all these countries, productivity was considered to be very important in construction, but it was not measured systematically at project or industry levels except in Korea where subcontractors' managers track it daily. Only Korea has a national programme for raising productivity, where the focus is mainly on worker training. Several large Australian and Chinese firms have productivity policies. The main driver of productivity improvement in China is the rising cost of labour. In Korea, main contractors and government drive productivity policies.

Besides the common unwillingness to invest in training and innovation, other obstacles to productivity improvement differ among countries. In China, pressure to enhance competitiveness drives firms measure productivity, especially among better-educated company managers. In Australia, a simple method of measurement would greatly encourage the productivity improvement. All the countries surveyed felt that productivity will become increasingly important in the future. In Korea, an ageing workforce and increasing wages are give impetus to the productivity issue.

Recommendations: a strategy

A productivity strategy for construction firms

In order to enhance the productivity of Singapore construction firms and practitioners, a there is a need to create strategies that create value.

The vision is that by 2025, the construction industry in Singapore will comprise firms competing through performance improvement in higher-level project parameters of productivity, quality, safety, health and environmental performance and making their due contribution to create value in the economy. The construction industry will have an improved and respected image. It will be perceived as productive and innovative. Construction firms will have path-breaking policies and leadership and management approaches. They will be applying advanced and relevant technologies in addition to healthy balance sheets.

The broad target is that by 2025, the construction industry in Singapore, with contractors playing a key role, will have productivity targets and attainments in line with the target set for all sectors of the economy.

The strategic objectives towards achieving this target are:

1. Measure, use and monitor productivity attainment
2. Productivity-driven corporate management
3. Productivity-driven project management
4. Productivity-enlightened client approach
5. Leadership by contractors and their association
6. Further development of government's productivity enhancement programme
7. Appropriate attitudes and orientations.

Selected recommendations

Construction firms can systematically develop their productivity-enhancing capabilities. They should measure productivity at trade, project and firm levels using relevant multiple indicators, and use the results to set corporate and project targets, monitor their work and assess performance.

Construction firms can formulate a productivity policy, have a director on site in charge of productivity and pursue productivity improvement in their normal operations.

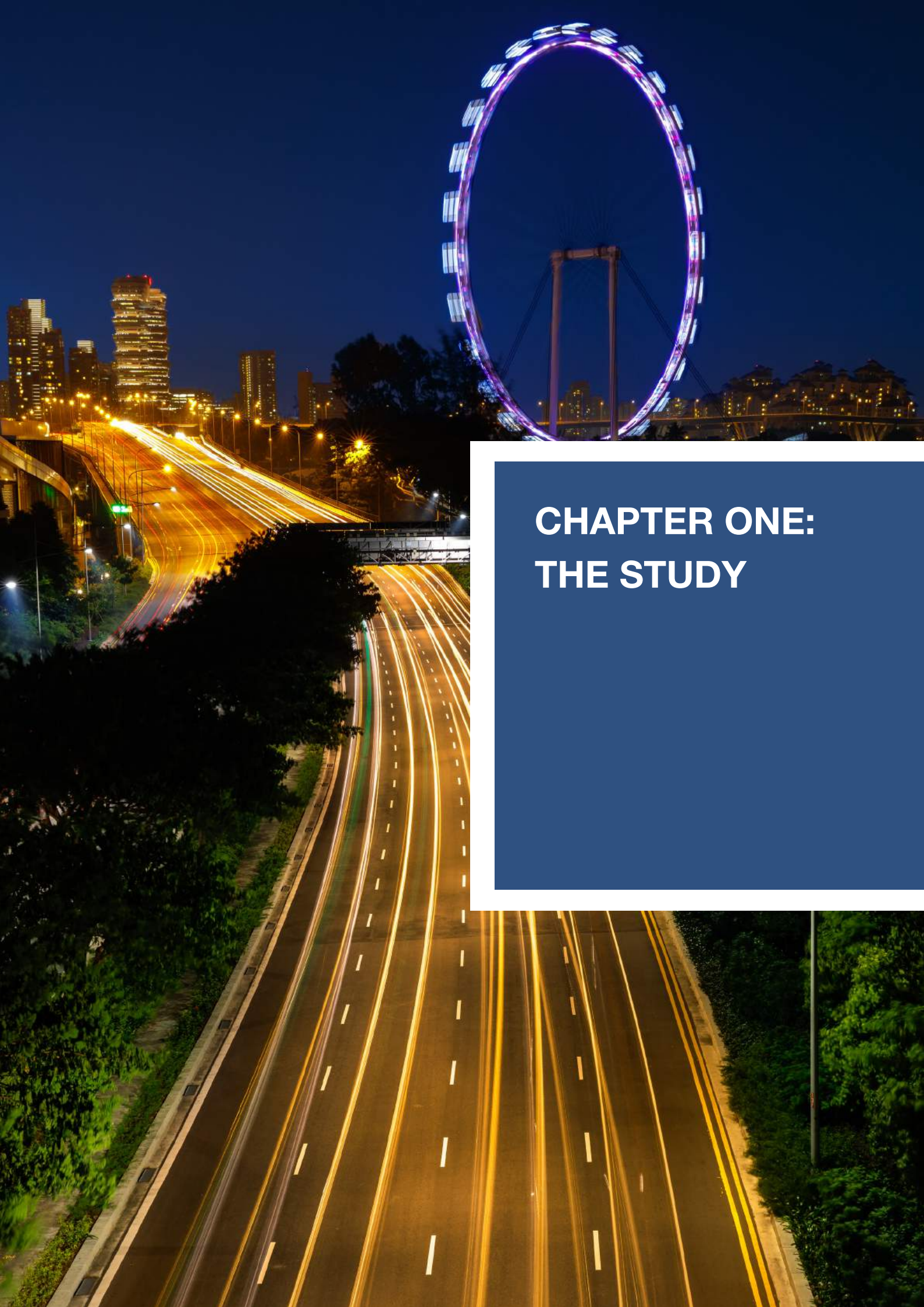
Construction companies can take measures to enhance the quality of their project management systems and procedures. They can use advanced project management software, identify the good productivity-enhancing practices on their projects, and share them within their firms by arranging sharing sessions among their project managers.

Clients can stress the need for attention to productivity on projects by setting goals (such as the winning of awards) and targets (beyond the regulated minimum), and instituting incentive schemes to encourage their attainment.

SCAL should set the tone for a new approach among firms which gives priority to productivity. It should provide leadership in this new era of transition towards a productivity-driven economy in Singapore.

BCA could work with CIJC to review the industry to make proposals that will encourage continuous productivity improvement and the delivery of timely, cost-effective, high quality, and environmentally responsive built items.

Essentially, firms need to adopt a productivity mindset. BCA and SCAL should work together to foster a productivity culture in firms. BCA can work with clients to help create a productivity mindset among firms, which it has successfully done for quality, environment, and safety.



CHAPTER ONE: THE STUDY

1.1 The rationale

It was proposed that a study by the Singapore Contractors Association (SCAL) and the Singapore Chinese Chamber of Commerce and Industry (SCCCI) on construction productivity in Singapore be undertaken. The first and key aspect of the proposed study was that the theme would be the effective measurement of construction productivity in Singapore at all the relevant levels of the industry.

The second aspect of the study was that it would involve SCAL and SCCCI as partners. It would be undertaken by a team of consultants. The consultants would report to a Steering Committee comprising representatives from SCAL and SCCCI. Finally, the study would follow an approach and method formulated by the research team, and reviewed and endorsed by the Steering Committee. The study would last about six months.

1.2 Aim of study

The intention of the parties in initiating and undertaking the study is as follows:

1. The study would consider aspects of construction productivity in Singapore which would supplement, not seek to replace or replicate, what already exists (unless it is clearly better)
2. The aim of the study was to derive findings and make recommendations which would help improve the construction industry, and help the government to devise better policies and programmes
3. The study was being launched at a time when the prevailing mood among key stakeholders in the construction industry in Singapore was that something needed to be done on the issue of productivity.

1.3 Scope of study

The scope of the study is as follows:

1. Analysing construction productivity data in Singapore to understand underlying factors which could be used to explain the situation in construction. Some of the relevant points were:
    a. How does the Department of Statistics measure productivity?
    b. How does the BCA measure productivity?
    c. How do Singapore construction companies measure productivity?
    d. What are the relationships among the three measures?
    e. What is the best way to measure construction productivity in Singapore?
        i. This should be useful to industry, to enable companies to adopt strategic measures to improve productivity – for example, it might include the consideration of cost or revenue as a measure or component
        ii. It should also enable construction productivity to be compared with that for other sectors of Singapore's economy, and with construction industries in other countries.
2. Studying new technologies applied, and procedures and processes adopted by the construction industry in Singapore in the past ten years or so. Some of the issues were:
    a. What have Singapore construction firms done to improve productivity?
    b. How have the policies of the government helped?
    c. What else needs to be done?

3. Exploring the productivity programmes, practices and performance in some countries
    a. The countries to be considered would initially be selected by the Steering Committee, and finally determined by the committee and the consultants, considering the availability of useful relevant information.
4. Studying, into some detail, the corporate policies and practices of selected top-performing construction companies in Singapore, and preparing case studies on them.

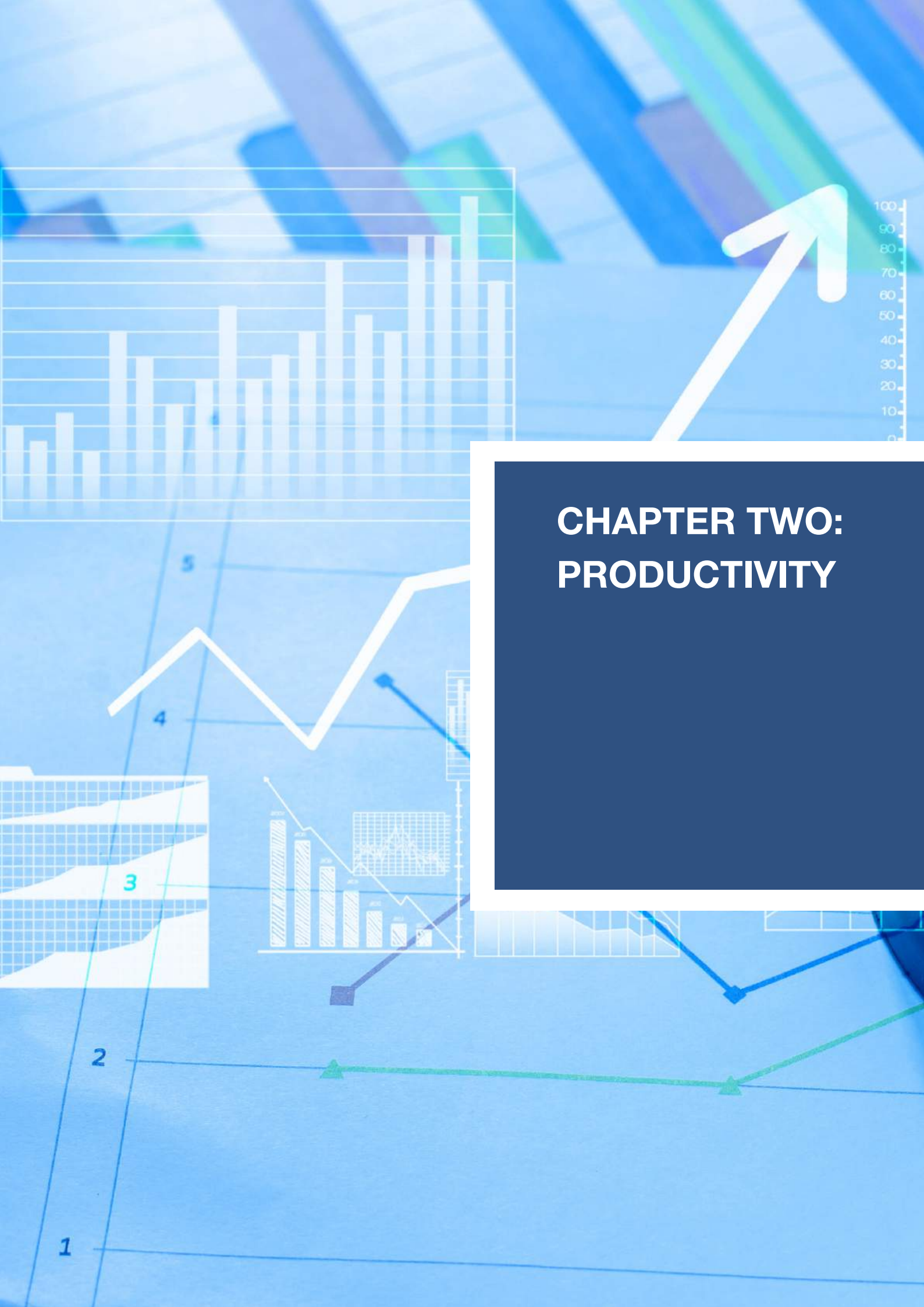
1.4 Method

1. The method to be adopted in the study is outlined below.
2. Review of the relevant literature in Singapore and abroad
3. Interviews of practitioners and government officers
4. A broad questionnaire-based survey of the construction industry
5. Case studies of up to five top-performing construction companies.

1.5 Study team members

The team which undertook the study comprised the following:

1. Dr George Ofori, Consultant
2. Mr Danny Lam, Consultant
3. Mr Dominic Choy, Second Vice President & Chairman, Productivity and Technology Subcommittee, SCAL
4. Mr Lam Kong Hong, Executive Director, SCAL (after April 2016)
5. Mr Lim Jit Say, Former Executive Director, SCAL (up to January 2016)
6. Mr Khaw Ping Ping, Manager (Economic Research), SCCCI
7. Mr Leong Teng Chau, Senior Director (Economics Research), SCCCI
8. Mr Huang Zhiwei, Contracts & Policy Executive, SCAL (after July 2016)
9. Mr Harry Chua, Former Senior Contracts & Policy Executive, SCAL (up to June 2016)



CHAPTER TWO: PRODUCTIVITY

2.1 Productivity

In this chapter, the need for, and usefulness of productivity is explained. The complexity of productivity in construction is discussed and the productivity improvement programmes of various countries are considered. Finally, the productivity improvement programme implemented in Singapore since 2010 is discussed.

2.2 Productivity, the economy and construction

2.2.1 Importance of productivity

Under the goal of High-Skilled People, Innovative Economy, Distinctive Global City, the Economic Strategies Committee (ESC) expressed this broad aim for Singapore's economy in 2010:[22]

> *We must make skills, innovation and productivity the basis for sustaining Singapore's economic growth. This will also provide for inclusive growth, with a broad-based increase in the incomes of our citizens (p. 3).*

The target was to achieve productivity growth of two to three per cent per year over the next ten years; this was more than double the one per cent rate achieved over the previous decade. It was acknowledged that this was a challenging target, particularly applied across the whole economy. Thus, attaining it would require a comprehensive national effort. ESC stated:

> *Our companies have to change the way they work. They have to rely more on technology and innovation, and improve skills among both their local and foreign employees as a basis for competitiveness and growth (p. 6).*

ESC also noted:

> *We must shift to achieving GDP growth by expanding productivity rather than the labour force. We must boost productivity in order to stay competitive, upgrade the quality of jobs, and raise our people's incomes. A slower growing workforce makes it all the more important for every enterprise to innovate to create more value, and to maximise the potential and performance of every worker (p. 3).*

Halfway through the period envisaged for attaining a productivity-driven economy, the bar was to be raised. In October 2015, the government set up the Committee on the Future Economy (CFE), which "will develop economic strategies to position Singapore well for the future – to be a vibrant and resilient economy with sustainable growth that creates value and opportunities for all".[23] The CFE will address these five areas: (i) future growth industries and markets; (ii) corporate capabilities and innovation; (iii) jobs and skills; (iv) urban development and infrastructure; and (v) connectivity. The key focus of the CFE would be "the challenge of moving the Singapore economy up the innovation ladder, from being one that is 'value-adding' to a 'value-creating' one".[24] In contrast to the specific annual productivity growth targets set by the ESC, the CFE would measure success by the opportunities and jobs the economy creates for Singaporeans since a shift to higher skills addresses productivity issues.

What is the role of the construction industry in the effort to attain these national economic goals and targets? Where is the place of construction in this new productivity-driven and value-creating economic framework? What has been the industry's productivity performance and

22 Economic Strategies Committee (2010) Economic Strategies Committee Report: *High Skilled People, Innovative Economy, Distinctive Global City*. Ministry of Trade and Industry, Singapore.

23 Committee on the Future of Economy Secretariat (2015) Committee on the Future Economy to review Singapore's economic strategies and position us for the future. Ministry of Finance, 21 December, http://www.mof.gov.sg/news-reader/articleid/1565/parentId/59/year/2015?category=Press%20Releases

24 Lee, M. (2015) Five future challenges for Singapore economy. *The Straits Times*, 29 October, Committee will look at these areas - jobs, companies, resources, technology, markets; http://www.straitstimes.com/singapore/five-future-challenges-for-singapore-economy

how does this compare with other sectors? What must be done to prepare the construction industry for its tasks in this new framework? How important will it be for the industry to improve its productivity performance as it makes its contribution to the overall effort?

How important is productivity and its growth to a nation? A prominent economist notes that productivity is considered to be a key source of economic growth and competitiveness and is therefore a basic statistical information for country performance assessments and international comparisons.[25] OECD[26] outlines objectives which are usually given for measuring productivity and its growth: (a) to trace technical change where technology appears either in its raw form (such as new blueprints, scientific results, new organisational techniques) or embodied in new products; (b) to identify changes in efficiency; (c) to determine real cost savings which come from the technology change and efficiency gains and various sources as a result of productivity growth; (d) to benchmark production processes to identify inefficiencies; and (e) to help in assessing standards of living and trends in it, as well as the economy's underlying productive capacity.

How important is productivity to organisations? In Singapore, SPRING notes that:[27] "Productivity is critical for the long-term competitiveness and profitability of organisations. It can be effectively raised if it is managed holistically and systematically" (p. 3).

2.2.2 Definition of productivity

Productivity is universally considered to be the relationship between the volume of output produced and the volume of one or more of the inputs used in the production process.[28] There are other definitions of productivity for different contexts, but all are based on the output-input consideration. For example, the American Association of Cost Engineers defines productivity as a "relative measure of labor efficiency, either good or bad, when compared to an established base or norm".[29]

As it measures how efficiently production inputs, such as labour and capital, are being used in an economy to produce a given level of output, productivity is important in all nations at all levels of development, and to all sectors of the economy. The ESC's vision of productivity-driven economic growth in Singapore has been discussed above. As an example, among emerging economies, Malaysia states that: "productivity is the primary engine of growth towards Malaysia's high-income target". A recent study[30] noted that in industrialised countries, economic growth, since the crisis of 2008 was deemed to have ended, has been weak. It stated:

There is a myriad of reasons behind the weak development of late: ballooning debt, antiquated labor markets, a lack of competitiveness, to name but a few. Their significance also varies from country to country. Almost all countries, however, have one thing in common; productivity growth is very weak.

This development is deeply alarming. After all, in the medium to long term, productivity growth is the main factor driving general economic growth… Without productivity growth, the European countries, in particular, will see their economic strength dwindle… In a nutshell: without productivity growth we will be unable to maintain the level of prosperity we have become accustomed to (p. 3).

25 Krugman, P. (undated) Defining and Measuring Productivity. OECD; http://www.oecd.org/std/productivity-stats/40526851.pdf
26 OECD (2001) Measuring Productivity: Measurement of aggregate and industry-level productivity growth. Paris.
27 SPRING Singapore (2011) *A Guide to Productivity Measurement*. Singapore.
28 Organisation for Economic Co-operation and Development (OECD) (2001) *Measuring Productivity: Measurement of aggregate and industry-level productivity growth*. Paris.
29 Rowings, J.E. (2003) Construction estimating. In Chen, W.F. and Liew, J.Y.R. (Eds) *The Civil Engineering Handbook*. CRC Press, Boca Raton, pp. 1-1 to 1-28.
30 Heise, M., Holzhausen, A. and Schneider, R. (2015) The Productivity Slump in the Advanced Economies: Explanations and need for action. Economic Research Working Paper No. 194. Allianz, Frankfurt.

Table 2.1 Selected indicators of role of construction in the economy

	2008	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*
Contribution of Construction to Gross Domestic Product (at 2010 market prices) (%)	3.87	4.73	4.41	4.39	4.70	4.79	4.79
Contribution of Construction to Gross Fixed Capital Formation (at current market prices) (%)	50.06	54.55	51.67	51.99	53.43	55.90	57.14
Progress Payments Certified ($ million)	26,217	30,894	27,428	28,861	31,639	33,682	35,845
Gross Fixed Capital Formation by Construction and Works (at current market prices) ($ million)	38,583	44,689	43,522	45,910	50,737	55,890	56,541
Gross Domestic Product in Construction (at current market prices) ($ million)	11,988	14,997	14,221	14,885	16,437	17,702	18,961
Proportion of Employees Residents Aged 15 Years and Above (%)	5.69	6.09	5.30	4.99	5.12	4.96	4.67

Source: Compiled from data from Department of Statistics (2015)[31]

2.2.3 Importance of construction

The construction industry plays a key role in any country's economy. Table 2.1 shows some of the data on the role of the construction industry in the economy of Singapore in the period 2008 to 2014. Construction contributed between 3.87 and 4.79 per cent of gross domestic product (GDP). These figures are similar to those found in most industrialised countries. It is also suggested that the figure depends on how the "construction industry" is defined, and can be much higher if the entire value chain of the industry is considered. For example, a study done for the Australian government[32] found that construction accounted for 14.4 per cent of GDP (instead of 6.3 per cent credited to it from the national accounts data). Another author noted that if the entire built environment was considered, the value of construction to the UK economy "may even be considered to be as high as 20% of GDP" (compared to 5-6 per cent using the narrow definition).[33]

The data in Table 2.1 show that from 2008 to 2014, the construction industry in Singapore was responsible for between 50 and 57 per cent of gross fixed capital formation (GFCF), which represents the nation's savings in the form of capital assets. The construction industry is also an important contributor of overall employment. Whereas the published data indicate that the proportion of total employment in Singapore contributed by the construction industry during that period ranged between 4.67 and 6.09 per cent, these figures are for the resident population only (defined as Singapore citizens and permanent residents), even though the industry employs significant numbers of foreign workers.

Table 2.2 Data on compensation of employees and taxes in construction

	2008	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*
Compensation of Employees in Construction as Proportion of Total (%)	5.52	6.12	6.21	6.23	6.54	6.80	6.90
Other Taxes Less Subsidies on Production on Construction as Proportion of Total (%)	8.09	38.60	11.01	9.90	14.69	19.70	23.15

Source: Department of Statistics (2015)

31 Department of Statistics (2015) *Yearbook of Statistics 2015*. Singapore.

32 Hampson, K. and Brandon, P. (2004) Construction 2020: *A vision for Australia's property and construction industries*. Cooperative Research Centre for Construction Innovation, Brisbane.

33 Ruddock, L. (2008) The importance of the construction sector: measuring its value. Proceedings of CIB W89 International Conference on Building Education and Research, Kandalama, Sri Lanka.

To demonstrate the size of the construction industry in Singapore, some aggregate monetary figures are shown in Table 2.1. They are for Gross Fixed Capital Formation by Construction and Works ($38.6 to $56.5 billion), Progress Payments Certified ($26.2 to $35.8 billion) and Gross Domestic Product in Construction ($11.9 to $19.0 billion).

Department of Statistics[34] (DOS) data show that between 2008 and 2014, Gross Operating Surplus in the construction industry rose from $5,106.8 million dollars in 2008 (3.6 per cent of the total) to reach its peak for the period of $7,232.2 million dollars the following year, in 2009 (4.9 per cent of the total), and then declined progressively from this peak to $4,649.4 million dollars in 2014 (2.4 percent of the total). Table 2.2 presents data on Taxes Less Subsidies on Production on Construction as a Proportion of the Total. In most years during that period, the figures (in quantum and percentage) were the third highest among all sectors of the economy; in 2014, it was the highest, and made up nearly one-quarter of the total.

The DOS data also show that, during the period 2008 to 2014, the construction industry had the lowest value of "total assets" (save for one year when accommodation and food services had the lowest figures). Overall there was hardly any increase in the total value. These data show the low barriers to entry into the construction industry.

In addition to its direct value chain, the construction industry also stimulates activities in several related sectors of the economy. These include manufacturing, wholesale and retail trade, transportation and storage, finance and insurance and business services. Thus, the industry has significant economic linkage effects.[35]

Other sectors of the economy rely on products of the construction industry. It is important for the building process to reduce the lead time in bringing production facilities on stream and for the built items to contribute, directly and indirectly, to enhance the users' own productivity in their business operations. It is also important to reduce the cost of their direct operations by minimising the expense involved in utilising and managing the facilities. This would enhance the cost competitiveness of the enterprises, and thus, the economy. Construction also improves the quality of life of the nation's citizens in building houses and social infrastructure.

Governments recognise the importance of construction to national development. An element of the vision of the UK for construction by 2025 is an industry "that drives and sustains growth across the entire economy by designing, manufacturing, building and maintaining assets which deliver genuine whole life value for customers in expanding markets both at home and abroad".[36] In New Zealand, the government noted that: "At home, we need to address a persistent productivity gap to make sure our businesses remain competitive on the world stage. Infrastructure will play a key role in lifting productivity and ensuring we can take advantage of opportunities in the global economy…" (p. 7).[37] The Irish government noted that in its path towards economic recovery, Ireland needed a strong and sustainable construction industry, because it needed good quality homes, high-quality commercial developments to underpin recovery and growth, and infrastructure fit for the future.[38]

The role of construction in the economy and in enhancing the wellbeing of the citizenry indicate the importance of high productivity in the construction industry's performance, and the need for its continuous improvement. It was suggested by a Japanese researcher:[39] "From the perspective of building social infrastructure efficiently, the improvement of labour productivity in the construction sector will lead to greater efficiency and international competitiveness of the overall economy, as well as to the long-term development of the construction industry".

34 Department of Statistics (2015) *Yearbook of Statistics 2015*. Singapore.
35 Hillebrandt, P.M. (2000) *Economic Theory and the Construction Industry*. Palgrave Macmillan, Basingstoke.
36 HM Government (2013) *Construction 2025 – Industrial Strategy: Government and industry in partnership*. London.
37 National Infrastructure Unit(2015) *The Thirty Year New Zealand Infrastructure Plan.* New Zealand Government, Wellington, http://www.infrastructure.govt.nz/plan/2015
38 Government of Ireland (2014) *Construction 2020: A strategy for a renewed construction sector*. Stationery Office, Dublin.
39 Sugii, T. (1998) The Construction Sector Suffers from Declining Labor Productivity. Industrial Research Department, NLI Research Institute, No. 117, pp. 18-26.

2.2.4 Importance of productivity in construction in Singapore

How important is it to enhance the productivity of the construction industry in Singapore? For the economy, a more productive construction industry is able to undertake the projects required for growth and long-term development with high levels of efficiency. New Zealand's Productivity Commission estimated that the cost of housing could be further reduced by 12 to 16 per cent "from productivity improvements in construction by taking advantages of scale or taking an industrial approach to construction" (p. 36).[40] A study in Australia found that if construction labour productivity grows in line with the market sector, it would lead to higher GDP, consumption and investment, an accumulated gain of A$12 billion in 2003 to 2010, from which all industries would gain.[41]

For the construction industry, higher productivity would strengthen its position as a key player in the economy and enabler of growth and long-term development. It would enhance its social standing. For the construction company, higher productivity means greater efficiency in usage of resources, which translates into higher volume of work in the same period, lower costs and increased competitiveness. With an improving bottom line, the company would be able to attract and keep good quality personnel.

2.3 Productivity in construction and influencing factors

2.3.1 Productivity in construction

'Productivity' has been the subject of much debate in the construction industry in many countries for many decades. The concept of productivity is not well understood in construction; many find it complex and difficult to understand. In this study, several main topics in the debate on construction productivity are highlighted. One research group identified the following pertinent questions when discussing productivity in construction: how construction is defined, how productivity is measured, and the factors which explain productivity growth.[42] For many reasons including the nature and inherent features of the construction industry and constructed items, it is difficult to define, measure, interpret and compare indicators of construction productivity.[43] However, productivity is growing even more important now in the construction industry. A prominent US executive noted:[44]

> *A lack of reliable and meaningful information is preventing the construction industry from attaining a clear vision of productivity… At the same time, there is strong interest in improving productivity as the industry works to conceive, design, and construct a sustainable and secure infrastructure for the 21st century. There is anecdotal evidence that great strides are being made in certain sectors of the industry, but the lack of widely accepted metrics and credible data makes it difficult to fully understand and evaluate the progress, as well as to devise strategies to extend these advances to other sectors (p. 46).*

2.3.2 Enablers of, and obstacles to, productivity improvement

To formulate and implement measures to improve productivity performance, it is necessary to identify and understand the factors which have an influence on it, as well as the relationships among them. What are the enablers of, and obstacles to, productivity improvement in construction? The factors which influence productivity in construction may be categorised under: (a) those inherent in the nature of construction activity; (b) those which the construction industry can influence; and (c) those lying outside the control of the industry. Box 2.1 shows factors determined by a major organisation.

40 Productivity Commission (2015) Using Land for Housing, Draft Report, http://www.productivity.govt.nz/inquirycontent/2060?stage=3

41 Tasman Economics (2002) *Productivity and the Building and Construction Industry*. Royal Commission into the Building and Construction Industry, Discussion Paper No. 17, Melbourne.

42 Goodrum, P.M., Haas, C.T. and Glover, R.W. (2002) The divergence in aggregate and activity estimates of US construction productivity. *Construction Management and Economics*, 20(5), pp. 415-423.

43 Yi, W. and Chan, A. (2014) Critical review of labor productivity research in construction journals. *Journal of Management in Engineering*, Vol. 20, Issue 2, pp. 214-225.

44 Bernstein, H.M. (2003) Measuring productivity: an industry challenge. *Civil Engineering*, December, pp. 46-53.

Box 2.1: Some factors causing lost productivity in construction

Intergraph identified 33 factors which affect labour productivity in construction which can be grouped under:

(a) *nature of the industry* – including "area practices" – observance or customs, practices or procedures unique to the craft, client, country or location; "confined space" – working in such spaces with limitations on egress and ventilation can result in non-productive work; "hazardous work area" – require special safety equipment and clothing, limits to time and exposure of workers, resulting in less time on tools; "stacking of trades" – when work is done in limited space with other firms, there can be congestion, more loss of tools, additional safety hazards and inability to optimise gang work

(b) *management* – including "errors and omissions", meaning changes are performed on a crash basis; "ripple effect" – caused when changes in other trades' work affect other work

(c) *human resource* – including "dilution of supervision" – when supervision is diverted from planned work to analyse and plan contract changes, expedite delayed materials, manage added workers, or other tasks not in the original work scope. Studies of such features have led to possible actions for improving productivity, such as prefabrication and volumetric construction to avoid the problems relating to "confined space".

Source: Intergraph (2012) Factors Affecting Construction Labor Productivity: Managing Efficiency in Work Planning.

https://www.intergraph.com/assets/global/documents/SPC_LaborFactors_WhitePaper.pdf

Factors inherent in nature of construction

The first set of construction productivity influencing factors to consider are those which emanate from the nature of the construction industry, the construction process and the constructed item. Construction work is undertaken in response to expressed demand; in most cases, the contractor has no control over the type or volume of items it will build, where they will be built, and what inputs will be required. This makes investments for future improvements in performance difficult. Much of construction work is labour-intensive, and difficult to mechanise or standardise. The uniqueness of projects has many implications for productivity. For example, it means that participants have to find solutions to fresh challenges on every project; there is a need to learn on-the-job, as experience from one project might not apply to others[45] and specific tests might be necessary in certain cases.

Construction is location-specific, and is therefore subject to both the realities and uncertainties in the physical environment where the work must be done. These include difficult-to-predict subsoil conditions, changes in the weather, and social and community issues. Site planning and logistics can be demanding on projects in remote parts of the country, and on confined sites in urban areas. Given the increasing proportion of off-site inputs in many countries, this can be a major issue in the management of the project. The heavy elements which must be manipulated and the heights at which work often takes place, together with the many activities in several trades which have to be undertaken, some of them simultaneously, increase the risk of incidents. Addressing these issues require time and effort which do not directly contribute to progress on the project and hence, productivity is affected.

45 Debrah, Y.A. and Ofori, G. (1997) Flexibility, labour subcontracting and HRM in the construction industry in Singapore: Can the system be refined? *International Journal of Human Resource Management*, Vol. 8, No. 5, pp. 690-709.

Factors the construction industry can influence

Productivity in construction is also influenced by inadequacies within the industry itself, including approaches to design, management practices, methods of work, business practices and the nature of the human resource. Some often-highlighted issues are: designs which are difficult to construct; errors in design; inadequate project preparation and planning; poor management of resources; and inadequate coordination of the work of the project team.[46] Other issues include changes in the design during construction; poor motivation of workers; and lack of attention to productivity in the company and on the project. Also of relevance is the prioritisation of other performance parameters in construction such as cost and time over productivity, and the possible failure to balance productvity with yet other parameters such as quality, safety and environmental performance.

Factors lying outside the contractor's control

Some factors influencing productivity on a project are controlled by the client and the design team. Others lie in the business environment of construction firms. The large number of firms and participants involved in each project makes it difficult to deploy new technologies, best practices or other innovations across a critical mass of owners, contractors and subcontractors.[47] These include poor performance by subcontractors and shortages or inadequate quality of materials and equipment. One author[48] notes that the greatest obstacle to construction productivity growth is the lack of a common comprehensive vision of an efficient and productive construction industry among the stakeholders. There is no agreement with regard to measures of success, and without clear benchmarks it will not be possible to develop strategies to realise significant changes across the industry (p. 52).

The construction process is one of the most highly regulated in any country, with a large number of provisions to be complied with, and approvals, certificates and inspections needing to be obtained for each project. The regulations affect methods of operations; they also change over time, becoming generally more stringent. The regulatory provisions increase the number of players in the process, and hence uncertainty and the possibility of inefficiency. A US study[49] found that land use regulation has a small but statistically significant negative effect on productivity growth in construction. Also, regulation increases construction costs by 3.7 per cent, and increases in regulation reduced construction productivity growth by only 0.1 percent a year. Some other factors influencing construction productivity which governments control include: public-sector project opportunities; procurement arrangements and contract conditions; the education and training policies and systems; and sector-specific development programmes.

Country examples of productivity-influencing factors

Several examples of how factors causing low construction productivity manifest themselves in some countries are now considered. Causes of low construction productivity in the US include:[50] diverse and fragmented stakeholders resulting in lack of financial mass required to pursue some improvement changes; segmented processes; image of the industry which makes it difficult to attract and retain skilled workers and recent graduates; unique, built-on-site nature of most projects which have a unique combination of design standards, delivery method

46 Winch, G. (1994) The search for flexibility: the case of construction. *Work, Employment and Society*, Vol. 8, No. 4, pp. 593-606.

47 Haas, C. (2009) An international perspective on construction competitiveness and productivity. In Committee on Advancing the Competitiveness and Productivity of the U.S. Construction Industry (Ed) *Advancing the Competitiveness and Efficiency of the U.S. Construction Industry*. National Academies Press, Washington, Appendix C, pp. 55-75.

48 Bernstein, H.M. (2003) Measuring productivity: an industry challenge. *Civil Engineering*, December, pp. 46-53, http://www.engr.uky.edu/~rsouley/CE%20120/12/Measuring%20Productivity%20An%20Industry%20Challenge.pdf

49 Sveikauskas, L., Rowe, S., James Mildenberger, J., Price, J. and Young, A. (2014) Productivity Growth in Construction. BLS Working Papers, No. 478. US Department of Labor, Bureau of Labor Statistics, Washington D.C.

50 Haas, C. (2009) An international perspective on construction competitiveness and productivity. In Committee on Advancing the Competitiveness and Productivity of the U.S. Construction Industry (Ed) *Advancing the Competitiveness and Efficiency of the U.S. Construction Industry*. National Academies Press, Washington, Appendix C, pp. 55-75.

and legal structure; variations in the standards, processes, materials, skills and technologies required by different types of projects; variation in building codes, permitting processes and regulations in states and localities; lack of an industry-wide strategy to improve construction efficiency; lack of effective performance measures for construction tasks, projects and the industry as a whole; and lack of an industry-wide research agenda and inadequate funding levels.

Factors identified in Canada were:[51] (a) project conditions – weather variability; (b) market conditions – material shortages, lack of experienced design and project management personnel; (c) design and procurement – large number of changes; (d) construction management – ineffective communications, inadequate planning and scheduling; (e) labour – restrictive union rules; government policy – slow approvals and issue of permits; and (f) education and training – lack of management training for supervision and project management.

Of the 45 productivity influencing factors in the construction industry in Kuwait,[52] the ten most significant were: clarity of technical specifications; extent of variation orders during execution; level of coordination among design disciplines; lack of labour supervision; proportion of work subcontracted; design complexity level; lack of an incentive scheme; lack of construction manager leadership; stringent inspection by the engineer; and delay in responding to requests for information.

Australia's Productivity Commission[53] identified these broad productivity challenges facing the construction industry: (i) project definition and procurement approaches; (ii) firm level project management; (iii) prefabrication; (iv) design; (v) labour utilisation and workplace relations; (vi) incentives for innovation; and (vii) regulation and competition. Analysis of research in Australia found the following major causes of lost productivity:[54] variability in subcontractor capability and performance; interruptions and poor coordination (waiting for the next trade, for information or instructions, for materials, for plant); working continually overtime (exhaustion or burn-out); size of the labour force (relative to size of site); unplanned increases in labour force (flooding the job 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 (productivity training); contractual conflict and poor subcontractor relationships; design (constructability, complexity, uniqueness, prefabrication); design management (timely and accurate information); productivity not being rewarded; lack of information about productivity improvement; and not measuring and monitoring productivity.

In a recent study in Singapore, a factor analysis of 27 possible contributors to low productivity at construction sites in Singapore grouped the factors under the following:[55] (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.

2.3.3 What is to be done?

Measures for improving productivity have been proposed and adopted in various countries over the decades. Singapore's ESC (2010)[56] noted that: "Australia's construction sector saw a significant improvement in productivity earlier this decade, following two decades of stagnant

51 Dozzi, S.P. and AbouRizk, S.M. (1993) *Productivity in Construction*. Institute for Research in Construction National Research Council, Ottawa.

52 Jarkas, A.M. and Bitar, C.G. (2012) Factors affecting construction labor productivity in Kuwait. *Journal of Construction Engineering and Management*, Vol. 138, Issue 7, pp. 811-820.

53 Productivity Commission (2014) *Public Infrastructure: Productivity Commission Inquiry Report,* Inquiry Report No. 71, Canberra.

54 Productivity Commission (2014) *Public Infrastructure: Productivity Commission Inquiry Report,* Inquiry Report No. 71, Volume 2. Canberra.

55 Teo, A.L., Ofori, G., Tjandra, I.K.T. (2015) Intelligent System for Determining Productivity and Safety Index using BIM. Research Project Report at Department of Building, National University of Singapore.

56 Economic Strategies Committee (2010) *Economic Strategies Committee Report: High skilled people, innovative economy, distinctive global city*. Ministry of Trade and Industry, Singapore.

productivity growth. It was achieved through industry reforms and incentives for contractors to substitute technology for labour. The localised and experienced workforce in Australia's construction sector also contributes to higher productivity, and contractors are generally willing to invest in the training and career development of their workers" (p. 3). Factors that have effected productivity growth in the US include: (1) skilled labour availability; (2) technology utilisation; (3) offsite fabrication and modularisation; and (4) use of industry best practices.[57]

Some other suggestions made for enhancing productivity in construction include:

1. Project management – improve planning and coordination, considering also the work of specialists and outsourced work; improve job site efficiency through more effective interfacing of people, processes, materials, equipment and information; use effective performance measurement tools to drive efficiency and support innovation; modernise logistics, materials management and materials handling; rationalise and clarify roles on the project; monitor progress on the work of subcontractors
2. Human resource management – develop comprehensive training and knowledge transfer programmes at all levels; maintain appropriate salary, compensation and incentive systems; demand excellence in both quality and quantity of work, and pay systematic attention to good work; leverage organisational expertise and best practices across the business;[58] give workers frequent feedback on performance
3. Technology adoption – mechanise and automate whenever possible; make greater use of prefabrication, pre-assembly, modularisation and off-site fabrication techniques and processes; utilise new technologies such as information and communication technology (ICT) in general, with Building Information Modelling (BIM), radio-frequency identification (RFID) and global positioning systems (GPS) techniques as examples, where relevant; undertake R&D on relevant issues
4. Management at company level – share productivity improvement ideas; make productivity the business of everyone in the organisation;[59] reduce indirect costs by restructuring unproductive areas; and look into standardising, codifying and documenting project management practices across the organisation to develop a portfolio of consistent processes for managing different types of projects across the firm.[60]

The Civil Engineering Research Foundation (CERF) in the US[61] suggests that to create a healthy and productive construction industry, all industry stakeholders (including constructors, designers, public and private-sector owners, regulators, risk managers, and members of the financial community) should collaborate to develop a broad understanding of productivity, and create metrics and tools for productivity and its growth.

Effective measurement of performance in relevant areas of construction is now emphasised in industrialised countries. An example worth highlighting is that in the US, the focus of firms on safety-related issues by tracking their performance against national statistics has resulted in the adoption of best practices to improve safety performance.[62] Singapore's experience with construction quality, safety and environmental performance in the construction industry has similarly been based on effective measurement at relevant levels.

57 Huang, A.L., Chapman, R.E. and Butry, D.T. (2009) *Metrics and Tools for Measuring Construction Productivity: Technical and Empirical Considerations*. National Institute of Standards and Technology, Gaithersburg, MA.

58 Pipeline and Gas Journal (2015) Getting basics of construction productivity right. November 2015, Vol. 242, No. 11, http://pgjonline.com/2015/11/13/getting-basics-of-construction-productivity-right/

59 James, R.E. (1980) Measuring construction productivity. *Construction Dimensions*, December, pp. 19-23.

60 Pipeline and Gas Journal (2015) Getting basics of construction productivity right. November 2015, Vol. 242, No. 11, http://pgjonline.com/2015/11/13/getting-basics-of-construction-productivity-right/

61 Bernstein, H.M. (2003) Measuring productivity: an industry challenge. *Civil Engineering*, December, pp. 46-53, http://www.engr.uky.edu/~rsouley/CE%20120/12/Measuring%20Productivity%20An%20Industry%20Challenge.pdf

62 NIST (2009) Publication offers constructive advice for construction industry efficiency. November 17, http://www.nist.gov/el/nrc_111709.cfm

2.4 Approaches to construction productivity development in other countries

National construction industry development strategies and initiatives invariably consider improvement in productivity as one of their main objectives. The initiatives to improve the performance and competitiveness of the construction industries launched in the early 2000s were based on the notion that the rate of growth of productivity in construction had been lower than in other sectors of the economy, and needed to be improved. Examples were those in Australia, Hong Kong, Malaysia, the Netherlands, Singapore (the Construction 21 exercise), Sweden and the UK. In Sweden alone, three government reports over less than a decade[63] had based their evaluation and proposals on this assumption.

What do some of the current national construction strategies (published since 2010) in some other countries say about construction productivity?

2.4.1 United Kingdom

Weaknesses in the UK construction industry identified in the strategic review of the industry undertaken by the government and the industry were:[64]

1. low vertical integration in the supply chain, with high reliance on sub-contracting which often leads to fracture between design and construction management and a fracture between the management of construction and its execution leading to lost opportunities to innovate
2. low investment in R&D and intangible assets such as new processes (particularly in contracting) due to uncertain demand for new goods and limited collaboration
3. lack of collaboration and limited knowledge sharing; learning points from projects are often team-based and lost when the project ends and the team breaks up, hence there is low technology transfer
4. high construction costs in comparison with foreign competitors, driven by inefficient procurement and processes rather than material input costs

It is evident that all the four weaknesses in UK construction highlighted relate directly to productivity. So what was proposed? The vision for UK construction in 2025 included an industry that:

1. attracts and retains a diverse group of multi-talented people, operating under considerably safer and healthier conditions, that has become a sector of choice for young people inspiring them into rewarding professional and vocational careers
2. leads the world in research and innovation, transformed by digital design, advanced materials and new technologies, fully embracing the transition to a digital economy and the rise of smart construction
3. has become dramatically more sustainable through its efficient approach to delivering low carbon assets more quickly and at a lower cost, underpinned by strong, integrated supply chains and productive long term relationships
4. drives and sustains growth across the entire economy by designing, manufacturing, building and maintaining assets which deliver genuine whole life value for customers in expanding markets both at home and abroad

This means that, in the UK, "Construction in 2025 is no longer characterised, as it once was, by late delivery, cost overruns, commercial friction, late payment, accidents, unfavourable workplaces, a workforce unrepresentative of society or as an industry slow to embrace change" (p. 18).

63 Olander, S. Widen, K. Hansson B. and Pemsel, S. (2010) Productivity comparisons, are they possible or even desirable? In Barrett, P., Amaratunga, D., Haigh, R., Keraminiyage, K. and Pathirage, C. (Eds) *Selected Papers in the Proceedings of CIB Working Commission W055 Building Economics – Papers and Postgraduate Papers from the Special Track*, Salford Quays, 10-13 May, pp. 58-67.

64 HM Government (2013) *Construction 2025 – Industrial Strategy: Government and industry in partnership*. London.

The ambition, under the strategy, was to achieve by 2025:

1. a 33 per cent reduction in both the initial cost of construction and the whole life cost of assets

2. a 50 per cent reduction in the overall time from inception to completion for new build and refurbished assets

3. a 50 per cent reduction in greenhouse gas emissions in the built environment

4. a 50 per cent reduction in the trade gap between total exports and total imports for construction products and materials.

The joint commitments made by government and industry included: (a) improving the image of the industry by inspiring young people and through a coordinated approach to health and safety and improving performance in the domestic repair and maintenance market; (b) engaging with bodies across the industry to ensure that capability and capacity issues in construction are addressed in a strategic manner; and (c) driving procurement efficiency and exploring options for further efficiency gains in the procurement process.

2.4.2 Ireland

The Irish government noted that its main tasks of "reform, renewal and recovery" in the effort to resuscitate the economy after the deep impact of the global economic crisis were "arguably more relevant to the construction sector than to most" (p. 4),[65] as the industry had been the hardest hit by job losses in the economy (61 percent for architects, 71 percent for plasterers and 82 percent for bricklayers). It was "time for a fresh start, one in which the lessons learnt from what went wrong are applied to the creation of a renewed and vibrant construction industry fit for the future" (p. 4). Construction would help to realise economic recovery and create jobs:

> *An appropriately sized construction sector can help to deliver jobs across the country, not just to those directly involved in the industry, but to the manufacturing, retail and professional sectors that it supports. It can help to underpin the future competitiveness of the country, ensuring that we continue to be well-positioned to attract the inward investment that has been so important to our economic development (p. 4).*

Ireland's vision was:

> *Ireland needs a competitive, innovative, dynamic, safe and sustainable construction sector; one that makes its full and proper contribution to the economy and to job creation, and one that is based on best practice and capable of delivering the economic and social infrastructure we need to build to sustain a prosperous future (p. 6).*

The issues to be addressed under Ireland's construction industry strategy included: (a) a strategic approach to the provision of housing, based on real and measured needs, with mechanisms in place to detect and act when things are going wrong; (b) continuing improvement of the planning process, striking the right balance between current and future requirements; (c) the availability of financing for viable and worthwhile projects; (d) ensuring we have the tools we need to monitor and regulate the sector in a way that underpins public confidence and worker safety; and (e) ensuring a fit for purpose sector supported by a highly skilled workforce achieving high quality and standards.

The Irish report recognised that adoption of new technologies, modern methods of construction and delivery processes would be crucial for sustainable competitive construction enterprises. It noted: "Increased productivity through improved training and skills and through the adoption of technology can make significant cost, building performance and project delivery differences" (p. 56).

65 Government of Ireland (2014) *Construction 2020: A strategy for a renewed construction sector*. Stationery Office, Dublin.

2.4.3 Other countries

Other countries also see an important role for construction in national development and recognise the need to improve its performance in many areas including productivity.

Australia

Australia has appointed three Royal Commissions into the construction industry in the past few years. The first one,[66] in 2002, had found that the main contributors to growth in construction productivity were: sharper competition facilitated by lower trade and investment barriers, deregulation and pro-competitive regulation; specialisation resulting from greater trade openness and access to new technologies; and increased flexibility to adjust the production and distribution process. The more recent enquiry into construction was on infrastructure, covering the subject of productivity substantially.[67] It identified many unrealised productivity and efficiency gains in the industry, including those through improvements in project planning, corporate operating and managerial processes; prefabrication and design; use of technology and choice of technique; labour utilisation and workplace relations; and regulatory and competition policy structures. Innovative approaches to design and planning and the expanded use of prefabricated or precast elements were identified as main factors having the potential to promote productivity growth.

Malaysia

The aim of Malaysia's "Construction Industry Transformation Programme 2016-20"[68] is "a transformation of today's construction industry into a modern, highly productive and sustainable industry that is able to enjoy continued growth and enable Malaysian companies to compete with international players whether domestically or abroad". The programme has four strategic thrusts: (1) quality, safety and professionalism; (2) environmental sustainability; (3)productivity; and (4) Internationalisation. On productivity, the target is to increase it by 2.5 times its 2011 value to US$16,500 per worker.

The broad initiatives under the productivity thrust are: (a) continue investment in human capital development in construction; (b) enhance control and balance of workforce supply; (c) accelerate adoption of Industrialised Building System (IBS), mechanisation and modern practices; (d) rollout technology advantage across project life-cycle; (e) enhance availability of strategic information via the National Construction Industry Information Centre; and (f) advance SME/*Bumiputera* capacity and capability-building.

Productivity was given high priority in the programme because of: (a) a low IBS adoption rate; (b) a largely unskilled workforce – 93 percent of the foreign construction workers were unskilled; and (c) high proportion of subscale SMEs and *Bumiputera* firms. Some of the main recommendations were:

1. enhance human capital development – drive targeted training and Specialist Apprenticeship programmes; accredit workers, contractors and personnel; and increase skill level and specialisation
2. drive scale of IBS adoption – establish economic mechanisms, such as equipment tax reduction, tax holidays, plot ratio incentives, and separate IBS procurement from main contract
3. increase capability of *Bumiputera* contractors – develop *Bumiputera* contractors with expertise in specialist trades, enhance holistic upskilling and develop more entrepreneurs, and increase opportunities through "carve-out and compete" programmes.

66 Tasman Economics (2002) *Productivity and the Building and Construction Industry*. Royal Commission into the Building and Construction Industry, (Discussion Paper No. 17), Melbourne, Australia.

67 Productivity Commission (2014) *Public Infrastructure: Productivity Commission Inquiry Report*, Inquiry Report No. 71, Volume 2. Canberra.

68 Construction Industry Development Board (2015) *Construction Industry Transformation Programme (CITP)* 2016-20. Kuala Lumpur.

2.5 Construction productivity development programme in Singapore since 2010

In the final section of this chapter, the construction productivity development programme in Singapore since 2010 is discussed. The progress attained in terms of productivity scores is discussed in greater detail in Chapter 3. Briefly, site productivity, which measures the floor area completed per man-day, has been improving at a rising rate, the average annual rate of which was 1.4 per cent between 2010 and 2014.[69] The focus of the discussion is on actions initiated by government and SCAL.

2.5.1 Rationale and benefits of productivity improvement in construction in Singapore

What have been the rationale, driving forces and benefits of construction productivity development in Singapore? In 2003, BCA noted that: "For many years, BCA has been promoting buildable design to the private sector as a means to reduce the industry's reliance on foreign workers."[70] Again, in 2014, BCA noted that: "Productivity and technological advancements are key to reducing reliance on foreign labour, enabling faster and better quality construction, and increasing the attractiveness of the built environment sector."[71]

Promotion of buildable design has been a major plank of the productivity development programme in Singapore. BCA highlighted advantages of buildable design: developers will build more efficiently, homeowners will have better quality homes, and the country will boast international building standards.[72] A contractor noted that companies benefit as prefabrication leads to labour savings. In 2003, a BCA study showed that the adoption of buildable designs could lead to manpower savings of between 20 to 60 per cent for structural works alone (which forms half of the total workforce on a project).[73] With prefabrication, developers and building owners benefit from "straighter, flatter walls - lesser need for touch-ups and more consistent quality", resulting in a superior end-product. In its guide book on trade productivity, BCA noted that trade productivity reflects the efficiency and quality of the workforce.[74]

BCA studies in 2013 showed that a five-point increase in the Buildability score resulted in manpower savings of approximately ten to fifteen per cent.[75] Recently, BCA highlighted wider benefits: in promoting the adoption of productive technologies such as drywalls and precast elements, it also considers whether the technologies can help to reduce dis-amenities to residents near the site, going beyond just labour efficiency;[76] off-site production means there is less noise and dust during construction.

2.5.2 Productivity strategy documents and initiatives

Following the ESC's suggestion that strong measures be taken to enhance productivity in Singapore's economy in order to attain sustained growth, the government launched a $250 million package of incentives to enable the construction industry to prepare for the policy changes which would be introduced, and play a role in the national endeavour.[77] BCA proposed a series of initiatives. The incentives under the Construction Productivity and Capability Fund (CPCF) would cover:

69 BCA (2015) Media Release – About 7,000 firms to benefit from s$450 million boost for construction productivity, http://www.bca.gov.sg/newsroom/others/BCA_Media_Release_COS_2015_100315.pdf

70 BCA (2003) Press Release – Better quality homes as industry gears up towards higher buildablity & prefabrication, http://www.bca.gov.sg/Newsroom/others/pr260303.pdf

71 BCA (2014) Media Release – Singapore Construction Productivity Week focuses on more productive, innovative and advanced building solutions, http://www.bca.gov.sg/Newsroom/pr28082014_BCA.html

72 BCA (2000) Press Release – New legislation to usher in new era of construction, http://www.bca.gov.sg/Newsroom/others/pr151200.pdf

73 BCA (2003) Press Release – Better quality homes as industry gears up towards higher buildablity & prefabrication, http://www.bca.gov.sg/Newsroom/others/pr260303.pdf

74 BCA (2012) *Builders' Guide on Measuring Productivity: A guide to help builders measure productivity of various trades*. Singapore.

75 BCA (2013) BCA to boost productivity through tighter buildability and constructability requirements and enhanced incentives, http://www.bca.gov.sg/Newsroom/pr11032013_P.html

76 BCA (2014) New measures for developers to drive construction productivity improvements, http://www.bca.gov.sg/Newsroom/pr10032014_BCA.html

77 BCA (2010) Media Release -- Measures to raise productivity and build capability in the construction sector, http://www.bca.gov.sg/Newsroom/others/pr08032010_construction_measures.pdf

1. Workforce Development – Co-funding manpower development through: upgrading courses and training in the use of technology; undertaking assessment of workers' skills; and offering of scholarships to attract local professional, managerial, executive and technical personnel (PMETs) to join and lead the industry
2. Technology Adoption – Funding support to encourage the adoption of technologies and use of equipment that could lead to significant productivity improvements. Greater assistance would be provided to small and medium-sized companies
3. Capability Development – Provision of financial support to help progressive construction firms to develop capability in complex civil engineering projects and complex building projects.

Construction Productivity Roadmap 2010

In 2010, the Construction Productivity Roadmap was launched. It sought "to transform the construction industry and raise its productivity".[78] The vision was that of "a highly integrated and technologically advanced construction sector led by progressive firms and supported by a skilled and competent workforce in 2020".[79] The key thrusts of the roadmap were: (a) regulating the demand and supply of low cost, lower skilled foreign workforce; (b) enhancing the quality of the construction workforce; (c) imposing regulatory requirements and minimum standards to drive widespread adoption of labour-saving technology; and (d) offering financial incentives to encourage manpower development, technology adoption and capability building.

Second Construction Productivity Roadmap and related actions[80]

The aim of the Second Construction Productivity Roadmap is to drive the industry towards achieving productivity gains over the next five years to meet the national productivity target of an average of 2-3 per cent improvement per annum from 2011 to 2020. This would require a strong productivity mindset among key stakeholders in the entire value chain. The following are focus areas and measures adopted: .

Focus area 1 – higher quality workforce:

The desired workforce profile for the built environment sector is one comprising a stronger pool of PMETs and at least 40 per cent of higher-skilled workers among the work permit holders. To achieve this, the quality of the workforce would be raised the through: (a) mandatory requirement for a minimum proportion of highly-skilled and experienced workers; (b) new pathway for upgrading basic-skilled workers; and (c)incentivising workforce upgrading and retention.

Focus area 2 – higher capital investment:

Measures to help the industry towards higher Design for Manufacturing and Assembly (DfMA) adoption: (a) levelling up standards through mandatory requirements; (b) public sector taking the lead (mainly in procurement); (c) requiring higher productivity for private-sector projects through Government Land Sales (GLS); (d) providing incentives for the adoption of productive technologies; and (e) encouraging continual innovation by the industry.

Focus area 3 – better integrated construction value chain:

To promote collaboration among developers, consultants, builders and suppliers, a BCA scheme provides funding under the CPCF for projects which adopt Virtual Design and Construction (VDC).

2.5.3 Regulations

Regulation has been a key part of the construction productivity development programme in Singapore. The regulations are continually revised, fine-tuned and generally made increasingly more stringent. In 2011, the submission of construction productivity data to BCA by builders

78 BCA (2012) Second Construction Productivity Week, http://www.bca.gov.sg/newsroom/others/pr16052012_SCPWB.pdf
79 BCA (2011) Background: Construction Productivity Roadmap, http://www.bca.gov.sg/newsroom/others/pr03032011_CPA.pdf
80 BCA (2015) Annex A: 2nd Construction Productivity Roadmap, http://www.bca.gov.sg/Newsroom/others/Media_Release_SCPW_2015_131015.pdf

became mandatory; companies use a common platform under the Electronic Productivity Submission System (ePSS) to submit the data which are used to establish the project-level productivity, and subsequently, industry-level data. Since November 2014, firms are required to use the Biometric Authentication System (BAS) at project sites while collecting this information.

Occasional major reviews of the regulations have been undertaken. The inter-ministry Construction Productivity Steering Committee was formed in 2013, to review, simplify and streamline government policies that may have an adverse impact on productivity in construction, and propose new measures to help the industry to improve productivity.[81] The inter-agency Building Innovation Panel (BIP) facilitates multiple agency evaluation and approval of proposals involving the adoption of innovative productivity-enhancing construction methods, processes and materials.

In 2014, the Building Control (Buildability and Productivity) Regulations were revised.[82] From 1 November 2014, projects are required to:

1. meet higher minimum Buildable Design and Constructability standards (which had previously been raised in 2013)
2. use prefabricated and standardised components: all non-landed residential developments are required to adopt drywall internal partitions in non-wet areas; and standardised floor heights and components such as precast staircases, precast refuse chutes and doors would be required for new projects
3. adopt "high-impact productive technologies" for projects under the GLS and industrial GLS (iGLS) programme including: (i) adoption of Prefabricated Bathroom Units (PBUs) on residential (non-landed) sites and in the residential (non-landed) component of mixed-use developments; and (ii) adoption of Prefabricated Pre-finished Volumetric Construction (PPVC) on selected GLS sites.

In 2015, the Building Control (Buildability and Productivity) Regulations 2011 were revised again. From 1 December 2015, higher minimum Buildable Design Scores (B-Scores) and Constructability Scores (C-Scores) for projects were introduced; a revised Buildable Design Appraisal System (BDAS)[83] with the requirement for the adoption of new items such as standard storey-heights for hotels and prefabricated components for specific types of projects was launched; and revised requirements and a new accreditation requirement for PPVC to encourage offsite construction were introduced. A Revised Constructability Appraisal System (CAS) was also released. It included changes to the maximum constructability score allocated to the architectural, mechanical, electrical and plumbing component, and the component on Good Industry Practices.

2.5.4 Human resource development

BCA Academy and SCAL Academy offer a range of productivity-related training courses for various levels of personnel. Some of these courses are mandatory requirements for certain purposes, such as for registration of construction firms. Some recent developments on construction human resource issues are now considered.

In 2014, BCA and MND launched a "five-year rebranding roadmap…to attract and retain more local talent in the built environment sector". BCA and the Construction Industry Joint Committee (CIJC), of which SCAL is a member, signed a Memorandum of Understanding (MoU) in 2014 to collaborate to achieve the shared vision "to transform the built environment sector

81 BCA (2013) SMS Lee Yi Shyan: Quantum leap in construction productivity possible with advanced technologies and having productivity culture, http://www.bca.gov.sg/Newsroom/pr23072013_CP.html

82 BCA (2014) BCA-URA joint release: New regulations to improve productivity in the construction sector, http://www.bca.gov.sg/Newsroom/pr06112014_BCA.html

83 BCA (2015) Amendments to Building Control (Buildability and Productivity) Regulations to Further raise Productivity in the Built Environment Sector, https://www.corenet.gov.sg/media/1588692/circular-on-amendments-to-buildability-productivity-regs_30-nov-15.pdf

into a workplace of choice led by professional and progressive firms with good HR practices".[84] By signing the Pledge for a Better Built Environment Workplace (or HR Pledge), the senior management of construction companies commit themselves to adopt good human resource practices based on these principles: (a) performance management; (b) recruitment and on-boarding; (c) staff engagement; (d) remuneration, rewards and benefits; and (e) wellness and support. The website shows that, as at April 2015, some 31 companies (clients, consultants and contractors) had signed the HR Pledge.[85] BCA will prepare a good practice guide for companies which will cover best practices adopted by industry stakeholders and available schemes for assisting firms to develop their human resources.

In January 2016, BCA launched a Sectoral Manpower Plan (SMP) for the built environment sector[86] to build up a strong core of local talent and to meet future manpower needs. The key strategies of the SMP are: (a) attracting and retaining local talents through greater career guidance; (b) creating high quality jobs and attractive career development pathways; and (c) deepening the skills of workers who are already in the sector. The initiatives under the SMP include: (a) scholarship and sponsorship programmes; (b) structured internships; (c) the SkillsFuture Study Awards; and (d) the Earn and Learn Programme (ELP) for Diploma and Institute of Technical Education (ITE) graduates to start their careers with construction companies and continue learning through structured on-the-job training and part-time institution-based courses. The target of the SMP is to train some 3,000 students and working professionals in future-ready skills over three years. The "priority skills areas" were identified as "green building capabilities" and "productive technologies". BCA will also identify emerging and priority skills to be developed to meet the needs of the sector as they change.

BCA and eight professional institutions and trade associations belonging to the CIJC, including SCAL, signed an MoU in 2016 to collaborate and drive SkillsFuture initiatives for the industry.

2.5.5 Awards

Productivity performance has been a criterion in some of the BCA awards for good performance and achievement in construction. In 2010, a dedicated award, the Construction Productivity Awards (CPA), was launched "to create greater awareness and ownership amongst the various stakeholders of the construction value chain in productivity";[87] and "to recognise all stakeholders' continual contributions towards the construction productivity drive at both the project and firm level". The award recognises practitioners and companies for their achievements in improving productivity, promotes productivity in the industry, and serves as a platform to measure productivity in the industry. It has two categories:

- CPA – Advocates assesses the efforts of developers, consultants, contractors and subcontractors in adopting designs, methods, processes and/or technologies which have significant productivity impact in their projects; and the actual productivity performance on the projects (both value-added productivity and physical productivity). The assessment criteria include: Buildable Design score; Constructability score; Productivity performance (physical and value-added productivity); and Productivity initiatives
- CPA - Projects is for teams who demonstrate productivity in their projects from design to construction. It aims to: "Encourage designers to come up with labour-efficient designs; Encourage the adoption of labour-efficient construction methods; and Recognise project teams for their excellent project planning and coordination in enhancing productivity".[88] Projects are assessed based on the Buildable Design score, Constructability score, simplicity of construction, integration of design and construction, and aesthetics. Civil engineering projects are assessed on the basis of design for ease of construction, use

84 BCA (2014) Built environment sector calls for more local talent, http://www.bca.gov.sg/newsroom/others/pr22052014_BCA.pdf
85 BCA (undated) Pledge for a better built environment workplace – pledge registry, http://www.buildingcareers.sg/pledge/
86 BCA (2016) Manpower plan launched for the built environment sector. 22 January, http://www.bca.gov.sg/Newsroom/others/Media_Release(BCA_ITE_Scholarship_Award).pdf
87 BCA (2016) Construction Productivity Awards 2016, http://www.bca.gov.sg/Awards/CPA/cpa.html
88 BCA (2015) Media release – Four firms recognised for driving construction productivity, http://www.bca.gov.sg/newsroom/others/BCA_Media_Release_CPA_2015_070515.pdf

of technology, site management, integration of design and construction, and adoption of innovative designs and products.

Best VAP Builder and Best VAP Improvement Builder Awards

The CPA – Best VAP (value-added per person) Builder Award and Best VAP Improvement Builder Award were intended to raise awareness of productivity among builders, and encourage them to increase their productivity by monitoring their companies' progress in productivity improvement.[89] An objective of the awards was to recognise firms which strive towards higher productivity and encourage more builders to join the efforts to improve productivity in construction.

In 2013, the new BCA Construction Productivity Award (CPA) for advocates was introduced. It integrated the previous CPA-Best Practices and Innovations and CPA-Value-added Productivity, "to give greater recognition to stakeholders – developers, consultants and builders – who play a crucial role in driving construction productivity within the built environment sector".[90]

What the two construction firms did to win the CPA-Projects awards in 2013 is instructive. On one project, the team installed precast external walls to eliminate the need for scaffolding; and adopted a 'one push-press fitting technology' for water pipe installation which required no tools during installation, reducing the time and manpower required. On another, the project team refined their design and construction methods to build more productively; a full precast system helped simplify construction, and the use of prefabricated steel frames for lifts reduced installation time. These two winning projects were also among the top scorers that year under the Construction Quality Assessment System (CONQUAS).

2.5.6 Incentives

Financial assistance

Another major driver of the productivity development programme is the range of incentives the government has been offering. Table 2.3 presents information on the assistance schemes under the CPCF. A BCA survey in 2015 showed that more than half of the responding firms had started their productivity improvement efforts as a result of the measures under the first

Table 2.3 Support schemes under Construction Productivity and Capability Fund (CPCF)

	Scheme	*Coverage*
1.	Workforce Training and Upgrading (WTU) Scheme	Facilitates upgrading of workforce at all levels by co-funding up to 90% of the cost for selected skills assessment and training courses*
2.	Mechanisation Credit (MECHC) Scheme	Provides assistance to builders to defray up to 70% of equipment costs*
3.	Productivity Innovation Project (PIP) Scheme	Provides assistance to companies to defray up to 70% of the cost for adopting more productive work processes*
4.	Building Information Modelling (BIM) Fund	Co-funds up to 70% of the supportable cost incurred by firms when leveraging BIM technology to improve multidisciplinary collaboration*
5.	Scholarship and Sponsorship Programmes	In partnership with built environment firms, BCA will co-fund scholarship and sponsorship programmes at the undergraduate, diploma, ITE, supervisory and foreman levels*

*Terms and conditions apply

Source: BCA (2015) Construction Productivity and Capability Fund (CPCF). *Build Smart*. June, p. 18.

89 BCA (undated) Best VAP Builder and Best VAP Improvement Builder Awards, http://www.bca.gov.sg/VAP/others/01_Best%20VAP%20Builder%20and%20Best%20VAP%20Improvement%20Builder%20Awards.pdf

90 BCA (2013) Progressive developers top new BCA Construction Productivity Award, http://www.bca.gov.sg/Newsroom/pr13052013_CPA.html

Construction Productivity Roadmap.[91] The initiatives for productivity improvement in construction have become increasingly enhanced. Examples of recent developments are outlined in the following paragraphs.

In 2013, the incentives under the CPCF were enhanced to promote wider adoption of DfMA and greater on-site productivity improvement.[92] By then, some $85 million of the CPCF had been committed, and over 2,300 firms had benefited from it, with over 80 per cent being small firms. The funding level of the Mechanisation Credit (MechC) scheme (which provides funding support for contractors to purchase or lease equipment) and PIP scheme (which encourages greater adoption of prefabrication and advanced technologies) were raised from 50 per cent to 70 per cent for firms which achieved at least 30 per cent improvement in productivity. The cap for firm-level applications was increased from $100,000 to $300,000 for the adoption of key productive technologies, such as system formwork, prefabricated bathrooms, self-compacting concrete, and precast and steel construction. The cap for industry-level applications was raised to $5 million per application for "projects that are game-changing and achieving at least 40 per cent productivity improvement".[93] The MechC Referral Programme was launched to encourage contractors to help their sub-contractors to act to improve their productivity: contractors can earn an additional $20,000 credit to increase their funding cap for every successful referral to the MechC scheme.

In 2014, BCA projects on selected sites sold under the GLS programme were required to adopt advanced construction technologies.[94] An additional $55 million was allocated to the CPCF, bringing the total to $335 million. BCA also launched a number of Integrated Construction and Precast Hubs (ICPHs) in 2014 which undertake automated manufacturing of precast components, PPVC modules and PBUs.

In March 2015, under the Second Construction Productivity Roadmap, an additional S$450 million was provided as the second tranche of the CPCF from June 2015 to May 2018 to help firms to invest in "impactful productive technologies" and improve the quality of their workforce.[95] It was estimated that this would benefit about 7,000 built environment firms. The funding limit of the PIP scheme under the CPCF was raised from S$5 million to S$10 million. Firms would also receive more incentives to upgrade their workforce as locals could be granted enhanced subsidies of up to 90 per cent under the Workforce Training and Upgrading (WTU) Scheme, which would also support more productivity-related courses. In October 2015, to promote collaboration among developers, consultants, builders and suppliers, BCA started funding projects that adopt VDC, which enables the integration of the design, prefabrication and construction stages.[96]

Procurement

The potential of using the public-sector procurement process to achieve increases in construction productivity growth has been given much attention in Singapore. BCA has promoted design and build and other integrative project organisation arrangements, including the involvement of more stakeholders in early stages of projects. Early involvement of the contractor would enable the consultant and contractor to work together to design for labour-efficient construction and resolve any constructability issues in the design before work starts on site.

91 BCA (2015) Media Release – About 7,000 firms to benefit from s$450 million boost for construction productivity, http://www.bca.gov.sg/newsroom/others/BCA_Media_Release_COS_2015_100315.pdf

92 BCA (2013) BCA to boost productivity through tighter buildability and constructability requirements and enhanced incentives, http://www.bca.gov.sg/Newsroom/pr11032013_P.html

93 BCA (2014) BCA to unveil second Construction Productivity Roadmap next year, http://www.bca.gov.sg/Newsroom/pr14102014_BCA.html

94 BCA (2014) BCA to unveil second Construction Productivity Roadmap next year, http://www.bca.gov.sg/Newsroom/pr14102014_BCA.html

95 BCA (2015) Media Release – About 7,000 firms to benefit from S$450 million boost for construction productivity, http://www.bca.gov.sg/newsroom/others/BCA_Media_Release_COS_2015_100315.pdf

96 BCA (2015) Media Release -- Productive builders will have an advantage when tendering for public projects, http://www.bca.gov.sg/Newsroom/others/Media_Release_SCPW_2015_131015.pdf

Construction firms with good productivity records in their past projects and their investment in technology adoption and workforce development have an advantage when tendering for government projects.[97] The weightage of the productivity component under the public-sector tender evaluation framework for consultancy services [Quality Fee Method (QFM)) was increased in 2014; and that under the public-sector tender evaluation framework for construction services [Price-Quality Method version 2 (PQMv2)] was revised to 10 per cent of the overall score (from 3-6 per cent) from January 2016.

2.5.7 Dissemination of information

The effort to disseminate information on productivity-enhancing construction methods, practices and procedures in Singapore has many elements. They include seminars and information sessions organised by BCA, SCAL and other organisations, guidebooks such as that on the measurement of trade productivity, magazines on the productivity programme such as BCA's *BuildSmar*t, and news releases and feature articles. SCAL holds workshops to provide information on, and hands-on training on the application process for, the available incentive schemes. The Construction Productivity Gallery, which opened in July 2015, is an interactive showcase of the history, achievements and future of Singapore's construction industry.[98] The exhibits include new technologies and equipment, training programmes, and planning, design and construction methods.[99] There are also accounts by companies and practitioners of best practices.

2.5.8 Other components of productivity programme

Several other issues form part of the construction productivity development programme. For example, BCA organises technical visits to enable administrators and practitioners to learn about productivity-enhancing initiatives, technologies and practices abroad. A visit to the UK underlined the need to create a productivity culture in Singapore which includes a mindset to pursue higher productivity, understand how technologies work, adopt ideas from other industries, and tackle the issues faced in adoption and implementation.[100] It was noted that cost and market acceptance would be among barriers to the adoption in Singapore of some promising technologies used in the UK. For example, unlike the UK, structural steel and cross-laminated timber (CLT) are more expensive in Singapore than concrete. This makes these technologies currently less attractive than reinforced concrete although they are more productive.

Another element of the productivity programme is research and development R&D. A number of grants have been provided for R&D on relevant topics. For example, in October 2015, the BCA launched a $2.6 million call for research proposals on construction productivity under a research fund of the Ministry of National Development (MND).[101] Research projects were expected to focus on solutions to drive DfMA and improve integration across the construction value chain.

A final item worth considering is attitudinal change. BCA's International Panel of Experts (IPE) emphasised the importance of promoting an appropriate mindset change across the construction value chain.[102] Effective change management was crucial for the industry to make significant progress in productivity growth. This was a key point in the second roadmap.

97 BCA (2015) Media Release -- Productive builders will have an advantage when tendering for public projects, http://www.bca.gov.sg/Newsroom/others/Media_Release_SCPW_2015_131015.pdf
98 BCA (2015) About Gallery, http://www.bca.gov.sg/constructionproductivitygallery/cpcg/about
99 Soh, G. (2015) Sneak preview of the BCA Construction Productivity Gallery, http://www.bca.gov.sg/constructionproductivitygallery/cpcg/happenings
100 BCA (2013) SMS Lee Yi Shyan: Quantum leap in construction productivity possible with advanced technologies and having productivity culture, http://www.bca.gov.sg/Newsroom/pr23072013_CP.html
101 BCA (2015) Media Release -- Productive builders will have an advantage when tendering for public projects, http://www.bca.gov.sg/Newsroom/others/Media_Release_SCPW_2015_131015.pdf
102 BCA (2014) BCA to unveil second Construction Productivity Roadmap next year, http://www.bca.gov.sg/Newsroom/pr14102014_BCA.html

2.6 SCAL'S productivity objectives and activities

What are the programmes, activities and aspirations of SCAL with respect to productivity? SCAL's aim is "to help all its members achieve greater professionalism and quality in their respective specialisations."[103] Its vision is "to facilitate members to become world-class builders"; and its mission is "to promote the continuous growth of the construction industry and lead our members in fulfilling the vision." It states that "this includes keeping in tune with technical developments and monitoring market changes to enable its members to stay in touch and adapt and develop."[104] Thus, SCAL is committed to leading its members to attain superior performance under all criteria, including productivity. A subcommittee of SCAL's Council is entrusted with the task of guiding the association and its members to fulfil this commitment with respect to productivity.

The objective of SCAL's Productivity and Technology Committee is "to enhance the productivity of the industry through building the capacity and capabilities of members."[105] Thus, enhancing the productivity performance of members is a major objective of SCAL. The subcommittee are involved in activities such as undertaking studies on productivity, encouraging members to adopt appropriate measures to improve productivity, educating members about new technologies and informing members about government's schemes.

Several of the initiatives and activities of SCAL are:

- liaising and working with government on regulations, policies, programmes and schemes which affect the construction industry
- organising information sessions on new government regulations and policies (such as the briefing session on the "Employment Act" by MOM in November 2014)[106]
- organising seminars on productivity such as "Productivity with BIM for Construction" (in May 2015)[107]
- offering productivity-related courses at all levels, workshops and briefing sessions by the SCAL Academy
- holding productivity clinics on government's productivity-targeted incentive schemes (the 43rd run was held in March 2015). Specific training sessions on particular initiatives such as ePSS (in January 2015 and March 2015) and schemes such as MechC (in March 2015) have also been organised
- organising annual competitions among groups of tradesmen to determine who is the most productive at trade tasks.

SCAL launched the Foreign Construction Worker Directory System in October 2015[108] and set up a portal which enables foreign workers to list their skill sets, thus allowing construction firms to search for, and recruit trained workers who are reaching the end of the duration of their work permits. This would enhance productivity as the industry would be able to retain skilled foreign workers who have gained experience in Singapore, instead of losing them (as they return home), and recruiting fresh ones. This would build a sustainable workforce, and also reduce employers' costs of repatriation, re-training and re-employment of workers.

2.7 Case studies of good practice

The winners of the CPA awards in 2015,[109] and the productivity features and initiatives they adopted

103 SCAL (undated) Our objectives and industry value, http://www.scal.com.sg/our-objectives-industry-value
104 SCAL (undated) Vision and mission, http://www.scal.com.sg/vision-and-mission
105 SCAL (undated) SCAL Subcommittees, http://www.scal.com.sg/scal-subcommittees
106 SCAL (undated) briefing session on "employment act" by MoM, http://www.scal.com.sg/register_event/briefing-session-on-employment-act-by-mom
107 SCAL (undated) list of events, http://www.scal.com.sg/landing
108 Ho, O. (2015) new online job portal to match construction bosses with foreign workers. *The Straits Times*, October 13, http://www.straitstimes.com/singapore/manpower/new-online-job-portal-to-match-construction-bosses-with-foreign-workers
109 BCA (2015) BCA Awards 2015: recognising excellence in the built environment. Singapore.

are shown in Tables 2.4 and 2.5. These winners are considered companies which have adopted good practice in construction productivity. Table 2.4 presents winners of the Platinum Award in the Construction Productivity Award – Project series; and the winners of the Gold and Merit awards in the Builder Category of the Construction Productivity Award – Advocate award are shown in Table 2.5.

Table 2.4 Construction Productivity Award – Project: Platinum Award Winners 2015

(a) Project; (b) Client/Developer/ Owner; (c) Category	*Contractor* *Key features*
a. 368 Thomson b. City Developments Limited c. Residential Non-Landed Buildings (for projects with GFA < 25,000 m²)	*Design and Build Contractor: Dragages Singapore Pte Ltd* • Repetitive unit design enabled standardisation of precast elements. • Combination of sheet piling and open cut methods employed for basement excavation, optimising cost and time. • System formwork was adopted for construction of pile caps in basements, retaining wall and columns to suit the structural configuration. • Extensive use of precast beams and slabs reduced the number of workers on site. • Off-site production of prefabricated bathroom units (PBUs) was adopted. • Buildable trades such as drywall partition, screedless flooring, rebated door with lift-off hinges and prefabricated bathrooms were adopted. • Use of system formwork for construction of shear walls eliminated the need for plastering works.
a. Cube 8 b. City Developments Limited c. Residential Non-Landed Buildings (for projects with GFA < 25,000 m²)	*Design and Build Contractor: Dragages Singapore Pte Ltd* • Hybrid method consisting of cast-in-situ vertical columns/walls with horizontal precast elements like planks and beams helped achieve average six-day cycle time. • Precast elements were used extensively. • PBU were installed. • Extensive use of drywall partition system was adopted. • Use of external cantilevered façade platforms, stair platforms, working platforms and internal shaft platforms eliminated the need for full-height scaffolding and also ensured safety. • Vertical reinforcement prefabrication yard on site allowed faster construction and helped to reduce wastage of reinforcement bars as double height reinforcement bars could be prefabricated on site.
a. TreeHouseCondominium b. Chestnut Avenue Developments PteLtd (City Developments Limited) c. Residential Non-Landed Buildings (for projects with GFA ≥ 25,000 m²)	*Design and Build Contractor: Tiong Seng Contractors (Pte) Ltd* • Use of full precast envelope system helped the project to achieve a typical floor cycle of seven days. • Flat plate system with precast perimeter beams was adopted. • Modularised heavy-duty, lightweight aluminium system formwork was adopted. • Drywall partitions were used for internal walls. • Use of mobile platform and working platform for construction of lift core for vertical access in the lift core eliminated the need for scaffolding. • Pile raft system was used in construction of the basement. • For high-rise vertical green wall, main steel structure and access for maintenance were produced in a modular system off-site and assembled with bolting system on site. • Chestnut Pavilion was constructed using a steel structure and full-length aluminium infill.

Source: Compiled from BCA (2015) BCA Awards 2015: Recognising excellence in the built environment. Singapore.

Table 2.5 Construction Productivity Award – Advocate: Winners 2015

(a) Firm; (b) Category; (c) Award	*Key Productivity Initiatives*
a. Unison Construction Pte Ltd (established in 2009) b. Builder (Open) c. Gold	• Unison Construction has pioneered the process of Research, Development and Demonstration (RD&D) for its projects. An example is the development of six types of PBU using different wall materials such as lightweight aerated concrete panels and hollow core concrete panels. • The company advocates the use of innovative technologies to help improve productivity on its projects. Examples are: * the use of integrated formwork systems such aluminum table form and jump form system formwork resulted in about 60 per cent manpower savings compared to conventional timber formwork * the adoption of flexible water pipes led to 30 per cent manpower savings compared to copper pipes • Unison puts emphasis on staff training and has participated in many learning journeys organised by BCA for the industry.
a. Soil-Build (Pte) Ltd (established in 1976) b. Builder (Open) c. Merit	• Soil-Build puts emphasis on developing its capability in BIM and formed an in-house BIM team for its projects. It used BIM in areas such as producing coordinated construction models, combined services drawings, and detecting and resolving clashes. • The firm advocated the wide use of mechanisation to improve productivity. Equipment and machinery used included concrete placing boom, concrete distributor, telescopic fork lift, storey crane, scissors lift and boom lift.

Source: Compiled from BCA (2015) BCA Awards 2015: Recognising excellence in the built environment. Singapore.

2.8 Increasing importance of productivity

Productivity has assumed even greater importance in many countries. In the wider economy, industrialised countries continue to be described as facing a productivity crisis, and governments are being called upon to act appropriately.[110] The discussion has become increasingly intense in the construction industry in certain countries. For example, the Chartered Institute of Building responded to a UK government report on poor construction productivity with its own report, in which it asked:[111]

- are the statistics and our impressions fooling us?
- is there something intrinsic to construction that its productivity path is inevitable?
- are there fundamental barriers blocking progress?

In that report, data showed that the rate of growth in construction productivity in the UK had been below that of services since the mid-1990s, and in the US and many European countries, it had fallen consistently since 2008. Another recent review in the UK urged the industry to "modernise or die", highlighting "low labour productivity" as one of ten "critical symptoms of failure and poor performance" of the industry.[112] The UK Construction Leadership Council

110 Atkinson, R.D. (2016) Think Like an Enterprise: Why nations need comprehensive productivity strategies. Information Technology & Innovation Foundation, http://www2.itif.org; Atkinson, R.D. (2016) Confusion about job creation is obscuring America's productivity crisis. *The Christian Science Monitor*, November 30, http://csmonitor.com

111 Green, B. (2016) *Productivity in Construction: Creating a framework for the industry to thrive*. Chartered Institute of Building, Bracknell.

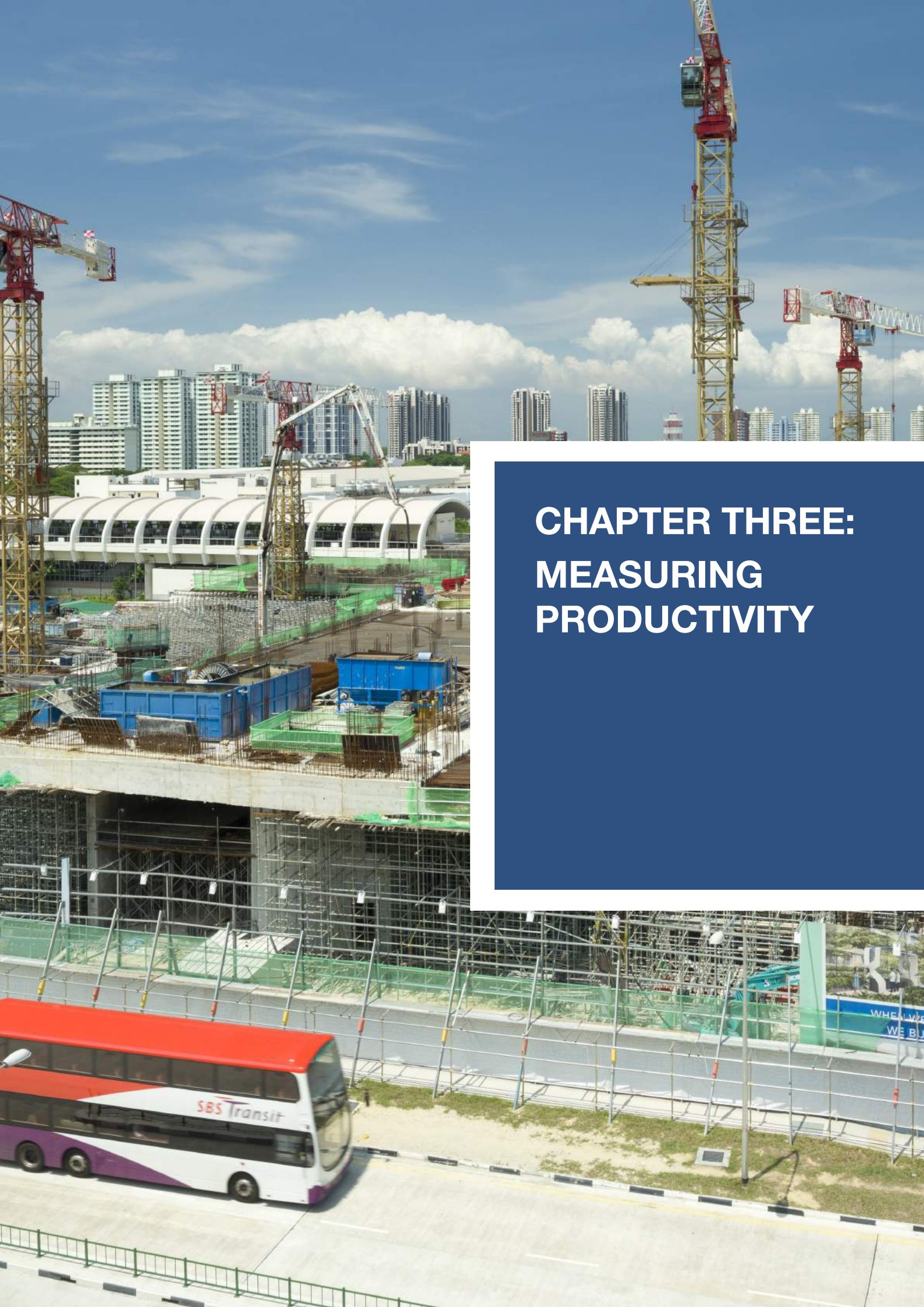
112 Farmer, M. (2016) *The Farmer Review of the UK Construction Labour Model: Modernise or Die Time to decide the industry's future*. Construction Leadership Council, London, p. 7.

has published a new roadmap to improve capacity, innovation and productivity.[113] It highlights the following key barriers: lack of collaboration; lack of demand; investment in suppliers who can support smart construction; lending, valuation and insurance; immature supply chain; risk-averse culture in construction; procurement models; business case for change; requirement of economies of scale; lack of performance data; and skills shortage. It identifies external drivers and major issues within the construction value chain, innovations and technologies which could be applied to overcome the barriers, enablers for success, and proposes that working groups be formed to formulate an action plan.

In Australia, which is often described as having a productive construction industry,[114] the Australian Construction Industry Forum (2016) noted recently:[115] "…the construction industry in Australia has not substantially improved its productivity in decades, and can waste up to 30 per cent of its efforts. This is not a uniquely Australian issue. Rather, it is a product of the structure of the construction industry, the increasing complexity of its services, and the creation and operation of 'silos' within that structure."[116] It proposes these actions: (a) establish an Independent Australian Centre for Procurement Excellence; (b) fairer, standard contracts; and (c) promote building information modelling. It suggests that "there is no need for more inquiries or reports. The imperative is to act on a handful of potential drivers of improvement that are developed collaboratively by governments, clients and service providers".[117] On 1 December 2016 the Building and Construction Industry (Improving Productivity) Bill 2013 and the Building and Construction Industry (Consequential and Transitional Provisions) Bill 2013 received Royal Assent.[118] The main object of the Act "is to provide an improved workplace relations framework for building work to ensure that building work is carried out fairly, efficiently and productively for the benefit of all building industry participants and for the benefit of the Australian economy as a whole".[119]

In Singapore, in October 2016, BCA announced that it had developed a construction productivity R&D roadmap to identify new knowledge, process and technology areas for development, adaptation and adoption. Some 35 key technologies under seven clusters were identified "to enable the built environment sector to change the way we build and sustain productivity improvements in the long term".[120] The areas include DfMA, automated equipment and robotics, information and communication technology, BIM and VDC, 3D printing, advanced construction materials and "productive solutions for civil engineering works". BCA awarded a total of S$2 million to four projects under an inaugural grant funded by MND that called for research into construction productivity. In 2016, it was also announced that more Government Land Sale sites will be required to adopt productive construction methods such as PPVC Codes of Practice (CoP) for BIM e-submission. This will facilitate information exchange across the various building disciplines, thereby helping firms to identify and address problems upfront before construction. BCA will be placing greater emphasis on productivity in the revision of the Construction Quality Assessment System (CONQUAS).

113 Construction Leadership Council (2016) *Roadmapping to improve Productivity, Capacity and Innovation in the Housing Sector*. London.
114 See Box 3.3.
115 Australian Construction Industry Forum (2016) *Boosting Construction Productivity Policy Paper.* Canberra, http://www.acif.com.au/documents/item/786, p. 1.
116 Australian Construction Industry Forum (2016) *Boosting Construction Productivity Policy Paper*. Canberra. http://www.acif.com.au/documents/item/786
117 Australian Construction Industry Forum (2016) *Boosting Construction Productivity Policy Paper.* Canberra. http://www.acif.com.au/documents/item/786, p. 2.
118 https://www.fwbc.gov.au/
119 The Parliament of the Commonwealth of Australia House of Representatives (2013) Building and Construction Industry (Improving Productivity) Bill 2013, http://parlinfo.aph.gov.au/parlInfo/download/legislation/bills/r5129_first-reps/toc_pdf/13207b01.pdf;fileType=application%2Fpdf
120 BCA (2016) Media Release: BCA identifies 35 key technologies for R&D to drive construction productivity in the next lap, https://www.bca.gov.sg/newsroom/others/Media_Release_SCPW_2016_181016.pdf



CHAPTER THREE:
MEASURING PRODUCTIVITY

3.1 Introduction

In this chapter, after considering why it is necessary to measure productivity, the various ways in which productivity in general is measured and how it is measured in the construction industry, are discussed. The debate on the most appropriate ways in which to measure construction productivity, especially at the industry level, is also presented. Initiatives to measure productivity in Singapore are considered, and the deliberations on the best way forward are discussed. Finally, international approaches to productivity measurement are considered.

3.2 Need for measurement and its challenges

3.2.1 Why measure productivity?

Why is it necessary to measure productivity? What are the data obtained used for? There is a difference in the preferences of the nature and level of complexity of the productivity measurement methods and yardsticks among stakeholders of the construction industry. At the industry level, government officers and economists want an indicator which enables ready assessment of performance in the industry and also a means of direct comparison with other sectors of the economy and those in other countries. However, industry players prefer measures which are meaningful and directly relevant and useful to them in their running of their companies and projects.

Indicators of productivity provide targets to enable the companies and project or task leaders to plan for activities, control costs, motivate their workers, evaluate performance, set benchmarks and guide wider company-level policy and action. Productivity metrics, measurement tools, and data will help companies to make more cost-effective investments in productivity-enhancing technologies.[121] Measuring productivity will also enable the company to monitor the activities of the components of its value chain and provide targets for each of them to achieve continuous improvement. When productivity is increased, clients and users benefit from improved efficiency in the usage of resources, early completion of built items and possibly, cost savings.

Considering the importance of productivity measurement, in 1980, an American construction practitioner included this proposal in the steps towards improving productivity:[122] "Each job site is charged with measuring and improving productivity: each is also charged with sharing with all other company job sites the findings that each has made in its measurement and improvement program. Set up a company-wide productivity coordinator to channel each finding from site to site" (p. 23). An US author recently suggested:[123] "by focusing on key metrics like the productivity formula, and by embracing new, technology-centric methods and strategies, companies can implement ground- breaking business practices not thought of previously. This, in turn, will help the most progressive firms improve productivity and manage costs in today's extremely competitive, labor-constrained business landscape". Thus, he noted that large construction firms consider productivity as a strategic objective for competitiveness and hence systematic measurement was important.

Productivity should be put in the context of overall corporate objectives. A New Zealand study noted that most firms are concerned with maximising returns for shareholders, rather than technical measures of productivity.[124] In order to perform well, a company must maintain and develop its workforce, use time effectively, adopt new technologies and so on, all of which have the effect of raising productivity on its projects, and this would also enhance overall industry and national-level productivity.

121 Huang, A.L., Chapman, R.E. and Butry, D.T. (2009) *Metrics and Tools for Measuring Construction Productivity: Technical and empirical considerations*. National Institute of Standards and Technology, Gaithersburg, MA.

122 James, R.E. (1980) Measuring construction productivity. *Construction Dimensions*, December, pp. 19-23.

123 *Pipeline and Gas Journal* (2015) Getting Basics of Construction Productivity Right. November 2015, Vol. 242, No. 11, http://pgjonline.com/2015/11/13/getting-basics-of-construction-productivity-right/

124 Page, I. and Norman, D. (2014) *Measuring Construction Industry Productivity and Performance*, Study Report SR 310. Branz, Wellington.

3.2.2 Issues facing measurement of productivity in construction

Construction productivity can be studied at four levels: trade, task or activity level (on site), project level, company level, and industry level. Sub-levels at which productivity can be measured and applied include work done by groups and attainments at stages, in parts of companies or in sub-segments of an industry. Numerous difficulties are encountered in attempts to measure construction productivity at each of these levels. Several are now discussed.

Challenges to productivity measurement at the project level include the fact that no two constructed items are identical; there are always differences, even if these lie only in location and soil conditions. Thus, there are limitations in using the data as benchmarks. The effect of technology and innovation, and of improvements in the quality of materials on productivity is difficult to fully determine and quantify, and the positive changes might not be adequately reflected in market prices. Any construction project will involve many closely related activities by different groups of specialist workers, undertaken in many locations of the works, and at different stages of the project. Each trade spans only a portion of the duration of the project, with a complex movement of workers to and from the site. This makes it difficult to measure the time taken to complete any single trade; and assumptions will not be the same on all sites. While recognising these challenges, firms and researchers continue to undertake studies with the aim of improving worker or group performance, with the expectation that appropriate actions, such as mechanisation, use of different tools, skills development or worker motivation can enhance productivity performance on projects.

The issues at the industry level include deciding what measure to use for output – gross output (as in the US) or value-added (as in Singapore); and what measure to use for labour input – work hours for all workers, or only non-supervisory workers (as in Singapore), or number of employees rather than hours. The next issue is finding accurate data, and agreeing on approaches to the measurement and analysis. A significant amount of construction work done by companies not classified as being in the construction industry is not included among the output data. This issue has partly been addressed in Singapore, as "production of pre-cast concrete components" is included in the Singapore Standard Industrial Classification (SSIC) (Listed as item 43904.[125] A full list of items in the SSIC is shown in Appendix Four). The next issue is that business cycles affect data on construction output and inputs, and there are usually differences between the rates of change of these two categories of data, which face different market conditions. Thus, it is difficult to find appropriate deflators to adjust the data to a common base determine productivity appropriately.[126]

It is also difficult to estimate the capital stock and the use of capital in the production of the output, and hence their impact on productivity. There are also issues concerning aggregation: in any period, the industry produces a wide variety of types of constructed items[127] and the mix changes from one period to another. A US study noted that the construction industry is composed of four segments (residential, commercial/institutional, industrial, and infrastructure)[128] which differ in the characteristics of the owners,[129] complexity of the projects, source and magnitude of financial capital, firm size, required skills, use of materials, technologies and knowledge. Owing to the heterogeneity of construction work, the usual productivity yardstick used in all sectors of the economy – i.e., output (or value-added) per person employed – is difficult to interpret when applied to construction. Finally, there is no consensus on the definition of

125 Department of Statistics (2015) *Singapore Standard Industrial Classification 2015*. Singapore.
126 Sveikauskas, L., Rowe, S., James Mildenberger, J., Price, J. and Young, A. (2014) Productivity Growth in Construction. BLS Working Papers, No. 478. US Department of Labor, Bureau of Labor Statistics, Washington D.C.
127 Hillebrandt, P.M. (2000) *Economic Theory and the Construction Industry*. Palgrave Macmillan, Basingstoke.
128 Huang, A.L., Chapman, R.E. and Butry, D.T. (2009) *Metrics and Tools for Measuring Construction Productivity: Technical and Empirical Considerations*. National Institute of Standards and Technology, Gaithersburg, MA.
129 Haas, C. (2009) An international perspective on construction competitiveness and productivity. In Committee on Advancing the Competitiveness and Productivity of the U.S. Construction Industry (Ed) *Advancing the Competitiveness and Efficiency of the U.S. Construction Industry*. National Academies Press, Washington, Appendix C, pp. 55-75.

'construction',[130] and international standards often define 'construction' differently; thus, making comparisons between or among them is not useful.

In a recent study in Singapore,[131] the obstacles to efforts to measure productivity in construction generally were (in descending order of importance): too much paperwork involved in the measurement of productivity; additional personnel required for the productivity measurement process; cost of productivity measurement process; lack of clear definition of productivity in construction; lack of direct benefits from the measurement of productivity; uncertainty about what is to be measured; and level of work subcontracted.

A study in Sweden[132] observed that "every study of productivity needs to be critically scrutinised with a high degree of skepticism" (p. 64). It notes that construction has been described as an industry with very limited satisfactory data and information for studying and understanding its own performance, to make improvements and to prepare for the future.

Apart from the measurement difficulties, it is also not easy to compare productivity data from different sites, companies or countries because of the possible differences in the definition of productivity, the assumptions made, conditions under which the task is undertaken, and measurement methods adopted. It was noted in a US report: "Challenges in construction productivity measurement have been recognised for many decades. While some aspects of construction productivity measurement have received attention, and notable improvements have been made, many fundamental challenges exist".[133] (p. 97). Therefore, there have been several attempts to develop common standards and principles for measuring productivity, mainly at the trade level[134] such as the BCA's guide for measuring trade-level productivity in Singapore.

3.3 Productivity metrics

3.3.1 Essential features of a productivity metric

What critical characteristics must an indicator of productivity have? A study[135] developed this set of basic requirements for efficiency measures:

1. Usability of the metric in relation to strategic goals
2. Low cost of data collection and coordination
3. Reliability of the data, regardless of who collects the data and when data are collected; this implies development of data collection methods applied with appropriate sampling techniques
4. Validity – enabling the measurement of relevant dimensions of what we really want to understand
5. Compatibility with other quantitative metrics within the same system, those in other industries, or those in other countries
6. Opportunities to develop and analyse time series of the data, including the choice of periodicity

130 Hillebrandt, P.M. (2000) *Economic Theory and the Construction Industry*. Palgrave Macmillan, Basingstoke.
131 Teo, A.L., Ofori, G., Tjandra, I.K.T. (2015) Intelligent System for Determining Productivity and Safety Index using BIM. Research Project Report at Department of Building, National University of Singapore.
132 Olander, S. Widen, K. Hansson B. and Pemsel, S. (2010) Productivity comparisons, are they possible or even desirable? In Barrett, P., Amaratunga, D., Haigh, R., Keraminiyage, K. and Pathirage, C. (Eds) *Selected Papers in the Proceedings of CIB Working Commission W055 Building Economics – Papers and Postgraduate Papers from the Special Track*, Salford Quays, 10-13 May, pp. 58-67.
133 Huang, A.L., Chapman, R.E. and Butry, D.T. (2009) *Metrics and Tools for Measuring Construction Productivity: Technical and empirical considerations*. National Institute of Standards and Technology, Washington, D.C.
134 Dozzi, S.P. and AbouRizk, S.M. (1993) *Productivity in Construction*. Institute for Research in Construction National Research Council, Ottawa.
135 Bröchner, J. and Olofsson, T. (2012) Construction productivity measures for innovation projects: case study. *Journal of Construction Engineering and Management*, 138, 670-677.

7. Short time between data collection and data usage
8. Existence of strong incentives to deliver data
9. Little (or no) risk of leakage of competitive business-critical information.

The usefulness of any productivity measurement framework for policy-makers and practitioners also depends on the extent to which it enables the identification of the underlying drivers of productivity[136] in order to support the development of necessary action. Moreover, the effort which must be made to ensure that the measurement is accurate must be balanced against that needed to collect the required data. Thus, in developing productivity metrics, it is necessary to address the following points:

1. Analyse the task, item or entity, and determine the most appropriate form of metric and form of measurement
2. Consider tangible benefits from the measurement in setting the productivity metrics and devising the measurement tool
3. Consider the resources (time, cost, human resource and equipment) and basic information which will be required in measurement and usage
4. Evaluate the risks in the formulation and usage of the metric
5. Assess the likelihood of usage of the metric; and consider what to do to promote, and enable usage.

3.3.2 Forms of productivity metrics

Productivity can be measured in terms of level and rates of change. Data on output and inputs should be measured in constant prices over time, or be appropriately deflated to a common base – these would be 'real' data. Ratios of real output to real input of particular items can be calculated to obtain Single Productivity measures. These show the savings that have been achieved over time in the use of each input per unit of output produced. Commonly measured single factor productivity indicators are Labour Productivity (LP), Capital Productivity (CP) and Intermediate Productivity. The latter two measure the relationship between output and capital input, and between output and intermediate inputs, respectively. Other forms of productivity indicators are Multi-Factor Productivity (MFP) and Total Factor Productivity (TFP).

LP is usually measured as value-added per worker or value-added per hour worked. A major problem is that, as any activity involves the combination of several inputs which are inter-related, a single productivity ratio does not measure the efficiency of the specific resource but also reflects the effect of many other factors.[137]

MFP considers the contribution of both capital and labour inputs to output.[138] It is usually expressed in terms of the growth rate. MFP growth of the economy is the rate of growth of value-added with respect to time, holding labour input and capital input constant. In other words, MFP is the ability to produce more output with the same inputs.[139] Changes in MFP reflect technological change, changes in capacity utilisation, economies of scale, in managerial skills, in the organisation of production, changes in resource allocation, and measurement error. MFP is a useful indicator as it represents the ability to gain a competitive edge without

136 Crawford, P. and Vogl, B. (2006) Measuring productivity in the construction industry. *Building Research & Information*, Volume 34, Issue 3, pp. 208-219.

137 Bernstein, H.M. (2003) Measuring productivity: an industry challenge. *Civil Engineering*, December, pp. 46-53, http://www.engr.uky.edu/~rsouley/CE%20120/12/Measuring%20Productivity%20An%20Industry%20Challenge.pdf

138 Krugman, P. (undated) Defining and Measuring Productivity. OECD, http://www.oecd.org/std/productivity-stats/40526851.pdf; Tasman Economics (2002) *Productivity and the Building and Construction Industry*. Royal Commission into the Building and Construction Industry, Discussion Paper No. 17, Melbourne, Australia. See also, Productivity Commission (2002) Productivity Estimates, http://www.pc.gov.au/work/productivity/performance.html

139 Huang, A.L., Chapman, R.E. and Butry, D.T. (2009) *Metrics and Tools for Measuring Construction Productivity: Technical and empirical considerations*. National Institute of Standards and Technology, Washington, D.C.

input price reductions. Several statistical agencies in industrialised countries, including Singapore, publish MFP indices at both national and sectoral levels.

TFP measures the contribution of labour, capital and intermediate inputs to output, and is increasingly becoming widely accepted as the best indicator of productive efficiency for an industry. TFP relates to gross output and considers labour, capital and intermediate inputs. It measures how the overall productive capacity of the economy shifts over time, due to advances in knowledge and resulting improvements in, and application of, equipment, methods and materials, as well as improvements in management and organisation. Many countries face difficulties in their efforts to develop TFP indices because of a lack of data.

Authors note that there are many measurement problems within the national accounts which make it difficult to put a precise figure on productivity growth.[140] The productivity figures in the national accounts are not collected directly, but are derived from other, more basic, parameters. Measurement problems also arise in collecting fundamental data, making price adjustments and allocating figures to individual sectors, especially the services and construction sectors "which comprise complex,…bundles of products, making allocation and price adjustments a laborious process" (p. 25).

Economy-level productivity metrics in Singapore

In Singapore, the main productivity indicator for the economy is a single one, value-added per worker. In the annual Yearbook of Statistics, DOS publishes data on Changes in Labour Productivity, in percentage terms and not real data on value-added per worker. An OECD report noted that, with the country's reliance on low-paid foreign workers, the impact on overall productivity growth has not been encouraging. Between 2000 and 2011, Singapore's GDP grew on average by 5.93 per cent per year.[141] However, TFP grew only at an average 1.80 per cent a year. In some years, TFP declined. Similarly, LP growth was an average of 0.57 per cent a year between 2006 and 2011, with declines in 2001, 2008 and 2009.

In November 2015, it was announced that Singapore's government will place greater emphasis on the metric of value-added per actual hour worked to measure labour productivity (instead of value-added per worker).[142] This metric is also used by many industrialised countries. As the economy is in transition towards a structure where labour productivity is expected to spur growth, it is important that an accurate indication of productivity is obtained. The Ministry of Trade and Industry (MTI) considers it a "more accurate" reflection of labour productivity than value-added per worker as it represents better the changes in Singapore's economic conditions and employment, particularly the higher number of part-time workers. As shown in Table 3.1, based on the new metric, labour productivity growth for the period 2010 to 2014 would be at a compounded annual rate of 2.9 per cent for real value-added per actual hours worked compared to 2.5 per cent for real value per worker. The ministry noted that there were "encouraging signs" across different sectors, "with the construction sector seeing better performance when using the new metric."

Explaining Value-Added

It is appropriate to explain here what "value-added" means. BCA provides a useful guide to the meaning and components of Value-added Productivity at the company level, which it defines as: Firm's Value-Added divided by Total Number of Firm's Employees.[143] The formula for company-level value-added is:

Company's Value-added = Total Remuneration + Operating Profit Before Tax + Depreciation + Indirect Taxes

140 Heise, M., Holzhausen, A. and Schneider, R. (2015) The Productivity Slump in the Advanced Economies: Explanations and need for action. Economic Research Working Paper No. 194. Allianz, Berlin.

141 OECD (2003) *Structural Policy Country Notes: Singapore – Southeast Asian Economic Outlook 2013: with perspectives on China and India*. Paris.

142 Soon, W.L. (2015) Shift to 'more accurate' productivity measure, but challenges remain. Business Times, November 26, http://www.businesstimes.com.sg/government-economy/shift-to-more-accurate-productivity-measure-but-challenges-remain

143 Guidance notes on BCA's Value-added per person calculator template, from BCA (2015), https://www.bca.gov.sg/VACalculator/

Table 3.1 Real value-added and labour productivity growth (%)

	2010	*2011*	*2012*	*2013*	*2014*	*2009-14 (CAGR)*	*2010-14 (CAGR)*
Real value-added	15.2	6.2	3.4	4.4	2.9	6.4	4.2
Real value-added per average hour worked	9.9	3.8	-0.2	0.6	0.9	2.9	1.3
Real value-added per worker	11.6	2.3	-0.5	0.3	-0.8	2.5	0.3

Source: Goh and Lin (2015)[144]

From this formula, it is evident that the key determinants of value-added are levels of remuneration and operating profit. Table 3.2 shows the explanations of these terms.

Table 3.2 Explanations of components of company-level value-added

Component	*Explanation*
Total Remuneration	Total compensation paid to all the company's employees, comprising: a. Wages and Salaries, Overtime Payments, Bonuses, Commissions, other payments b. Directors' Fees c. Benefits in Kind (including housing, travelling expenses relating to work, medical and welfare benefits) d. Employer's CPF contributions e. Contributions to Pension Funds and Insurance Premiums for Employees
Operating Profit Before Tax	This is obtained from Total Operating Receipts Less Total Operating Expenditures
Depreciation	Depreciation on items owned by the company, including: a. Land, Buildings and Structures b. Plant, Machinery and Equipment c. Transport Vehicles used for Business Activities d. Computers and related Equipment including printers and scanners e. Furniture and Fittings
Indirect Taxes and Levies	Indirect Taxes include Property Tax, Road Tax, Stamp Duty, License Fees Indirect Taxes do not include Corporate Taxs and Personal Income Tax Levies refer to the Foreign Worker Levy

3.3.3 Construction productivity metrics

Trade-level labour productivity data are useful to contractors in calculating the cost of the project (or parts of it), setting targets and monitoring site activity and outsourced work. LP here is expressed as (a) units of output per dollar; (b) units of output per work-hour or (c) units of output per man-day. Typical output units on a construction project are: linear (such as kerbs), area (such as for formwork

144 Goh, K. and Lin, T. (2015) Trends in actual hours worked and implications for labour productivity. Ministry of Trade and Industry, 4 November, https://www.mti.gov.sg/ResearchRoom/SiteAssets/Pages/Economic-Survey-of-Singapore-Second-Quarter-2015/BA_2Q15.pdf

and painting), volume (for example, concrete placement), tonnage (such as steel reinforcement), or number (for example, bricks). The physical metrics can also be used in planning the project schedule; and both the physical and monetary data can be used in evaluating quotations of, setting targets for, and monitoring the progress of subcontractors. Some contractors also use the inverse rate (i.e., work-hours per unit of output, or man-days per unit of output) which can be useful for estimating the cost of the item of work.

There are many methods for measuring trade-level productivity. Manuals prepared in various countries (such as Canada,[145] the US[146] and Singapore) provide guidelines on labour productivity measurement. The criteria which should be considered in the selection of a measurement method include: the nature of the task; simplicity of the method; replicability of the measurement; accuracy and precision required; the skills of the persons who will undertake the measurement; and the use to which the productivity data will be put.

At the construction project level, both LP and TFP have been used. LP at project level is reported in two forms: productivity for a reporting period, and the cumulative productivity to date. It is a composite measure of output such as square metres of built-up floor area per man-day (used in Singapore) or square metres per dollar. Apart from the difficulty in measuring TFP, its main weakness is that it cannot be measured in physical terms; the units of labour, equipment and materials should be in monetary value. Hence, it can be affected by business cycles and other difficulties, as discussed above.

At the construction industry level, four productivity concepts are used: LP, CP, MFP and TFP. MFP has been estimated for the construction industries of most industrialised countries and Singapore.[147] TFP indices have also been estimated for the construction industries of most industrialised countries, including Singapore[148] and Hong Kong.[149] Owing to the difficulty in calculating MFP and TFP, LP is the most commonly used productivity concept in the construction industry.

3.3.4 Disparity between economic and physical measurement of industry-led productivity

In many countries, a disparity between the trends in the results of the monetary and physical measures of construction productivity has been observed. Whereas the former shows little progress in construction productivity growth, where the latter is measured, it provides evidence of some achievement. For example, a study in the US found major differences between physical output measures and economic (value-added based) ones, despite many theoretical adjustments that had been made.[150] Practitioners and researchers have noted that the industry has been building items of greater complexity and higher quality than in the past and is doing so in shorter periods of time.[151] The application of ICT is speeding up many aspects of work and aiding the rationalisation of the process of project delivery and management of resources. Thus, it would neither be fair nor accurate to state that productivity is declining across the board in the construction industry.

On the other hand, there are many examples of studies which conclude that construction productivity has been stagnant or declining. For example, a study in New Zealand concluded that traditional measures of productivity – LP, CP and MFP – suggest that there has been practically no

145 Dozzi, S.P. and AbouRizk, S.M. (1993) *Productivity in Construction*. Institute for Research in Construction National Research Council, Ottawa.

146 Chapman, R.E., Butry, D.T and Huang, A.L. (2009) Measuring and improving U.S. construction productivity. https://www.irbnet.de/daten/iconda/CIB19044.pdf

147 Tan, W. (2000) Total factor productivity in Singapore construction. *Engineering, Construction and Architectural Management*, Vol. 7, No. 2, pp. 154-158.

148 Mao, Z., Goh, B.H. and Ofori, G. (2003) Total factor productivity growth accounting in the construction industry of Singapore. *Construction Management and Economics*, 21, 707-718.

149 Chau K.W.and Walker A. (1988) The measurement of total factor productivity of the Hong Kong construction industry. *Construction Management and Economics*, 6, 209-224.

150 Sveikauskas, L., Rowe, S., James Mildenberger, J., Price, J. and Young, A. (2014) Productivity Growth in Construction. BLS Working Papers, No. 478. US Department of Labor, Bureau of Labor Statistics, Washington D.C.

151 Bernstein, H.M. (2003) Measuring productivity: an industry challenge. *Civil Engineering*, December, pp. 46-53.

growth in construction productivity in that country since 1990.[152] What is causing this disparity? The New Zealand report suggested possible explanations. First, the construction industry had not been able to pass on price increases; the prices it charged for its outputs had risen more slowly than what it is charged for its inputs. Second, the nature of the items the industry builds: New Zealand's industry is based on residential construction, which is subject to large fluctuations in demand, and has lower labour productivity than other sub-sectors. The third point is how the industry responds to demand. Businesses keep their workers even during downturns, leading to declines in productivity, whereas the opposite is true in upturns. The fourth is the uncertainty over the industry's workload which makes it unable to invest in human resources and technology. The final issue is labour quality: hourly levels of productivity in construction had remained flat although the use of mechanisation had increased; this suggests there had been no improvement in skill levels.

Similar points were made in a study in Japan,[153] which gave reasons why the labour productivity in construction was lower than manufacturing as: (a) built-to-order production – the unique nature of each project and strong owner input, with frequent changes, makes it difficult to standardise and rationalise work; (b) labour intensity of the work; (c) small company size – thus, the level of managerial expertise is rather low; (d) complex division of functions – significant outsourcing of construction work of general contractors leads to a complex multi-level structure of subcontractors; (e) seasonal fluctuations; (f) fewer large-scale projects – (especially during low demand) which achieve high productivity through mechanisation and automation, causes overall labour productivity to decline; (g) bloated staff – firms are slow to streamline their operations in a slump following a boom; and (h) lower unit costs – clients put pressure on builders to reduce costs, resulting in lower value-added.

Other fundamental factors include, first, the preponderance of small projects as well as non-new work (repairs, maintenance, retrofitting and demolition) which are more labour-intensive; and the low barriers to entry into the industry which is highly fragmented, comprising an overwhelming majority of small companies with limited ability to invest in productivity-enhancing methods or skilled workers. A US study[154] found that, over the last two decades, shifts from high to low productivity segments of construction reduced productivity by 0.26 per cent a year. Second, there are many possible ways to undertake a task in the industry, and non-productive methods can also be viable and might be cheaper. The final factor here is the practice of price-based tendering which often leads to a race for the bottom. This approach to competition results in low profit margins on projects. The authors of another US study[155] are among many who have blamed measurement difficulties and iits associated errors for the disparity:

> *Measuring productivity growth in construction is especially difficult due to the nature of production in the industry and the limitations of available data. In particular, the price indexes used to deflate output are a major problem because reliable deflators are sparse and the available data suggest productivity has declined for many decades, which is somewhat difficult to believe.*

Studies continue to explore the issue. For instance, the relationship between construction productivity measures at various levels of aggregation has also been investigated, for example, to ascertain why clear increases in labour productivity and results on the construction project fail to be reflected in industry level data.[156]

152 Page, I. and Norman, D. (2014) *Measuring Construction Industry Productivity and Performance*, Study Report SR 310. Branz, Wellington.

153 Sugii, T. (1998) The Construction Sector Suffers from Declining Labor Productivity. Industrial Research Department, NLI Research Institute, No. 117, pp. 18-26.

154 Sveikauskas, L., Rowe, S., James Mildenberger, J., Price, J. and Young, A. (2014) *Productivity Growth in Construction*. BLS Working Papers, No. 478. US Department of Labor, Bureau of Labor Statistics, Washington D.C.

155 Sveikauskas, L., Rowe, S., Mildenberger, J., Price, J. and Young, A. (2014) *Productivity Growth in Construction*, Working Paper 48. United States Bureau of Labor Statistics, Washington, D.C.

156 Brochner, J. and Sezer, A.A. (2014) Services, goods and business client productivity: learning from construction, *Construction Management and Economics*, Vol. 32, 6, pp. 565-574.

3.3.5 Need for range of productivity indicators in construction

Several studies note that the current data on construction productivity do not represent an understanding of the management tools and processes firms are adopting, and the extent to which they attribute improved performance to these systems.[157] A study in Sweden[158] concluded that:

> *Instead of trying to achieve one uniform measure of productivity, a set of key performance indicators may be used … in order to obtain more qualitative facts about the state of the construction industry. Uncertain measurements of productivity need to be replaced with the measurement of well-defined indicators that, when analysed together, can give insights about value creating factors as well as increased efficiency and productivity (p. 64).*

A New Zealand study[159] suggested a basket of potential measures of efficiency for construction firms (Table 3.3). Companies can use the data from these indicators to establish rules of thumb or consider their outcomes relative to their peers using available benchmarking data.

Table 3.3 Possible performance measures in construction

Measure name	*How to measure this*	*Industry benchmarking available?*
Financial measures		
Solvency	Current assets/current liabilities; greater than 1.0 needed	
Profitability	Gross, taxable or net profit / turnover	Yes
Return on Assets	Taxable or net profit / net assets	Yes
Customer satisfaction		
Formal written feedback from client	Qualitative, basic survey questionnaire may help	Yes
Call back rate	% of jobs requiring a call-back	
Fixing of defects	hours required, $ of labour costs	
Repeat clients	% of annual work value or jobs that is repeat business	
Staff retention		
Worker turnover rate or average tenure	Average years in job per worker, (joiners + leavers) / average staff level	Yes
Job turnover rate	Jobs disestablished / jobs filled at start of year	Yes
Innovation		
Innovation spend	% of turnover	
New management tools / processes	Qualitative assessment of changes	
Prefabrication	% of value of work put in place	Yes

Source: Page and Norman (2014)

A recent study in Singapore[160] cites many other studies in various countries which advocate the use of multiple indicators of productivity. Some management indicators suggested by SPRING Singapore is presented in Box 3.1; it urges companies to use a range of these indicators.

It has been suggested that the whole industry should work together to find appropriate measures

157 Page, I. and Norman, D. (2014) *Measuring Construction Industry Productivity and Performance*, Study Report SR 310. Branz, Wellington.

158 Olander, S. Widen, K. Hansson B. and Pemsel, S. (2010) Productivity comparisons, are they possible or even desirable? In Barrett, P., Amaratunga, D., Haigh, R., Keraminiyage, K. and Pathirage, C. (Eds) *Selected Papers in the Proceedings of CIB Working Commission W055 Building Economics – Papers and Postgraduate Papers from the Special Track*, Salford Quays, 10-13 May, pp. 58-67.

159 Page, I. and Norman, D. (2014) *Measuring Construction Industry Productivity and Performance*, Study Report SR 310. Branz, Wellington.

160 Low, S.P. (2015) A review of construction productivity indicators in Singapore. *The Singapore Engineer*, August, pp. 24-30.

and tools, in the broader context of the variety of dimensions and parameters of performance in the construction industry. In the US, CERF[161] suggests that industry stakeholders should collaborate to: develop an understanding of the relationships among innovation, productivity, profitability and competitiveness; define productivity, associated terms, and measures of success; define the parameters and metrics of construction productivity; and use the parameters and metrics to initiate programmes to collect appropriate data on a consistent, objective basis.

Box 3.1: Key management indicators

In its productivity guide, SPRING Singapore suggested ten key management indicators:

A. Productivity

- Labour productivity

B. Increase Sales

- Sales per employee

C. Increase Output Per Unit Cost of Production

- Value-added to sales ratio
- Profit margin...Operating profit over Sales
- Profit to value-added ratio (%)...Operating profit divided by Value-added

D. Optimise Use of Labour

- Labour cost competitiveness (times) ... Value-added divided by Labour cost
- Labour cost per employee ($)

E. Optimise Use of Capital

- Sales per dollar of capital (times)...Sales divided by Fixed assets
- Capital intensity ($)...Fixed assets divided by number of employees
- Capital productivity (times)...Value-added divided by Fixed assets

…….

F. Other indicators for Manufacturing Industry:

- Delivery on time...Number of orders delivered on time divided by Total number of orders
- Innovation or idea conversion rate...Number of suggestions divided by Total number of suggestions
- Defect rate...Number of defects divided by Total number of goods produced
- Capability or flexibility of workforce...Roles or jobs per worker divided by Total of jobs
- Overall equipment effectiveness...Availability x Performance x Quality

G.Relevant additional indicator for Services sector

- Investment in training per employee

Source: SPRING Singapore (2011)[162]

161 Bernstein, H.M. (2003) Measuring productivity: an industry challenge. *Civil Engineering*, December, pp. 46-53, http://www.engr.uky.edu/~rsouley/CE%20120/12/Measuring%20Productivity%20An%20Industry%20Challenge.pdf

162 SPRING Singapore (2011) *A Guide to Productivity Measurement*. Singapore.

3.4 Construction productivity measures in Singapore

How is construction productivity measured in Singapore? A recent study reviews construction productivity indicators in Singapore.[163] One of the recommendations of the first Construction Productivity Roadmap, published in 2010, was that BCA should establish benchmark indicators especially at project and trade levels for builders to track their own productivity performance.

Four types of LP indicators are used in Singapore: value-added per worker or value-added per hour worked are most commonly used. Other indicators mentioned include: "construction volume per employment", and "contribution of the construction industry to GDP versus employment share".[164] The physical indicator, square metres of completed floor area per man-day, could be considered to be more accurate than value-added per worker as it eliminates the effect of cyclical factors. However, it is not published in most countries. Thus, international comparison is difficult.

3.4.1 Trade-level construction productivity

BCA published a guidebook on trade-level productivity in 2012,[165] which "sets out the best practices on how to measure the productivity for the 12 key trades which are commonly found in most construction projects". It defined productivity as units of output per man-hour. The trades were: (a) formwork; (b) reinforcement; (c) concrete placement; (d) drywall; (e) painting; (f) timber door; (g) wall tiling; (h) floor tiling; (i) suspended ceiling; (j) air-conditioning ducting; (k) electrical conduit; and (l) water pipe installation. BCA worked with a group of builders to develop the guide and uses to study trade productivity.

The best practices are illustrated with flowcharts and photographs that show the activities involved in each trade. The book provides productivity monitoring forms for each of the key trades which provide information on the activities and parameters that firms should monitor and measure. They constitute a set of common tools for measuring trade productivity. Table 3.4 presents productivity indicators for the 12 key building trades studied in the pilot project; BCA obtained the data by sampling a number of projects.

3.4.2 Value-added per worker

According to the Construction Productivity Measurement Study Team (CPST),[166] construction value-added in Singapore is estimated using parameters and output indicators. For building and civil engineering construction, value-added is estimated from progress payments, and for alterations and renovation works, it is estimated from renovation bank loans and data from the Housing and Development Board (HDB) and Urban Redevelopment Authority (URA). Real value-added is then obtained by deflating the nominal value with relevant price indices. For precast construction, real value-added is estimated from the production volume. This industry-level indicator is used for inter-sectoral comparisons.

Table 3.5 shows data on the rate of change in productivity as measured by value-added per worker from 2008 to 2014.Construction showed strong growth in productivity between 2008 and 2012, with the strongest showing in 2009, at 8.1 per cent. In 2008, 2009 and 2012, construction was the best performing industry in terms of productivity growth. In those years, the "Total (excluding Construction)" figures were higher than those for the whole economy. These figures fell in 2013 and 2014.

Similarly, a BCA census,[167] of which a summary of results were released in the annual report for 2012-13, found that with exceptionally strong construction demand in 2008, total construction turnover increased by 84 per cent from $27.9 billion in 2005 to $51.3 billion in 2010. The average profitability ratio rose from between 2.7 per cent and 3.1 per cent in previous censuses to 8.5 per cent in 2010. This increase in net operating surplus led to a rise in the industry's value-added by 131 per cent

163 Low, S.P. (2015) A review of construction productivity indicators in Singapore. *The Singapore Engineer*, August, pp. 24-30.
164 Construction 21 Steering Committee (1999) *Re-inventing Construction: The Construction 21 report*. Ministry of Manpower and Ministry of National Development, Singapore.
165 BCA (2012) *Builders' Guide on Measuring Productivity: A guide to help builders measure productivity of various trades*. Singapore.
166 Construction Productivity Measurement Study Team (1998) Study Report. Ministry of National Development, Singapore.
167 BCA (2012) *Annual Report 2012-13 – Inspiring Change for a Better Tomorrow*. Singapore, p. 14.

between 2005 and 2010, resulting in an increase in average value-added per employee for the whole industry, from $28,222 in 2005 to $39,475 in 2010.

Table 3.4 Trade productivity indicators of 12 key building trades

	Work item	*Units*	*Productivity indicators*
	Structural Work		
1.	Formwork (Table form for Slab / Beam)	m^2/man-hour	2.07 to 2.53 (Average – 2.30)
2.	Reinforcement placing and fixing (Slab)	kg/man-hour	68 to 83 (Average – 75)
3.	Concrete placement (with concrete pump) (Slab)	m^3/man-hour	1.677 to 2.04 (Average – 1.85)
	Architectural Work		
4.	Drywall (12mm thick board)	m^2/man-hour	2.03 to 2.48 (Average – 2.25)
5.	Painting (Emulsion – 3 coats) (using roller)	m^2/man-hour	4.95 to 6.05 (Average – 5.50)
6.	Timber door including door frame	Number/man-hour	0.31 to 0.37 (Average – 0.34)
7.	Ceramic wall tiling (using adhesive)	m^2/man-hour	1.52 to 1.86 (Average – 1.69)
8.	Ceramic floor tiling (using adhesive)	m^2/man-hour	1.83 to 2.23 (Average – 2.03)
9.	Suspended ceiling (exposed grid system)	m^2/man-hour	4.54 to 5.54 (Average – 5.04)
	Mechanical, Electrical and Plumbing Work		
10.	Air-conditioning duct (formed and insulated on site)	m^2/man-hour	2.60 to 3.19 (Average – 2.90)
11.	20mm diameter UPVC electrical conduit with wires fixed to ceiling	m/man-hour	2.44 to 2.98 (Average – 2.71)
12.	20mm diameter copper pipe for water (concealed in wall)	m/man-hour	1.50 to 1.84 (Average – 1.65)

Source: BCA (2014)[168]

Table 3.5 Changes in value-added per worker by industry (per cent)

	2008	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*
Total[1]	-7.2	-3.3	11.6	2.3	-0.5	0.3	-0.8
Total (excluding Construction)	-6.7	-2.9	11.9	2.2	-0.3	0.9	-0.6
Goods producing industries[2]	-12.1	-1.7	25.0	5.8	-2.2	-2.2	0.1
a. Manufacturing	-11.2	1.5	32.2	7.9	-1.2	0.3	2.5
b. Construction	2.3	8.1	4.0	2.7	2.2	-2.6	-2.3
Services Producing Industries[2]	-3.6	-4.2	6.7	1.9	0.3	2.3	-1.1

[1]Based on Gross Domestic Product at 2010 Market Prices

[2]Based on Gross Value-added at 2010 Basic Prices

Source: Department of Statistics (2015)

Difficulties with measurement of productivity with value-added per person employed outlined in a recent work in Singapore[169] include understanding what the concept means and the cost in collecting sufficient data for construction to obtain an accurate figure owing to the diversity, complexity and dispersal of projects. The study noted that off-site construction usually means improvements in productivity are credited to manufacturing. Such issues have been discussed in Singapore for many decades. A study in 1992[170] and another in 1998[171] highlighted problems with value-added per person data, including the effect of business cycles on construction value-added, the focus on site production (which is the least productive part of the construction process), lack of consideration of contractors' contribution to design-and-build projects and possible inaccuracies in manpower data.

168 Building and Construction Authority (BCA) (2014) *Trade Productivity*. Singapore.
169 Low, S.P. (2015) A review of construction productivity indicators in Singapore. *The Singapore Engineer*, August, pp. 24-30.
170 Task Force on Construction Productivity (1992) *Raising Singapore's Construction Productivity*. CIDB, Singapore.
171 Construction Productivity Measurement Study Team (1998) Study Report. Ministry of National Development, Singapore.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The debate on appropriate measurement at industry level continues in Singapore. A senior administrator recently made points similar to those made in the 1990s, noting that value-added per worker, on its own, is insufficient as a way of "sizing up what is really happening on the ground" in the building industry.[172] The industry's reputation as a sector with poor productivity was not merited if other sector-specific indicators were used. "Site productivity", measured in constructed floor area per man-day "shows how efficiently construction is being carried out - through good planning, adoption of technologies and deployment of a quality workforce". The value-added per worker indicator is influenced by economic and sectoral business cycles including profit margins, and could turn weak when these margins decline. He noted that, "If site productivity is achieved, you use fewer workers. Eventually it will reflect on VA [value-added] productivity, other things being equal". He concluded: "We think this metric is more realistic in measuring productivity for the construction sector…I don't think you can do the same for every sector. Each sector has its own specific indicator to use – in addition to VA productivity. VA productivity is not useless, but it can't be the only indicator".

BCA has provided a template for calculating value-added per person employed at the company level for use by construction firms; this is shown in Appendix Five. It also provides instructions on how to use the form (see Appendix Five) and answers common questions.

The decision of the Singapore government to place more emphasis on value-added per paid hours worked will provide a more appropriate productivity indicator for the construction industry. It will also enable international comparison, which will avoid differences in labour regulations and practices such as paid holidays, the duration of a working day, and influence of part-time work.

3.4.3 Square metres of gross floor area per man-day

BCA stresses physical productivity indicators as it considers productivity as: "the amount of floor area completed per man-day". To BCA, this is "consistent with the industry's method of measurement and is also in line with the measurement of trade productivity which is defined as the amount of physical output per man-hour". It is measured as square meters of gross floor area completed per man-day, and is the weighted average of the physical productivities of different types of buildings.

A recent study[173] explained how the productivity indicator is estimated. As mentioned above, construction firms must submit data to BCA [under the Building Control (Buildability and Productivity) Regulations 2011], through the ePSS, if they are working on projects of total area of 5,000 square metres or more. To ensure the accuracy of the data, firms are encouraged to adopt the BAS. Projects are grouped into categories by type: private residential (landed); private residential (non-landed); public housing; commercial; industrial; and institutional. Data for projects under each category in a particular year are aggregated to calculate the project productivity indicators for each type of building. The Industry Overall Productivity Indicator (square metres per man-day) in a year is calculated by applying to the total GFA for each category, a weightage rate derived from the certified progress payments. The study states that BCA's on-site productivity measurement is "a reliable and realistic construction industry-specific productivity indicator" (p. 29).

The data on this productivity indicator from 2008 to 2014 are shown in Table 3.6. It is evident that there was progressive improvement in the annual figures during the period. The indicator relates only to building projects and work done on site. BCA explains further that the site management team is not included in the number of site workers; and only on-site works are considered when calculating the project productivity.

Table 3.7 shows data on various segments of the industry. The data show that public residential projects have had the highest productivity.

3.5 International measurement of various levels of construction productivity

This section discusses approaches to the measurement of industry-level construction productivity in several countries, mainly, the US, UK and Australia.

172 Lee, M. (2016) Value-added 'falls short as measure of productivity'. *Business Times*, January 14, http://www.businesstimes.com.sg/government-economy/value-added-falls-short-as-measure-of-productivity

173 Low, S.P. (2015) A review of construction productivity indicators in Singapore. *The Singapore Engineer*, August, pp. 24-30.

Table 3.6 Industry Overall Productivity Indicator (m^2 per man-day)

Year	*Industry Overall Productivity Indicator*
2008	0.375
2009	0.380
2010	0.381
2011	0.384
2012	0.389
2013	0.395
2014	0.403

Source: BCA (2015)

Table 3.7 Project productivity by building category (m^2 per man-day)

Year	*Public Housing (HDB Projects)*	*Residential (landed)*	*Residential (non-landed)*	*Commercial*	*Industrial*	*Institutional*
2008	0.450	0.192	0.306	0.331	0.498	0.336
2009	0.455	0.192	0.317	0.330	0.505	0.337
2010	0.439	0.190	0.319	0.328	0.495	0.319
2011	0.441	0.192	0.321	0.330	0.501	0.342
2012	0.449	0.194	0.326	0.335	0.508	0.344
2013	0.459	0.196	0.331	0.341	0.513	0.348
2014	0.470	0.199	0.337	0.348	0.523	0.355

Source: BCA (2015)

3.5.1 United States

In the US, the annual publication, R.S. Means Building Construction Cost Data Book provides, for individual construction tasks, estimates of daily output, crew requirement, labour hours, material cost, labour cost, equipment cost, and overheads and profits. It is used as a reference guide for project planning, budgeting and estimating. The data are based on surveys of contractors and suppliers. The current (2016) version is the 74th edition. The ASTM guide presented in Box 3.2 provides a new approach to productivity measurement and the use of the data, as the tool it offers, Job Productivity Measurement (JPM), is used on the 'live' project and the results guide action as the work proceeds. The Bureau of Labor Standards calculates labour productivity for sectors such as manufacturing, but not for construction (due to a lack of "suitable data").[174]

Box 3.2 A 'live' measurement tool

In 2011, the American Society of Testing and Materials International (ASTM)[175] issued a new guide, ASTM E2691, for productivity measurement in construction at the task, project and industry levels. The technique is called Job Productivity Measurement (JPM). JPM produces two measurements: construction production rate and productivity. It measures the overall production rate by comparing construction put in place (CPIP) to the time elapsed in the construction schedule, and measures overall job productivity through a comparison of labour usage to a reference point.

ASTM describes the scope of JPM as: (i) it is based on ASTM's UNIFORMAT II format for organising building data, established in Classification E1557,[176] and depending on the level where measurement is applied (industry, total job, or

174 Sveikauskas, L., Rowe, S., James Mildenberger, J., Price, J. and Young, A. (2014) Productivity Growth in Construction. BLS Working Papers, No. 478. US Department of Labor, Bureau of Labor Statistics, Washington D.C.

175 American Society of Testing and Materials International (2011) ASTM E2691-11, *Standard Practice for Job Productivity Measurement*, ASTM International, West Conshohocken, PA.

176 American Society of Testing and Materials International (2015) E1557-09(2015), *Standard Classification for Building Elements and Related Sitework*—UNIFORMAT II. ASTM International, West Conshohocken, PA.

building element), JPM measures construction productivity at three levels: task, project, and industry; (ii) by comparing labour hours used against CPIP, JPM allows for unified measurement of established building elements (according to the UNIFORMAT II format); (iii) JPM measures labour productivity of the installation processes on a construction job; (iv) CPIP is measured with input from the labour performing the installation, utilising elements of statistical process control (SPC) and industrial engineering; (v) JPM takes into account the difficulty of installation at any given point on a job; and (vi) JPM evaluates relative productivity changes using trend monitoring.

JPM issues early warning signals for construction. It identifies productivity deviations in the form of any gains or losses in productivity, and anomalies, from the productivity reference point. It measures the productivity changes to individual building elements (according to UNIFORMAT II format). It also measures ongoing changes in labour usage. It measures productivity wherever the labour is used in construction by any contractor or construction manager. Use of this practice will reduce the need for end-of-the-job inspection on projects by providing ongoing and periodic feedback on errors, repairs, and rework. These issues can be resolved as they are identified with JPM as the job progresses. Other advantages over current methods of measuring productivity are:[177] JPM enables project managers to better manage subcontractors' performance; and it facilitates the timely preparation of accurate claims for payment.

Source: ASTMS (2011)

The difficulties in measuring construction productivity have long been recognised in the US. In 1933, one author[178] referred to several alternative data definitions in measuring productivity in construction: whether to include only projects awarded through contracts, whether to include repair and alterations work, and whether there should be a minimum contract sum for projects to be included. On inputs, problems included issues such as usage and rental of equipment, and how to deal with higher grade building materials used. In 1965, one work[179] explained the labour productivity trend in construction in the US, based on six sources: increase in capital per worker; shifts in the construction product mix; shifts in the geographical distribution of construction (owing to differences in design and building codes in different states); increase in the corporate share in contract construction; declining average age of construction workers; introduction of new building techniques; and usage of labour-saving materials. Subsequent studies in the 1980s found that these shifts accounted for only a fraction of the change in productivity growth.[180]

An often mentioned and more recent study[181] used official data on the real output of construction per work-hour and found that the construction industry's labour productivity declined by 0.72 percent at an annual compound rate from 1964 to 2000. Whereas some other reports have 'confirmed' this declining trend, other US experts challenge the notion that construction productivity has been

177 McKonly and Asbury (2011) How do you measure productivity? http://www.contractorscenterpoint.com/2011/10/how-do-you-measure-productivity.html

178 Gill, C. (1933) Construction statistics. *Journal of the American Statistical Association*, 28(181), pp. 31-54; cited in Brochner, J. and Sezer, A.A. (2014) Services, goods and business client productivity: learning from construction, *Construction Management and Economics*, Vol. 32, 6, pp. 565-574.

179 Dacy, D.C. (1965) Productivity price trends in construction since 1947. *Review of Economics and Statistics*, 47, 406-411.

180 Stokes (1981) Stokes, H.K. (1981) An examination of the productivity decline in the construction industry. *The Review of Economics and Statistics*, 63(4), pp. 495-502; cited in Brochner, J. and Sezer, A.A. (2014) Services, goods and business client productivity: learning from construction. *Construction Management and Economics*, Vol. 32, 6, pp. 565-574.

181 Teicholtz, P. (2001) Discussion: US construction labour productivity trends, 1970-1998. *Journal of Construction Engineering and Management*, Vol. 127, No 5, pp. 427-429.

declining. A subsequent report[182] developed measures of labour productivity growth in three construction industry segments, where reliable output deflators exist, over 2002 to 2011: single family residential construction, multiple family residential construction, and the construction of highways, streets, and bridges (one quarter of construction output). It found no sustained productivity decline. A more recent report which used data from the Census of Construction taking into consideration the period 1987-2014 for housing but shorter periods for the others) also found that "labour productivity growth has been positive, and fairly substantial, in all four [segments of the industry] where reliable deflators now exist"[183] Many industry leaders and experts have long maintained that the labour productivity trend in the US has been increasing.[184]

3.5.2 United Kingdom

In the UK, trade-level productivity data are published in the annual Spon's Architect's and Builders' Price Book. The 2016 version is the 141st edition of the book. The UK Office for National Statistics[185] published data on industry-level construction labour productivity until September 2001. It halted the publication because the measure was not meaningful and could not be defended in terms of quality; it even withdrew the previously published data. The main issue was that to estimate the output of self-employed persons and those working in firms not registered for sales tax purposes (who together, comprised 25 percent of the employment), it assumed a productivity level and multiplied it by an estimate of the number of self-employed in the industry. This meant that the output and the labour parts of the calculation were both derived in part from some of the same figures.

Productivity is one of the key performance indicators (KPIs) of the UK construction industry; data are published on the KPIs each year. Here, productivity is defined as value-added per (full-time) employee.[186] (In earlier annual KPI reports, productivity was defined as the median turnover per employee.) Here, value-added is the turnover less the cost of goods and services purchased from other parties or subcontracted to other parties. Value-added per employee for the UK construction industry was £48,900 in 2010; £59,300 in 2011, and £60,000 in 2012, £60,900 in 2013/14, and £61,300 in 2015.

The UK construction KPIs are in these categories: Economic; Environment; and Respect for People. The Economic KPIs are:[187] (i) Client Satisfaction – product, service, value for money; (ii) Contractor Satisfaction – performance, provision of information, payment; (iii) Defects (impact at handover); (iv) Predictability Cost – project, design, construction; (v) Predictability Time – project, design, construction; (vi) Profitability; and (vii) Productivity. The other KPIs are in the following categories: Respect for people KPIs; Environment KPIs – Product Performance; and Environment KPIs – Construction Process Performance.

3.5.3 Other countries

The Australian Bureau of Statistics (ABS) publishes LP, Capital Productivity (CP) and MFP indices for the construction industry. It measures LP as the ratio of construction gross value-added to hours worked. The aggregate data in Australia indicate a significant increase in LP and MFP from 1994-95 and from 2012-13, although most of the improvement was concentrated in relatively short bursts, including most recently in 2011-12. However, productivity growth in the ten years preceding 1994-95 was sluggish, and it has been flat since 2012-13. One driver of the historically weak labour productivity growth appears to be relatively low levels of capital deepening (capital

182 Sveikauskas, L., Rowe, S., James Mildenberger, J., Price, J. and Young, A. (2014) Productivity Growth in Construction. BLS Working Papers, No. 478. US Department of Labor, Bureau of Labor Statistics, Washington D.C.

183 Sveikauskas, L., Rowe, S., Mildenberger, J. and Price, J. (2016) Productivity Growth in Construction. *Journal of Construction Engineering and Management*, Vol. 142, No. 10, October, http://ascelibrary.org/doi/full/10.1061/(ASCE)CO.1943-7862.0001138

184 Bernstein, H.M. (2003) Measuring productivity: an industry challenge. *Civil Engineering*, December, pp. 46-53.

185 Office for National Statistics (2002) Labour productivity measures for the non-production industries. *Economic Trends*, No 579.

186 http://www.KPIzone.com

187 KPI Team (2015) *UK Industry Performance Report: Based on the UK Construction Industry Key Performance Indicators*. Glenigan, CITB, Constructing Excellence, Department for Business, Innovation and Skills and BRE SMARTWaste, London.

investments which allow output from a given worker to increase from the use of better equipment). In contrast, capital productivity has been high.

In Malaysia, productivity is measured by "the average value in RM [Ringgit Malaysia] contributed by each worker".[188]

3.5.4 International comparison

The difficulties faced in obtaining data for TFP and MFP in construction, as mentioned above, mean that LP (as value-added per paid hour worked or value-added per employment) is more commonly used in international comparisons.[189] The differences in definition mentioned above make comparisons difficult. For example, countries calculate the volume of construction differently. US uses Value of Construction Put in Place which is the total value of new and remodelling construction contracts, while in Singapore, the indicator is Value-Added.

On international comparisons of value-added per worker data, a study in Singapore[190] outlines these issues: the unreliable and inadequate government statistics in many countries which are also difficult to interpret; differences in construction cycles in different countries even at the same point in time; currency exchange difficulties when reducing the data to a common monetary base; differences in wages; and differences in material and methods used in various countries.

Despite the difficulties, international comparisons are still made. ESC[191] compared construction labour productivity (real value-added per worker in 2006 to 2008) among countries, and found the following (with Japan's figure as 100): UK, 79; Australia, 64; US, 63; Germany, 59; South Korea, 42; Singapore, 34; Taiwan, 21; and Asean, 6. Malaysia's CIDB compared construction productivity data: at 2005 constant figures, the construction productivity of various countries were:[192] Australia, US$66,000, Japan, US$47,000, Singapore, US$17,000, Turkey, US$16,000, and Malaysia, US$7,000.

It is pertinent to consider some of the difficulties involved when comparing productivity data from different countries. Value-added in construction in Singapore is often compared with that in Australia.[193] Several key points on the figures and components of value-added in construction in Australia are shown in Box 3.3. The points are drawn from a report which states that: "Generally we find that construction is a productive industry with a value-added per worker above the average of all industries and well above the average, if extremely productive industries such as mining are excluded. Some parts of construction such as heavy and civil engineering are very productive, generating productivity 53 per cent higher than the Australian average".[194]

Box 3.3: Extract from conclusions of a report on construction productivity in Australia

…construction is a large industry in Australia accounting for 7.6 per cent of GDP, while its total sales and service income is a rather large 21 per cent of GDP.

…productivity in construction is relatively high, with a value-added per worker of $96,838 per annum compared with the Australian industry average of $94,052. Even then, the industry average is biased upward by a couple of very high industries. Productivity is therefore relatively high in construction overall,

188 Construction Industry Development Board (2015) *Construction Industry Transformation Programme (CITP) 2016-20*. Kuala Lumpur.
189 Shreyer, D. and Pilat, D. (2001) *Measuring Productivity*. OECD Economic Studies, No. 33, 2000/11. OECD, Paris.
190 Low, S.P. (2015) A review of construction productivity indicators in Singapore. *The Singapore Engineer*, August, pp. 24-30. See also Low, S.P. (2015) The myth of low construction productivity. *The Straits Times*, June 2, http://www.straitstimes.com/opinion/the-myth-of-low-construction-productivity
191 Economic Strategies Committee (2010) *Economic Strategies Committee Report: High skilled people, innovative economy, distinctive global city*. Ministry of Trade and Industry, Singapore.
192 Construction Industry Development Board (2015) *Construction Industry Transformation Programme (CITP) 2016-20*. Kuala Lumpur.
193 As was done by the ESC and Malaysia's CIDB as discussed in the previous paragraph.
194 Richardson, D. (2014) *Productivity in the Construction Industry*, Technical Brief No. 33. Australia Institute, Canberra.

and when we looked at individual components of construction it appeared that heavy and civil engineering and the building construction sub-industries are very productive, being 53 and 24 per cent higher than the Australian average.

…productivity growth in construction from 1994–95 and 2012–13 was almost exactly the same as the market sector as a whole. However, comparing multifactor productivity growth and capital productivity growth we found that construction outperforms the rest of Australian industry by a wide margin. For multifactor productivity, growth is more than three times higher in construction than the rest of industry. For capital productivity, growth was 11 per cent from 1994-95 to 2012-13, while it was a negative 27 per cent for Australian industry as a whole.

The high productivity growth in construction is confirmed for the sub-industries over the period since 2007-08. Over that period heavy and civil engineering had a productivity growth of about the industry average of 3.52 per cent, while building was a very high 6.38 per cent.

Recent discussion by the Productivity Commission suggests that productivity growth has been sluggish. The Productivity Commission is inclined to put some of the blame on industrial relations issues but believes the orders of magnitude are too small to be picked up by the aggregate studies that have been cited in the literature. It also argues that there are other factors that are more important, at least for the future of productivity growth in the industry.

Profitability is also an important and related issue in the productivity debate. In terms of the share of value-added going to profits, construction is slightly below average. … However, when we compare the profitability of construction as a return on capital …it becomes the most profitable industry of those the ABS allows us to measure. Construction shows an exceptional rate of return of 107 per cent, which far exceeds the Australian industry average of 21.8 per cent.

…we have to conclude that in construction we are considering a productive industry that achieves a level of profitability disproportionate to the capital intensity of the industry.

Source: Richardson, D. (2014) *Productivity in the Construction Industry*, Technical Brief No. 33. Australia Institute, Canberra.

From the formula for value-added which is outlined in Table 3.2, it is evident that the differences in the figures for various countries can be explained by factors other than superior performance in production rates. For example, taking wages, which form the most significant component of "Total Remuneration", an important variable in the value-added formula, the average hourly wage of a site construction worker in Singapore was indicated in a study[195] to be about S$3.98 per hour (about S$700 per month).[196] The same study gave these wages for construction workers in several industrialised countries: S$11.11 per hour in France, S$16.87 in the UK, and $19.27 in the US.[197] The annual wage for a site construction worker in Singapore is about S$8,400, compared

195 Cuellar, J. (2014) Is being a construction worker in Singapore really as bad as other countries? moneysmart.sg, May 19, http://blog.moneysmart.sg/opinion/is-being-a-construction-worker-in-singapore-really-as-bad-as-other-countries/

196 It is pertinent to note that there are wide variations in the wages. For example, it is suggested that, among the foreign construction workers, those from China earn monthly wages of between $1,000 and $1,500 on average, whereas their counterparts from India and Bangladesh, earn between $480 and $800.

197 Cuellar, J. (2014) Is being a construction worker in Singapore really as bad as other countries? moneysmart.sg, May 19, http://blog.moneysmart.sg/opinion/is-being-a-construction-worker-in-singapore-really-as-bad-as-other-countries/

with S$32,000 in France, S$34,000 in the UK and S$39,000 in the US.[198] In Australia, the average weekly ordinary-time earnings for full-time construction workers in a survey in 2015 was A$1475, only slightly below the figure for all industries of A$1477 per week.[199] Thus, if one assumed that profit and depreciation for a construction company in Singapore and its counterpart of a similar size in any of these countries working in the same trades are similar, then the value-added of the Singapore firm would be much lower than its counterpart.

Profitability is also an important issue to consider in the discussion on productivity and in making international comparisons. As noted in section 3.4.2, the superior performance of Singapore's construction industry in growth in value-added productivity between 2008 and 2012 was due in part to the high total turnover of the industry; the high demand meant an industry operating at full capacity with good margins. This is also borne out by studies in Australia (see Box 3.3) where the industry, which is described as being productive, is found to have levels of profitability, measured as a return on capital, which far exceeds the Australian industry average.[200]

3.5.5 Rate of growth of construction productivity in other countries

Since 2003, the OECD Productivity database has provided time-series of productivity measures and their components for member countries.[201] The measures include data on MFP which were first constructed at the level of entire economies. In 2008, an exercise to develop MFP measures by industry was launched. Data on average annual percentage change in LP (in value-added per paid hour worked) and MFP from 1990 to 2009 for OECD countries (the total, and for three sectors: construction, manufacturing and wholesale and retail trade, hotels and restaurants) are shown in Table 3.8 and Table 3.9 respectively. It is evident that in all the countries, the average annual change in labour productivity in construction was lower than that for manufacturing, and for the economy. Moreover, in seven of the nineteen countries, including Germany, the Netherlands and the US, the average for construction over the period was negative. The figures for MFP are much worse: 12 of the 19 countries recorded negative figures, and this list included: Finland, Germany, the Netherlands, Sweden, the UK and US. Similarly, another study[202] showed that the construction data contained in the Euro-KLEMS[203] database (containing productivity and other data relevant to economic growth for European Union member states) indicate that both labour and MFP have declined in most countries.

Data on annual rate of change in value-added per hour worked in construction for the OECD member countries in the years between 1999 and 2014 are shown in Table 3.10. These data also show that in every country, there were several years of negative growth in labour productivity.

198 The cost of the foreign construction worker per month in Singapore also includes: (1) Approximately $280 for accommodation (with meals and laundry); (2) Monthly levy of between $300 and $950 depending on the category of the worker (current levy rates are at http://www.mom.gov.sg/passes-and-permits/work-permit-for-foreign-worker/sector-specific-rules/construction-sector-requirements); (3) Approximate medical insurance of $8.40; (4) Insurance bond of $100 to $120 (a one-time charge for a new worker); (5) Approximate Workman Injury Compensation Insurance of $16.60; and (6) Cost of transportation, about $80.

199 Ai Group (2015) Australia's Construction Industry: Profile and outlook, July 2015. http://cdn.aigroup.com.au/Economic_Indicators/Construction_Survey/2015/Construction_industry_profile_and_Outlook.pdf

200 Richardson, D. (2014) *Productivity in the Construction Industry*, Technical Brief No. 33. Australia Institute, Canberra.

201 Arnaud, B., Dupont, J., Koh, S-H. and Schreyer, P. (2011) Measuring Multi-Factor Productivity by Industry: Methodology and first results from the OECD Productivity Database. OECD, Paris.

202 Abdel-Wahab, M. and Vogl, B. (2011). Trends of productivity growth in the construction industry across Europe, US, and Japan. *Construction Management and Economics*, 29(6), 635-644.

203 The full name of the EU-KLEMS project is: Productivity in the European Union: A comparative industry approach. It "aims to create a database on measures of economic growth, productivity, employment creation, capital formation and technological change at the industry level for all European Union member states from 1970 onwards", http://www.euklems.net/project_site.html

Table 3.8 Labour Productivity, Average annual percentage change, 1990-2009 (or closest year available)

	AUT	*BEL*	*CAN*	*CZE*	*DEU*	*DNK*	*ESP*	*FIN*	*FRA*	*GBR*	*IRL*	*ISL*	*ITA*	*KOR*	*NLD*	*NOR*	*POL*	*SWE*	*USA*
Total	1.5	1.2	1.3	3.5	1.8	1.2	1.1	2.2	1.7	2.4	--	2.7	0.9	5.1	1.3	1.7	4.4	2.1	1.9
Manufacturing	2.8	2.6	2.4	6.3	2.2	2.1	0.8	5.2	3.5	3.4	7.2	4.4	0.8	8.9	2.4	1.6	8.2	4.6	4.6
Construction	0.4	1.1	0.5	-0.9	-0.6	-1.7	0.6	0.0	0.5	1.7	0.0	0.0	-1.2	2.6	-0.1	-0.6	2.4	0.3	-1.2
Wholesale and Retail Trade – Restaurants and Hotels	0.9	-1.0	1.9	5.6	1.2	1.3	0.2	0.7	1.5	2.0	--	3.1	0.6	3.5	2.7	4.5	2.8	3.1	2.8

Source: OECD Productivity by Industry Database, 2001 (from Arnaud et al., 2011)

Table 3.9 Multi-Factor Productivity, Average annual percentage change, 1990-2009 (or closest year available)

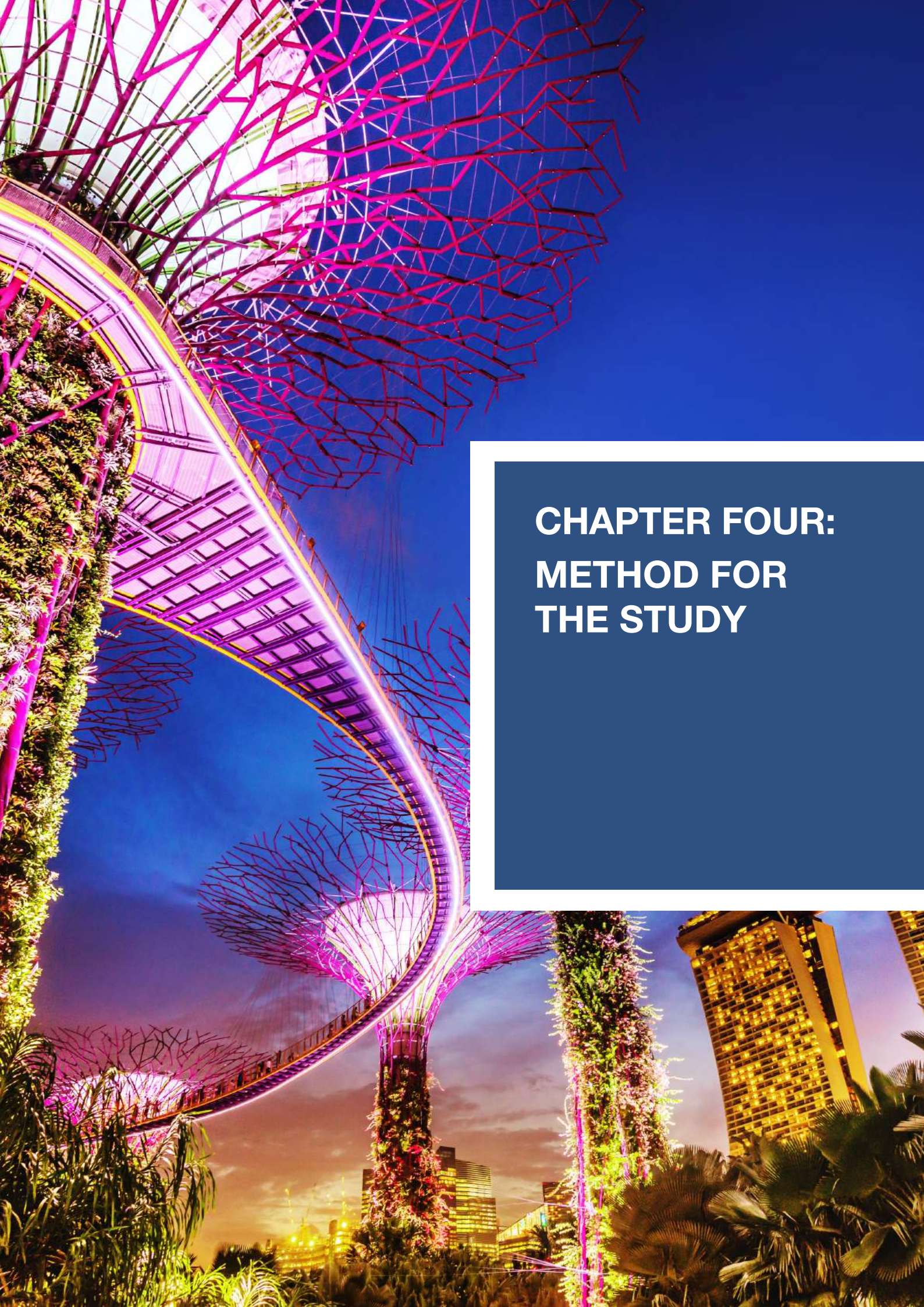
	AUT	*BEL*	*CAN*	*CZE*	*DEU*	*DNK*	*ESP*	*FIN*	*FRA*	*GBR*	*IRL*	*ISL*	*ITA*	*KOR*	*NLD*	*NOR*	*POL*	*SWE*	*USA*
Total	1.2	--	1.0	4.1	1.2	0.7	0.3	1.8	1.2	--	--	--	--	4.0	1.6	1.9	--	2.2	1.2
Manufacturing	2.3	1.8	1.8	6.3	1.2	2.1	0.7	4.3	2.8	3.5	5.2	3.1	0.7	6.9	2.6	1.4	5.3	4.8	3.5
Construction	0.3	0.6	0.3	-2.0	-0.8	-1.6	-1.5	-0.3	0.3	-0.1	-1.7	0.0	-1.4	2.1	-0.1	-1.2	0.1	-1.2	-1.6
Wholesale and Retail Trade – Restaurants and Hotels	0.9	-1.4	1.3	4.3	1.0	0.9	-0.3	0.5	1.2	2.4	--	4.8	0.4	2.7	3.0	5.3	0.7	2.9	2.4

Source: OECD Productivity by Industry Database, 2001 (from Arnaud et al., 2011)

Table 3.10 OECD Countries: Productivity and ULC by main economic activity (ISIC Rev.4) – Gross Value-added per Hour Worked: Construction, Constant Prices

		1999	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2001-14*
Australia		-3.3	-9.2	10.3	10.8	-2.3	-0.7	2.9	-2.4	4.2	1.8	0.8	0.5	10.9	..	..	..	..
Austria		0.4	2.0	0.7	3.3	3.4	2.0	0.9	-2.7	0.3	-5.3	-6.7	-5.4	-2.0	-1.2	-0.7	-2.5	-1.3
Belgium		..	3.7	1.2	4.3	4.4	6.4	5.0	3.6	-2.4	-1.4	2.9	0.5	-1.7	1.5	0.4	1.6	1.9
Canada		..	..	..	..	..	..	..	..	..	-4.0	2.7	0.3	0.4	0.4	..	..	..
Czech Republic		-9.8	-2.3	4.5	-0.9	3.0	7.1	0.3	0.5	6.5	-3.1	-6.0	2.2	-2.5	0.1	4.9	4.5	1.2
Denmark		1.0	-3.1	-6.7	1.7	6.5	-0.9	-4.2	3.1	-3.4	9.2	1.1	-3.1	1.3	4.9	-1.1	1.2	1.2
Estonia		..	..	1.7	8.2	-2.0	3.3	14.4	-12.6	-10.9	12.2	4.9	26.7	-5.5	6.1	-5.6	-6.2	2.0
Finland		-8.2	-2.1	-6.5	0.8	5.6	3.3	-0.1	-1.2	-1.7	-4.1	1.0	5.9	-1.2	-4.2	-0.2	-1.0	0.2
France		2.7	4.6	2.3	-0.4	0.1	-2.2	-0.7	-1.0	-1.5	-4.2	-5.0	-1.4	-1.9	-4.6	2.5	-1.7	-1.7
Germany		0.5	1.6	1.2	2.0	0.0	-0.5	-0.4	-2.3	-2.9	-0.5	-1.8	5.8	2.1	-1.1	-0.5	1.8	0.1
Greece		10.2	0.2	4.6	-4.0	22.6	9.9	-30.3	49.2	-19.6	-27.0	7.4	14.6	0.9	14.2	-5.9	6.8	0.9
Hungary		0.3	11.2	7.5	10.3	-11.2	-2.8	9.8	-5.2	-9.7	-6.5	7.9	8.8	4.8	-3.8	6.8	8.2	1.1
Ireland		-1.6	-8.1	-2.7	1.2	3.1	-0.9	-3.5	-6.3	-1.8	8.7	14.9	-2.4	-4.6	2.9	6.1	-1.6	1.1
Israel		1.6	3.2	3.0	2.5	0.4	2.5	9.4	-0.6	-6.6	2.7	4.8	4.4	13.1	9.3	-4.3	-6.3	2.2
Italy		-1.8	2.0	-1.3	1.3	0.6	-1.7	-2.9	-0.7	-4.3	-2.5	-6.4	-1.5	-3.3	2.8	5.0	1.8	-1.0
Korea		..	..	..	..	..	..	1.5	-1.9	2.5	1.8	8.7	-5.7	0.9	-6.2	6.7	-5.0	..
Luxembourg		..	..	-4.3	1.8	-0.8	0.3	-2.0	1.3	9.0	-7.6	1.6	3.1	4.0	-10.5	7.9	4.0	0.8
Mexico		..	..	..	..	..	..	..	..	..	..	..	..	2.7	4.0	-3.1	..	..
Netherlands		3.3	2.6	-0.8	-0.3	0.3	-0.1	4.6	3.1	1.9	2.8	-3.2	-5.6	0.0	-4.7	-0.1	6.0	0.3
New Zealand		..	..	..	..	..	..	..	..	..	..	..	-3.9	5.0	11.5	1.7	..	..
Norway		-2.7	1.7	-1.7	0.3	-1.8	0.5	-1.0	-0.8	1.2	-3.7	-1.7	-0.3	-0.9	1.6	-0.8	0.8	-0.5
Poland		..	..	-11.9	4.9	2.9	0.3	0.2	0.1	-5.4	-13.1	6.3	12.2	11.7	-0.7	1.2	5.3	1.8
Portugal		-1.5	-3.8	5.4	-6.4	-1.2	3.4	-0.9	0.9	0.6	-0.4	-2.1	-2.7	3.7	7.3	3.3	2.8	0.6
Slovak Republic		-9.9	15.3	-11.0	19.7	-17.8	-5.4	-1.2	15.0	3.6	8.3	-6.1	-4.8	11.0	10.3	-7.5	8.3	2.0
Slovenia		5.7	-7.6	0.4	0.7	2.7	0.3	2.5	8.0	6.4	-6.9	-13.3	-11.0	2.5	3.9	-3.2	5.7	-0.3
Spain		-5.6	-8.1	-2.3	-2.0	-2.8	-3.5	-4.0	-3.7	-4.2	12.9	18.1	-1.0	2.2	7.2	4.6	0.4	1.6
Sweden		-1.4	1.5	0.2	3.0	4.0	4.5	-3.2	6.8	-0.8	-10.4	-7.2	2.5	-4.7	-7.9	-4.4	11.1	-0.7
Switzerland		..	..	..	..	..	..	..	..	..	..	..	..	-2.3	0.3	2.2	1.3	..
United Kingdom		0.3	-0.7	0.1	4.9	4.3	3.9	-6.3	-0.8	-1.0	0.0	-12.4	13.8	4.0	-7.4	-0.5	2.6	0.2
Euro area (19 countries)		..	..	-0.2	0.0	0.3	-0.8	-2.4	-0.4	-3.0	1.0	1.5	0.7	0.7	1.0	2.2	1.1	0.1
European Union (28 countries)		..	..	0.2	1.9	1.4	0.1	-3.7	-0.7	-2.7	-1.0	-1.8	3.3	0.8	-0.5	1.7	1.9	0.1
Non-OECD Member Economies	Latvia	12.2	12.8	-15.6	30.6	-1.8	14.2	10.8	-4.0	9.4	-1.4	1.7	-18.8	18.4	12.3	-1.3	1.7	4.9
	Lithuania	-5.6	-16.4	8.5	8.2	7.2	-0.3	4.4	15.7	16.8	3.4	-20.4	18.8	18.2	-9.7	-0.7	15.9	5.3

Source: OECD.Stat, http://stats.oecd.org/index.aspx?queryid=28226



CHAPTER FOUR:
METHOD FOR THE STUDY

4.1 Introduction

In this chapter, the overall design and approach of the study, and the methods adopted in undertaking the study are explained. The structure and contents of the survey questionnaire and interview guide are outlined. It is argued that the broad approach, as well as certain methods in particular, are appropriate to the task involved in the study.

4.2 Research method

The main elements of the research method adopted for the study were: a series of interviews of prominent practitioners working in construction companies in Singapore; a focus group meeting with several leaders of the industry; and a questionnaire-based survey to which the members of SCAL were invited to respond. A quick survey of international experts on productivity was also undertaken.

4.3 The survey questionnaire

A set of survey questionnaire was prepared. It was available in English and Chinese. The latter was mainly for the benefit of the members of SCCCI. The main bases of the questionnaire were: points in the literature relating to productivity measurement, performance and improvement in construction; 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.

The questionnaire had the following main sections:

1. Views on industry-level productivity
2. Causes of low productivity
3. Corporate practices on productivity measurement
4. Corporate practices on productivity improvement
5. Possible future improvement
6. Profile of firm and respondent

The respondents were requested to answer the questions from the perspective of their companies. The questions were in a mixture of formats. There were 'Yes' or 'No' questions, where respondents chose from a number of suggested points; and also questions where respondents expressed a view on a continuum. A five-point Likert Scale was used in these continuum-based questions. Respondents were asked to express their views from 1 to 5, with these corresponding descriptions: 1 = "of least use"; 2 = "not useful"; 3 = 'neutral'; 4 = 'useful'; 5 = "very useful". There were also several "open-ended" questions, where respondents were to provide their own input.

In Section A of the questionnaire, respondents were asked to:

1. indicate the meaning of the term 'productivity' in their view, selecting from a set of suggested definitions
2. express their views on the usefulness to their companies of various current measures of construction productivity (on a five-point Likert Scale)
3. express their views on whether the productivity of various segments of the construction industry in Singapore was high, average or low
4. indicate whether, between 2010 and 2015, the productivity of the construction industry in Singapore had increased, remained the same or decreased
5. indicate whether, between 2016 and 2020, the productivity of the construction industry in Singapore will increase, remain the same or decrease
6. indicate whether the suggested stakeholder of the construction industry in Singapore (government, contractor, consultant, client) paid adequate attention to productivity (a 'Yes' or 'No' question)

7. indicate whether they agreed with the government's statistics which show that, in most years, the construction industry's productivity growth is one of the lowest for all sectors (a 'Yes' or 'No' question)
8. (if they responded 'No') indicate which of the many suggested points underlay their views. These included: government's approach to productivity measurement is inappropriate; it is difficult to find accurate data on construction in Singapore; the construction industry should not be treated like other sectors of the economy; there are many ways of measuring productivity; it is difficult to calculate construction productivity and its growth; and the construction industry comprises many segments and as such, they should not be grouped together.

In Section B of the questionnaire, respondents were asked to:

1. indicate (on a five-point Likert Scale) the level of importance of factors which relate to the policies and practices of the construction firm, that may be causes of low construction productivity in Singapore. These included: poor skills of workers; communication difficulties between workers and supervisors, and among workers; poor motivation of workers; reworks to rectify defects; inappropriate working methods; inadequate pre-project planning and pre-work planning; lack of monitoring of project plans (programmes); over-reliance on labour subcontractors; lack of adoption of prefabricated construction; poor materials management; inadequate application of information technology; and high proportion of subcontracting; poor attitude of contractors to productivity
2. indicate (on a five-point Likert Scale) the level of importance of various entities in terms of their influence on productivity on their firms' projects. The entities were: Main Contractor; Specialist Subcontractor; Labour Subcontractor; and Supplier of Materials
3. indicate (on a five-point Likert Scale) the level of importance of various professionals and entities in their influence on productivity on projects undertaken by their firms. These were: Client; Architect; Structural Engineer; Mechanical and Electrical Engineer; and Approving Authority
4. indicate (on a five-point Likert Scale) the level of importance of factors which relate to the matters outside the control of your firm, that may be causes of low construction productivity in Singapore. The factors included: type of procurement approach adopted; complexity of project; clients' request for buildability; changes in design; delays in providing information to contractors; delays caused by compliance with regulations; lack of guidelines for measuring productivity; priority given to other project parameters such as cost, quality and safety; and contractual disputes.

In Section C of the questionnaire, respondents were asked to:

1. report whether their companies had written policies on the improvement of productivity on their projects (a 'Yes' or 'No' question)
2. (if they reported that their companies had productivity policies) indicate the main components of the policies. The choices were: the company's vision for productivity policy; the company's aims and objectives with respect to productivity; the company's productivity targets; the company's definition of productivity; the company's productivity measurement approach; how the company plans to use its productivity data; and how the company involves its business partners in its value chain in its productivity efforts
3. report whether their companies measure productivity (at any level) on their projects (a 'Yes' or 'No' question)
4. (if they answered 'Yes' to Question 15) report what the company uses this measure of project-level productivity for. The possible uses provided were: to monitor progress on its projects; to monitor the progress of its subcontractors; to benchmark itself against its competitors; and to meet government requirements
5. indicate (on a five-point scale) the level of importance of factors regarded as obstacles to


CAUTION

productivity measurement in the construction industry. The factors were: lack of a clear definition of "productivity"; uncertainty about what is to be measured; cost of measurement process; lack of direct benefit from productivity measurements to firms; requirement of personnel to measure productivity; high proportion of work subcontracted; because the government is already measuring it; because measurement of productivity by contractor is not a mandatory requirement; because clients do not demand its measurement; because your company provides data to the Electronic Productivity Submission System (ePSS)

6. report how their companies assessed overall productivity on their projects. The options were: by considering output per person-hour on key trades; by considering total revenue per month; by estimating square metres per man-day; by the Buildable Design Score; by the Constructability Score; and by value-added per worker
7. indicate whether their companies set targets of productivity to achieve on its projects (a 'Yes' or 'No' question)

In Section D of the questionnaire, the respondents were requested to:

1. indicate whether their companies had taken any of the measures presented to enhance productivity on their sites since the year 2010. They were requested to indicate also the level of importance (on a five-point scale) of each of the measures which their companies either took, or could have taken, to enhance productivity. The measures were: investment in mechanisation; training of workers; increasing the number of direct workers; increasing the extent of subcontracting; measuring productivity systematically; more effective project planning and monitoring; introduction of incentive schemes for workers; adoption of prefabrication; re-engineering of designs; engagement of more supervisors; applying information technology (including BIM); use of design-and-build; monitoring Buildability and Constructability Scores; and providing information for Electronic Productivity Submission System (ePSS)
2. indicate which government incentive schemes their firms had used. The options listed were: Workforce Training and Upgrading Scheme; Construction Productivity and Capability Fund; Construction Engineering Capability Development; Mechanisation Credit; Productivity Improvement Projects; Building Information Modelling (BIM) Fund; Investment Allowance Scheme; Productivity and Innovation Credit; and Quieter Construction Fund
3. indicate the importance of factors that motivate their firms to improve productivity (on a five-point scale). The factors were: increase profitability; deliver projects on time; enhance corporate competitiveness; reduce number of foreign workers; keep within Man-Year Entitlement (MYE) quotas; enhance corporate image; and win national construction productivity awards
4. indicate the importance of factors that help their firms to improve productivity (on a five-point scale). The factors were: pressure from the presence of foreign contractors; competition within the industry; government's incentive schemes; guidance from government programmes; role models in the industry; support of clients; support of subcontractors; and support of consulting teams
5. indicate the importance of factors that hinder your company's efforts to improve productivity (on a five-point scale). The factors were: restrictions on employment of foreign workers; lack of incentives from government; lack of support from suppliers; poor quality of subcontractors; lack of support from consulting teams; delays in payment by clients; lack of competent professional, management, executive and technical (PMET) personnel; and insufficient time to plan and execute work properly
6. indicate the proportion of their companies' construction work which was subcontracted in 2010 and 2015 (in percentage ranges)
7. provide a breakdown of their companies' employees (excluding subcontractors) in terms of

percentages of the total in 2000 and 2015. The categories were: professionals, technician and skilled tradesmen

8. provide an indication of the firms' investment in mechanisation and information technology in 2010 and 2015, as a percentage of the firms' revenue (in percentage ranges)
9. provide an indication of their companies' investment in training in 2010 and 2015, as a percentage of payroll
10. indicate the level of importance (on a five-point scale) of factors which are often suggested by others as measures which can help to enhance construction productivity in Singapore. The factors were: clients' insistence on productivity; training of workers; review of relevant government regulations; more extensive use of prefabrication; better service from suppliers; standardisation of components; mandatory requirement for contractors to pay attention to productivity; reduction of man-year entitlement; increase of man-year entitlement; more attention to productivity by firm's leaders; increased mechanisation of construction work; greater extent of design-and-build; involvement of contractor in design; reduction of extent of subcontracting; increase in extent of subcontracting; better service from subcontractors; prompt payment from clients; longer construction period; complete and firmed-up design; applying techniques to reduce amount of work; input by contractors of accurate data to Electronic Productivity Submission System (ePSS)
11. express their views on measures which can be taken by various stakeholders to enhance construction productivity in Singapore. The stakeholders included: the authorities, contractors, clients, consultants and subcontractors.

In the final section of the questionnaire, respondents were requested to provide information on the company and themselves. These items included: name of company (optional); company's current BCA Registration; company's turnover in 2014; the origin of firm (i.e., whether it is a local firm, a local/foreign joint venture, or a foreign company; and the designation of the person completing the questionnaire).

Pilot test

The pilot testing of the questionnaire involved members of the SCAL Council's Productivity and Technology Committee, both in a meeting with the committee and in subsequent correspondence by e-mail. Discussions on the questionnaire yielded many comments by the committee members that were related mainly to the length of the questionnaire, format and presentation and usage of terms. In particular, the committee recommended the use of tables, and the setting of the open sub-questions in Question 30 which enabled respondents to express their views on necessary actions by various stakeholders to improve construction productivity.

4.4 Interview guide

Interviews were held with senior practitioners in construction companies. A guide was prepared for this purpose. It covered:

1. the interviewee's views of the level of productivity of Singapore's construction industry; whether it had increased since the year 2010; and the interviewee's views on statistics which indicate that the rate of growth of productivity in construction is one of the lowest among all the sectors
2. the interviewee's views on the existing ways in which construction productivity is measured in Singapore: (a) at trade level; (b) at the project level; and (c) at the industry level
3. whether the interviewee's firm have a policy on construction productivity in general
4. how the interviewee's firm measured productivity on its projects; and if the firm did not measure productivity, whether the interviewee thought such a measure would be useful to the firm

5. what the companies use their productivity measurements for
6. the interviewee's views on the obstacles to construction productivity measurement; and to productivity improvement in the construction industry
7. the interviewee's views on the main enablers and drivers of construction productivity improvement in Singapore
8. the interviewee's views on the government's productivity development programme
9. the interviewee's account of what the company had done to enhance productivity since the year 2010; and what the construction industry had done to increase productivity in that period
10. the proposals the interviewee would like to make on how construction productivity can be improved.

4.5 Sampling approach

The respondents were construction companies in Singapore. They were all members of SCAL and/or SCCCI.

4.6 Undertaking the field study

The interviewees were selected by SCAL. They came from a diverse range of construction firms: local and foreign; and large and small. Their companies were also involved in various types of construction work: building, civil engineering, and specialist work. The interviews were mainly held in the offices of the interviewees. The duration of each interview was about one hour.

A focus group meeting was held with the members of the Productivity and Technology Committee of SCAL. The guide developed for the interviews was also used for the focus group meetings, to enable the information to be consolidated and compared.

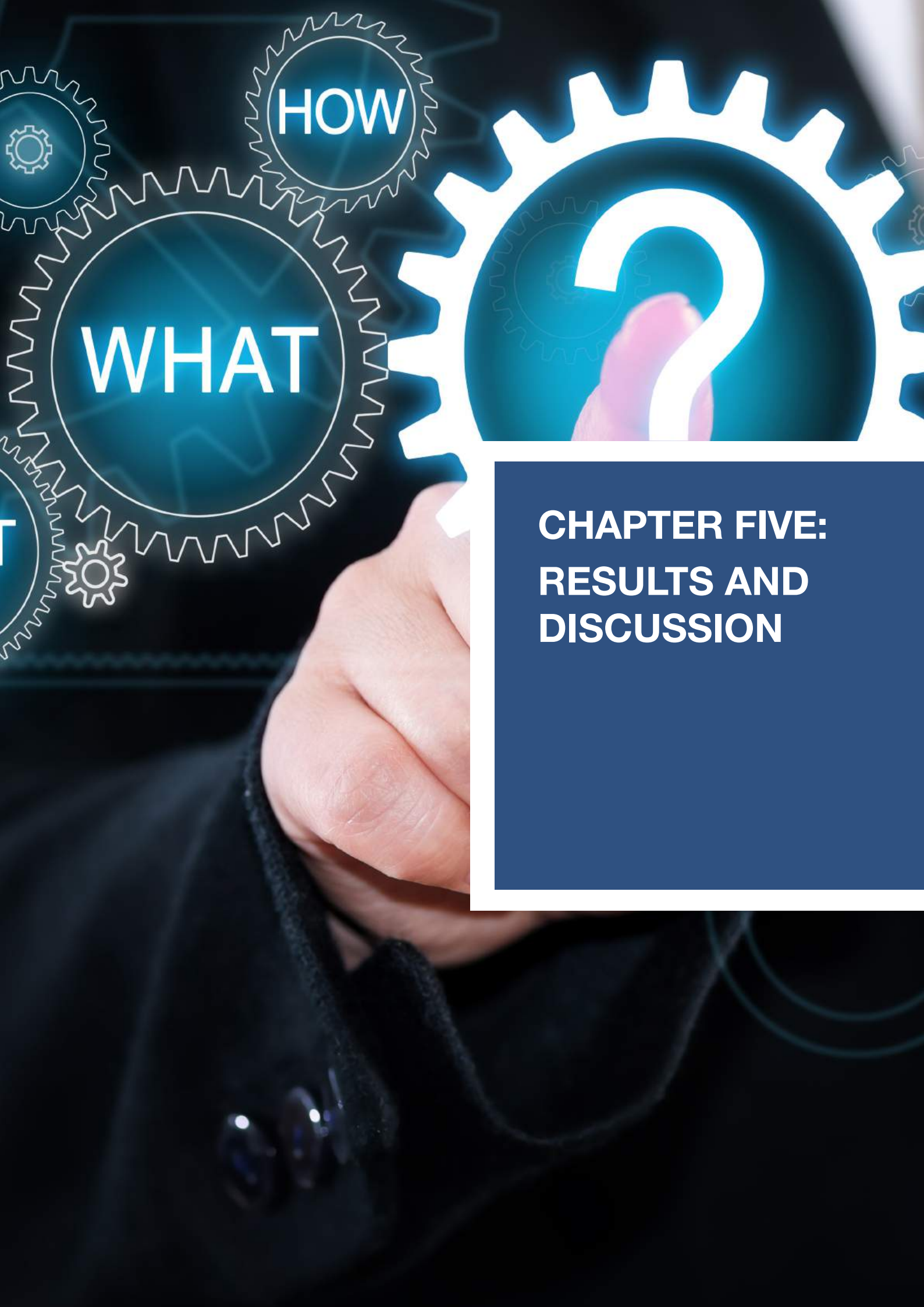
The questionnaire-based survey was undertaken online. The electronic survey template was placed in Survey Monkey, and SCAL sent letters to all its members to request that they respond to the survey. SCCCI sent a similar letter (in Chinese) to its members who are in the construction industry.

Reminders were sent by the SCAL and SCCCI to their members to encourage them to complete the questionnaire.

A group of students was engaged to help with the survey. The role of the students was to visit the companies to approach and encourage the relevant individual to complete the questionnaire. Each of the students was given a list of 20 companies and a target to complete ten interviews.

4.7 Quick international survey

A quick survey of international experts on productivity was also undertaken. A list of brief questions was sent by e-mail to senior academics and practitioners and they were requested to provide short answers to them. The questions related to the importance of productivity in the construction industry in the country; how productivity is measured in the country at the project and industry levels; whether there is a national programme for enhancing productivity in construction; main drivers and obstacles of productivity improvement in the country; what will promote productivity measurement in construction at the project level in the country; and current trends in productivity in the country.



CHAPTER FIVE:
RESULTS AND DISCUSSION

5.1 Introduction

In this chapter, the results of the field study are analysed and discussed. The profile of the respondents in the study is presented, to support the argument that the data received forms a legitimate basis on which to draw inferences and formulate relevant recommendations for consideration by various stakeholders, including government, and provide guidance for construction firms. Areas where the findings differ from the prevailing views of various sections of the construction industry in Singapore are highlighted.

5.2 Questionnaire-based survey

5.2.1 Response rate and profile of respondents and their companies

Response rate

The electronic mail messages sent to members of SCAL and relevant members of SCCCI requesting them to complete the questionnaire was accompanied by an official letter from SCAL or SCCCI, as well as a link to the electronic questionnaire on the Survey Monkey Internet platform. The e-mail request was sent to all3032 members of SCAL, who are also members of SCCCI. This was followed by a reminder. Following special requests, hard copies of the questionnaire and a covering note were sent to 305 Ordinary, Associate and Trade (OAT) members of SCAL by post. Personal telephone calls were also made to several leaders of the OAT members. The student assistants were provided with a list of SCAL members from companies which had indicated their names in the online responses had been removed.

The sample size and number of responses received are shown in Table 5a1. A total of 110 responses were received, giving a response rate of 3.62 per cent.

Table 5a1 Sample and response rate

Number in sample, and respondents	*Number and rate*
Members of SCAL to whom questionnaire was mailed	3032
Number responding to questionnaire	110
Response rate (%)	3.62

Despite the relatively small number of responses received, the profile of the respondents and their companies indicated that the information collected would provide an excellent indication of the views of construction firms and practitioners in Singapore. The number of responses also constitutes a viable set of data for statistical analysis.

BCA registration of company

Some 44 of the 110 respondents to the questionnaire indicated the registration grade of the companies they work for, the details of which are shown in Table 5a2. More than half of these companies (26) were in the top registration grade (A1). The respondents were working for a wide range of companies in the construction industry, in terms of size and types of specialist construction activity.

Origin of company

The respondents were requested to indicate the origin of the firms they were working for. They were provided with three options: local, foreign joint venture, or foreign. The 66 companies whose origins the respondents indicated comprised 53 local companies and 13 foreign firms.

Company's turnover

The respondents were asked to provide the company's turnover in 2014. The highest figure indicated was over 900 million dollars and the lowest figure was S$1 million. The turnover data for

the companies are presented in Table 5a3. The data show that nearly one quarter of the companies earned up to S$10 million; another quarter had a turnover of S$10-50 million, and slightly less than one quarter earned over S$200 million in 2014.

Table 5a2 BCA registration grade of company

Registration grade	*Number*
A1	26
A2	1
B1	1
B2	2
C1	3
C2	0
C3	2
L6	3
L5	1
L4	1
L3	1
L1	1
CW12, CR08, CR12	1
Total	**44**

Table 5a3 Company turnover

Range of turnover (S$ million)	*Number*
0 to 10	14
10 to 50	15
50 to 100	2
100 to 200	13
200 to 500	8
Over 500	4
Total	**56**

Designation of respondents

As shown in Table 5a4, the respondents held senior positions in their organisations. Nearly half of them held posts from General Manager to Managing Director (including also Executive Director and Director). The managers included: Commercial Manager, Construction Manager, Contract Manager (2), Human Resource Manager, Marketing and Sales Manager (2), Planning Manager, and Quality Manager.

Table 5a4 Designation of person completing the questionnaire

Designation of respondent	*Number*
Managing Director	12
Executive Director	2
Director	14
General Manager	5
Assistant General Manager	3
Head, Quality, Environmental, Safety and Health	1
Senior Project Manager	2
Senior Manager	1
Project Manager	4
Assistant Project Manager	1
Manager	18
Assistant Manager	1
Personal Assistant	1
Total	**65**

5.2.2 Interview questions: One to thirty

Question One

As shown in Table 5.1 and illustrated in Figure 5.1, while more than two-thirds of respondents considered productivity to be the conventional definition of "output per person employed", it was also observed that a significant proportion of respondents also considered time saved and unit cost of work. Time saved on the project was selected by the second highest number of respondents (29 per cent), with unit cost the third highest (24 per cent). The significance of time and cost to the respondents' companies is worth noting. The former shows the importance of setting reasonable project schedules, and the latter highlights the need to consider the cost implications of actions which contractors are expected to take on their projects in order to improve their performance.

Figure 5.1 Respondents' views on the definition of 'productivity

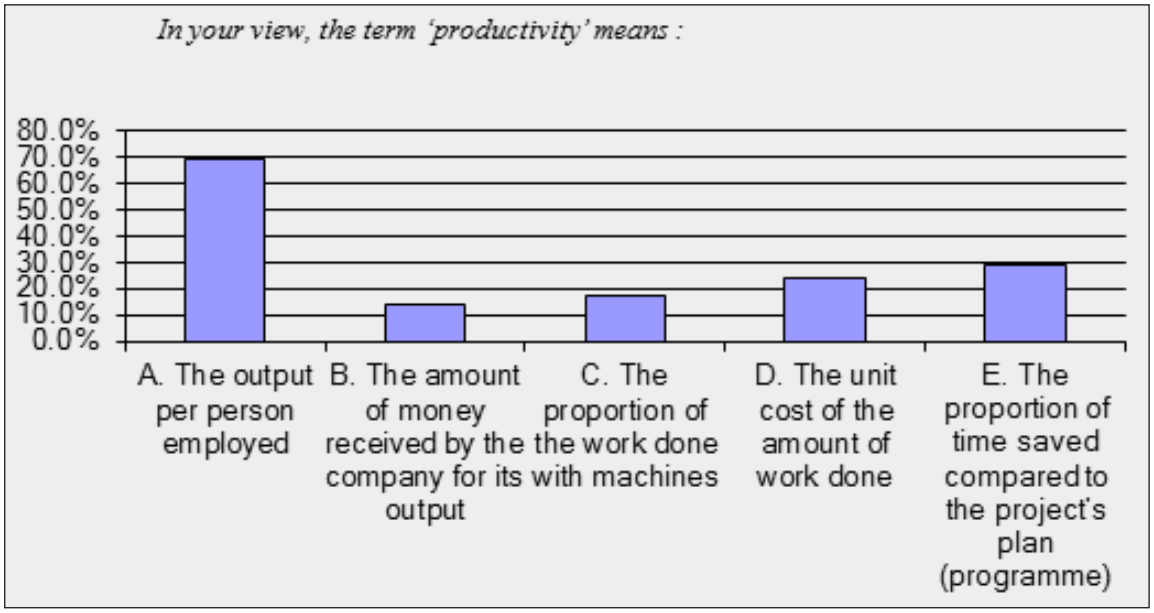


Table 5.1 Respondents' views on the definition of 'productivity

In your view, the term 'productivity' means:		
Answer Options	*Response Percent*	*Response Count*
The output per person employed	69.7	76
The amount of money received by the company for its output	13.8	15
The proportion of the work done with machines	17.4	19
The unit cost of the amount of work done	23.9	26
The proportion of time saved compared to the project's plan (programme)	29.4	32
Others		4
	answered question	109
	skipped question	1

Additional definitions mentioned by the respondents included: "output versus the input of manpower deployed"; and "manpower per square metre or square metre of particular work done".[204] The range of 'meanings' of productivity indicated by the respondents also shows that companies should be encouraged to consider more than one measure of productivity.

Question Two

The respondents were requested to consider the usefulness, to their companies, of the current measures and indicators of construction productivity. The results are shown in Table 5.2 and illustrated in Figure

204 The comments in the 'others' section under the questions which are presented in this chapter are not edited.

5.2. The mean scores for many of the measures were close. The ranking, according to the mean-score, was: (1) “Gross Output per Worker”; (2) “Value-added per worker”; (3) “square metre per man-day”; and (4) “Gross Output per Month”. Although Buildable Design Score and Constructability Score were ranked lower, it is evident that they remained highly regarded measures, with a close mean score of 3.31 and 3.27 respectively. It is pertinent to note that the top-ranked measures of productivity resulting from the survey are operationally useful to the companies. Thus, they would be worth tracking by the firms.

Other measures of construction productivity suggested by the respondents included: “square metre per rig”; “standardization of output for all activity per square metre per man-day”; “cost of man-day”; and ‘man-hours’; and “gross output per worker per discipline”.

Figure 5.2 Respondents’ views on usefulness of current measures of productivity

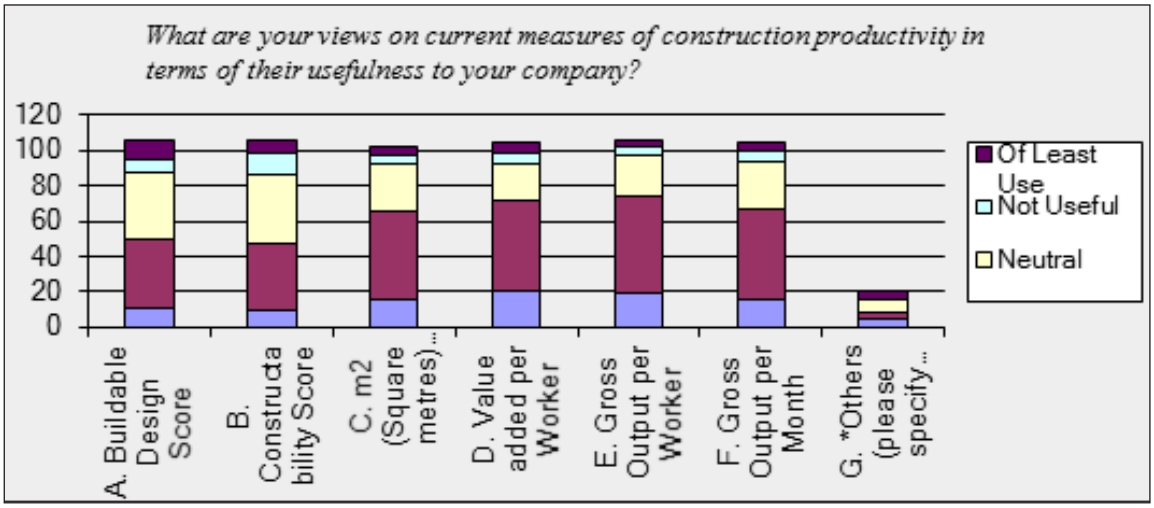


Table 5.2 Respondents’ views on usefulness of current measures of productivity

What are your views on current measures of construction productivity in terms of their usefulness to your company?							
Answer Options	*Of Least Use*	*Not Useful*	*Neutral*	*Useful*	*Very Useful*	*Mean*	*Response Count*
Buildable Design Score	10	8	37	39	11	3.31	105
Constructability Score	8	12	39	37	10	3.27	106
m^2 (square metres) per man-day	5	5	26	50	16	3.66	102
Value-added per Worker	6	6	20	52	20	3.71	104
Gross Output per Worker	4	5	23	55	19	3.75	106
Gross Output per Month	5	5	27	51	16	3.65	104
*Others	4	0	8	3	5	3.25	20
*Others							11
answered question							109
skipped question							1

Question Three

The respondents were requested to indicate their views on the extent of growth in productivity in various segments of the construction industry in Singapore. The data, which are presented in Table 5.3 and illustrated in Figure 5.3, are largely in harmony with the annual data published by the BCA (see Table 3.6), with public housing topping the list, followed by institutional buildings. High-end civil engineering construction was not considered by the respondents to have significantly high productivity.

Figure 5.3 Respondents' views on the extent of growth in productivity in various segments of the construction industry.

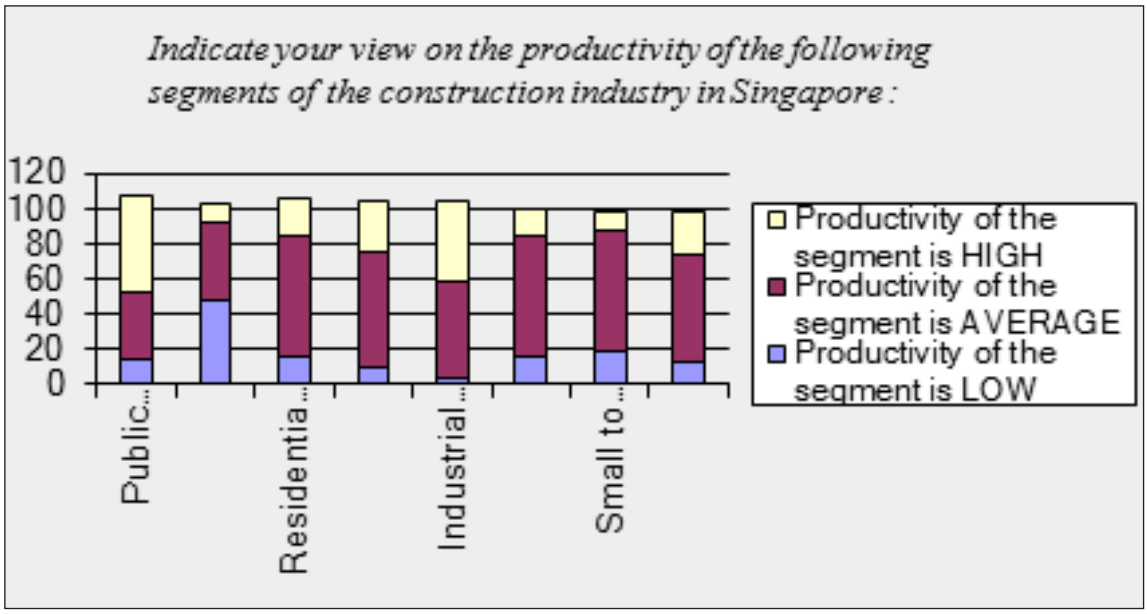


Table 5.3 Respondents' views on the extent of growth in productivity in various segments of the construction industry.

Indicate your view on the productivity of the following segments of the construction industry in Singapore:				
Answer Options	*Productivity of the segment is HIGH*	*Productivity of the segment is AVERAGE*	*Productivity of the segment is LOW*	*Response Count*
Public Housing	54	39	14	107
Residential (Landed)	10	45	48	103
Residential (Non-landed)	21	69	16	106
Commercial Buildings	30	65	10	105
Industrial Buildings	46	54	4	104
Institutional Buildings	16	68	16	100
Small to Medium Sized Civil Engineering	12	68	19	99
High-end Civil Engineering	25	61	13	99
			answered question	109
			skipped question	1

Questions Four and Five

The respondents were requested to consider the period between 2010 and 2015, and indicate whether, in their view, the level of productivity of the construction industry had increased, remained the same, or decreased. The results are shown in Table 5.4. Most respondents (54 per cent) indicated that the productivity of the construction industry had increased between 2010 and 2015. However, a significant 33 per cent of respondents considered productivity to have decreased during the period.

The respondents were next requested to consider the period 2016 to 2020 and indicate the probable changes in productivity. The results are shown in Table 5.5. Again, whereas most respondents (52 per cent) expected productivity to increase during this period, a fair number (37 per cent) expected it to remain the same (a suggestion that the industry has reached its peak in productivity improvement). A few respondents expected a decline in productivity.

Table 5.4 Respondents' views on changes in overall productivity, 2010 to 2015

In your view, between 2010 and 2015, the productivity of the construction industry in Singapore has :		
Answer Options	*Response Percent*	*Response Count*
Increased	54.1	59
Remained the same	33.0	36
Decreased	12.8	14
	answered question	109
	skipped question	1

Table 5.5 Respondents' views on changes in overall productivity, 2016 to 2020

In your view, between 2016 and 2020, the productivity of the construction industry in Singapore will :		
Answer Options	*Response Percent*	*Response Count*
Increase	52.3	57
Remain the same	36.7	40
Decrease	11.0	12
	answered question	109
	skipped question	1

The proportion of respondents who indicated that the productivity of the construction industry increased between 2010 and 2015 was similar to that of those who thought that productivity would rise from 2016 to 2020. This indicates that the industry does not expect a dramatic shift in its productivity performance in the near future.

Question Six

As shown in Table 5.6, the government, followed by contractors, was considered by the highest number of respondents to be paying adequate attention to productivity. Under half of the respondents considered consultants to be paying sufficient attention to productivity and a slightly smaller proportion of them thought clients paid adequate attention.

Table 5.6 Respondents' views on whether stakeholders pay attention to productivity

Do you think this stakeholder of the construction industry in Singapore pays adequate attention to productivity?			
Answer Options	*YES*	*NO*	*Response Count*
Government	97	11	108
Contractors	88	19	107
Consultants	48	59	107
Clients	42	65	107
Others* (please specify below)	8	4	12
Others (please specify)			9
		answered question	109
		skipped question	1

The respondents acknowledged the government's leadership role in the productivity improvement programme in Singapore. They also indicated that contractors took the issue seriously. Given the respondents' indication of the importance of the role that consultants play in determining productivity performance on construction projects in Singapore (see Question 11), ways should be found to ensure their closer involvement in the productivity drive.

The client can set the tone for attention to productivity on the construction project by stressing

its importance, using contractors' previous productivity performance as an important criterion in procurement, providing incentives and requiring the submission of progress reports regarding productivity. Clients should be persuaded with a solid business case for project-level productivity, and could be given incentives to do so.

Consultants have a major say in productivity on the construction project with regards to the selection of materials and often, methods of construction. There should also be efforts to involve them in the improvement measures.

Other players indicated by the respondents as not paying adequate attention to productivity included: sub-contractor; manufacturing industry; architectural and interior design consultants; workers; and construction related civil service government agencies.

Question Seven

As shown in Table 5.7, while a higher proportion of respondents (55 per cent) agreed, compared to those who did not, with official data that, in most years, productivity growth in the construction industry is the lowest for all sectors, the difference between the two figures is small. The results show that the construction industry is almost evenly split on the acceptance or otherwise of productivity growth data that are based on value-added per person employed as an indicator. This may be interpreted that a significant proportion of contractors are of the opinion that there is a need for action to address the rate of growth of productivity in the industry.

Table 5.7 Respondents' agreement or otherwise with data which show construction has lowest productivity growth

Government's statistics show that, in most years, the construction industry's productivity growth is one of the lowest for all sectors. Do you agree with such a finding?		
Answer Options	*Response Percent*	*Response Count*
YES	55.0	60
NO	45.0	49
	answered question	109
	skipped question	1

Question Eight

The respondents who answered 'No' to Question Seven (on the official productivity statistics) were requested to indicate possible reasons for their view. It is pertinent to note that almost all respondents answered this question. The top three reasons chosen from the options provided to respondents (see Table 5.8), in descending order of importance, were: the construction industry comprises many segments which would be best considered separately, productivity can be measured in many ways, and construction should not be treated like other sectors of the economy.

Several of the respondents gave other reasons why they did not agree with the finding that construction productivity growth is the lowest among the sectors of the economy. The reasons included: (i) "Some of the Government's approaches to productivity measurement are inappropriate"; (ii) "Safety comes first"; (iii) "In Singapore more foreigners are working in the construction industry with cheaper rate and the productivity measurement shouldn't be [based on] the cheap labour rate; it's misleading". Two further comments under 'others' were:

1. "There are trades in the construction industry where it is necessary for one [worker] to operate one machine, hence it might not be appropriate to measure productivity based on manpower savings, rather how much time is saved for a particular project, not necessarily by increasing manpower, but by other measures such as ensuring there is no delay in the entire process"
2. "In construction if you use two group sections to measure the productivity, you can see that the productivity increase in these two groups are: first group being (a) client, architect, consultant,

interior designer; and second group being (b) main contractor, structural subcontractor, architectural subcontractor, M&E subcontractor, interior subcontractor. In this way, you can find out which group's productivity is low. Many times, the first group pulls down the productivity".

Some of the 'reasons' stated by the respondents under this section are general comments on various aspects of productivity. They included: (i) "Certain trades face discrimination in terms of grants distribution"; (ii) "The extremely high workers levy and dormitory is [killing] all the smaller SMEs"; and (iii) "Government policies related to education, immigration and taxation are not fostering increased productivity in construction".

(The answers to this question should be considered as supplementary information that are not statistically valid, given that many of the respondents might not have given the right indicators owing to technical issues with Question 8 in the template.)

Figure 5.8 Reasons why respondents do not agree with official data on construction indicating that construction has low productivity growth

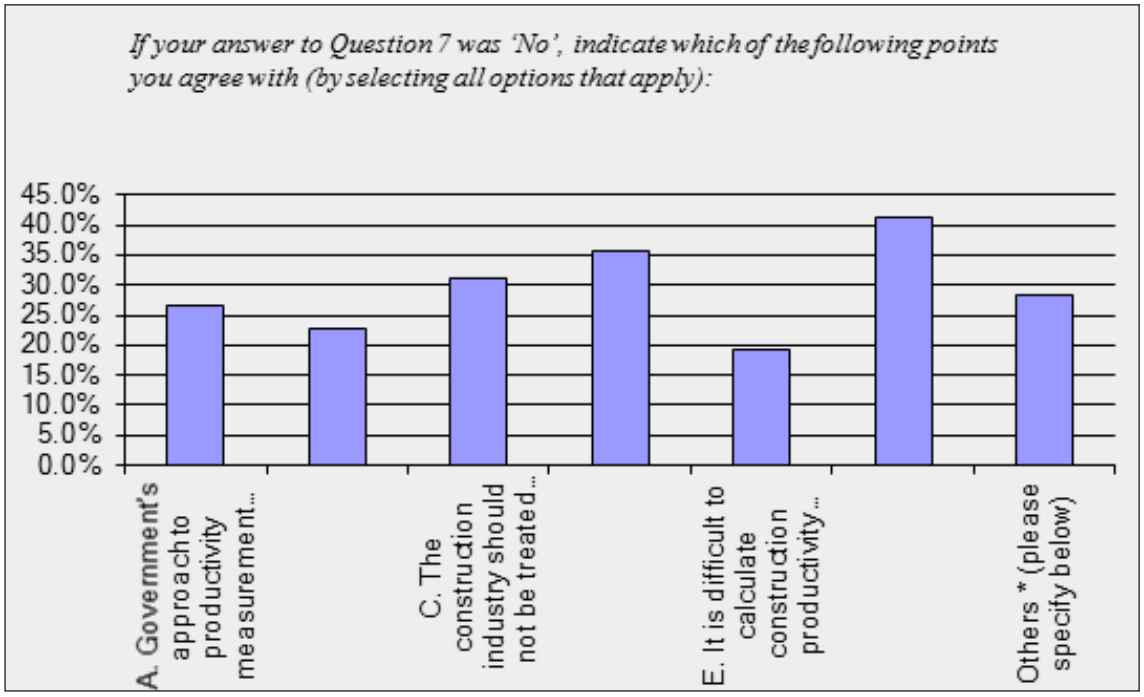


Table 5.8 Reasons why respondents do not agree with official data on construction indicating that construction has low productivity growth

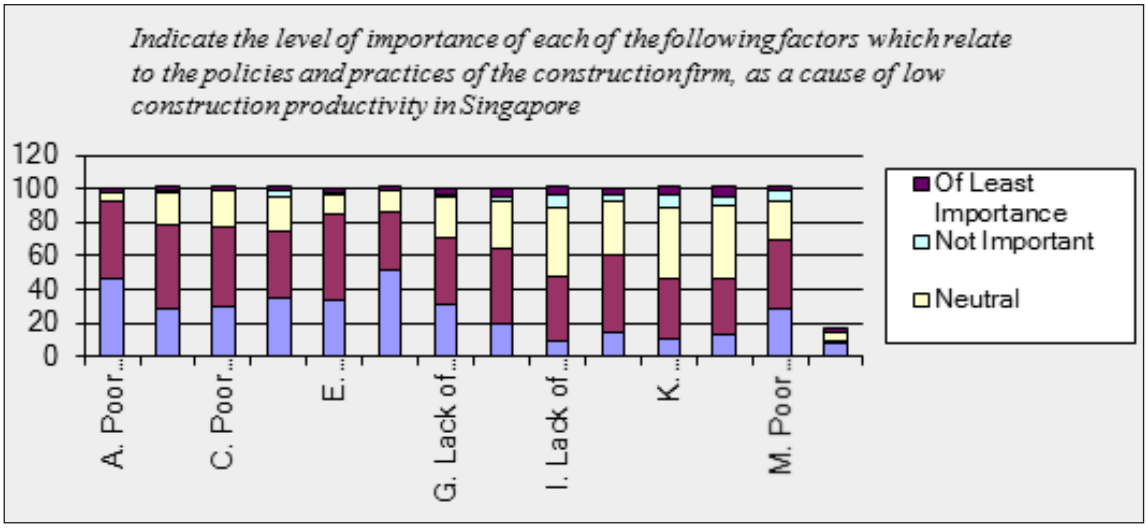
If your answer to Question 7 was 'No', indicate which of the following points you agree with (by selecting all options that apply):		
Answer Options	*Response Percent*	*Response Count*
Government's approach to productivity measurement is inappropriate	26.6	29
It is difficult to find accurate data on construction in Singapore	22.9	25
The construction industry should not be treated like other sectors of the economy	31.2	34
There are many different ways of measuring productivity	35.8	39
It is difficult to calculate construction productivity and its growth	19.3	21
Construction industry comprises many segments and they should not be grouped together	41.3	45
Others *	28.4	31
answered question		109
skipped question		1

Question Nine

The probable causes of low construction productivity in Singapore were examined under three questions. The first question (No. 9) examined factors which relate to the internal policies and practices of construction firms. The respondents' views here are important as they point to the fact that there are many areas within the control of the construction firms which respondents felt needed to be addressed.

As shown in Table 5.9 and illustrated in Figure 5.9, the factors which cause low productivity, in descending order of importance, were: (1) poor skills of workers; (2) inadequate pre-project planning and pre-work planning; (3) inappropriate working methods; (4) poor motivation of workers; (5) communication difficulties between workers and supervisors, and among workers; and (6) reworks to rectify defects (this particular finding highlights the potential to consider an integrated measure of quality and productivity for the project).

Figure 5.9 Importance of factors relating to policies and practices of construction firms, as a cause of low construction productivity in Singapore



One significant point worth highlighting is "poor attitude of contractors to productivity", which was ranked in eighth position. This is in line with the result from Question 6 which showed that contractors paid attention to productivity in construction. Considering that each of the factors considered in this question is under the direct control of the main contractor, the findings show that the industry itself acknowledges that it needs to take action to improve productivity, and it is aware of areas where action is needed.

Further probable factors causing low construction productivity that were highlighted by the respondents included: (i) "Pay labour based on international standards"; (ii) "Lack of value engineering"; (iii) "Pay labour based on international standard"; (iv) "Selection, retention and training of workers"; (v) "C.O.W. attitude"; (vi) "Cost of implementation of productivity measures"; and (vii) "Even if using low technology one can be highly productive if job is planned and executed well. Hi-tech not done well will not be productive". The other comments made were:

1. "(1)Unrelated skills of the worker; (2) Companies don't have budget for upgrade; (3) Worker can't pass the skills assessment/trade tests; (4) It is difficult to communicate with the workers; (5) Incomplete construction drawings and frequent changes by consultants, (6) Too many regulations imposed by various authorities"

Questions Ten and Eleven

An attempt was made to determine the industry's perception of the level of importance of the various parties in the industry in terms of their influence on productivity. As shown in Table 5.10,

Table 5.9 Importance of factors relating to policies and practices of construction firms, as a cause of low construction productivity in Singapore

Indicate the level of importance of each of the following factors which relate to the policies and practices of the construction firm, as a cause of low construction productivity in Singapore							
Answer Options	*Of Least Importance*	*Not Important*	*Neutral*	*Important*	*Very Important*	*Mean*	*Response Count*
Poor skills of workers	2	0	5	46	47	4.36	100
Communication difficulties between workers and supervisors, and among workers	2	1	20	49	29	4.01	101
Poor motivation of workers	2	0	22	47	30	4.02	101
Reworks to rectify defects	2	4	20	40	35	4.01	101
Inappropriate working methods	2	2	11	51	34	4.13	100
Inadequate pre-project planning and pre-work planning	2	0	13	34	52	4.33	101
Lack of monitoring of project plans (programmes)	4	1	24	40	31	3.93	100
Over-reliance on labour subcontractors	5	3	28	45	19	3.70	100
Lack of adoption of prefabricated construction	5	7	41	38	10	3.41	101
Poor materials management	4	4	31	46	15	3.64	100
Inadequate application of information technology	5	7	43	35	11	3.40	101
High proportion of subcontracting	6	5	44	33	13	3.42	101
Poor attitude of contractors to productivity	2	6	23	41	29	3.88	101
Others*	2	0	5	2	8	3.82	17
Others							11
					answered question		101
					skipped question		9

the respondents considered the main contractor to be the most important party, followed by specialist subcontractors, suppliers of materials and labour subcontractors.

The results for Question 10 (see Table 5.10 and Figure 5.10) show that the industry is aware of the prime position of the main contractor in productivity improvement, and that many of the other players on projects (subcontractors and suppliers) play important roles, and have an influence on productivity performance. Thus, there is a need for a whole value chain approach in the consideration of measures to improve productivity in construction.

Figure 5.10 Level of importance of entities in their influence on productivity on firms' projects

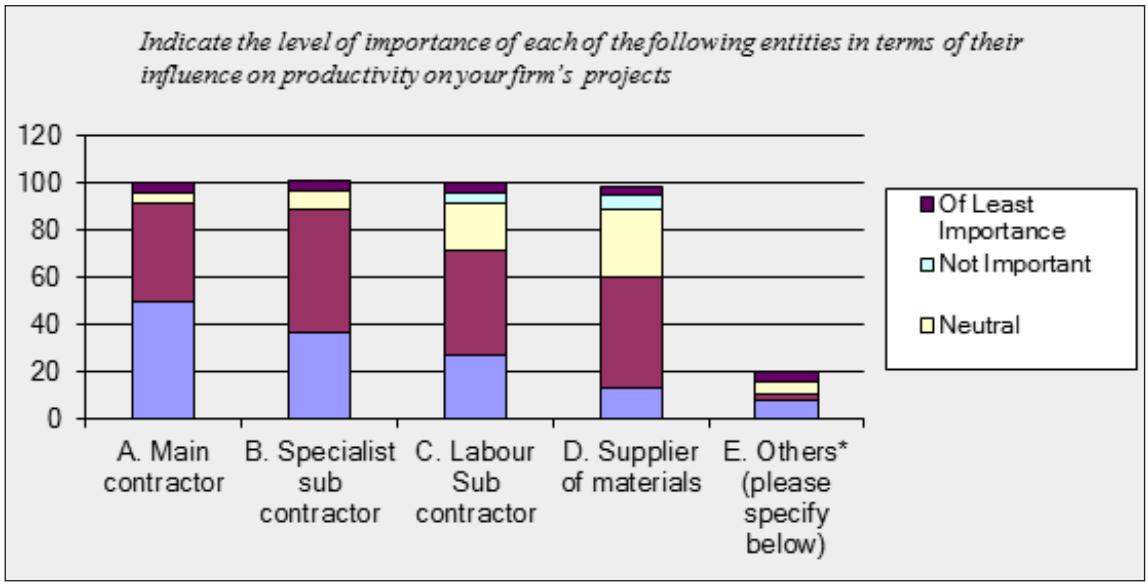


Table 5.10 Level of importance of entities in their influence on productivity on firms' projects

Indicate the level of importance of each of the following entities in terms of their influence on productivity on your firm's projects							
Answer Options	*Of Least Importance*	*Not Important*	*Neutral*	*Important*	*Very Important*	*Response Count*	*Mean*
Main contractor	4	0	4	42	50	100	4.34
Specialist sub contractor	4	0	8	52	37	101	4.17
Labour Sub contractor	4	4	20	45	27	100	3.87
Supplier of materials	4	6	29	47	13	99	3.60
Others*	4	0	5	3	8	20	3.55
Others						11	
					answered question	101	
					skipped question	9	

Other factors suggested by the survey respondents under Question 10 were: (i) "Consultants such as the architects and structural engineer play important roles. The design for precast elements must be decided at an early stage of design. You cannot use cast in-situ and convert the design to precast"; (ii) "Attitudes of staff in the organisation"; (iii) "Consultant's design"; (iv) "Complete instruction and information from clients"; (v) "Government approving agency"; (vi) "Planning (methods) – Supervision"; (vii) "Client, architect, consultants, C.O.W. and interior designer"; and (viii) "Client and consultant are never aware of the low buildability of their poor concept and poor design quality; and too many drawing conflicts".

In Question 11, respondents were requested to consider the influence of various professionals and entities on productivity. The respondents (see Table 5.11 and Figure 5.11) rated all the parties highly (each of them had a mean score above 4.0). The ranking (by mean-score and in descending order of importance) was as follows: architect, client, structural engineer, approving authority, and mechanical and electrical engineer.

Figure 5.11 Level of importance of professionals and entities in their influence on productivity on firms' projects

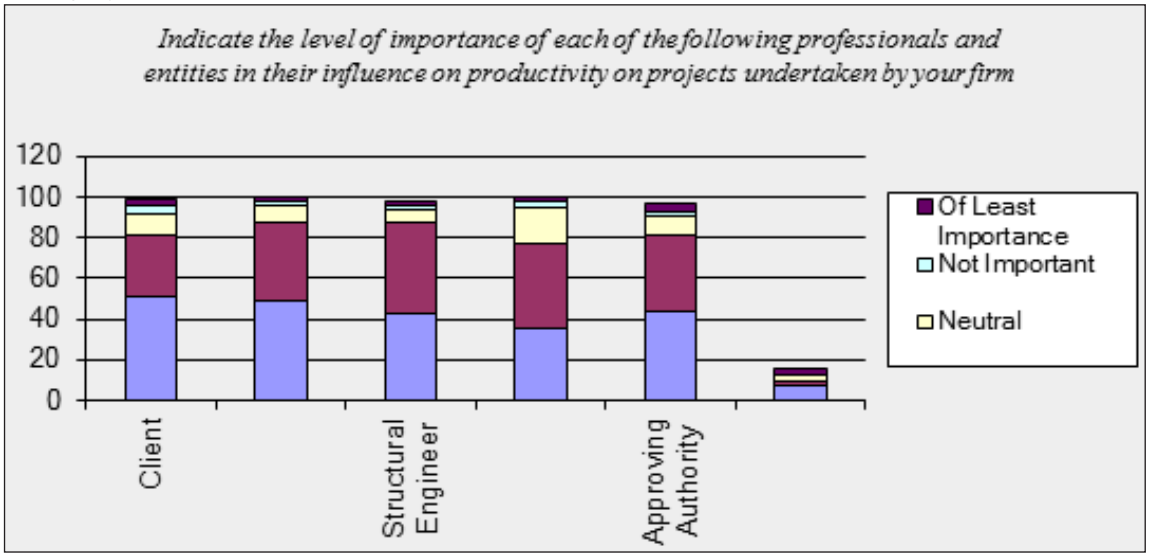


Table 5.11 Level of importance of professionals and entities in their influence on productivity on firms' projects

Indicate the level of importance of each of the following professionals and entities in their influence on productivity on projects undertaken by your firm							
Answer Options	*Of Least Importance*	*Not Important*	*Neutral*	*Important*	*Very Important*	*Response Count*	*Mean*
Client	3	4	11	30	51	99	4.23
Architect	2	2	9	38	49	100	4.30
Structural Engineer	2	2	7	44	43	98	4.27
Mechanical and Electrical Engineer	2	3	18	42	35	100	4.05
Approving Authority	4	2	10	37	44	97	4.19
Others*	3	0	4	2	7	16	3.63
Others						10	
					answered question	101	
					skipped question	9	

The results from Question 11 are related to those under Question Six where respondents were requested to indicate whether each of the parties shown "pays adequate attention to productivity". Clients, Architects, and Structural and Mechanical and Electrical (M&E) Engineers (referred to as Consultants in Question Six) are deemed to have high levels of influence on productivity performance. This reinforces the need for action to involve such parties in the productivity improvement drive. The role of the "Approving Authority" was also considered by respondents to be important.

Other persons and entities suggested under Question 11 were: (i) "Governments' policies and direction in addressing productivity"; (ii) "RE/RTO"; (iii) "Consultants are not very flexible, very often they over design and they always [think] that contractors want to take short [cuts] but actually we are doing value engineering"; (iv) 'MOM'; (v) "Interior Designer & RTO"; (vi) "Interior designer & C.O.W"; and (vii) "Interior designer".

Question Twelve

The respondents were asked to indicate the importance of factors outside the control of the construction companies that may be causes of low construction productivity in Singapore. The results are shown in Table 5.12 and illustrated in Figure 5.12.

Figure 5.12 Level of importance of factors outside firms' control as a cause of poor productivity in Singapore

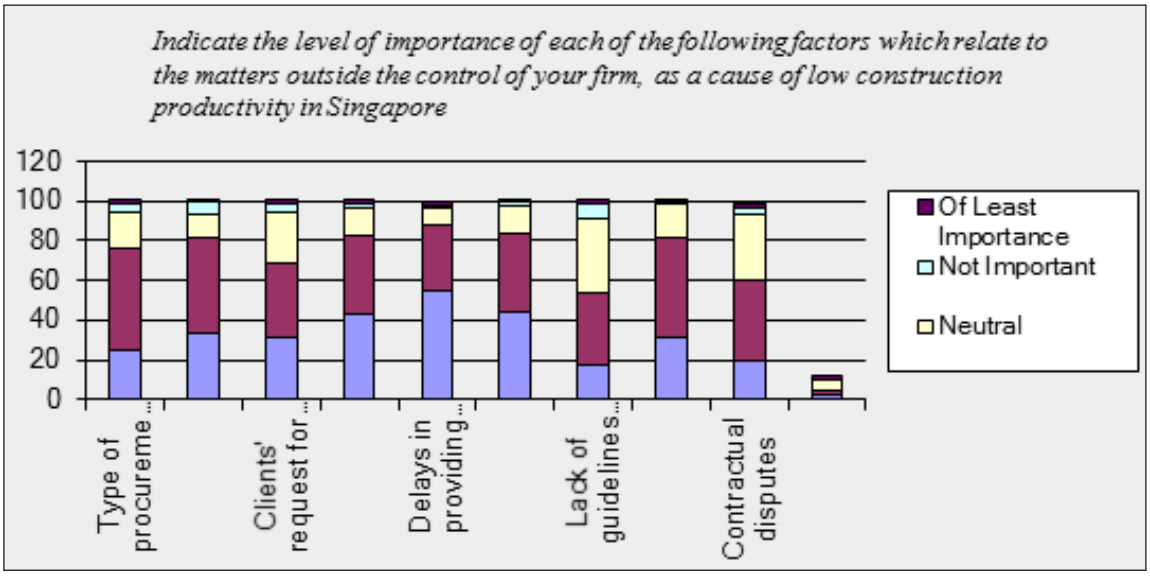


Table 5.12 Level of importance of factors outside firms' control as a cause of poor productivity in Singapore

Indicate the level of importance of each of the following factors which relate to the matters outside the control of your firm, as a cause of low construction productivity in Singapore							
Answer Options	*Of Least Importance*	*Not Important*	*Neutral*	*Important*	*Very Important*	*Response Count*	*Mean*
Type of procurement approach adopted	2	5	18	51	25	101	3.91
Complexity of project	1	7	11	49	33	101	4.05
Clients' request for buildability	2	5	25	38	31	101	3.90
Changes in design	2	2	14	40	43	101	4.19
Delays in providing information to contractors	2	1	9	33	55	100	4.38
Delays caused by compliance with regulations	1	2	14	40	44	101	4.23
Lack of guidelines for measuring productivity	2	8	37	36	18	101	3.59
Priority given to other project parameters such as cost, quality and safety	1	1	17	51	31	101	4.09
Contractual disputes	2	4	33	40	20	99	3.73
Others*	2	0	5	2	3	12	3.33
Others						6	
					answered question	101	
					skipped question	9	

From the mean scores, the top five factors that cause low productivity were: delays in providing information to contractors; delays caused by compliance with regulations; changes in design; priority given to other project parameters such as cost, quality and safety; and complexity of project. This further underlines the importance of the client, the consultants and the regulatory authorities in the productivity improvement drive. The reference by the respondents to the low priority given to productivity among the project performance parameters is also instructive.

Other factors suggested under Question 12 were: (i) "Completeness of design and level of coordination amongst the various consultants"; (ii) "Constructing to difficult and non-practical design"; (iii) "Absence of vocational training in construction, limitations of labour importation, low salaries in construction"; (iv) "Consider two groups and measure their productivity separately – Group A: client, architect, consultants, interior designer, RTO (COW); and Group B: main contractor, subcontractor, all trades".

Question Thirteen

The respondents to the survey were requested to indicate whether their companies had written policies on the improvement of productivity on their projects. Less than half of the respondents reported that their companies had such policies; more than 57 per cent indicated that their companies did not have productivity policies. While many firms in the construction industry in Singapore have written environmental and health and safety policies, productivity has not been accorded similar importance.

Table 5.13 Company policy on productivity in Singapore

Does your company have a written policy on the improvement of productivity on its projects?		
Answer Options	*Response Percent*	*Response Count*
YES	42.9	42
NO	57.1	56
	answered question	98
	skipped question	12

Question Fourteen

Respondents who indicated that their companies had productivity policies were requested to indicate the main components of the policies. The results are presented in Table 5.14, and illustrated in Figure 5.14. They show that the main components are (in descending order of frequency): the company's aims and objectives with respect to productivity; the company's productivity targets; the company's vision for productivity; and the company's productivity measurement approach.

(The answers to this question should be accorded less weight, and considered supplementary and statistically insignificant, given that many of the respondents might not have given the right indicators owing to technical issues with Question 14 in the template.)

Question Fifteen

As shown in Table 5.15, two-thirds of the respondents reported that their companies measure productivity on their projects. It is pertinent to note that respondents were requested to consider any level at which such a measurement was made. As construction companies are directly responsible for the projects they execute, they have control over the measurement of productivity during the projects. This may be at the trade level, or the overall project level. However, it should be noted that a significant proportion of firms do not measure any productivity performance at any level.

Figure 5.14 Main components of companies' policies on productivity

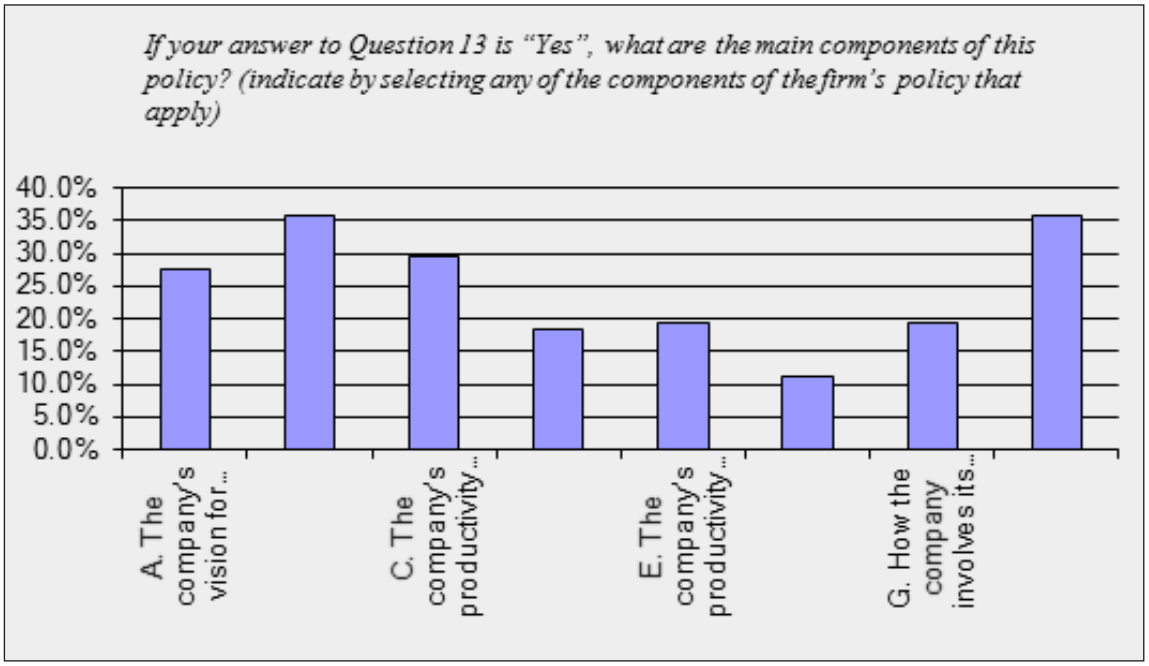


Table 5.14 Main components of companies' policies on productivity

If your answer to Question 13 is "Yes", what are the main components of this policy?		
Answer Options	*Response Percent*	*Response Count*
The company's vision for productivity policy	27.6	27
The company's aims and objectives with respect to productivity	35.7	35
The company's productivity targets	29.6	29
The company's definition of productivity	18.4	18
The company's productivity measurement approach	19.4	19
How the company plans to use its productivity data	11.2	11
How the company involves its business partners in its value chain in its productivity efforts	19.4	19
Others*	35.7	35
answered question		98
skipped question		12

Table 5.15 Measurement of productivity by companies

Does your company measure productivity (at any level) on its projects?		
Answer Options	*Response Percent*	*Response Count*
YES	67.3	66
NO	32.7	32
answered question		98
skipped question		12

Question Sixteen

It was pertinent to ascertain in the survey how companies use the productivity data obtained in their measurements. Thus, respondents who indicated that their companies measure productivity at project level were requested to indicate what the results are used for. The results are shown in Table 5.16 and illustrated in Figure 5.16. More than two-thirds of the respondents reported that their companies use

Figure 5.16 How companies use project-level productivity data

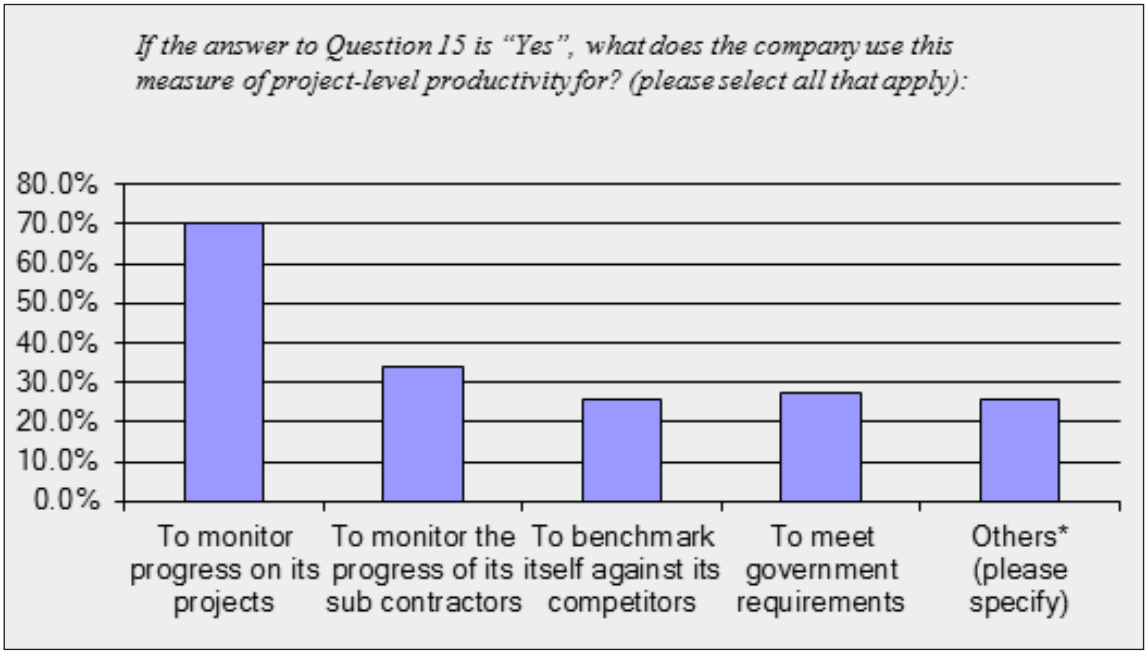


Table 5.16 How companies use project-level productivity data

If the answer to Question 15 is "Yes", what does the company use this measure of project-level productivity for? (please select all that apply)		
Answer Options	*Response Percent*	*Response Count*
To monitor progress on its projects	70.4%	69
To monitor the progress of its subcontractors	33.7%	33
To benchmark itself against its competitors	25.5%	25
To meet government requirements	27.6%	27
Others* (please specify)	25.5%	25
	answered question	98
	skipped question	12

the results to monitor progress on the firms' sites. One-third use the data to monitor the progress of their subcontractors' work, just over one-quarter use them to meet government requirements, and another one-quarter use the information for benchmarking themselves against their competitors.

The results show that productivity data are of direct benefit to the construction companies in Singapore. They help in project administration, as well as enable them meet commercial and regulatory requirements. As consideration of bidders' productivity performance becomes more common in project procurement, such measurement data will grow even more important.

(The answers to this question should be accorded less weight, and considered supplementary and statistically insignificant, given that many of the respondents might not have given the right indicators owing to technical issues with Question 16 in the template.)

Other factors suggested by the survey respondents were: (i) "In relation to cost"; (ii) "To monitor output against input, to monitor wastage for each project"; (iii) "To meet client requirements"; (iv) "For self-improvement"; and (v) "To measure input resources (labour, materials, ...) against output (square metre, square cube, ...)".

Question Seventeen

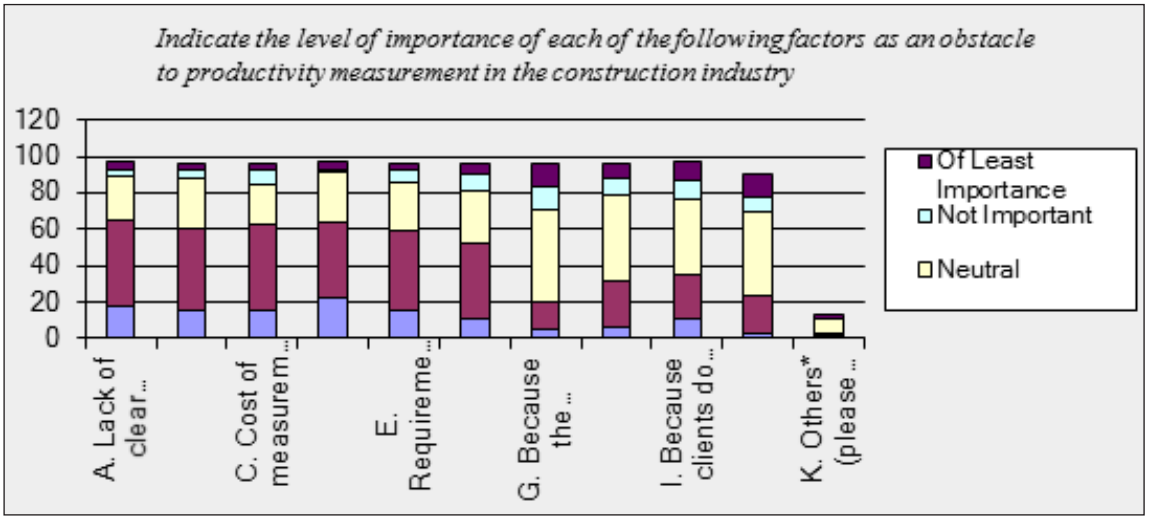
As shown in Table 5.17 and illustrated in Figure 5.17, the respondents ranked the top five obstacles to productivity measurement in the construction industry as: lack of direct benefit from productivity

measurements to firms; lack of clear definition of productivity; cost of measurement process; uncertainty about what is to be measured; and requirement of personnel to measure productivity.

Table 5.17 Factors which constitute obstacles to productivity measurement in the construction industry

Indicate the level of importance of each of the following factors as an obstacle to productivity measurement in the construction industry:							
Answer Options	*Of Least Importance*	*Not Important*	*Neutral*	*Important*	*Very Important*	*Response Count*	*Mean*
Lack of clear definition of "productivity"	4	4	24	47	18	97	3.73
Uncertainty about what is to be measured	4	4	28	45	15	96	3.66
Cost of measurement process	3	8	22	48	15	96	3.67
Lack of direct benefit from productivity measurements to firms	4	2	27	42	22	97	3.78
Requirement of personnel to measure productivity	4	6	27	43	16	96	3.64
High proportion of work subcontracted	6	9	29	41	11	96	3.44
Because the government is already measuring it	13	12	51	15	5	96	2.86
Because measurement of productivity by contractor is not a mandatory requirement	8	9	48	25	6	96	3.13
Because clients do not demand its measurement	10	11	41	24	11	97	3.15
Because your company provides data to the Electronic Productivity Submission System (ePSS)	12	9	46	20	3	90	2.92
Others*	2	0	8	1	2	13	3.08
Others						5	
					answered question	98	
					skipped question	12	

Figure 5.17 Factors which constitute obstacles to productivity measurement in the construction industry



The obstacles to productivity measurement as reported by respondents were largely in line with what are often highlighted in the literature (see Chapter 2), as well as by administrators and practitioners in Singapore. The cost of measurement and the need for personnel to perform the measurement are points which are frequently given by practitioners. The factors which received low scores were: because government measures productivity and the fact that the companies make submissions to the ePSS. Thus, it is relevant to propose measurement tools the companies can use.

One other set of factors suggested by a respondent was a "lack of trained construction workers in Singapore and restrictions in importation of labour".

Question Eighteen

The respondents were asked to indicate how their companies measure productivity on their projects. The results are shown in Table 5.18 and illustrated in Figure 5.18. The five leading methods are: by considering output per person-hour on key trades; by considering total revenue per month; by estimating square metres) per man-day; by value-added per worker; and by the Constructability Score.

Figure 5.18 How companies assess overall productivity on projects

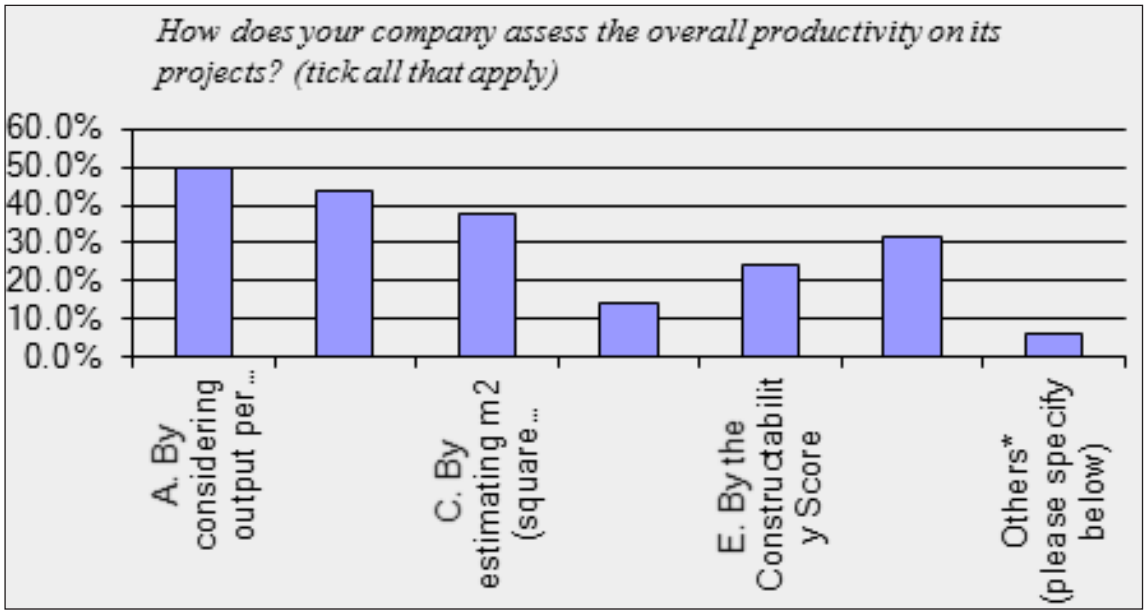


Table 5.18 How companies assess overall productivity on projects

How does your company assess the overall productivity on its projects? (tick all that apply)		
Answer Options	*Response Percent*	*Response Count*
A. By considering output per person-hour on key trades	50.0	49
B. By considering total revenue per month	43.9	43
C. By estimating m^2 (square metre) per man-day	37.8	37
D. By the Buildable Design Score	14.3	14
E. By the Constructability Score	24.5	24
F. By value-added per worker	31.6	31
Others* (please specify below)	6.1	6
	answered question	*98*
	skipped question	*12*

The high ranking given by the respondents to total revenue per month and value-added per worker is significant here. This further underlines the importance (to the companies of the

respondents) of financial considerations in productivity assessment. It is pertinent to note that the Buildability and Constructability Score was not ranked highly under this question.

Other factors suggested were: (i) “square metre per rig day”; (ii) “Time saved”; (iii) “Actual cost vs. planned cost”; (iv) “square cube of concrete per man-day”; and (v) “man-days worked against man-days budgeted”.

Question Nineteen

As shown in Table 5.19, nearly 60 per cent of respondents reported that their companies set targets of productivity on their projects. Whereas this is a significant indication, it is pertinent to relate this answer to the results under Question 15, where two-thirds of firms measure productivity, and Question 16 where 70 per cent of firms use the data to monitor progress on their projects.

Table 5.19 Setting targets to be achieved on projects

Does your company set targets of productivity to achieve on its projects?		
Answer Options	*Response Percent*	*Response Count*
YES	59.2	58
NO	40.8	40
	answered question	98
	skipped question	12

Question Twenty

The respondents indicated that their companies have taken a wide range of measures to enhance productivity on their construction sites since 2010. They stated various levels of importance of the schemes from the perspective of their companies. The results are shown in Table 5.20 and illustrated in Figure 5.20.

Measures that companies have not taken up are revealing. These measures include: monitoring Buildability and Constructability Scores; adopting prefabrication; measuring productivity systematically; and applying ICT.

The top five measures which companies have taken were: training of workers; more effective project planning and monitoring; investment in mechanisation; re-engineering designs; and introduction of incentive schemes for workers. One other measure suggested by a respondent was: “Selection and retention of workers”.

Figure 5.20 Measures taken by companies to improve productivity

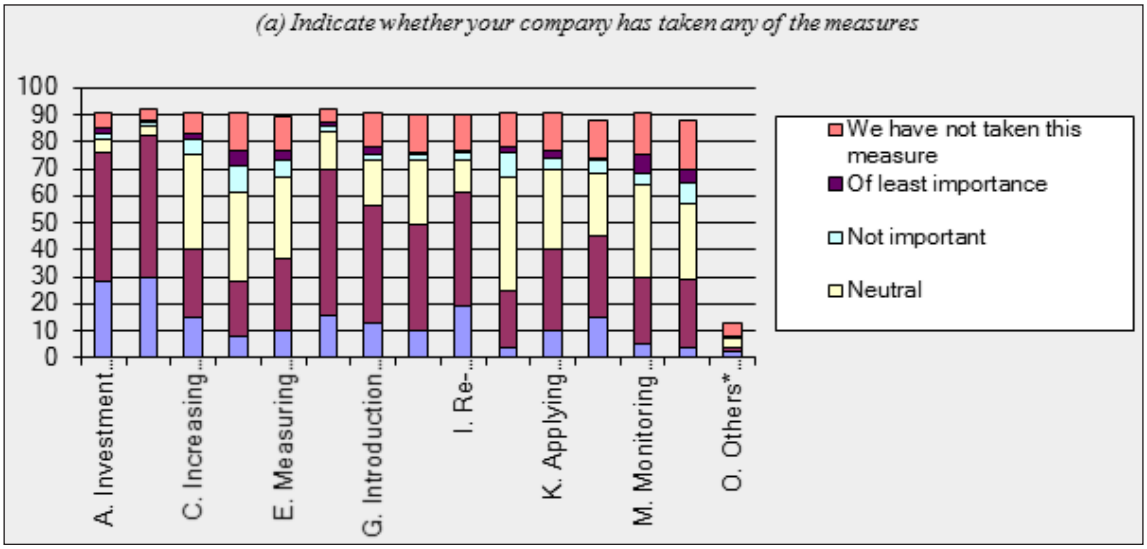


Table 5.20 Measures taken by companies to improve productivity

(a) Indicate whether your company has taken any of the measures below to enhance productivity on its sites since the year 2010 (by (please select all that apply). (b) Indicate also ONE level of importance of each of the measures below which your company either took, or could have taken, to enhance productivity							
Answer Options	*We have not taken this measure*	*Of least importance*	*Not important*	*Neutral*	*Important*	*Very important*	*Response Count*
Investment in mechanisation	6	2	2	5	48	28	88
Training of workers	4	1	1	4	52	30	88
Increasing the number of direct workers	8	2	6	35	25	15	88
Increasing the extent of subcontracting	14	6	10	33	20	8	87
Measuring productivity systematically	12	4	6	30	27	10	86
More effective project planning and monitoring	5	1	2	14	54	16	88
Introduction of incentive schemes for workers	13	3	2	17	43	13	88
Adoption of prefabrication	14	1	2	24	39	10	87
Re-engineering of designs	13	1	3	12	42	19	87
Engagement of more supervisors	13	2	9	42	21	4	87
Applying information technology (including BIM)	14	3	4	30	30	10	87
Use of design-and-build	14	1	5	23	30	15	85
Monitoring Buildability and Constructability Scores	16	7	4	34	25	5	87
Providing information for Electronic Productivity Submission System (ePSS)	18	5	8	28	25	4	84
Others*	5	0	1	3	2	2	13
Others							4
						answered question	88
						skipped question	22

Figure 5.21 Government's productivity-related incentive schemes used by companies

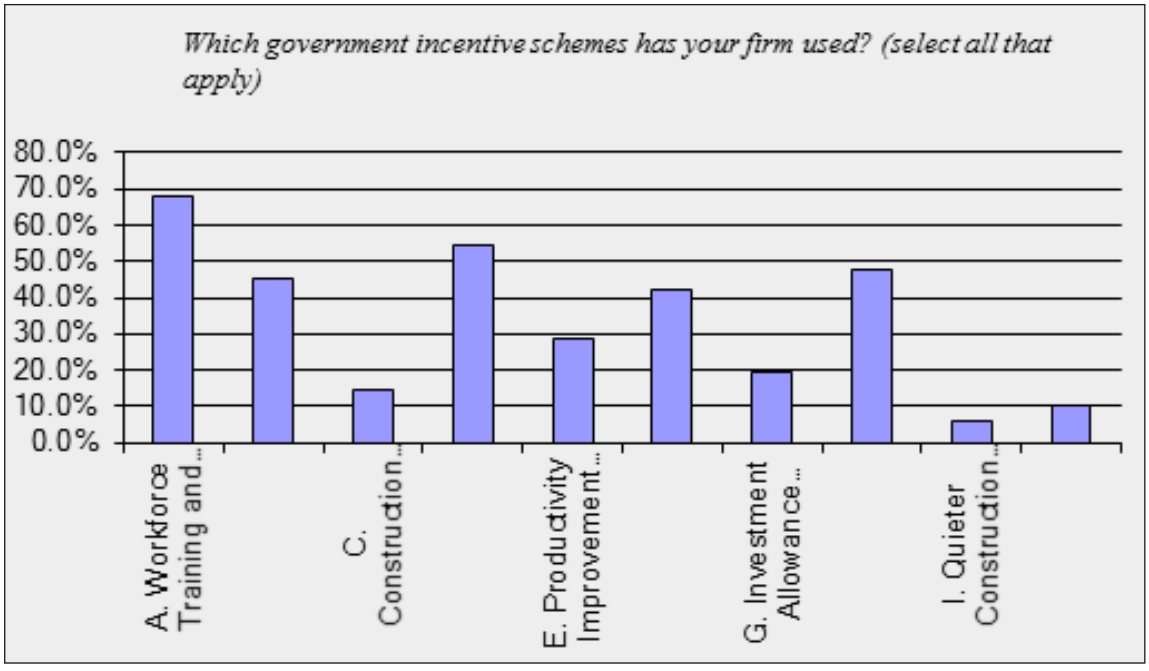


Table 5.21 Government's productivity-related incentive schemes used by companies

Which government incentive schemes has your firm used? (please select all that apply):		
Answer Options	*Response Percent*	*Response Count*
Workforce Training and Upgrading Scheme	68.2	60
Construction Productivity and Capability Fund	45.5	40
Construction Engineering Capability Development	14.8	13
Mechanisation Credit	54.5	48
Productivity Improvement Projects	28.4	25
Building Information Modelling (BIM) Fund	42.0	37
Investment Allowance Scheme	19.3	17
Productivity and Innovation Credit	47.7	42
Quieter Construction Fund	5.7	5
Others* (please specify below)	10.2	9
	answered question	88
	skipped question	22

Question Twenty-one

The respondents highlighted the government's productivity-related incentive schemes, which their companies have used. The results are shown in Table 5.21 and illustrated in Figure 5.21. The top five of these schemes are: Workforce Training and Upgrading Scheme; Mechanisation Credit; Productivity and Innovation Credit; Construction Productivity and Capability Fund; and BIM Fund.

A comment by a respondent in the 'others' section under this question was: "Mech-C application was rejected despite fulfilling requirements".

Question Twenty-two

The study also ascertained the factors that motivate respondents' companies to improve productivity. The results are shown in Table 5.22 and illustrated in Figure 5.22. The top ranked factors, in descending order of importance, were: deliver projects on time; increase profitability; enhance corporate competitiveness; and enhance corporate image.

It is pertinent to note that reducing the number of foreign workers and keeping within the MYE quotas are not considered to be priorities.

Figure 5.22 Factors which motivate companies to improve productivity

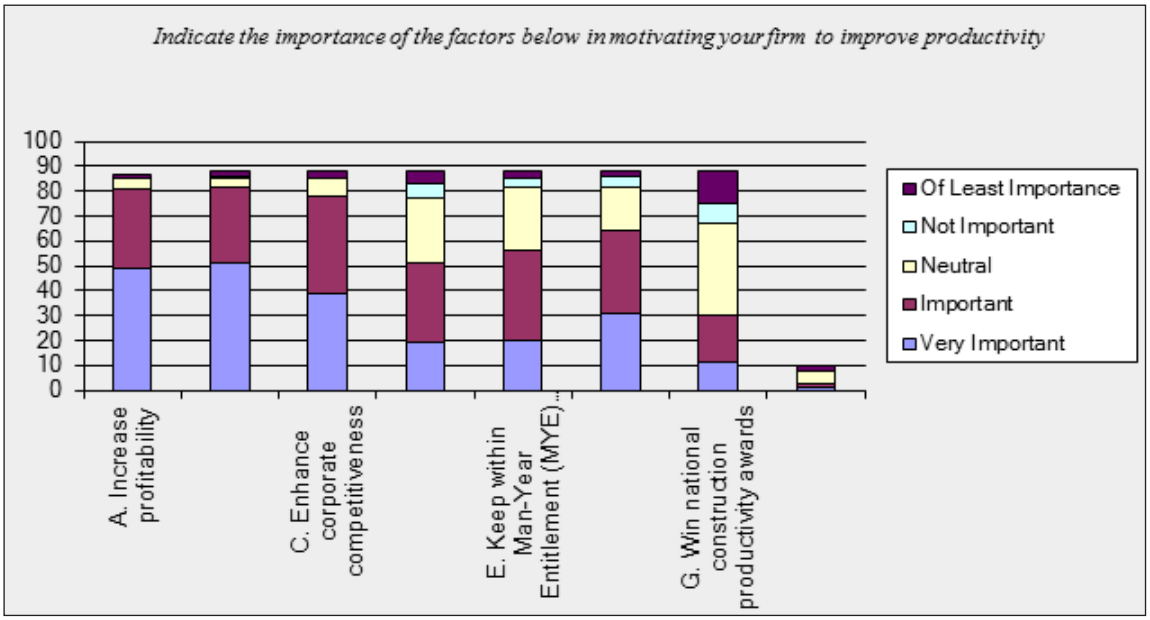


Table 5.22 Factors which motivate companies to improve productivity

Indicate the importance of the factors below in motivating your firm to improve productivity							
Answer Options	*Of Least Importance*	*Not Important*	*Neutral*	*Important*	*Very Important*	*Response Count*	*Mean*
Increase profitability	2	0	4	32	49	87	4.45
Deliver projects on time	2	1	3	31	51	88	4.45
Enhance corporate competitiveness	3	0	7	39	39	88	4.26
Reduce number of foreign workers	5	6	26	32	19	88	3.61
Keep within Man-Year Entitlement (MYE) quotas	3	3	26	36	20	88	3.76
Enhance corporate image	2	4	18	33	31	88	3.99
Win national construction productivity awards	13	8	37	19	11	88	3.08
Others*	2	0	5	2	1	10	3.00
Others						3	
					answered question	88	
					skipped question	22	

Question Twenty-three

The study also sought to find out the factors which help the companies of the respondents to improve productivity, and the relative importance of these factors. The results are presented in Table 5.23 and illustrated in Figure 5.23. The top five factors are: support of clients; government incentive schemes; competition within the industry; support of subcontractors; and support of consulting teams. The other factors indicated were also given relatively high scores. The factor accorded least weight was pressure from the presence of foreign contractors.

Figure 5.23 Factors which help companies to improve productivity

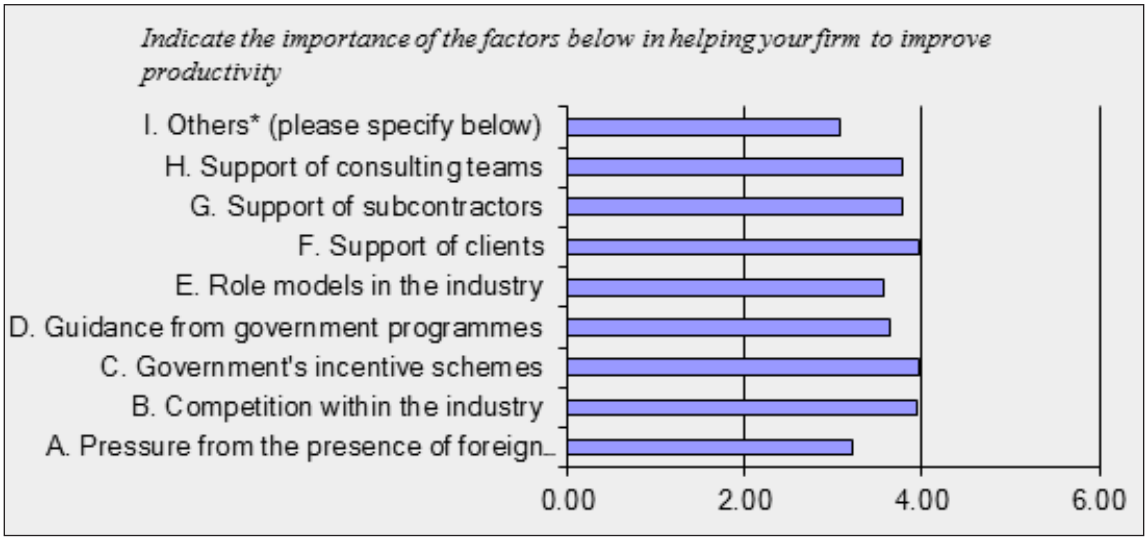


Table 5.23 Factors which help companies to improve productivity

Indicate the importance of the factors below in helping your firm to improve productivity								
Answer Options	*Of Least Importance*	*Not Important*	*Neutral*	*Important*	*Very Important*	*Rating Average*	*Response Count*	*Mean*
Pressure from the presence of foreign contractors	7	8	37	26	7	3.21	85	3.21
Competition within the industry	3	3	13	44	23	3.94	86	3.94
Government's incentive schemes	4	2	13	41	26	3.97	86	3.97
Guidance from government programmes	4	3	27	39	13	3.63	86	3.63
Role models in the industry	5	2	33	32	14	3.56	86	3.56
Support of clients	4	1	15	39	27	3.98	86	3.98
Support of subcontractors	4	3	20	40	19	3.78	86	3.78
Support of consulting teams	5	5	19	33	24	3.77	86	3.77
Others*	4	0	5	3	3	3.07	15	3.07
Others							8	
						answered question	88	
						skipped question	22	

It is pertinent to note that none of the factors in this question was given an overall mean score of 4.0 or above by the respondents. This strongly indicates that the productivity drivers in Singapore construction are relatively weak and particular action is required to attain improvement.

Factors suggested in the 'others' section were: (i) "Quality, completeness and clarity of upstream design are critical"; (ii) "Support of RE/RTO"; (iii) "Labour importation and training schemes"; and (iv) "Reducing time spent on one task, delegating time to other jobs".

It should be noted that the Clerk of Works (COW) and Resident Engineer (RE) exert an influence on the efforts of respondents' companies to improve productivity on their projects. They were often cited by respondents in the 'others' section of numerous questions.

Question Twenty-four

Hindrances to the efforts of companies to improve productivity were also ascertained. The results are presented in Table 5.24 and illustrated in Figure 5.24. The top five hindrances were: excessive regulation of construction activity; insufficient time to plan and execute work properly; lack of support from clients; delays in payments by clients; and restrictions on employment of foreign workers.

Other factors suggested were: (i) "Lack of support from RE/RTO"; and (ii) "Lack of vocational training in the construction industry, low salaries in construction".

It is pertinent to note that among the top hindrances was lack of incentives from the government, although in Question 23, respondents had indicated that such incentives were among the most important drivers. In addition, one of the main productivity improvement obstacles highlighted was the restrictions on employment of foreign workers. The lack of competent Professional, Management, Executive and Technical (PMET) personnel was also indicated as an obstacle.

Figure 5.24 Hindrances to companies' efforts to improve productivity

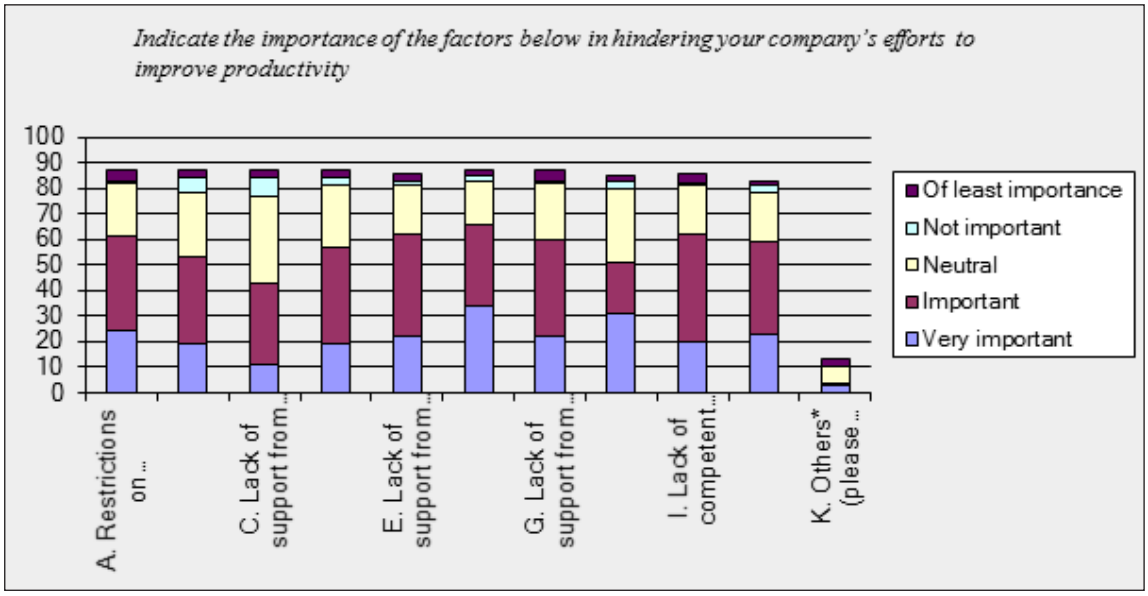


Table 5.24 Hindrances to companies' efforts to improve productivity

Indicate the importance of the factors below in hindering your company's efforts to improve productivity							
Answer Options	*Of least importance*	*Not important*	*Neutral*	*Important*	*Very important*	*Response Count*	*Mean*
Restrictions on employment of foreign workers	4	1	21	37	24	87	3.87
Lack of incentives from government	3	6	25	34	19	87	3.69
Lack of support from suppliers	3	7	34	32	11	87	3.47
Poor quality of subcontractors	3	3	24	38	19	87	3.77
Lack of support from clients	3	2	19	40	22	86	3.88
Excessive regulation of construction activity	2	2	17	32	34	87	4.08
Lack of support from consulting teams	4	1	22	38	22	87	3.84
Delays in payments by clients	2	3	29	20	31	85	3.88
Lack of competent Professional, Management, Executive and Technical (PMET) personnel	4	1	19	42	20	86	3.85
Insufficient time to plan and execute work properly	2	3	19	36	23	83	3.90
Others*	3	0	6	1	3	13	3.08
Others						5	
					answered question	88	
					skipped question	22	

Question Twenty-five

The current trend and level of subcontracting in the construction industry were ascertained in the study. Respondents were requested to indicate the proportion of their companies' construction work which was subcontracted in 2010 and 2015. The results are presented in Table 5.25.

Table 5.25 Level of subcontracting in the construction industry

Indicate the proportion of your company's construction work which was subcontracted in 2010 and 2015						
% for 2010						
Answer Options	*0 - 10*	*10 - 25*	*25 - 50*	*50 - 75*	*75 - 100*	*Response Count*
Proportion of firm's work subcontracted in 2010 (in %)	18	10	13	28	18	87
Proportion of firm's work subcontracted in 2015 (in %)	14	15	12	25	20	86
% for 2015						
Answer Options	*0 - 10*	*10 - 25*	*25 - 50*	*50 - 75*	*75 - 100*	*Response Count*
Proportion of firm's work subcontracted in 2010 (in %)	19	9	11	28	19	86
Proportion of firm's work subcontracted in 2015 (in %)	14	14	9	29	20	86
						Question Totals
					answered question	87
					skipped question	23

The data show that in 2010, 32 per cent of the respondents' companies subcontracted 50-75 per cent of their construction work. In 2015, the proportion whosublet similar levels of their work fell slightly to 29 per cent. In 2010, 21 per cent of respondents' companies sublet 75-100 per cent of their work; and in 2015, the proportion of companies subcontracting the same level had fallen slightly to 23 per cent. The data indicate that the extent of the practice of subcontracting in the construction industry in Singapore has remained largely similar in the last five-year period.

Question Twenty-six

An attempt was made to establish the structural profile of the construction workforce in Singapore. The trend in the changes in the structure was also determined. The respondents were requested to indicate the breakdown of their companies' employees in 2010 and 2015. The results are presented in Table 5.26. The data show that the structure of the workforce did not change in a significant manner between 2010 and 2015.

Question Twenty-seven

The level of investment made by the companies of the respondents in mechanisation and information technology (IT) was ascertained. Respondents reported investment figures for 2010 and 2015. The results, which are shown in Table 5.27, indicate that the companies' investments in both items increased. The proportion of companies which invested 10 – 15 per cent and 15 – 20 per cent of their turnover in IT in 2015 increased significantly compared to 2010.

Question Twenty-eight

The level of investment made by the companies of the respondents in training was also investigated. The respondents reported on their investment in 2010 and 2015. The results are shown in Table 5.28. The data show that the companies' investment in training increased over the five-year period. The number of companies which respondents reported as investing 2-4 per cent of payroll in training

Table 5.26 Structural composition of companies' employees

Provide a breakdown of your company's employees (i.e., excluding subcontractors') in terms of percentages of the total in 2000 and 2015						
2010 in %						
Answer Options	*0 - 5*	*5 - 15*	*15 - 25*	*25 - 50*	*50 - 75*	*Response Count*
A. Professionals	37	26	14	6	4	87
B. Supervisors	28	28	18	9	5	88
C. Skilled tradesmen	24	12	6	12	34	88
2015 in %						
Answer Options	*0 - 5*	*5 - 15*	*15 - 25*	*25 - 50*	*50 - 75*	*Response Count*
A. Professionals	29	29	16	9	4	87
B. Supervisors	20	28	23	12	5	88
C. Skilled tradesmen	15	15	7	20	31	88
						Question Totals
					answered question	88
					skipped question	22

Table 5.27 Companies' investment in mechanisation and information technology 2010 and 2015

Provide an indication of your firm's investment in mechanisation and information technology in 2010 and 2015					
2010 in %					
Answer Options	*0 - 5*	*5 - 10*	*10 - 15*	*15 - 20*	*Response Count*
A. Mechanisation	52	14	14	7	87
B. Information technology	60	15	7	6	88
2015 in %					
Answer Options	*0 - 5*	*5 - 10*	*10 – 15*	*15 - 20*	*Response Count*
A. Mechanisation	36	21	11	19	87
B. Information technology	46	18	9	15	88
					Question Totals
				answered question	88
				skipped question	22

Table 5.28 Companies' investment in training in 2010 and 2015

Provide an indication of your company's investment in training in 2010 and 2015, as a percentage of payroll				
2010 in %				
Answer Options	*0 - 2*	*2 - 4*	*Over 4*	*Response Count*
Training (% of payroll)	59	19	10	88
2015 in %				
Answer Options	*0 - 2*	*2 - 4*	*Over 4*	*Response Count*
Training (% of payroll)	34	30	24	88
				Question Totals
			answered question	*88*
			skipped question	*22*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increased from 19 per cent in 2010 to 30 percent in 2015, and those investing over 4 per cent of payroll rose from 10 per cent to 24 per cent.

Question Twenty-nine

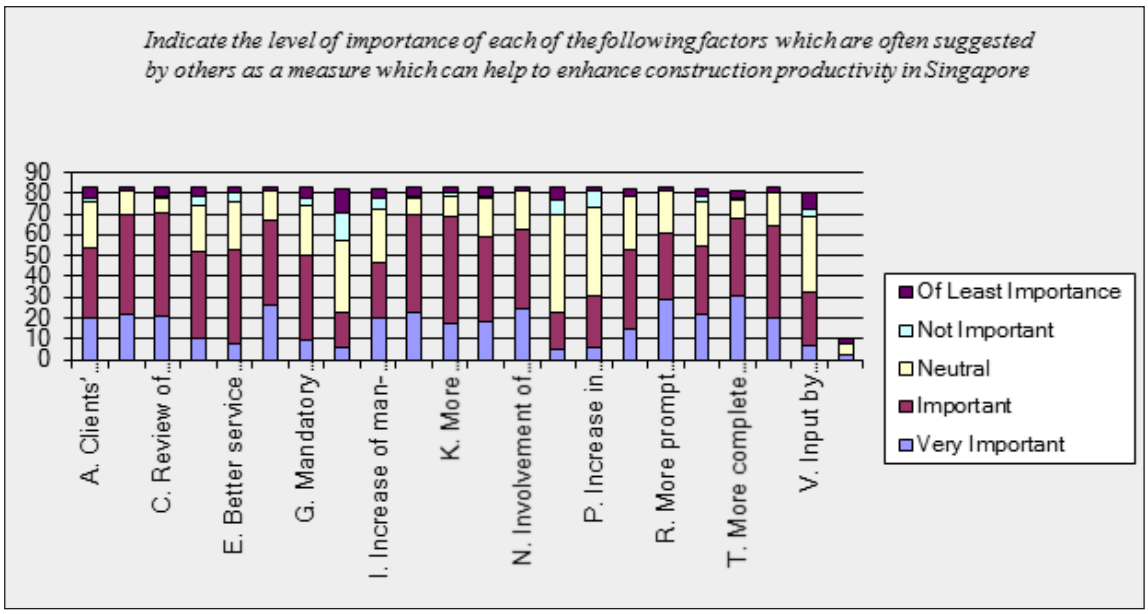
The opportunity was taken to obtain respondents' views on construction-productivity enhancing factors and measures which are often suggested by administrators, practitioners and researchers in Singapore. The results are shown in Table 5.29 and illustrated in Figure 5.29. The top seven factors (with mean scores of 4.0 and above) were: more complete and firmed-up design; standardisation of components; training of workers; more prompt payment from clients; more attention to productivity by firm's leaders; review of relevant government regulations; and involvement of contractor in design.

The factors and measures which were given the least scores by respondents, in ascending order of scores, were: reduction of MYE; reduction of extent of subcontracting; input by contractors of accurate data to Electronic Productivity Submission System (ePSS); increase of extent of subcontracting; and mandatory requirement for contractors to pay attention to productivity.

One 'other' set of suggestions offered by one respondent was: "For precast components, BCA should enforce the standardisation of the types of components. For BTO HDB projects designed by HDB, some of the designs are not standardised, such as beams with long cantilevered rebars".

Question Thirty

Figure 5.29 Relevance and level of importance of productivity-enhancing factors and measures which are often suggested



The respondents were provided the opportunity to make their own proposals on measures which can be taken by various stakeholders to enhance construction productivity in Singapore. The stakeholders, indicated as a guide, were: the authorities; contractors; clients; consultants; and subcontractors. Numerous suggestions were offered by the respondents. Summaries of the suggested measures are presented in the following sections.

The summaries are grouped according to stakeholders. Under each stakeholder, a sample of the sets of actions proposed by respondents is presented as a broad example of the more detailed proposals by other respondents.[205] Following that, compilations of suggestions consolidated according to similarity are then presented. (The numbers in brackets show the number of respondents who made suggestions on the same points.)

205 These 'direct' inputs have been edited to make them clearer.

Table 5.29 Relevance and level of importance of productivity-enhancing factors and measures which are often suggested

Indicate the level of importance of each of the following factors which are often suggested by others as a measure which can help to enhance construction productivity in Singapore							
Answer Options	*Of Least Importance*	*Not Important*	*Neutral*	*Important*	*Very Important*	*Response Count*	*Mean*
Clients' insistence on productivity	5	2	22	34	20	83	3.75
Training of workers	2	0	11	48	22	83	4.06
Review of relevant government regulations	4	1	7	50	21	83	4.00
More extensive use of prefabrication	4	5	22	42	10	83	3.59
Better service from suppliers	3	4	23	45	8	83	3.61
Standardisation of components	2	0	14	41	26	83	4.07
Mandatory requirement for contractors to pay attention to productivity	5	4	24	41	9	83	3.54
Reduction of man-year entitlement	11	14	34	17	6	82	2.91
Increase of man-year entitlement	4	6	25	27	20	82	3.65
More attention to productivity by firm's leaders	4	1	8	47	23	83	4.01
More mechanisation of construction work	3	1	10	52	17	83	3.95
Greater extent of design-and-build	4	1	19	41	18	83	3.82
Involvement of contractor in design	2	0	18	39	24	83	4.00
Reduction of extent of subcontracting	6	7	47	18	5	83	3.11
Increase in extent of subcontracting	2	8	42	25	6	83	3.30
Better service from subcontractors	3	0	26	38	15	82	3.76
More prompt payment from clients	2	0	20	32	29	83	4.04
Longer construction period	3	3	21	33	22	82	3.83
More complete and firmed-up design	3	1	9	37	31	81	4.14
Applying techniques to reduce amount of work	3	0	16	44	20	83	3.94
Input by contractors of accurate data to Electronic Productivity Submission System (ePSS)	8	3	37	25	7	80	3.25
Others* (please specify below)	2	0	6	0	2	10	3.00
Others (please specify)						4	
					answered question	83	
					skipped question	27	

5.2.3 Actions authorities can take

General points: The following four sets of general suggestions of actions the authorities can take was made by one respondent. They are presented here as examples of the more detailed inputs of other respondents.

1. "Measure productivity for each trade, reward the company with best productivity, award contracts on the basis of productivity (but not only precast concrete), enable the use of more design and build."
2. "(a) State clearly in the tender documents requirements for productivity and follow up with award based on productivity requirements. (b) Understand better the requirements to improve productivity that goes beyond surface level improvements. (c) Give higher weightage in tender scoring to productivity input."
3. "(a) BCA should ensure there is no monopoly of the market by specialists; it should also educate contractors on each productivity product such as PPVC; and publish a list of the vendors for easy reference. (b) Both BCA and MOM should advise contractors on the safety risks of each product installation."
4. "(a) Simplify the grant application processes; and show leniency in awarding of grants. (b) Accord recognition for early completion or adoption of highly productive technologies. (c) Provide a platform for industry players to share ideas on productivity."

Incentives: It was suggested that: government should provide more incentive, assistance and support schemes (11); increase the cap on Mech-C and raise the percentage of the grant for technology adoption and provide more grants for training (3); and use an assessment method to ensure it is effectively delivered (2). The authorities should also provide special incentives to locals to encourage them to join the construction workforce and provide incentives for productive design. One suggestion on incentives that was related to approach rather than quantum was: "Be flexible and exercise empathy in disbursement of grants to specialist builders".

Regulations and policies: There was a broad call for regulations to be reviewed (2) and reduced (3). The authorities should aim to have more self-regulation by industry. Some specific regulations highlighted were: review training, immigration and taxation policies. On the other hand, there were also suggestions that there should be more stringent regulations, and that these should be better enforced. Specific ones were: make productivity a mandatory requirement (3); increase the required Buildability Score; enforce more standard designs; make modular design a mandatory requirement for all building projects; and insist on reasonable duration for construction projects.

It was suggested that the approval process should be reviewed and expedited (2). These calls included: "reduce layers of approvals"; "expedite permit process" (4); and specifically, "LTA should improve its approval process". It was also suggested that, for each project, the design should be ready for construction before the permit is issued (2). In general, it was proposed that the agencies should streamline the processing of applications for permits or other approvals.

On policies, apart from broad suggestions such as: review existing guidelines and set clear ones (2), some suggestions were made for changes in specific policies. These included: "reduce the foreign worker levy"; and "increase the foreign workers quota and give monetary aid".

Relationship with industry: Some specific suggestions of actions by the authorities were: "provide education across the whole industry on the regulations"; "share productivity knowledge with all stakeholders"; "heed the contractors' feedback"; and "involve contractors more on issues". The agencies should also: "engage developers to review design to encourage productivity". There was an even more general suggestion: "increase construction building work".

General attitude and approach: The authorities should have good understanding of the construction process; be more supportive of the industry's activities; exercise flexibility in policy formulation and implementation (2); and adopt a gradual approach when implementing policies.

5.2.4 Actions contractors can take (75 responses)

General point: An example of a set of suggestions of actions contractors can take which was made by one respondent is: "(a) Be pro-active in search of new methods and latest technology. (b) Be willing to accept change. (c) Recognise sub-contractors for early completion or adoption of highly productive technologies."

Training: It was suggested that contractors should undertake continuous talent development and better training of their workers and supervisors (7). An area highlighted was training in productivity-related management skills. They should assess achievements of workers before and after training to check on its effectiveness.

Planning and organisation; and project management: Contractors should improve planning (9) and work preparation; and undertake constant review and fine tuning of plans. They should also improve their overall management; organisation (4); programming; project management; co-ordination (2); and construction methods (2). Contractors should speed up projects; ensure better operational efficiency; and undertake regular assessment of real-time production.

Resource and value chain management: Contractors should engage adequate numbers of workers; increase their workers' wages; give the workers incentives (2); and demand high standards of productivity from the workers. They should also undertake effective management of inputs and of the value chain such as awarding the sub-contract to the precaster well ahead of the time of delivery; and engaging specialist contractors to undertake the special tasks.

Construction methods: Contractors should adopt greater levels of mechanisation (2) and more extensive use of fabrication; improve on construction methods (2); and proactively adopt constructable methods (2).

Involvement in design: Contractors should be more involved in the design process (3); contribute suggestions for changes to simplify designs; review designs for DfMA; and convince other stakeholders to be willing to change architectural designs in order to make construction less labour-intensive.

Measurement and improvement of productivity: Contractors should measure productivity, set measurable targets on productivity, and take the initiative to explore and adopt measures to increase productivity (3).

Project performance: Contractors should "secure tenders with good and workable tender prices" (2); and perform well and deliver on time (2).

Attitudes and mindset: Contractors should ensure compliance with relevant regulations; be creative; have an appropriate mindset; be more willing to take risks; be proactive and less cost driven; and be willing to co-operate with other stakeholders.

5.2.5 Actions clients can take (73 responses)

General points: Examples of sets of suggestions of actions which clients can take, each of which was made by one respondent, are as follows:

1. "Select/award on productivity criteria, measure productivity per rig, open FDL, allow the proposal of alternative or adopt design and build procurement."
2. "(a) Be willing to accept both proven and new methods and/or products. (b) Minimise changes during construction. (c) Pay for claims promptly. (d) Give recognition for early completion or adoption of highly productive technologies."
3. "Give more time up-front for the design to be complete. Make decisions promptly. Don't change your mind."
4. "(a) Understand ways to improve productivity that goes beyond the surface level. (b) Lead and reward contractors who propose productive methods."

Procurement: It was suggested that clients should insist on efficient design, especially, cost-effective design. They should press for standardisation in order to increase constructability and more buildable designs. Clients should be systematic in the selection of consultants and contractors (3). They should adopt design and build (2) and pay reasonable professional fees. They could also adopt arrangements which involve early contractor involvement (ECI). Clients should give preference to contractors proposing to apply productive methods (3).

It was suggested that clients should insist on productivity (6), for example, by setting specific targets and incorporating the requirements for productivity in tender documents and be willing to pay for the associated cost (12). In addition, at the tender stage, clients should be willing to pay a premium to contractors offering productive measures, and provide incentives for productivity improvements (5).

Project and contract administration: Clients should confirm direct sub-contracts early (2). They should also ensure that design changes are kept to the minimum (3). They should enforce, but also, adhere to, the main contract for the project. They should ensure prompt payment to the contractor (6); and provide incentives to relevant stakeholders (2). Clients should allow the design and construction teams a reasonable period to work (6); and monitor the project closely.

Attitudinal and behavioural factors: Clients should support productivity initiatives (3), and have the following outlook concerning productivity: comply with agreed provisions and terms in the contract; be less cost driven; be generally open; and "maintain better communications and effective decision making".

5.2.6 Actions consultants can take (73 responses)

General points: Examples of sets of suggestions of actions consultants can take, each of which was made by one respondent, are now presented.

1. (1) "Be receptive to new, highly productive technologies, even [if] it means changing the specifications. (2) Keep abreast with productive technologies and practices. (3) Be prepared to advise clients on productivity."
2. "Improve design quality as it can affect progress, quality and productivity a lot."
3. "Respect specialist subcontractors as we are more experienced than them. What they design sometimes don't even comply with regulations and are not practical at all."

General approach to design: It was suggested that consultants should generally aim for efficiency and effectiveness in design (2). They should provide complete (6), integrated and coordinated design (2) before construction, with complete information (so that there will be fewer instances of "requests for information") (2). Consultants should also ensure thorough alignment and coordination of all disciplines in the design (2). They should speed up the design and ensure early approval of design works; and "allow for more flexibility in design" (2). Consultants should "incorporate details of interfacing in the drawings instead of leaving it to contractors"; and "take responsibility for design, don't always indicate 'to specialist design'".

Design for productivity: Consultants should take productivity into consideration during design (3). For example, they should consider prefabrication (2) and DfMA; design for easy construction and repetition; provide for standardised components (2) such as PBU; make all designs modular; and specify appropriate, ready-made products (2). They should take into account the key construction-stage requirements (4); and also pay attention to DfS.

Procurement: Consultants should share information and drawings, including BIM. They should "encourage clients on methods to improve productivity", set tangible targets on productivity and specify productivity requirements in tender documents. Consultants should promote ECI in design and work with contractors to achieve more buildable designs. They should encourage and assist contractors to make contributions to improve the design. They should be knowledgeable about the

specialist products and services required on the project (2), and involve specialist subcontractors, such as the precaster, in the early stage of design

Project administration: Consultants should work closely with site teams, reduce response and action time (5), "be in the constructor's shoes", reduce the need for revision to drawings (2) and give solutions to problems.

5.2.7 Actions subcontractors can take (72 responses)

Business practices: Subcontractors should consider providing integrated services, for example, plumbing, electrical and air-conditioning services. They should be able and willing to participate in the early stages of design. They should be willing to spend more money on aspects of the project such as providing incentives to their workers (3); and to invest in, and use, new equipment (2).

Project planning and preparation: Subcontractors should fully support the main contractors (2); and comply with relevant instructions. They should be involved with main contractors in planning their work activities; stick to, and meet, agreed schedules (2); proactively adopt "constructable work methods"; seek early approval of shop drawings and materials; and provide better supervision.

Project delivery and performance: Subcontractors should set productivity improvement targets; take measures to increase their own companies' productivity (3); and be in line with, and cooperate with the main contractor to increase productivity. Subcontractors should produce good quality work (5); reduce cost; achieve timely delivery (3); and eliminate accidents and seek to achieve a zero-accident environment.

Training: Subcontractors should provide more, and continuous, training for their workers to improve their skills and output (11). They should improve the levels of knowledge and standards of competence of their workers and supervisors (3). Some specific aspects and skills highlighted included: training their workers and supervisors to follow plans and to be able to undertake multi-tasking; and improving the foreign (NTS) workers' skills to achieve cost effectiveness.

Communication and cooperation: Subcontractors should share difficulties with the main contractor during the design process; maintain closer communications with the main contractor (4); and share resources with the main contractor.

Attitudes and general approach: Subcontractors should: be willing to accept change (2); pursue a corporate orientation of competitiveness; and "show professionalism". They should: take pride in their work; be willing to co-operate; and be committed and disciplined.

5.3 The interviews

5.3.1 Introduction

The following summaries of the interviews and the focus group meeting are grouped under sub-headings from the guide used for the interviews.

5.3.2 Summary of interviews

1. Views on level of productivity of Singapore's construction industry: whether it has increased since the year 2010; and views on statistics which indicate that the rate of growth of productivity in construction is one of the lowest among all sectors

There was general agreement among the interviewees that the level of productivity in Singapore's construction industry has improved since 2010. One noted:

> *Productivity has improved significantly on the building site. Just look at the formwork. Now it is all systems formwork, steel forms and re-useable materials. There has been a huge impact from mechanisation. Look at rebar; it was all bent on site. Now it is all off-site. We are 100 percent more productive than 2010. At the same time, I think Singapore has improved safety significantly. Improvements in quality and safety have meant being able to put more people on site.*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As an example of the changes in technology, it was noted that, over the last five years, main contractors have generally switched to system formwork. One interviewee believed that, in terms of physical work, productivity in Singapore has increased since 2010 and is on par with those in industrialised countries, noting that: "work productivity between Japan, Hong Kong and Singapore are not far apart".

It was pointed out that increases in productivity are the result of conscious action. The increase realised in Singapore was mainly attributed to the government's push for precast and prefabricated construction.

Various views were expressed on the official industry-level data on productivity growth, based on value-added per person. It was generally agreed that the depiction of the construction industry as a laggard in productivity improvement is not helpful. As one interviewee noted: "The perception that we have the poorest productivity growth is tarnishing the image of the industry." It was also acknowledged by several of respondents who noted that although there had been an increase in physical productivity around 2008-09 (as shown by official data, in which value-added per worker grew when major projects, such as the integrated resorts and the Marina Coastal Expressway (MCE) were being constructed, and most companies made large profits), it has been virtually stagnant since 2010.

It was generally acknowledged that there was room for improvement in productivity performance. An interviewee noted: "Mechanisation has helped to raise productivity…we have increased speed but the industry is still labor-intensive". Therefore, more action was required. Another observed: "There is still scope for improvement but this has to be pushed by many factors and the authorities. Left to its own devices, the industry will not change". Some believed there should be a change in emphasis in the productivity drive. One noted:

> *Government is pushing for higher productivity but already, most of the foreign workers do overtime. So I suspect they might not be as productive. I analysed our project and found that most of our workers maximised overtime but do they need to do so? Do all our workers need to work overtime?*

Some possible hazards in measuring productivity and making comparisons with other countries were mentioned. An example was this statement:

> *To benchmark us with other countries is not fair. There is a difference in expectations. Here, the standard of finishing work is high. Often, you have to hack the tiles and do it again because it is considered to be not good enough. Here, we have got our CONQUAS and others... Our guidelines are much more stringent. Another aspect is the high cost of land and thus, real estate costs. For example, in Japan, for a three-bedroom house, there may be only one toilet, with vinyl floors. Here, there will be separate bathrooms, and tiled finish.*

Some interviewees suggested that productivity in certain segments of the construction industry has not increased. One noted that productivity in civil engineering has not improved although a great deal of new technologies, equipment and materials had been applied. The main reason is that:

> *…we have been overlooking the essence. Who makes productivity? It is human, not technologies, not equipment. The new technologies, equipment and materials are merely a kind of tools used by humans. We need to make the human being work with his near-most ability...*

2. Views on existing ways in which construction productivity is measured in Singapore: (a) at trade level; (b) at the project level; and (b) at the industry level

It was generally acknowledged that trade-level productivity was the most straightforward among the indicators to measure. It was suggested that the industry should focus on useful aspects of productivity where greater change can be realised. One interviewee suggested: "Trade level productivity is good but it does not change industry; it is no use. Labour is human; in no way

will it increase by leaps and bounds." He suggested that trade productivity could be measured once every five years. In his view, it does not improve productivity as a whole significantly. Another interviewee noted: "On physical labour-type issues, you are not going to improve productivity. You can't do the work faster".

There is a challenge in measuring and maintaining productivity data because, at the trade level, a task can be accomplished in many possible ways. One interviewee noted that, with regards to concrete on site, the current ways of measurement have to be further developed since system formwork is now "the normal" in the market. A specialist subcontractor whose operations required the use of heavy equipment noted that there are no available industry data. The company uses its own norms such as: the time it takes to set up the system; number of workers; and floor-by-floor cycle time (the company gave the study team some of these data).

The issue of cost was raised at many points during the interviews. On productivity measurement, it was suggested that: "You need to bring in the dollar value in construction". One example that was given was that, in Australia, on big projects on remote sites, the cost of a person was about $80 per hour. "In such an environment, it is better to hugely mechanise", it was noted.

The interviewees also expressed different views on the usefulness of the productivity measurement methods at the project and industry levels. One noted: "Value-added per worker causes a lot of confusion. In the company, who do we consider to be our worker? At any one time, we have 100 workers but we engage 1000 sub-contractors' workers". Another interviewee remarked: "I find it difficult to visualise, consider and understand productivity at the project level".

Another interviewee was more positive about value-added per worker. He noted: "At project level I would measure work productivity but at industry level, we should measure value-added per person ". He reported that his company measures value-added per worker every year. This tells them how competitive they are in the industry. They set an annual growth rate target. The growth rate went down in 2014 but they believed their work productivity had actually improved.

Interviewees were significantly less knowledgeable on the measurement of productivity at the industry level. In particular, the application of value-added per worker at the industry level poses challenges. One interviewee observed:

> *Grouping of buildings in order to measure productivity is a better way than lumping them all together. At trade level, comparison is fundamental and straightforward. At project level, there are too many trades to group them together. The construction industry finds it difficult to understand and use value-added per worker.*

3. Whether firms have policies on construction productivity in general

None of the interviewees' companies had a written policy on productivity. One noted: "Many companies may have had company policies on productivity but may find it difficult to understand how it is actually defined. Companies have norms on wastage and so on, but not on productivity". Another reported that his company has environmental, sustainability, safety and quality policies. The company considers productivity in various way in all of these policies. For example, in this company, at the design stage, safety considerations are made with some regard to productivity as well.

However, all the companies of the interviewees consider productivity in some way. One interviewee noted:

> *Many companies have explicit quality policies and environmental policies but not on productivity. It is because these are easier to measure. For each project, we consider our manpower requirements; and our wastage levels. Attempts to measure productivity do not make sense.*

One interviewee reported that his company does not have a distinct policy on productivity, "but we are clear in our mind...we are design and build contractors so we know that buildability and

constructability are key". Another reported that the firm has no formal policy on productivity, but it has a procedure for attaining the productivity norms which it applies on its projects.

There are companies that understand and use various methods and norms of productivity. As noted above, one interviewee indicated that at project level, the company tracks output, but at company level, they track value-added productivity. Another company's productivity target is a focus on total revenue. Each project has a fixed revenue, which is allocated by the head office, and it is the paramount guiding factor; no matter what the circumstances are, the managers and engineers must work to attain the set figure.

The merits of productivity measurement are not convincing to all the interviewees. One noted, concerning value-added productivity targets at project level: "Certain projects you tender with bigger margins, others not. It also depends on market conditions."

4. How companies measure productivity on their projects at trade and project levels; for firms which do not measure productivity, whether such a measure would be useful to the firm

The interviewees indicated many ways in which their companies assess productivity: one company focuses on total manpower for the project. Another company, which undertakes infrastructure work, measures day-inches for labour for pipework. Yet another firm does not use any special tools to measure productivity; it monitors revenue. Another interviewee noted: "We measure our productivity from floor to floor. The figures are within industry norms. We find that, to improve, we will need drastically new methods."

One interviewee noted:

> *We don't have a policy that quantifies productivity but it is included in our integrated management system. Our policy says we must finish the project on time and with a positive monetary outcome. We do…compare with other projects. For example, in previous projects, what did we achieve?*

Some interviewees do not think many of their counterparts in the industry assess productivity. For example, one interviewee observed that: "None of the companies is measuring productivity constantly. I know one company measured productivity because it was given a grant by BCA to do so."

A view that was expressed was that the main contractor should show interest in, and take responsibility for, the approach of its subcontractors to productivity. One interviewee noted:

> *For subcontractors, they know the time span and resources, and their productivity levels, but do they monitor and check? If they are not hitting those figures, it will hit me. … We track their number of workers, by trade also.*

It was reported that, in Korea, the subcontractors' revenue must be monitored by the main contractor because the subcontracting companies are small and there is a high rate of bankruptcy among them. Therefore, the subcontracts require them to submit cash flow statements to the main contractors.

5. What firms use their productivity measurements for at trade and project levels

With respect to trade productivity, subcontractors have the data, and they use them in working out their quotations and controlling their work. One specialist subcontractor interviewed observed: "We use the target to promote our services owing to the level of competition in the industry. And not only on productivity; it's also the costs and materials we are using".

One interviewee reported that the company's objective is "to reduce headcount"; it is the company which measures total manpower per project. The company which focuses on revenue considers the monitoring and forecasting of the company's whole revenue and cash flow.

Another interviewee noted that, for civil construction, certain common items, such as man-day or

man-hour per cubic metre for concrete could be measured. There are industry norms for these, but they are not published. The company uses its productivity data to ensure that it is competitive in bidding. He observed:

> *We track these norms. If we are getting variances, we would ask ourselves why. Over time, we look at how we would improve those, whether we can, for example, mechanise welding, etc.*

6. Obstacles to construction productivity measurement

Several obstacles to the measurement of productivity were highlighted by the interviewees. The views expressed included:

1. "It requires manpower to measure – especially trade productivity."
2. "On site, everyone is pressing for progress and completion so time for measurement is an issue. Second is the skill to do it; both technical and supervisory. Third is availability of manpower."
3. "The key obstacle is the definition of productivity. I think from one worker to another, productivity would be the same. You could have a five or ten per cent difference."
4. "The question is how you deploy the worker… there are disruptions owing to changes to design. It is difficult to measure productivity. So planning, and management of resources are key. So the main enablers are the people who make decisions: consultants, client, project manager."

A fundamental issue is the difference in the level of conviction about the merits of productivity measurement. One interviewee noted: "If you do the work more efficiently, with the same number of workers, you get a higher output. Then your margin is there. That is how people look at productivity". On the other hand, two views were:

1. "Contractors want to know what they will get from the effort in doing the measurement."
2. "You've got to ask the question: what is the benefit for companies?"

It was reported that some companies are systematically collecting data, and not only because it is mandatory. One interviewee noted:

> *Our company faces no obstacles to productivity measurement …we have all the data. We collect all our data. ePSS is not…biometric. So you have to collect your own data and send them to BCA. We are developing our own software for biometric capture on site. We have facial recognition on site. It is now 70 per cent accurate but we have sorted out the problem... it was due to uneven lighting at certain times of the day. We will soon be able to increase it to 100 per cent. Other contractors are using the thumbprint. There are often difficulties with clarity of the markings on the fingers.*

7. Obstacles to productivity improvement in the construction industry

The obstacles to productivity improvement highlighted by one of the interviewees were: (i) issues relating to contract administration, such as hurried mobilisation; unfair contracts (both public and private standard forms of contract); (ii) variation orders where work is done, but not paid for; (iii) design issues; and (iv) aspects of labour productivity which are under the main contractor.

One interviewee observed:

> *There is a need for examination of the Resident Engineer and Clerk of Works positions. They should be participative, and involved in planning, and facilitate, to enable the work to go on smoothly, instead of rejecting work done, having it redone, not accepting tolerances.*

Another noted: "Stopping work as it is being done wastes more time than if the work is completed and the correction is made".

One interviewee highlighted: lack of manpower management skills; and lack of effort to manage manpower. Another comment was: "The obstacles are human factors; more the key players than the workers."

One interviewee noted that the obstacles are: one-third relating to labour productivity (which is under the contractor); another one-third related to design; and another one-third related to contract administration. He suggested that it is necessary to address the other two-thirds outside the control of the contractor to increase value-added per person.

One interviewee re-framed the question: "What stops a contractor from improving productivity?", and he provided the following answers: (i) Short tender periods – there is limited time to confirm that possible alternatives to the design are viable; (ii) Tighter programmes; and (iii) Reluctance of government authorities to accept alternatives. He noted that: "There seems to be a fear of loss of face – 'how could somebody do it cheaper, or have a better design than us?' It got worse after Nicoll Highway, when they got very conservative. Australia is using a higher grade rebar (10 per cent improvement over Singapore) than in Singapore"

Another interviewee stated: "Consultants are not willing to change. If you think that it can be done faster, they say that you should keep to the concept. So developers should push their consultants to involve the contractor early". It was suggested that the corporatisation or the farming out of engineering expertise in Singapore (as has also happened in many other countries) means there is less capacity in the public sector to consider and assess design alternatives.

One interviewee stated: "For us, it is cost and time". He went on:

> *What does the developer look for? Even if it's design and build, we are constrained because the client has a consultant. So I have got a time effect and a cost effect. For all the effort I put in to improve productivity, they don't give me extension of time...it's all top down.*

It was suggested that care should be taken to avoid focusing on obvious but insufficiently significant and impactful factors. One interviewee noted:

> *Last minute design changes from the client are not so risky to contractors. Constrained sites require careful planning to make use of the site and take care of logistics and delivery of materials. This causes delay, and stand-by time. Contractors' managers and engineers need to improve planning and change their mindset. This has time and cost implications. For design changes the contractor can obtain extension of time.*

An interviewee stated: "The biggest obstruction is supervision. Others are: low pay levels; itinerant foreign workforce; and working conditions – the long hours in the hot and humid conditions, and a six-day work week". This interviewee also said: "It is a real conundrum; where construction work is not seen as something Singaporeans would like their children to do. The push is for higher education. There is a real stigma attached to the industry".

Another suggested that this question should be asked: "Is the industry set up to achieve holistic productivity?" He noted that, in Singapore, design and build means to 'follow our notional scheme'. It is not left to the contractor to design the details.

8. Main enablers and drivers of construction productivity improvement in Singapore

One interviewee observed that the enablers lie in three areas: what can be done by the contractor, what the client can do, and the administration of the project. The government has mandated all public client agencies to adopt serious measures. For example, they consider tenderers' productivity track record in project procurement. To another interviewee, the main parties, with respect to productivity improvement, are the main contractor and the government.

Another interviewee suggested that it was pertinent to consider some basic questions: (a) Are procurement approaches correct? (b) Are design options that are open to industry correct? and (c) Are design codes being fully utilised? Are they too conservative? He provided an example: "Using a tunnel-boring machine for a square pedestrian underpass doesn't make sense commercially, considering the prohibitive cost and heavy process involved in setting up the machine for a 150m to 200m tunnel only".

Some other obstacles to productivity improvement outlined by interviewees were:

- Cost of using system formwork versus outsourced reinforced concrete – the Chinese subcontractors can supply more people so they are fast
- Safety considerations – "we don't compromise safety; 'safety comes first'".
- Tendering prices getting lower and lower
- High liquidated damages.

Some interviewees highlighted cost considerations. One noted: "The drivers for us are cost and time, and competitiveness. By driving productivity, it enables us to finish on time and it would be cheaper". Another observed: "What drives productivity? It is an economic issue. For example, Australia has high labour costs and huge union issues. So there is a need to reduce labour risks".

9. Views on the government's productivity development programme

These comments were made by interviewees on the government's productivity development schemes:

1. "The government schemes are very useful. Probably we are the only country where the government puts so much money into this aspect of construction. For example, volumetric construction...we went into it and we found it useful."
2. "Constructability, Buildability, etc. these are individual bits and pieces but they all add up. It has been a useful, good programme."
3. "Workers become better trained, new methods are used. It's all good."
4. "Government should try to influence the developers and consultants."

The government's involvement was considered to be necessary. Remarked one interviewee: "Some of the things have to be government-led. Otherwise, different contractors do different things".

Some possible drawbacks of the schemes were also highlighted:

1. "…the scores are so rigid. It doesn't give much room for flexibility. Also, clients want the cheapest."
2. "The intentions of these programmes are OK generally. However, they need to be more flexible in respect of application. For example, current government projects include compulsory precast elements which is not practicable or rather decrease productivity. An example is a passenger platform wall and slab in an MRT station. I understand why LTA asks for precasting of platform wall, but each element is 18 tons. Their launching and installation are very difficult. Hence, there is need for flexibility. Meeting this requirement has caused more cost and time because of the need for a special crane and special locomotive.
3. "The precast elements are from Malaysia. The transportation is challenging. It needs police escort (which requires two-weeks' advance notice); some roads with pedestrian bridges cannot be used, and so the route is much longer."
4. "The incentives the government is bringing in for mechanisation and training are very good. However, if precast bathrooms were cost-effective, developers and contractors would have taken them up. Singaporean contractors are not slow to adopt methods that will lead to higher productivity, if they are cost-effective."
5. "With a lot of precast construction, HDB blocks now look the same. Condominiums might soon all look the same, if the productivity drive is taken further, for example, in government sales of land."
6. "The squeeze has been huge on the contractor. People are working longer hours to get the job done because we don't have enough workers. It is also a safety issue because people are tired; in many of the safety incidents, fatigue is a factor."

An interviewee from an SME noted:

> *The existing incentive schemes are not helpful to our SME company. PPVC and precast construction are threats to systems formwork companies. We will eventually get a lower and lower share of the market. We will need time to find the opportunity in the new arrangement. We are now turning this local threat to looking for opportunities overseas because every country needs to develop and they all need systems formwork. Now we are looking into Indonesia. They are keen on systems formwork and we may be getting some orders coming in.… but we are not getting any support.…*

One interviewee looked towards the future:

> *Our journey on construction productivity has evolved. Our third roadmap is looking at government agencies. Now they must bravely look at value-added per person.*

10. What companies have done to enhance productivity since the year 2010

All interviewees indicated that their companies endeavour to improve their productivity performance, and had taken a wide range of measures. One interviewee reported that his company had invested a great deal of money in automation in precast manufacturing; advanced technology including mechanisation; BIM; and "hand holding" subcontractors, training them in BIM utilisation using funds from SPRING under the Partnership Programme.

Another noted: "We have taken advantage of some of the government schemes. We've also tried to improve our management skills, and tried to maximise the utilisation of resources. We are trying to improve our scheduling".

Other respondents had positive feedback as well:

> *We have moved on to P6 Primavera; that has improved our planning. We have built up our BIM team, from one to eight. We are using BIM to do clash detection. We have built an edge and a niche in PPVC because we developed our own concrete system. BIM has been useful.*
>
> *"Government-driven productivity products such as BIM have been good. Government incentives have been helpful. This has enabled us to benefit by winning projects".*
>
> *We have been approved about ten PIP by BCA CPCF and the company encourages staff to be effective. It gives them incentives. For example, the company formed a tunnel boring machine team with experienced staff and this team runs training sessions for all the related staff, and goes on business trips for advice on physical tunnelling work on on-going projects, and sometimes appoints experienced staff to on-going projects in order to improve tunnelling work productivity.*

One interviewee outlined some of the productivity-enhancing technologies his company had adopted. At trade level, they included: system formwork, self-compacting concrete, RFID, multi-deck blasting, and muck disposal system. At the project level, they included: value engineering, for example, second bored pile replaced with soldier pile and sheet pile (as they perform the same function), and contiguous bored pile replaced with earthwork.

Another stated: "Where it makes economic sense to improve productivity, we do so. For example, we introduced semi-automatic welding; and more off-site precasting where it is cost effective." Finally, one interviewee reported that the company had bought "more advanced and high-technology equipment"; it balances a number of parameters. He noted:

Safety is very important; a safe and good environment leads to high productivity. Maintenance is also important for us. We must be able to maintain our systems. So we do this, so that we can produce more, and fast.

One interviewee noted: "We standardise. We normally set the targets for B-score and C-score.

This would drive productivity." He then explained how design and build enables the company to improve productivity, using one of the company's projects as an example:

> *We take the owner's requirements and then design the building based on the land given, taking into account setbacks and so on. From the client's use statement, we then consider buildability. Then standardisation of grid lines, with optimum floor-to-floor heights and so on. For example for [Building A], we aimed for high buildability; we went for beam-less, flat slabs. In staircases, everyone in Singapore uses precast concrete. In industrial buildings, cranage becomes an issue because [the component] is very heavy. So we used a steel staircase.*
>
> *We used insulated facades made of a composite material. We won a Green Mark Platinum Award for the building. The productivity was super. All the windows and doors were standardised. The perimeter was fire-rated dry board walls. So once it is watertight, I go for the dry board method. This helps in terms of both productivity and safety.*
>
> *We have been using the innovations on that building in our subsequent projects where the clients and consultants allow.*

The interviewee went on: "This was through a group effort. We all brainstormed. With some clients, our hands are a bit tied. Moreover, there are often limits to standardisation. For example, when designing an industrial building, standardisation is difficult because users' workflow and building uses differ. So we come up with innovative designs".

One interviewee reported that at the project level, value engineering during the design stage has been important to the company. It has applied BIM in a big way in its work, and learnt some lessons:

> *BIM itself is a very good tool for improving productivity. However, two things are required to utilise BIM fully. Firstly, it should be a person who knows physical civil, architectural and M&E works, sequences, resources required, productivity of each resource, the requirements (civil, architectural and M&E), and how to operate BIM. Secondly, all the drawings should be completed to input in BIM. Hence it is difficult to use BIM in fast-track projects. These limitations need to be overcome.*

11. What the construction industry as a whole has done to increase productivity since the year 2010

The leading role played by the government was unanimously acknowledged and appreciated. One interviewee noted that: "The industry has been supportive in the government's call to increase productivity. Most companies have invested quite substantially". Said another interviewee: "BCA is strongly driving the programme to improve productivity. [Many other countries] do not have that." Another noted: "Government has set B score and C score. These are driving the industry. The MYE cut is forcing companies to see how to meet it". Another highlighted the following government initiatives that he felt were driving its productivity effort: "PIP, Mech-C through CPCF, and Coretrade".

A point was made about the role of foreign firms, which seemed to be bucking the trend of progress towards improved productivity being made by the local companies:

> *Unfortunately, it is the foreign companies which have not done so. They only use conventional methods. They employ no people; they are not putting any money into training. And yet a lot of our projects go to them. They poach people from other companies. The local companies have done their part. The smaller companies have problems. There is a need for their comprehensive development.*

Other actions which the construction industry had taken were highlighted:

> *SCAL has carried out forums to provide feedback on BCA policies and programmes. It has set up courses on BIM, etc. Consultants have been trying to adapt. Contractors are at the implementation end of the pipe. Many of BCA's ideas and options need to be adopted at the conceptual design stage. Design for Safety is another consideration.*

One interviewee noted: "In the last two years, emphasis has been moving upstream. Clients must commit to using PPVC, BIM, higher Buildability before they can buy government land. In Japan, government has been providing leadership so their projects are systematic".

One interviewee sounded a note of caution on possible over-reliance on government action:

> *This industry is being government driven. That should not be the case. For productivity, the industry should be playing the key role. Everything is government oriented. There is nothing wrong, but the innovation is not coming from the industry.*

12. Interviewees' proposals on how construction productivity can be improved

One interviewee's only suggestion with regard to productivity improvement was an important one: "Focus on VAP (value-added per person)".

Several proposals to productivity improvement were made. They included: (i) Standardisation of design; (ii) Standardisation of components; (iii) Acceptance of alternative designs; (iv) Training of workers; (v) Mechanisation, wherever possible; and (vi) Rationalisation of regulations (an example given was on how gross floor area (GFA) is calculated, as attempts by designers to maximise the floor area makes construction complex, for example by creating voids in floor slabs, and awkward shapes and angles).

One interviewee noted:

> *We need to find ways to do less. An example may be reviewing what we do, and cutting down some layers, for example spending time writing reports, or doing BCA audits. We need a lean approach.*

Another suggested:

> *There should be emphasis on getting the information on time. Everyone in the whole chain must respect the need to get the information to the construction site on time...It may be a cultural thing because in the US, one could not get away with this.*

Another suggestion was:

> *There is no Productivity Management System. So, unlike mandatory ISO 9001, ISO 14000 and 18001, there is no requirement for productivity. The approach has been different. We need a Productivity Management System.*

Other suggestions made were: (i) Improve manpower management skills (of managers and engineers); (ii) Improve the qualified person's design capacity as he is the main agent of value engineering; (iii) Nominate experienced staff to manage scheduling and actual site progress; (iv) Give greater publicity to the government's intention to improve productivity; and (v) ensure flexible application of regulations such as MYE reduction and use of precast elements.

Some points made by one interviewee were:

1. "Consider developing a plan and providing significant subsidies to get Singaporeans back into the construction industry. If it is attractive, it will eventually come around."
2. Put a higher weighting on productivity and safety initiatives in government tenders. In Singapore, the proportion is 80:20; in Hong Kong, SAR, it is 60:40.
3. Contractor registration grading system should require foreign contractors to be Grade A1 registered, or enter into a joint venture with local firms. So foreign companies which have not contributed to the development of the construction industry face stricter regulations when they come in to bid for large jobs.
4. Engineers' salaries in Singapore are still quite low.

Another set of suggestions was: standardisation of sizes and shapes of columns could help enhance productivity; elimination of unnecessary features in buildings which slow down progress in productivity improvement; skills and training.

A small contractor made these points:

1. For SME's, "We are not entitled to MYEs, only the main contractor is. But the government is pushing for more productivity; all that is pushed to us."
2. "Help us with our labour. We can't have a five-day week. Paternity … and child care leave are expensive for us. Safety is an issue too; the responsibility is ours. Now main contractors have pushed it to us."

Some final points were: (i) Promote design and build; (ii) Incentivise the developers by providing them with extra GFA for increased productivity, as is done for Green Mark Platinum; (iii) Work to change the perception of construction among Singaporeans; and (iv) Promote early contractor involvement.

5.3.3 Other relevant issues considered in interviews

The following are several cross-cutting issues that emerged during the interviews.

Core benefit of productivity improvement

One interviewee gave a sharp reminder about the need to improve construction productivity: "One of the reasons Singapore attracts investors is that projects are built quick and cheap. This will make us more competitive. This is one of Singapore's advantages."

Value-added per Person in future?

The measurement of productivity using the indicator of value-added per person was discussed in most of the interviews. In particular, one interviewee commented on it at length, and made several suggestions. He stressed that value-added per person and square metre per man-day are both important indicators of productivity. He urged the industry to pay more attention to the former, noting:

> *Value-added per person is not wrong; neither is it inappropriate to construction. It measures economic value and the industry's actual contribution. Physical productivity in construction had grown but value-added per person had been stagnant. Other industries have been enjoying benefits from…growing value-added per person. In construction, remuneration is not better and the industry is unable to attract good people. It is only if the industry is financially doing well that it will thrive.*

That interviewee suggested that it is important to give more thought to why the construction industry has not grown financially; and specifically, why its value-added per person growth has been negative. He noted: "For long-term viability of the industry, we should not shun value-added per person; we should be open about it and find out why it has been negative. We should create a forum to discuss it". He continued: "Government, at national level, have understood that value-added per person is not complete, and a physical measure is necessary." He added that, in construction, most people, including even CEOs, do not understand value-added per person. He suggested reasons why value-added per person in construction is low:

> *We are in a very competitive procurement industry. At the end of the day it is the lowest bidder who gets the job. What shows that this is the best price?... In Singapore, some of the factors include foreign competition and loss-making on projects.*

A brief international comparison

One interviewee drew many differences between the way things are done in Singapore and another country (referred to here as "Country A"). He noted:

> *Singapore's issue is human. BCA has many initiatives but Singaporean professionals don't go to the site as often as their Country A counterparts. The engineer needs knowledge to appreciate issues and manage human resources on site…The most important thing is that at design stage, more attention is paid to value engineering. Singapore QP engineers have low skills and perceptions compared with their Country A counterparts. They fail to see alternatives.*

The difference between Country A and Singapore contractors is that those in Country A focus on targets. Time and cost come later. This does not mean that things are completely smooth: "Country A clients abuse their rights but are willing to listen". He observed that in Singapore, public-sector clients tend to respect the main contractor, but not the private sector, where they tend to boss over contractors.

On delays caused by changes in design, he noted that the Country A attitude is to accept the engineer's instruction, work, before talking about cost and time. For companies in Singapore, the practice is to calculate time and cost and submit a calculation for approval before commencing work. The Country A approach does not mean that the client always agrees. There are long negotiations and quarrels.

Building up a local core of workers

One interviewee had stressed in the discussion that: "Good productivity is driven by good supervision". He related his company's experience with its local workforce over the years, and offered some suggestions. The company has been in operation since 1971. It recently awarded productivity prizes to two Singaporean supervisors. They have been in the company for 40 years. One started as a labourer, climbed through various stages, including as a crane operator, and is now a foreman. So why are promotions like that not prevalent now? He noted:

> *…in those days, there was not that big disparity in pay between construction and other fields. Now you're just not gonna get them in, because the salary is too low. McDonald's pays $5 to $6 an hour. In construction, the worker gets $3 to $4 an hour. Adding levies, it becomes a cost of about $10 per hour to the company. Experienced workers get more, but in hand, the majority get $3 to $4 per hour.*
>
> *The construction industry is not seen in Singapore as an industry for people to work in. In Australia, the labourer might get a gross of $100,000 a year. In remote sites, during the construction and resources boom, people could be paid $200,000. In Australia people enter at labourer level, and then build up their skills with trade courses.*
>
> *In Singapore, you've lost those great Singaporean supervisors. Our older supervisors are very good; as good as you can get anywhere. Our two Singaporean supervisors were sent to [Country B] to run a pipe jacking project because the skill level at that time was higher than in [Country B], in terms of pipe jacking.*

On subcontractors

One interviewee stressed the role of subcontractors in productivity performance, and the approach towards managing them. He noted:

> *Productivity is very important. My subcontractors will pass all the high costs to me. This will make my costs high. This means I can't win projects. Also, we can't watch them go down because if they go down, it will affect me. So we must ensure that they are productive.*
>
> *This is the driver, not only of productivity, but also safety, quality and others. I tell all my vendors and subcontractors: 'I will treat you as a partner, but during construction, I will treat you as my contractor, to push you'.*

5.4 Survey of international experts

A quick survey of international experts in productivity in construction was undertaken. The experts were either senior academics or executives. The potential respondents were contacted by electronic mail and requested to write quick responses to these questions:

1. How important is productivity considered to be in the construction industry in the country?
2. How is productivity measured in the country at the project and industry levels?

3. Is there a national programme for enhancing productivity in construction? If so, what are the main elements?
4. Do construction companies in the country have productivity policies?
5. What are main drivers of productivity improvement in the country?
6. What are the main obstacles to productivity improvement in the country?
7. What will promote productivity measurement in construction at the project level in the country?
8. What are the current trends in productivity in the country?

The experts approached were in these countries (the number of persons approached in each country is shown in brackets): Australia (2), China (2), Hong Kong (1), Korea (1), Sweden (1), UK (2) and US (2). Responses were received from these countries: Australia (2), China (2) and Korea (1). A compilation of the responses is presented in Table 5.30.

Summary of international productivity practices

The responses from Australia, China and Korea show that productivity is considered to be very important in all the countries. However, it is not systematically measured at the project and industry levels except in Korea where a manager of the subcontractor tracks it daily (because the project owner pays on the basis of work done). Some large Australian and Chinese construction companies have productivity policies. The drivers are different among the countries, but in general, increasing cost and changing structure of the workforce are major drivers. In Korea, government and main contractors are driving productivity growth. The main obstacles to productivity improvement also differ from one country to the next. Unwillingness to invest in training and innovation was a common factor. In China, pressure to measure productivity will come from the need to enhance competitiveness. In Australia, it will be the simplicity of the method of measurement. In all the countries, productivity is expected to be even more important in future. In Korea, an ageing workforce and increasing wages are giving it impetus. In China, the focus will be stronger as more managers are better educated and recognise the importance of productivity.

A major difference between Singapore and the countries surveyed is that Singapore benefits from strong government leadership and a national productivity development programme, while the surveyed countries do not, although there is a training-focused national programme in Korea. A lesson of particular relevance is the preference given to firms which employ specially trained workers, and the relationship between main and sub-contractors in Korea.

Table 5.30: Current approaches to construction productivity in selected countries:responses of experts.

	China 1	*China 2*	*Australia*	*Australia 2*	*Korea*
1. How important is productivity considered to be in the construction industry in the country?	Productivity is considered more important than before since cost of labour price is increasing in the construction industry in China	Very important (in comparing to other dimensions such as environmental performance)	Very important; it is central to the government's economic agenda and in 2014/15 there was a major productivity inquiry into the construction industry.[206]	Productivity improvement in the construction industry is considered to be a key factor for stimulating the overall economy as well as to improving living standards in the nation. It is given a higher place in the national agenda by the government and industry groups and institutions.	Because the duration of a project is deeply related to the project's cost, productivity management is essential. Unlike other industries, construction project comprises several manual-handling tasks, and still most Korean projects rely on labourers' work. Thus, improving individual level productivity is regarded as a key issue and mostly managed by project manager.
2. How is productivity measured in the country at the project and industry levels?	Not seriously measured at project level, while output per capita is used at industry level.	Normally, turnover per capita	Hardly at all. Firms do not do it, and nor does the government. The productivity report is excellent and sets this out and calls for someone to do this. I published some of the results of what is happening in Australia in ECAM[207] last year from a subcontractor's perspective. Brookfield Multiplex (BM) has a productivity committee; it has developed a productivity strategy. BM are the most advanced but progress in implementation is slow. The biggest problem is measuring it and not over complicating it! We have tried that on a number of projects.	Productivity is expressed as a quantitative relationship between industry output and the labour and capital inputs. The 'value-added' created by the industry is used to measure the output. In the case of labour inputs, the best measure is hours worked.	Productivity is usually measured by comparing 'work done' and 'work planned'. For the project level, a manager from the subcontractor may track each process everyday (e.g., how much work is done by a certain worker). Project owner pays for 'work done', and general contractor can roughly measure the productivity as the cash flow. For industry level, productivity can be measured in a much simpler way such as comparing timeline of the work-done and work-planned as a percentage of the procedure.

206 BCA (2012) Second Construction Productivity Week, http://www.bca.gov.sg/newsroom/others/pr16052012_SCPWB.pdf

207 'ECAM' stands for "Engineering, Construction and Architectural Management", a good academic journal.

3. Is there a national programme for enhancing productivity in construction? If so, what are the main elements?	Not yet.	No specific programme at national level.	No, but I have argued many times that there should be.	There used to be a national commission set up by the government to promote construction productivity, named Australian Construction Commission. This was replaced by Fair Work Building and Construction in 2013 (check this report in the footnote[208]). The new government promised to resurrect the commission, but this has not yet been done.	There are various policies from the government, and two programs follow. The 'Skilled Worker Training Program' promoted by KICTE (Korea Institute of Construction Technology Education) includes design, construction, quality control, and safety/health issues. When workers complete the courses, they can be promoted as higher-skill workers and granted advantage when finding a job. Ministry of Land, Infrastructure and Transport recommends that companies should hire the skilled workers who have completed the course, and gives tax breaks to the companies which do so. This policy can motivate unskilled workers to become skilled workers. The other program is for foreign workers; it is called 'Employment Permission'. Through this system, firms can hire well-prepared foreign workers who have also passed the Korean language test. The policy enables foreign workers to find a job 'legally', which is directly related to their job security.
4. Do construction companies in the country have productivity policies?	May have but not a priority.	Only those large and stated owned companies have such policies.	Yes, BM does (informally). Lend Lease had a productivity director but he was moved and they abandoned the position. They would all say they do but in reality they do not.	I am not sure about individual companies, but the Construction Industry Forum develops policies and recommendations for the industry as a whole. (See report in footnote.)[4]209	There are no specific policies at the company level. However, construction managers have responsibility for improving productivity. Managers are educated occasionally for project control and technological issues.

208 https://www.fwbc.gov.au/
209 http://www.acif.com.au/policies

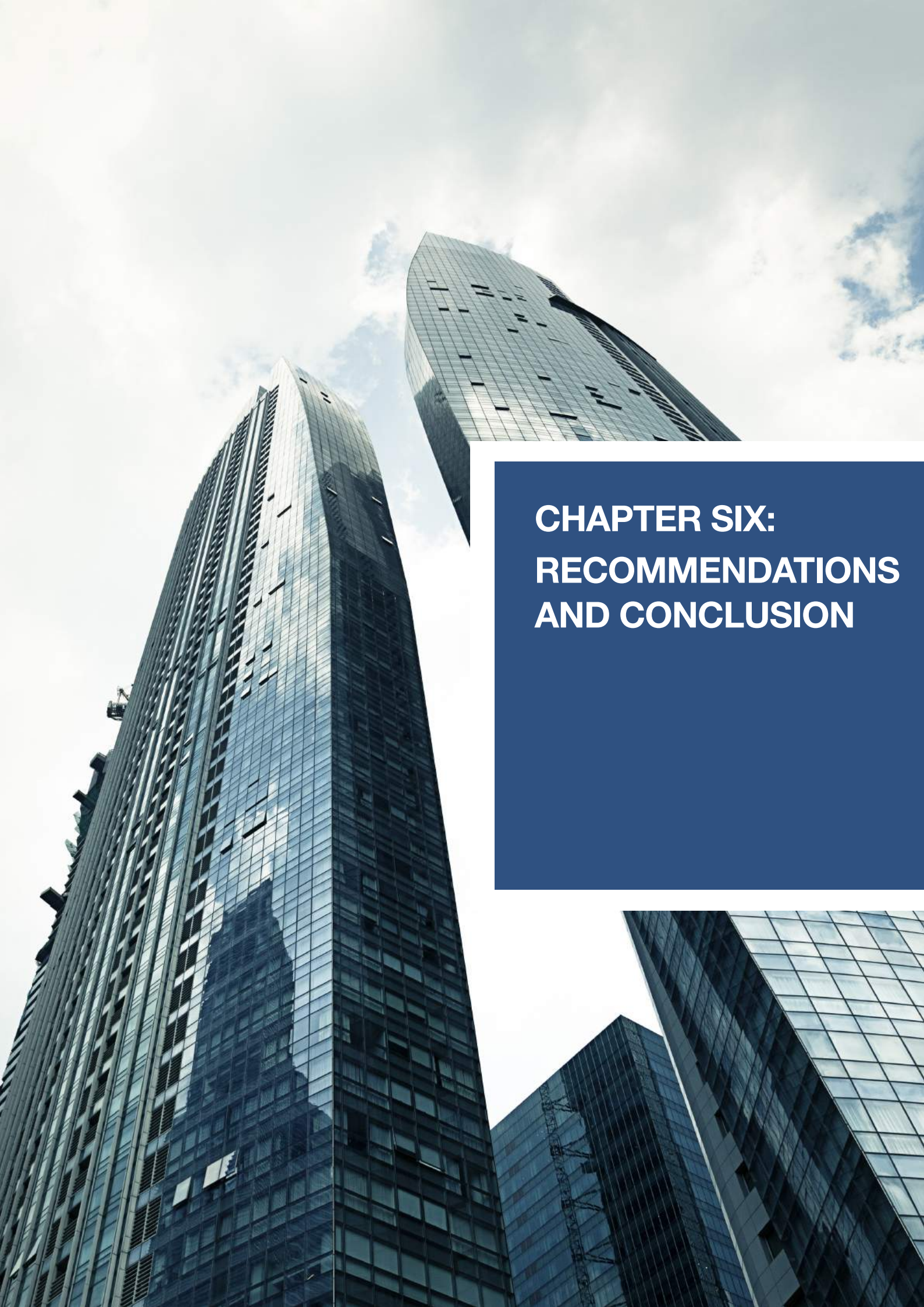
5. What are main drivers of productivity improvement in the country?	Labour cost.	Saving cost, making profit.	See the report above, and also my paper in ECAM.	Innovation and technology adoption are considered the main drivers of productivity. Innovative materials and methods and ICT (web technologies, mobile computing, BIM) are examples. Effective supply chain management is also considered a driver.	Government; if it shows interest in productivity or safety, most companies will directly respond them. Second, general contractors. The contractor may control the subcontractors by shortening the duration or lowering the budget, both of which are core factors of productivity. Background information: in South Korea, the relationship between general contractor and subcontractor is quite strict, and responsibility for higher productivity and lower cost is shifted onto subcontractors, who then shift the pressure onto each worker and require them to work faster and perfectly. This bottom-up process may improve or worsen productivity.
6. What are the main obstacles to productivity improvement in the country?	Labour cost is not that high.	Poor skills and lower education for on-site workers.	Many say industrial relations (there have been 3 Royal Commissions into the industry… the most of any industry in Australia). I say not. I say it is a distraction. The biggest problem here is complacency after 24 years of continuous economic growth. Foreign competition is going to wake us up. There is only now one Australian owned contractor (Lend Lease) and I have heard they will be on the market soon. A Chinese or Japanese firm will buy them up.	Lack of investment or unwillingness to invest in, innovation and technology adoption is a key barrier, particularly among small and medium-sized companies. Similarly, skill level of employees to adopt innovation and technologies is a barrier. Organisational culture is also a barrier for innovation and technology adoption.	General contractors usually do not invest in training or education of workers for skills improvement or better labour conditions. The answer to this question is similar to that for Question 5. The bottom-up responsibility system can hinder growth of stagnating productivity. Aging society and lack of skilled workers are also obstacles to productivity improvement. Since labour conditions (wage, job security, social status, etc.) in construction are worsening, young ones are not entering it. Although some new workers are young, they are not well-trained and they easily quit due to low wages and hard work. Thus, only unskilled workers and foreigners (from China, Pakistan, Vietnam etc.) remain, with low wages that eventually decreases the productivity of the industry.

7. What will promote productivity measurement in construction at the project level in the country?	Pressure to improve competitiveness.	The level of advanced technology used and the skills level or education of the construction workers.	At industry or project level? Simplicity. Complex approaches do not work.	(Refer to the link in the footnote.)[210]	Productivity is measured and recorded by all managers. In case of project delays, the project owner may want to find out who is responsible. Also, responsibility for productivity control is clearly stated in the contract, for the parties involved to note. Historical data from productivity measurement can be a reference for a new project. When companies have records of successful productivity management, they can have an advantage in later projects.
8. What are the current trends in productivity in the country?	It is becoming more and more important.	This will improve as more managers become well educated and have greater awareness of the importance of the subject for the sustainable development of their organisations. They will make appropriate investments and form relevant policies.	See the linked report above; that says it all.	Please refer to the link in the footnote[211]	The answers to this question are similar to those for Question 6, an aspect of the aging society. Foreign workers are rapidly replacing young Korean workers, and controlling the foreign workers has become a challenge. Understanding their language, culture, and identity can influence their performance. The other trend is related to 'cost saving'. In Korea, workers' minimum wages are increasing (especially those for skilled workers). Therefore, companies attempt to make savings from other parts of projects. As part of such efforts, companies do long-term investment in automation of work processes, from BIM technology to be used do approximate estimating to construction robots which can replace human workers.

Source: OECD.Stat, http://stats.oecd.org/index.aspx?queryid=28226

210 http://www.aigroup.com.au/portal/binary/com.epicentric.contentmanagement.servlet.ContentDeliveryServlet/LIVE_CONTENT/Economic%2520Indicators/Construction%2520Survey/2015/Construction%2520industry%2520profile%2520and%2520Outlook.pdf

211 http://www.aigroup.com.au/portal/binary/com.epicentric.contentmanagement.servlet.ContentDeliveryServlet/LIVE_CONTENT/Economic%2520Indicators/Construction%2520Survey/2015/Construction%2520industry%2520profile%2520and%2520Outlook.pdf



CHAPTER SIX:
RECOMMENDATIONS AND CONCLUSION

6.1 Introduction

In this chapter, a strategy for productivity improvement, spearheaded by SCAL, is presented. Some recommendations are outlined, based on the objectives of the strategy.

6.2 Developing a strategy to improve the productivity of contractors

Rationale for SCAL and contractors to take ownership of productivity

The enhancement of productivity is a key factor in a nation's economic growth. It is also essential in the healthy growth and competitiveness of companies. Singapore has had a government-led programme for improving productivity performance in the economy for many decades. The improvement of productivity in the construction industry has been driven by medium-term strategies, regulations and incentives. Construction companies have also taken measures to improve their productivity. While views differ on whether productivity has grown over the years, it is acknowledged by all the stakeholders that there is much room for improvement. Measuring productivity at relevant levels will help to determine where action is needed, and what can be done.

Productivity improvement in construction is a complex undertaking, which requires action by all the parties involved in projects. The contractor bears the responsibility of delivering the physically built item, in which the contributions of the stakeholders culminate, and where productivity performance of the project is determined. It is time for construction firms in Singapore, and their trade association, SCAL, to take ownership of productivity performance in the construction industry and provide leadership towards its continuous improvement. This action would supplement the ongoing efforts of the government and other industry stakeholders. A strategy for contractors is thus required.

Aim

The strategy should aim to realise the full potential of the concept of productivity to enable the construction industry, through its component enterprises and practitioners, to create value in the economy of Singapore for the benefit of the citizens.

Vision

The vision of the strategy is: by 2025 the construction industry in Singapore will comprise enterprises competing in the performance of projects at a higher level in productivity, quality, safety, health and environment and creating value in the economy. The construction industry will have a sound social image. It will be widely perceived as productive and innovative. Construction companies will have path-breaking corporate policies, and leadership and management approaches. They will be applying the most advanced and relevant technologies. They will have healthy balance sheets.

Broad productivity targets

By 2025, the construction industry in Singapore, with contractors playing a key role, will have productivity targets and attainments at least equal to the target set for all sectors of the economy.

Objectives to improve productivity

Here are some strategic objectives that contractors can focus on:

1. Measure, use and monitor productivity
2. Productivity-driven corporate management
3. Productivity-driven project management
4. Productivity-enlightened client approach
5. Leadership by the contractors and their association
6. Further development of government's productivity enhancement programme
7. Appropriate attitude and orientation: Adopting a productivity culture.

Although these objectives as well as any initiatives formulated under them are interconnected, they are considered individually below, together with some proposals presented under each of them.

6.2.1 Objective One: Measure, use and monitor productivity

Productivity is important for the growth and competitiveness of construction companies. In this industry with traditionally low margins, continuous efforts to improve productivity is a sound business objective. Another reason is the tightening market for human resources. "Doing more with fewer" and "Building more with less" should be vanguard expressions of construction firms.

1. Construction companies could take a systematic approach to the development of their productivity-enhancing capabilities and capacities at the trade, project and company levels. They should measure productivity at these levels, and use the results to develop and set appropriate targets within the company and at the relevant stages of their projects, to monitor their work, and to assess their performance.
2. Construction companies could adopt a comprehensive approach to productivity measurement. The approach would include the adoption of multiple measurements, indicators and benchmarks, each for different purposes, within the group, project or company. A list of these indicators is suggested in Table 6.1.

Measuring trade-level productivity

1. Who should measure? Main contractors should take ownership of trade-level productivity on projects because much of the work is undertaken by labour subcontractors. A poor performance by, or failure of, the subcontractor can have an impact on progress of the project and poses risks to the main contractor.
2. What tools and guidelines should be used? Companies could use the BCA guide on measurement of trade-level productivity as it provides the necessary guidelines and support.
3. What should the data be used for? Construction firms can use trade-level productivity data: (a) for estimating all-in rates for preparing bids or for comparison with subcontractors' quotations; (b) to plan and schedule projects; and (c) to set targets at relevant stages of the project by the main contractor, subcontractors, suppliers and other enterprises in the value chain.
4. What enhancements can be made?
    a. BCA could further develop the guide for measuring trade-level productivity. The list of trades could be extended; and data on trade productivity could be published to form industry norms.
    b. The trade productivity levels could be re-measured every three years through a joint effort of BCA and SCAL, and published in the revised versions of the guide.
    c. SCAL could widen the range of trades in the annual competition among groups of workers from member companies (held during the Singapore Construction Productivity Week (SCPW)), and use it to collect and publish trade productivity norms. These norms could be outliers, but they could be targets for companies to aim to attain.

Measuring project-level productivity

1. Who should measure? Main contractors should also take ownership of project-level productivity as they have direct control of the sites, and the information gathered is most beneficial to them.
2. What tools and guidelines should be used? Firms can use the data that they have collected for the submission of their projects through ePSS. The data can be used for their own purposes in estimating productivity at the project level, and at sub-levels of the project.

3. What should the data be used for? Construction firms can use project-level productivity data for: (a) making comparisons with achievements on previous projects; (b) making comparisons with BCA's industry data; (c) benchmarking their performance against those of competitors; and (d) setting targets for future projects.
4. What enhancements can be made? Construction companies can address these issues:
    a. take measures to ensure that the data collected are accurate and appropriately categorized.
    b. consider calculating trade productivity data from the project-level information they have collected; this will require appropriate structuring of the data collection instrument.
    c. (over the medium to long term) consider using their data on productivity and other project performance parameters such as cost, time, quality, safety, health and environmental performance to establish a company approach to making trade-offs among the parameters in various contexts.

Measuring industry-level productivity

1. Who should measure? DOS and BCA are the relevant government agencies to measure industry-level productivity.
2. What tools and guidelines should be used? DOS is able to estimate both value-added per worker and value-added per paid hour worked. BCA has collected useful data on projects submitted through ePSS.
3. What should the data be used for? Both the monetary and physical indicators are useful in assessing the performance of the industry. The results could be related to each other as trends in each of them might indicate the need for different courses of action. The monetary indicator is also useful in assessing performance in comparison with that of other sectors and construction industries in other countries.
4. What enhancements can be made? A number of enhancements can be made:
    a. DOS can make a minor but important change when it comes to presenting data on annual productivity growth of sectors of the economy to avoid the impression that the focus is on construction. It can: (i) omit the figures for "total without construction"; or (ii) include a note indicating the reason for doing this, for example, noting how different construction is from other sectors, and where readers can find other construction productivity data (such as the physical measures).
    b. DOS and BCA can estimate and publish future trends in both indicators of industry-level productivity, and highlight likely contributors to lost productivity, to enable the industry to take action, where possible. For example, the physical indicator might be lower in future as, owing to the ageing stock, the volume of output includes increasingly greater proportions of renovation, retrofitting, conservation and rehabilitation.
    c. Given the imminence of the productivity-driven economy, BCA, CIJC and other industry stakeholders could study the components of "value-added" in construction as they could provide indications of broad actions for change in the construction industry. For example, issues under the components of the numerator in the equation are (see Appendix Five):
        i. Total Remuneration, especially Wages and Salaries, should grow if the industry is to be able to attract good-calibre personnel
        ii. Operating Profit will be low if price remains the basis of competition in the industry
        iii. On Indirect Taxes and Levies, the possible impact of levies on profit in a competitive market could be borne in mind.

List of measurements and indicators for companies

What should be measured? Construction companies in Singapore could use various measures of productivity on their projects and in their companies, which relate directly to their operations at various levels. A range is presented in Table 6.1.

Table 6.1 List of productivity indicators in construction

Indicator	*How to measure it*	*Usefulness*	*Measures to ensure accuracy*
Reducing MYE	Set MYE target and assess its real usage	As the MYE quota is increasingly being reduced, and its allocation for the project is fixed, a reduction is an indicator of efficiency in allocating manpower. Policies adopted to achieve this reduction can be replicated and further developed.	Monitor subcontractors' use of foreign workers.
Square metre of Completed Floor Area per Manday	Data on all workers involved in the project is collected as the project progresses. Company can estimate its own figure when submitting data to BCA via ePSS.	The physical indicator of completed floor area per manday is most useful for the construction company. Data can also be aggregated to obtain industry measures.	(a) The physical data collected should be really accurate; (b) the workers' information should also be captured to appropriate levels of detail, to enable finer analysis; (c) there should be proper association of each piece of work with the manpower input.
Project Cycle Time (per floor)	Number of days worked per completed floor.	Project team and company can compare their performance with industry norm.	This is an industry metric, and there are performance norms. SCAL and BCA could work together to define categories of buildings and measurement guidelines, in order to obtain industry benchmarks.
Value-added per Person Employed	Use BCA's template.	This may be calculated at both project and company levels. It can also be determined by trade (focusing on the major trades which constitute the bulk of project value), so that companies can focus on improving performance at that level, for example, through alternative methods. The data on projects and trades can be compared over time, as well as among trades.	At both project and company levels, having the complete and accurate records of both the output (components of value-added) and input (number of persons employed) would be critical.
Value-added Per Paid Hour Worked	Use BCA's template, and calculate Total Time Worked (obtain this from ePSS data).	Similar to value-added per person employed. This metric is more accurate than the value-added per person employed indicator, and provides a more accurate indication of how the company allocates manpower.	There is the need for even greater accuracy in the compilation of the input (paid hours worked) data.

Target Buildability vs Attained figure, following design changes	B-Score upon approval vs re-calculated B-Score	This is useful if there had been a change in design or materials applied, which would influence the B-Score.	--
Target Constructability vs Attained figure, following design changes	C-Score upon approval vs re-calculated C-Score	This is useful if there had been a change in design, materials or methods applied, which would influence the C-Score.	--
Time Saving	Planned completion time vs Actual completion time	Company saves time, which leads to other savings in areas such as labour, interest on loans, equipment and other applied assets. Time saved frees capacity, enabling the firm to take up other projects. Time saved on project builds track record and enhances competitiveness.	--
Cost Saving	Total Cost as in Budget vs Final Cost	This implies better usage of resources than anticipated. If revenue is, at least, maintained, this leads to higher profit (see below).	--
Profit Level	Total Revenue less Cost	This builds reserves, enables investment and higher worker compensation, contributes to corporate growth and development, and enhances competition.	--
Progress towards completion; or Cumulative time vs Target time for completion	Determined from project's Schedule	This indicates progress, and gives a warning, where relevant.	--
Cumulative Periodic Revenue (say monthly)	Determined from project's Cumulative Revenue estimates	This can be calculated for own firm and subcontractors, to monitor progress by both entities.	--
Cumulative Periodic Cost (say monthly)	Determined from project's Cumulative Cost estimates	This can be calculated for own firm and subcontractors, to monitor progress by both entities.	--


STRATEGY
TEAMWORK
SOLUTION
DEVELOPMEN

6.2.2 Objective Two: Productivity-driven corporate management

Productivity growth is fundamental to the healthy growth and development of any company. Companies need to take a strategic approach to productivity improvement and encourage their business partners to do the same, for their mutual benefit.

1. Each construction company could: (a) formulate a productivity policy; (b) appoint a director in charge of productivity at the corporate level, and a person to take responsibility for it on each of its sites (in the short term, and to save cost, the project manager can take up this responsibility, but it should be a clear, separate task); (c) communicate the productivity policy throughout the organisation (and on sites) and among the business partners; and (d) pursue productivity enhancement in a systematic manner in all its operations.
2. Construction companies could adopt a value-chain approach to productivity performance improvement on projects, and guide and nurture their subcontractors, suppliers and other business partners to be concerned about it, and take measures to enhance their own productivity. Through considerations in incentives, guidelines for project procurement procedures and productivity awards, BCA could build and foster such a value chain orientation among the companies.
3. As part of the value chain orientation, construction companies should improve their relationships with subcontractors. The companies could nurture the growth and development of their subcontractors. They could monitor the subcontractors' performance as projects proceed, review subcontractors' performance after each project, and help them to improve.
4. Construction companies could adopt a comprehensive approach to improving their human resources. This requires the effective application of strategic human resource development and management, including needs assessment, human resource planning, training, assessment of effectiveness of training, appropriate compensation, motivation, career development and suitable deployment for continual career progression. In this context, companies could focus on the development of project managers and supervisors as it was found in the study that they are deemed to be very important in the productivity drive. Companies could also ensure the coverage of "productivity" in the training of its personnel at all levels where relevant.
5. Construction companies could adopt more advanced technologies, where relevant. For example:
    a. ICT and its various applications such as BIM, could be used to facilitate data collection, tracking of productivity performance during the project, such as its measurement, monitoring of work and comparison with the target via productivity indicator(s), and monitoring of subcontractors' work
    b. companies could consider adopting further mechanisation, where relevant on the project, and where it is in line with strategic corporate objectives. The firms could develop in-house decision-making systems for supporting the selection of productivity-enhancing technologies, based on a balance of factors including costs, risks, availability of skills, and sustainable use of the item
    c. off-site production is being promoted and supported in a major way in Singapore. Companies can take advantage of the increasingly maturing segment of the industry.

6.2.3 Objective Three: Productivity-driven project management

Management inadequacies are identified in literature as the greater cause of poor productivity as compared to workers' skills. In the interviews, the quality of supervision was highlighted as one of the key determinants of good productivity performance on projects.

1. Construction companies could take measures to enhance the quality of their project management systems and procedures. They could:

a. invest in, and use advanced project management software to facilitate their efforts

b. maintain a continually updated record of productivity-enhancing approaches and practices on each project; and identify the good practices on their projects and share them within each company

c. arrange occasional (say quarterly) sharing sessions among its project managers.

2.. Project preparation and project planning were given a very high ranking in the survey among the actions needed to enhance productivity. Construction firms could undertake these procedures systematically, taking into consideration all the key inter-related aspects of the project, including subcontracted and outsourced elements such as prefabricated items.

3. Construction companies could adopt and develop appropriate project management policies and practices, which involve a systematic approach to productivity and are geared towards enhancing the performance of productivity. These should recognise the place of productivity in the range of project performance parameters. Over time, and from project records, the companies could develop guidelines on how their project managers should "balance" the parameters, in different, broadly categorised circumstances.

4. Construction companies could adopt a practice of maintaining a project productivity health card on each project. This card would be used to monitor performance on all the project parameters. On productivity, it would include the information under the panel of productivity indicators, selected by the company.

6.2.4 Objective Four: Productivity-enlightened client approach

Clients have the responsibility to set the right tone for the entire project. They can influence the behaviour and approaches of all participants towards productivity. Clients should make the productivity of their projects their business.

1. Clients could stress to project teams the need for attention to productivity on their projects starting from its inception, by setting appropriate goals (such as the winning of productivity awards) and targets (beyond the minimum requirements in the regulations), and instituting incentive schemes to encourage their attainment (such as a productivity bonus scheme).

2. Clients should recognise the relevance and usefulness of the enhancement of productivity on their projects. Here are some ways that they can contribute:

   a. consider giving some weight to productivity in the procurement of the services of design consultants and contractors for their projects—they could be guided by the example set by the government

   b. influence the design team to be productivity-oriented in their design, and in the administration of the project; these could include:

      i. designing for ease of construction to allow simplicity, buildability and use of prefabrication, PBU and PPVC, where appropriate.

      ii. ensuring coordination of the inputs of all design team members

      iii. minimising design changes after work starts on site

      iv. responding to requests for information from other project participants promptly

   c. consider adopting "integrative" procurement approaches such as design-and-build, or early involvement of construction firms in the project to contribute to the design

   d. ensure that projects are properly prepared (in terms of documentation) before they start on site

   e. set reasonable time targets for projects—it would be useful for a mechanism to be established under which clients could seek guidance on the appropriate duration of their projects.

3. BCA could encourage private clients to give productivity performance greater consideration as has been attained for quality and environmental performance. The government's example of adjusting the procurement formula is a demonstration of leadership. In addition, the government could consider giving a bonus, such as additional floor area, to clients in the development of their productivity awareness.

6.2.5 Objective Five: Leadership by contractors and their association

Productivity has not been given much attention by contractors and other members of design and construction teams for projects in Singapore. However, it has been a major policy intention of the government even before the ESC recommended the new productivity-driven economic growth strategy for the nation, and the CFE stressed value creation.

1. SCAL should set the tone for a new approach among construction firms which gives priority to productivity. The association should provide the leadership, from which the companies need in this new era of transition towards a productivity-driven economy in Singapore.
2. SCAL could:
    a. advise construction companies to be guided in their corporate policies by nationally planned approaches and aspirations, which are formulated for the economy as a whole, specifically for the construction industry.
    b. encourage recognition of the importance of productivity at all levels of the industry and in every company i.e. policy formulation, education, awareness building and reminders on sites.
    c. arrange periodic best practices sharing sessions on productivity for members; there could be three levels—Directors in Charge of Productivity; Project Managers; and Site Productivity Officers.
    d. make productivity a topical agenda item in each SCAL Council meeting, and meetings of CIJC.
3. SCAL should translate the commitments it has made on behalf of its members in various areas into action. The MoU on the HR Pledge is most pertinent here. The various principles of the pledge could guide companies in formulating and implementing their human resource development policies and practices; SCAL could propagate the pledge among its members and organise courses on how the firms could realise the commitments.
4. SCAL could foster strong partnership between main and subcontractors as a business orientation among its members. One of SCAL's own sub-objectives could be that main contractors should help their subcontractors to grow and to improve their performance as it is mutually beneficial.
5. SCAL could act to supplement the government's actions on the enhancement of the performance of the construction industry in general, and in this context, productivity. Some actions SCAL could take are:
    a. publishing an annual guide on productivity, which covers the following topics:
        i. explanation of productivity and its merits and applications in the context of a construction company and the industry
        ii. the productivity indicators
        iii. incentive schemes available, and how to apply for each of them
        iv. the training courses and funding support available
        v. regulations on productivity which have direct relevance for the contractor
    b. providing training courses on productivity, especially on its measurement, for example, on the indicators shown in Table 6.1. Other topics could be identified from feedback from the industry.

6. SCAL could work more closely with BCA on initiatives and projects which are beneficial to the construction industry. For example, BCA Academy and SCAL Academy could work together to minimise duplication and gaps in coverage.
7. SCAL could also occasionally develop and publish its own knowledge products on key aspects of the construction industry (this is a key function of professional institutions and trade associations in industrialised countries). The report from this study could be developed into one such publication.
8. SCAL could institute a series of construction productivity awards. There could be awards at the:
    a. trade level such as at annual competition at SCPW
    b. construction company level
    c. client organisation level.

These awards could be given much publicity and given out at major events, and their prestige burnished over time to make them desirable.

6.2.6 Objective Six: Further development of productivity enhancement programme

The government-led construction productivity development programme, which has been in place since the mid-1980s, has led to improvements in many areas of the industry, and evident upticks in physical productivity. It could be further enhanced, in a new phase of the productivity enhancement programme which: (a) involves stronger public agency and industry partnership; (b) stresses measurement of productivity attainment at appropriate levels; and (c) targets incentives to encourage and support good practice.

1. BCA could work with CIJC and other relevant industry stakeholders to undertake a comprehensive review of the construction industry and make concrete proposals for its organisation and setting up for continuous productivity improvement and the delivery of timely, cost-effective, high quality, environmentally responsive built items. Some of the issues to consider would be:
    - the project performance parameters. An agreement from the project's stakeholders should be made on striking an appropriate balance between productivity and performance parameters such as quality, safety, health and environment
    - procurement policies and procedures
    - the regulatory environment
    - business practices
    - appropriate incentives and support programmes to encourage good practice in the new set up.
2. BCA could adopt a (holistic) global approach to the planning, promotion and support of making improvements to the performance of the construction industry. For example, currently, productivity and environmental performance have separate road maps, development programmes and incentive schemes. This can lead to a silo approach. A strategic, consolidated and comprehensive approach could be pursued.
3. BCA could do more to explain to the construction industry the definition of "productivity" and its relevance to companies. It could:
    a. educate the industry on the need for greater sensitivity towards productivity in the context of the new productivity-driven, and (soon to be) value-creating economy of Singapore
    b. explain the various productivity indicators which are relevant at different levels of the industry and how they come together. In particular, the merits and appropriateness of the value-added productivity indicator could be further explained to the industry.

4. In this study, reviewing and reducing regulations; and rationalisation of the approval process (especially in multi-agency situations and the need for firms to complete various documents) were suggested by many respondents. BCA could take these issues up. For example, the implementation of regulations and schemes could be closely followed up in the initial two years or so, in order to obtain feedback from industry for fine-tuning them. On approvals, BCA could monitor, through industry feedback, areas where the work of the BIP could be further enhanced.
5. The incentives for productivity improvement have been useful to construction companies. BCA could:
    a. publicise the incentive schemes further, such as on a dedicated webpage
    b. follow each of the schemes up systematically, for example, to ensure the intentions in terms of coverage, quantum and eligibility criteria are appropriate
    c. periodically review and fine-tune the various schemes after getting feedback from beneficiaries and the industry in general
    d. publish key issues on each of the incentives, for example, providing an annual or twice yearly account of
        i. how much support has been provided under each scheme
        ii. what the common success criteria for applications under each scheme were
        iii. what the common mistakes and causes of failure at application stage were
6. BCA could provide direct incentives for construction firms to measure trade-level productivity. BCA could also collaborate with other agencies to offer relevant support schemes to segments of the construction industry. For example, it could work with SPRING Singapore to develop an appropriate support programme for SMEs, for example, through strengthening the relationship between main and subcontractors such as in technology transfer partnerships.
7. BCA could base relevant parts of the productivity development programme on lessons from the construction Quality and Environmental performance enhancement programmes. For example, a Productivity Bonus Scheme on public-sector projects, based on real performance on the contractor's current project, could provide an incentive to measure, monitor and improve productivity.
8. BCA could prepare a guide for the industry based on the documents collected of the good practices adopted by winners of the Productivity Awards over (say) the first three-year period upon its submission for the award, which could be updated (say) every two years. This could be supplemented with information on new technology and practices available in the market.
9. BCA could also "market" productivity growth as being highly beneficial to all construction industry stakeholders and society. In this regard, the client would appear to be one of the most important players. Some possible initiatives that can be taken up by clients include:
    a. instituting a productivity award, specifically for the client
    b. consideration of productivity achievement on the client's previous projects in GLS exercises
    c. offering of additional floor area for projects with high productivity attainment, on a graduated scale (the productivity figures could be derived from both value-added per paid hour worked and square metre per man-day)

    End purchasers and users of buildings would also be appropriate targets of a programme, which educates them about the merits of productivity in the construction industry. BCA could prepare a booklet or flyer on these wider benefits of a "productive" construction industry.

10. BCA's ePSS data submission system is a useful mechanism, which can yield valuable information for many aspects of project performance besides project-level physical productivity. BCA could:
    a. make efforts to make it as easy to use by contractors as possible, and to ensure that the data they submit are as accurate and appropriately categorised as possible
    b. encourage and train construction companies to use ePSS to capture both trade- and project-level figures. These could then be appropriately modelled into macro-level figures for the industry. Thus, BCA could estimate and release data on value-added per paid hour worked, in addition to the physical productivity figures compiled from the ePSS submissions.
11. BCA's Value-added per Worker Template is a useful tool. Here are some suggestions:
    a. it could be given more publicity
    b. project level versions could also be provided
    c. a mobile application could be prepared(?) This would enable the idea of "value-added" to reach the middle and lower levels of the industry. Individuals, groups and Project Managers could calculate value-added for their own activities, group tasks and the projects
    d. there could also be a template for value-added per paid hour worked.
12. At the national level, BCA could anticipate and plan for the development of "specialist" workers for new technologies to be introduced. A fundamental question to be considered is whether the current range of "trades" is what is desired in the new productivity-driven industry. Another question to consider is whether the titles and combinations of the "trades" need to be changed to reflect what they currently involve, or what they will involve in future.

6.2.7 Objective Seven: Adopting appropriate attitudes and orientations: a productivity culture

"Productivity not gained is productivity lost." This should be the attitude of all stakeholders involved in construction projects as the potential benefits of productivity growth accrue to all of them, and to society.

1. Construction firms need to adopt a productivity mindset, especially in the era of productivity-driven economic growth. This mindset could give equal attention to both the economic (especially value-added per paid hour worked) and physical measures of productivity at both project and industry levels, because, in an economy that is value creating, each sector will be expected to show how it is doing this. The companies could diffuse this awareness of the importance of productivity within their organisations.
2. Construction companies could encourage and assist businesses in their value chain to adopt a productivity orientation. This could be in the form of preference for companies with good productivity performance or productivity-assisting practices and procedures in the construction firms' procurement exercises.
3. BCA and SCAL could collaborate to foster a productivity culture among construction firms. BCA could also work with (public- and private-sector) clients to help to create the productivity mindset among construction firms, as has been done for quality, environment and increasingly, health and safety.

6.2.8 Objective Eight: Lean construction and management of waste

"While much of the efforts to improve productivity have been based on adoption of technology and mechanization, the opportunities to gain productivity by reducing waste of productivity cannot be ignored"

1. All stakeholders involved in the industry should constantly identify leakages in productivity such as unnecessary waiting time, repetitive tests or checks, and late provision of information needed to move the job along.
2. In particular, companies and individuals should examine where their actions, or inaction may be causing delays to other parties (since it may not be felt by the party causing the delay and therefore may be perpetuated into habits that disrupt productivity).
3. BCA and SCAL could work together to bring in experts on the subject to share their knowledge with industry practitioners.
4. Companies could be encouraged to adopt programmes to have constant improvements in productivity or waste reduction such as the Japanese Kaizen system.

6.3 Further studies

Some further studies that can be considered are as follows.

1. BCA has the relevant data on all construction projects. It could undertake these studies:
    a. physical productivity indicator of man-hours per square metre for the industry
    b. relationship between man-hours per square metre and:
        i. Buildability Score
        ii. Constructability Score
        iii. relationship between man-hours per square metre and value-added per paid hour worked
        iv. using a long-term series of value-added per paid hour worked data to estimate MYE for various types of projects.
2. With BIM so widely used, and expected to enhance productivity on projects, it would be appropriate for BCA to consider calculating productivity on the entire construction project (including design).
3. SCAL and BCA could seek to develop a Productivity Management System for Construction in Singapore.

6.4 Conclusion

Productivity is an important concept at the level of an economy, an industry, and a company. It has been identified as lying at the root of economic growth, increasing income and long-term national development. It is a determinant of the healthy and sustained growth of a company. In all countries, it has been acknowledged that action is required to attain productivity growth. Measuring productivity performance at relevant levels is critical to this action.

Productivity is a difficult concept to define particularly in construction owing to the nature of the industry, its processes and its products. There are many factors causing productivity in construction to be low. Measuring productivity in construction at any level is also a challenging task. However, efforts are made to measure productivity at four levels: the trade, project, company and industry levels. At trade and industry levels, it is possible to obtain both monetary and physical indicators of productivity. In many countries, the usual monetary indicators of productivity in construction show that periods of productivity decline can occur. There are arguments about whether such findings are correct, considering the existence of progress in the industries in terms of the technologies adopted, the processes, systems and knowledge applied and the complex buildings and infrastructure items realised. However, there is a general agreement that productivity should be improved.

Productivity improvement is receiving greater attention. For example, it is suggested that, in the US, the large construction companies in the industrialised countries now consider improvements in productivity as a survival strategy,[212] especially in view of the level of international competition. Owing to the diverse range of sizes of construction companies in the fragmented industry, the companies do not have the same ability to deal with the issue. The review of the literature and a survey of experts showed that the strong leadership from the government in Singapore and the high volume of financial support is quite rare. A stronger partnership between the government and the contractors' association would help in further developing the construction productivity programme.

As greater focus is being put on productivity-driven economic growth, it is time for construction companies and SCAL to show greater understanding of productivity and its enhancement, and adopt a systematic approach to the improvement of the productivity performance of the industry. It is time for construction firms to embark on the necessary steps towards a productivity culture in their companies and the industry. The seven-objective strategy proposed can help in this endeavour.

While acknowledging the importance of productivity, it is necessary to avoid considering it as a single, stand-alone, independent issue. In construction, productivity performance is only one of a range of success criteria. It is important to put it in the context of other parameters, and to adopt a holistic approach to performance improvement, at both the company and firm levels, in which productivity is given appropriate attention.

212 Bernstein, H.M. (2003) Measuring productivity: an industry challenge. *Civil Engineering*, December, pp. 46-53.

ABBREVIATIONS

ASTM	American Society of Testing and Materials International
BAS	Biometric Authentication System BAS
BCA	Building and Construction Authority
BDAS	Buildable Design Appraisal System
BIM	Building Information Modelling
CAS	Constructability Appraisal System
CFE	Committee on the Future Economy
CIDB	Construction Industry Development Board
CIJC	Construction Industry Joint Committee
CLT	Cross-laminated timber
CoreTrade	Construction Registration of Tradesmen
CP	Capital Productivity
CPCF	Construction Productivity and Capability Fund
CPIP	Construction put in Place
CONQUAS	Construction Quality Assessment Scheme
CPST	Construction Productivity Study Team
D&B	Design and Build
DfMA	Design for Manufacturing and Assembly
DfS	Design for Safety
ECI	Early Contractor Involvement
ELP	Earn and Learn Programme
GDP	Gross Development Product
GFA	Gross Floor Area
GFCF	Gross Fixed Capital Formation
GLS	Government Land Sale
GPS	Global Positioning Systems
IBS	Industrial Building Systems
iGLS	Industrial Government Land Sale
ICT	Information and Communication Technology
IPE	International Panel of Experts
IT	Information Technology
ITE	Institute of Technical Education
JPM	Job Productivity Measurement
LP	Labour Productivity
LTA	Land Transport Authority
ePSS	Electronic Productivity Submission System

MCE	Marina Coastal Expressway
MechC	Mechanisation Credit
MFP	Multi-Factor Productivity
MND	Ministry of National Development
MOF	Ministry of Finance
MOM	Ministry of Manpower
MoU	Memorandum of Understanding
MTI	Ministry of Trade and Industry
MYE	Man-Year Entitlement
NTS	Non-traditional sources
OECD	Organisation for Economic Cooperation and Development
PBU	Prefabricated Bathroom Unit
PIP	Productivity Innovation Project
PMET	Professionals, Managers, Executives and Technicians
PPP	Purchasing Power Parity
PPVC	Prefabricated Prefinished Volumetric Construction
PQM	Price Quality Method
QFM	Quality Fee Method
R&D	Research and Development
RD&D	Research, Development and Demonstration
RE	Resident Engineer
RFID	Radio-Frequency Identification
RTO	Resident Technical Officer
SCAL	The Singapore Contractors Association Ltd
SCCCI	Singapore Chinese Chamber of Commerce and Industry
SCPW	Singapore Construction Productivity Week
SME	Small and Medium-sized Enterprises
SMP	Sectoral Manpower Plan
SSCI	Singapore Standard Industrial Classification
TFP	Total Factor Productivity
VAP	Value-added per person
VDC	Virtual Design and Construction
WTU	Workforce Training and Upgrading

APPENDICES

APPENDIX ONE: INTERVIEWEES

Individual Interviews

Boustead Projects

Mr Howard Hoe, Director (Safety)

Mr Steven Koh, Deputy Managing Director (Operations)

FHS Formwork, Formwork Hire (S.EA.) Pte Ltd

Mr Adrian Choo, Operations Manager

Mr Winston Yeo, Director

McConnell Dowell South East Asia Pte Ltd

Mr Murray Dundas, Managing Director

SK E&C

Mr Cho Seong Soo, Planning Manager

Mr Tan Hwee Nguan, Human Resource and Administration Manager

Tiong Seng Holdings Pte Ltd

Mr Pek Lian Guan, CEO.

Focus Group Meeting

Mr Dominic Choy, Executive Director, Hexacon Construction Pte Ltd

Mr Chong Kar Wee, Senior Manager (Projects), SembCorp Design & Construction Pte Ltd

Mr David Leong, General Manager, Low Keng Huat (Singapore) Limited

Mr Johnny Lim, Executive Director, Teambuild Construction Pte Ltd

APPENDIX TWO: INTERVIEW GUIDE

Construction productivity in SIngapore: Effective measurement to facilitate improvement

An SCAL-SCCCI Project, 2015

Interview Questions for Main and Sub-Contractors

1. What is your view of the level of productivity of Singapore's construction industry? Do you think it has increased since the year 2010? What are your views on statistics which indicate that the rate of growth of productivity in construction is one of the lowest among all the sectors?

2. What are your views on the existing ways in which construction productivity is measured in Singapore: (a) at trade level; (b) at the project level; and (b) at the industry level?

3. Does your firm have a policy on construction productivity generally?

4. How does your firm measure productivity on its projects?

(i) at the trade level; and (ii) at the project level?

If your firm does not measure productivity, do you think such a measure would be useful to the firm?

5. What does your firm use its productivity measurements for?

(i) at the trade level; and (ii) at the project level?

6. What are the obstacles to construction productivity measurement?

7. What are the obstacles to productivity improvement in the construction industry?

8. What are the main enablers and drivers of construction productivity improvement in Singapore?

9. What are your views on the government's productivity development programme?

(Buildability and Constructability; Precast Construction; Volumetric Units; Incentives; Training; Design and Build; Electronic Productivity Submission System)

10. What has your company done to enhance productivity since the year 2010?

11. What has the construction industry as a whole, done to increase productivity since the year 2010?

12. What proposals would you make on how construction productivity can be improved? (indicate the top 5 only)?

END OF INTERVIEW

APPENDIX THREE: SURVEY QUESTIONNAIRE

CONSTRUCTION PRODUCTIVITY IN SINGAPORE: EFFECTIVE MEASUREMENT TO FACILITATE IMPROVEMENT -- A SCAL-SCCCI PROJECT, 2015

SURVEY QUESTIONNAIRE FOR MAIN CONTRACTORS AND SUB-CONTRACTORS

A. Views on Industry-Level Productivity

1. In your view, the term 'productivity' means (please indicate by placing a 'tick' (✓) against the item):

..... a. the output per person employed

..... b. the amount of money received by the company for its output

..... c. the proportion of the work done with machines

..... d. the unit cost of the amount of work done

..... e. the proportion of time saved compared to the project's plan (programme)

..... f. others (please specify) .....

2. What are your views on current measures of construction productivity in terms of their usefulness to your company (1 = "of least use"; 2 = "not useful"; 3 = 'neutral'; 4 = 'useful'; 5 = "very useful"):

a. Buildable Design Score	1	2	3	4	5
b. Constructability Score	1	2	3	4	5
c. m^2 per man-day	1	2	3	4	5
d. Value-added per Worker	1	2	3	4	5
e. Gross Output per Worker	1	2	3	4	5
f. Gross Output per Month	1	2	3	4	5
g. Others (please specify)	1	2	3	4	5

3. Please indicate your view on the productivity of the following segments of the construction industry in Singapore by placing a 'tick' (✓) in the appropriate box:

Sector of industry	*Productivity of the segment is HIGH*	*Productivity of the segment is AVERAGE*	*Productivity of the segment is LOW*
Public Housing			
Residential (Landed)			
Residential (Non-landed)			
Commercial Buildings			
Industrial Buildings			
Institutional Buildings			
Small to Medium Sized Civil Engineering			
High-end Civil Engineering			

4. In your view, between 2010 and 2015, the productivity of the construction industry in Singapore has (please indicate by placing a 'tick' (✓) against the item):

..... a. Increased
..... b. Remained the same
..... c. Decreased

5. In your view, between 2016 and 2020, the productivity of the construction industry in Singapore will (please indicate by placing a 'tick' (✓) against the item):

..... a. Increase
..... b. Remain the same
..... c. Decrease

6. Do you think this stakeholder of the construction industry in Singapore pays adequate attention to productivity? (please indicate by placing a 'tick' (✓) against the answer in each case):

Stakeholder of industry	*Yes*	*No*
Government		
Contractors		
Consultants		
Clients		
Others (please specify)		

7. Government's statistics show that, in most years, the construction industry's productivity growth is one of the lowest for all sectors. Do you agree with such a finding? (please place a 'tick' (✓) against the answer):

..... a. Yes

..... b. No

8. If your answer to Question 7 was 'No', indicate which of the following points you agree with by placing a 'tick' (✓) against all the answers that apply:

..... a. government's approach to productivity measurement is inappropriate

..... b. it is difficult to find accurate data on construction in Singapore

..... c. the construction industry should not be treated like other sectors of the economy

..... d. there are many different ways of measuring productivity

..... e. it is difficult to calculate construction productivity and its growth

..... f. construction industry comprises many segments and they should not be grouped together

..... g. others (please specify) .....

B. Causes of Low Productivity

9. Indicate the level of importance of each of the following factors which relate to the policies and practices of the construction firm, as a cause of low construction productivity in Singapore (1 = "of least importance"; 2 = "not important"; 3 = "neutral"; 4 = "important"; and 5 = "very important"):

a. poor skills of workers	1	2	3	4	5
b. communication difficulties between workers and supervisors, and among workers	1	2	3	4	5
c. poor motivation of workers	1	2	3	4	5
d. reworks to rectify defects	1	2	3	4	5
e. inappropriate working methods	1	2	3	4	5
f. inadequate pre-project planning and pre-work planning	1	2	3	4	5
g. lack of monitoring of project plans (programmes)	1	2	3	4	5
h. over-reliance on labour subcontractors	1	2	3	4	5
i. lack of adoption of prefabricated construction	1	2	3	4	5
j. poor materials management	1	2	3	4	5
k. inadequate application of information technology	1	2	3	4	5
l. high proportion of subcontracting	1	2	3	4	5
m. poor attitude of contractors to productivity	1	2	3	4	5
n. others (please specify)	1	2	3	4	5

10. Indicate the level of importance of each of the following entities in terms of their influence on productivity on your firm's projects (1 = "of least importance"; 2 = not important"; 3 = neutral; 4 = important; and 5 = "very important"):

a. Main Contractor	1	2	3	4	5
b. Specialist Subcontractor	1	2	3	4	5
c. Labour Subcontractor	1	2	3	4	5
d. Supplier of Materials	1	2	3	4	5
e. Others (please specify)	1	2	3	4	5

11. Indicate the level of importance of each of the following professionals and entities in their influence on productivity on projects undertaken by your firm (1 = "of least importance"; 2 = not important"; 3 = neutral; 4 = important; and 5 = "very important"):

a. Client	1	2	3	4	5
b. Architect	1	2	3	4	5
c. Structural Engineer	1	2	3	4	5
d. Mechanical and Electrical Engineer	1	2	3	4	5
e. Approving Authority	1	2	3	4	5
f. Others (please specify)	1	2	3	4	5

12. Indicate the level of importance of each of the following factors which relate to the matters outside the control of your firm, as a cause of low construction productivity in Singapore (1 = "of least importance"; 2 = "not important"; 3 = "neutral"; 4 = "important"; and 5 = "very important"):

a. type of procurement approach adopted	1	2	3	4	5
b. complexity of project	1	2	3	4	5
c. clients' request for buildability	1	2	3	4	5
d. changes in design	1	2	3	4	5
e. delays in providing information to contractors	1	2	3	4	5
f. delays caused by compliance with regulations	1	2	3	4	5
g. lack of guidelines for measuring productivity	1	2	3	4	5
h. priority given to other project parameters such as cost, quality and safety	1	2	3	4	5
i. contractual disputes	1	2	3	4	5
j. others (please specify)	1	2	3	4	5

C. Corporate Practices on Productivity Measurement

13. Does your company have a written policy on the improvement of productivity on its projects?

..... a. Yes

..... b. No

14. If your answer to Question 13 is "Yes", what are the main components of this policy? (please indicate by placing a tick (✓) against any of the components of the firm's policy that apply in the list below)

..... a. the company's vision for productivity policy

..... b. the company's aims and objectives with respect to productivity

..... c. the company's productivity targets

..... d. the company's definition of productivity

..... e. the company's productivity measurement approach

..... f. how the company plans to use its productivity data

..... g. how the company involves its business partners in its value chain in its productivity efforts

..... h. others (please specify) .....

15. Does your company measure productivity (at any level) on its projects?

..... a. Yes (Please proceed to Question No. 16.)

..... b. No (Please proceed to Question No. 17.)

16. If the answer to Question 15 is "Yes", what does the company use this measure of project-level productivity for? (please indicate by placing a 'tick' (✓) against all that apply):

..... a. to monitor progress on its projects

..... b. to monitor the progress of its subcontractors

..... c. to benchmark itself against its competitors

..... d. to meet government requirements

..... e. others (please specify) .....

17. Indicate the level of importance of each of the following factors as an obstacle to productivity measurement in the construction industry (1 = "of least importance"; 2 = not important"; 3 = neutral; 4 = important; and 5 = "very important"):

a. lack of clear definition of "productivity"	1	2	3	4	5
b. uncertainty about what is to be measured	1	2	3	4	5
c. cost of measurement process	1	2	3	4	5
d. lack of direct benefit from productivity measurements to firms	1	2	3	4	5
e. requirement of personnel to measure productivity	1	2	3	4	5
f. high proportion of work subcontracted	1	2	3	4	5
g. because the government is already measuring it	1	2	3	4	5
h. because measurement of productivity by contractor is not a mandatory requirement	1	2	3	4	5
i. because clients do not demand its measurement	1	2	3	4	5
j. because your company provides data to the Electronic Productivity Submission System (ePSS)	1	2	3	4	5
k. others (please specify)	1	2	3	4	5

18. How does your company assess the overall productivity on its projects? (please tick all that apply):

..... a. by considering output per person-hour on key trades
..... b. by considering total revenue per month
..... c. by estimating m^2 per man-day
..... d. by the Buildable Design Score
..... e. by the Constructability Score
..... f. by value-added per worker
..... g. others (please specify)

19. Does your company set targets of productivity to achieve on its projects? (please indicate by placing a 'tick' (✓) against the answer):

..... a. Yes
..... b. No

D. Corporate Practices on Productivity Improvement

20. (a) Indicate whether your company has taken any of the measures below to enhance productivity on its sites since the year 2010 (by (please indicate by placing a 'tick' (✓) against all that apply).

(b) Indicate also the level of importance of each of the measures below which your company either took, or could have taken, to enhance productivity (1 = "of least importance"; 2 = "not important"; 3 = "neutral"; 4 = "important"; and 5 = "very important"):

..... a. investment in mechanisation	1	2	3	4	5
..... b. training of workers	1	2	3	4	5
..... c. increasing the number of direct workers	1	2	3	4	5
..... d. increasing the extent of subcontracting	1	2	3	4	5
..... e. measuring productivity systematically	1	2	3	4	5
..... f. more effective project planning and monitoring	1	2	3	4	5
..... g. introduction of incentive schemes for workers	1	2	3	4	5
..... h. adoption of prefabrication	1	2	3	4	5
..... i. re-engineering of designs	1	2	3	4	5
..... j. engagement of more supervisors	1	2	3	4	5
..... k. applying information technology (including BIM)	1	2	3	4	5
..... l. use of design-and-build	1	2	3	4	5
..... m. monitoring Buildability and Constructability Scores	1	2	3	4	5
..... n. providing information for Electronic Productivity Submission System (ePSS)	1	2	3	4	5
..... o. others (please specify)	1	2	3	4	5

21. Which government incentive schemes has your firm used? (please place a tick (✓) against all that apply):

..... a. Workforce Training and Upgrading Scheme
..... b. Construction Productivity and Capability Fund
..... c. Construction Engineering Capability Development
..... d. Mechanisation Credit
..... e. Productivity Improvement Projects
..... f. Building Information Modelling (BIM) Fund
..... g. Investment Allowance Scheme
..... h. Productivity and Innovation Credit
..... i. Quieter Construction Fund
..... J. Others (please specify) .....

22. Indicate the importance of the factors below in motivating your firm to improve productivity (1 = "of least importance"; 2 = "not important"; 3 = "neutral"; 4 = "important"; and 5 = "very important"):

a. increase profitability	1	2	3	4	5
b. deliver projects on time	1	2	3	4	5
c. enhance corporate competitiveness	1	2	3	4	5
d. reduce number of foreign workers	1	2	3	4	5
e. keep within Man-Year Entitlement (MYE) quotas	1	2	3	4	5
f. enhance corporate image	1	2	3	4	5
g. win national construction productivity awards	1	2	3	4	5
h. others (please specify)	1	2	3	4	5

23. Indicate the importance of the factors below in helping your firm to improve productivity (1 = "of least importance"; 2 = "not important"; 3 = "neutral"; 4 = "important"; and 5 = "very important"):

a. pressure from the presence of foreign contractors	1	2	3	4	5
b. competition within the industry	1	2	3	4	5
c. government's incentive schemes	1	2	3	4	5
d. guidance from government programmes	1	2	3	4	5
e. role models in the industry	1	2	3	4	5
f. support of clients	1	2	3	4	5
g. support of subcontractors	1	2	3	4	5
h. support of consulting teams	1	2	3	4	5
i. others (please specify)	1	2	3	4	5

24. Indicate the importance of the factors below in hindering your company's efforts to improve productivity (1 = "of least importance"; 2 = "not important"; 3 = "neutral"; 4 = "important"; and 5 = "very important"):

a. restrictions on employment of foreign workers	1	2	3	4	5
b. lack of incentives from government	1	2	3	4	5
c. lack of support from suppliers	1	2	3	4	5
d. poor quality of subcontractors	1	2	3	4	5
e. lack of support from clients	1	2	3	4	5
f. excessive regulation of construction activity	1	2	3	4	5
g. lack of support from consulting teams	1	2	3	4	5
h. delays in payment by clients	1	2	3	4	5
i. lack of competent professional, management, executive and technical (PMET) personnel	1	2	3	4	5
j. insufficient time to plan and execute work properly	1	2	3	4	5
k. others (please specify)	1	2	3	4	5

25. Please indicate the proportion of your company's construction work which was subcontracted in 2010 and 2015 by placing a tick (✓) in the appropriate box:

	2010 (in percentages)					2015 (in percentages)				
	0-10	10-25	25-50	50-75	75-100	0-10	10-25	25-50	50-75	75-100
Proportion of firm's work subcontracted										

26. Please provide a breakdown of your company's employees (ie., excluding subcontractors') in terms of percentages of the total in 2000 and 2015 by placing a tick (✓) in the appropriate box for each of the years:

	2010 (in percentages)					2015 (in percentages)				
	0-5	5-15	15-25	25-50	50-75	0-5	5-15	15-25	25-50	50-75
Professionals										
Supervisors										
Skilled tradesmen										

27. Please provide an indication of your firm's investment in mechanization and information technology in 2010 and 2015, as a percentage of the firm's revenue, by placing a tick (✓) in the relevant box for each of the years:

	2010 (in percentages)				2015 (in percentages)			
	0-5	5-10	10-15	15-20	0-5	5-10	10-15	15-20
Mechanisation								
Information technology								

28. Please provide an indication of your company's investment in training in 2010 and 2015, as a percentage of payroll by placing a tick (✓) in the appropriate box for each of the years:

	2010 (in percentages)			2015 (in percentages)		
	0-2	2-4	Over 4	0-2	2-4	Over 4
Training (percentage of payroll)						

E. Possible Future Improvement

29. Please indicate the level of importance of each of the following factors which are often suggested by others as a measure which can help to enhance construction productivity in Singapore (with 1 = "of least importance"; 2 = "not important"; 3 = "neutral"; 4 = "important"; and 5 = "very important"):

a. clients' insistence on productivity	1	2	3	4	5
b. training of workers	1	2	3	4	5
c. review of relevant government regulations	1	2	3	4	5
d. more extensive use of prefabrication	1	2	3	4	5
e. better service from suppliers	1	2	3	4	5
f. standardisation of components	1	2	3	4	5
g. mandatory requirement for contractors to pay attention to productivity	1	2	3	4	5
h. reduction of man-year entitlement	1	2	3	4	5
i. increase of man-year entitlement	1	2	3	4	5
j. more attention to productivity by firm's leaders	1	2	3	4	5
k. more mechanization of construction work	1	2	3	4	5
m. greater extent of design-and-build	1	2	3	4	5
n. involvement of contractor in design	1	2	3	4	5
o. reduction of extent of subcontracting	1	2	3	4	5
p. increase in extent of subcontracting	1	2	3	4	5
q. better service from subcontractors	1	2	3	4	5
r. more prompt payment from clients	1	2	3	4	5
s. longer construction period	1	2	3	4	5
t. more complete and firmed-up design	1	2	3	4	5
u. applying techniques to reduce amount of work	1	2	3	4	5
v. input by contractors of accurate data to Electronic Productivity Submission System (ePSS)	1	2	3	4	5
w. others (please specify)	1	2	3	4	5

30. Please indicate the measures which can be taken by each of the following stakeholders to enhance construction productivity in Singapore:

Actions Authorities can take	*Actions Contractors can take*	*Actions Clients can take*	*Actions Consultants can take*	*Actions Sub-contractors can take*
1.				
2.				
3.				
4.				

PROFILE OF FIRM AND RESPONDENT

Name of Company (optional) .....

Company's Current BCA Registration ..... Company's Turnover in 2014 .....

Origin of Firm (please tick (✓)): a. Local ..... ; b. Local/Foreign Joint Venture ..... ; c. Foreign .....

Designation of Person Completing this Questionnaire .....

End of Questionnaire

THANK YOU VERY MUCH FOR YOUR HELP

APPENDIX FOUR: EXTRACT FROM SINGAPORE STANDARD INDUSTRIAL CLASSIFICATION[213]

SECTION F: CONSTRUCTION

41 CONSTRUCTION OF BUILDINGS

410 CONSTRUCTION OF BUILDINGS

4100 Construction of Buildings

41001 General contractors (building construction including major upgrading works)

41002 Structural repair contractors

41009 Building construction n.e.c.

42 CIVIL ENGINEERING

421 CONSTRUCTION OF ROADS AND RAILWAYS

4210 Construction of Roads and Railways

42101 General contractors (non-building construction)

42102 Road construction

42103 Bridge, tunnel, viaduct and elevated highway construction

422 CONSTRUCTION OF UTILITY PROJECTS

4220 Construction of Utility Projects

42201 Water and gas pipe-line and sewer construction

42202 Communications and power line construction

429 CONSTRUCTION OF OTHER CIVIL ENGINEERING PROJECTS

4290 Construction of Other Civil Engineering Projects

42901 Land reclamation works

42902 Dam and drainage construction

42903 Marine construction (eg harbours, piers, docks, wharves)

42909 Construction of other civil engineering projects n.e.c. (eg playground systems)

43 SPECIALISED CONSTRUCTION ACTIVITIES

431 DEMOLITION AND SITE PREPARATION

4311 Demolition

43110 Wrecking and demolition works

4312 Site Preparation

43121 Soil investigation, treatment and stabilisation (including grouting and guniting)

43122 Excavation and earthmoving works

43129 Site preparation n.e.c.

432 ELECTRICITY, PLUMBING AND CONSTRUCTION INSTALLATION ACTIVITIES

4321 Electrical Installation

43210 Electrical works 43210

213 Department of Statistics (2015) *Singapore Standard Industrial Classification 2015*. Singapore.

4322 Plumbing, Heat and Air-Conditioning Installation

43220 Plumbing, heating (non-electric) and air-conditioning 43220

4329 Other Construction Installation

43291 Installation and erection of building equipment (eg lifts, escalators, travellators)

43292 Installation of fire protection and security alarm systems

43293 Installation of building automated systems for remote monitoring

43294 Installation of awning and window shades

43295 Installation of thermal and sound insulation (including solar control films)

43296 Signcraft installation

43299 Other construction installation n.e.c.

433 BUILDING COMPLETION AND FINISHING

4330 Building Completion and Finishing

43301 Renovation contractors

43302 Tile setting and plastering

43303 Joinery and other woodworks (eg laminated or parquet flooring)

43304 Painting and decorating

43305 Glass and glazing works (including mirror and shower screen installation)

43306 Curtain walling/cladding works

43307 Installation of doors, gates, grilles and windows

43309 Building completion and finishing n.e.c.

439 OTHER SPECIALISED CONSTRUCTION ACTIVITIES

4390 Other Specialised Construction Activities

43901 Foundation works (including micropiling, conventional piling and underpinning)

43902 Brick laying, stone setting and cement works

43903 Roofing works (including timber carcassing)

43904 Production of pre-cast concrete components

43905 Scaffolding works

43906 Sandblasting/Shotblasting works (except ships)

43909 Other specialised construction and related activities n.e.c.

APPENDIX FIVE VALUE-ADDED PER WORKER TEMPLATE

VAP Calculator 2 (to calculate VAP improvement over 2 consecutive years)

Particulars of Firm

Firm Name:

Name of contact person:

Financial Year End Date:
(dd/mm/yy)

Contact number:

Annual Turnover:
(Based on latest financial statements)

Email:

1. Calculate your firm's VAP by entering the items from your firm's audited accounts into the calculator below.
2. Fill in the fields for the previous 2 years (column B to C) if you would like to calculate your changes in VAP over 2 consecutive years.

	A	B	C
Year	2015	2014	2013
<Note: As the GDP deflator for 2015 will only be available in Feb 2016, the GDP deflator for 2015 in the VAP calculator is assumed to be similar to 2014 until further update>			
Total Remuneration (S$)			
Operating Profit before tax (S$)			
Depreciation (S$)			
Indirect Taxes and Levies (S$)			
Total number of employees			

Reset | Calculate VAP Improvement

Firm's VAP (in current prices) (S$ per employee)			
Firm's VAP* (in 2010 market prices) (S$ per employee)			
Year on year VAP improvement (%)			

*To derive VAP of firm in 2010 market prices (Year 2010 is the current base year used in Singapore's national accounts), VAP of firm in current market prices has been deflated by the construction GDP deflator.

Please click here to view the FAQs on VAP submission

To compare the performance of your firm's VAP to Singapore's construction sector, you may refer to the table here.

Certification by Auditor:

CALCULATION OF VALUE ADDED PRODUCTIVITY (at firm level)

Value Added Productivity (VAP)

$$\text{Value Added Productivity (VA per employee)} = \frac{\text{Firm's Value Added (\$)}}{\text{Total number of employees on firm's payroll}}$$

Components of Value Added

Value added of a firm can be calculated from a **firm's audited accounts** by adding the following components.

FIRM'S VALUE ADDED	= TOTAL REMUNERATION + OPERATING PROFIT BEFORE TAX + DEPRECIATION + INDIRECT TAXES AND LEVIES
Total Remuneration*	***This refers to total compensation to employees*** (including all local and foreign workers, PMETs and directors on your Company's payroll) ***which constitutes the following:*** • ***Wages & salaries, overtime payments, commissions, bonuses & payments*** under profit-sharing schemes (e.g. employee stock options) • ***Working and non-working directors' fees*** • ***Benefits in kind*** (such as housing, travelling expenses to and from work, medical and welfare benefits) • ***Employer's CPF contribution*** • ***Pension funds and insurance premiums for employees*** *Total Remuneration should not net off Jobs Credit grants received by your Company.
Operating Profit before tax	***This is derived after deducting all operating expenditure from operating receipts.*** Items such as interest paid, amortisation, assets/stocks written off, bad debts, loss of sales of fixed assets/stocks/foreign exchange transactions, rental of land, donations and association subscriptions are ***NOT operating expenditure.*** Items such as gains from sales of fixed assets/stocks/other securities/foreign exchange transactions, recovery of bad debts, provision written back, interest received, dividends received, insurance claims are ***NOT operating receipts.***
Depreciation	***This refers to depreciation on:*** ***1) Land, Building & Structure*** (owned by your enterprise but not for resale purpose) ***2) Plant, Machinery and Equipment*** ***3) Transport Vehicles*** (used for business activity only) ***4) Computers & Peripheral Equipment*** (includes computers, printers, scanners, etc) ***5) Computer Software*** (which are capitalized) ***6) Furniture & Fittings***
Indirect Taxes and Levies	***Indirect taxes*** refer to property taxes, road tax and other taxes such as license fees, stamp duties but *exclude corporate taxes and personal income taxes.*

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