CAENZ

NEW ZEALAND CENTRE FOR ADVANCED ENGINEERING

Executive Report

Enhancing SME Labour Productivity in the New Zealand Horizontal Infrastructure Construction Sector

Mail: Private Bag 4800, University of Canterbury Campus, Christchurch 8140, New Zealand
Street Address: 39 Creyke Road, Ilam, Christchurch, New Zealand
Phone: 03 364 2478 Fax: 03 364 2069 e-mail: info@caenz.com www.caenz.com

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December 2010

CAENZ is an independent-think tank and research facilitator funded by grants and sponsorships. CAENZ's mission is to advance social progress and economic growth for New Zealand through broadening national understanding of emerging technologies and facilitating early adoption of advanced technology solutions.

Report Author: Neil Allan and Dr Yun Yin

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Address for Correspondence

New Zealand Centre for Advanced Engineering, University of Canterbury Campus
Private Bag 4800, Christchurch 8140, New Zealand

Phone: +64 3 364 2478 Fax: +64 3 364 2069 E-mail: info@caenz.com www.caenz.com

Preface

The most significant challenge facing the New Zealand infrastructure industry is how to raise productivity whilst containing costs. This challenge has proved particularly problematic for small and medium-sized companies (SMEs) that may be unable to reap the benefits of bulk purchasing and supply chain arrangements.

As the Industry Training Organisation for civil infrastructure, InfraTrain considers it an essential part of its role to help SMEs and the wider industry to raise productivity. Having successfully applied for funding from the Tertiary Education Commission, we developed a two-stage project that would (a) find the drivers of SME productivity and (b) develop materials to help SMEs raise their productivity.

We engaged the New Zealand Centre for Advanced Engineering (CAENZ) who already had a long history of significant and innovative research in the broad field of New Zealand construction.

I am delighted to present this report, which marks the completion of the first stage of the project. It summarises the process and conclusions of the CAENZ research, and it also includes a Competency Framework that lists and prioritises the competencies that employees need in order to achieve productivity gains for their organisation. The Competency Framework also forms the basis of the second stage of the project, which will see InfraTrain and partners working to develop practical materials and methods to help infrastructure SMEs meet the productivity challenge.

I hope you enjoying reading this report. If you have any questions or feedback on the content, please contact me or my colleagues at InfraTrain.

Dr Claire Cohen
Business Development Manager
InfraTrain NZ

InfraTrain New Zealand

Level 12
40 Mercer Street
PO Box 2759
Wellington 6140
New Zealand

Phone 04 499 9144
Fax 04 499 9145

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The Productivity Challenge

The aim of this study is to understand and identify the barriers to labour[1] productivity gains in small and medium enterprises (SMEs)[2] in the New Zealand horizontal infrastructure construction sector. For ease of reading we will from here forward refer to the horizontal infrastructure construction as simply infrastructure.

A recent Treasury report[3] highlighted as a priority the need to improve New Zealand's comparatively low productivity. Construction generally accounts for approximately 10% of GNP, yet in common with many countries growth in construction productivity lags other industrial sectors, making it particularly important to target for improvement, see Figure 1 below.

SMEs are key drivers of economic growth, employment and performance. This is especially true in construction where close to 99% of all companies are SME; they employ over 80% of all the workers in construction and contribute over 2/3rd of the industry turnover.

Trend analysis shows that the productivity overall of SMEs in the US and the EU has been reducing since 1964 and that labour productivity reduces with the size of firm. Yet the construction industry in New Zealand is dominated by small businesses. SME infrastructure construction productivity improvement would result in better affordability of projects for clients, higher profitability and increased earnings, in the long-run and more secure jobs for those involved in the industry.

Improving productivity is therefore a major concern for New Zealand, the construction industry and any profitable organisation, representing the effective and efficient conversion of resources into marketable products and services. Considerable effort has been directed to understanding the productivity issue in construction in New Zealand and overseas, yet real sustainable improvements seem elusive. Much previous research has been aimed at large construction organisations and has tended to focus on isolated snapshots of part of the problem.

This study[4] is different: it adopts a 'systems thinking' perspective that takes account of the diverse views and knowledge across the sector, using a soft systems methodology[5]. Productivity is a multi-faceted issue and there is no single magic bullet for improving productivity.

A more holistic understanding of what affects SME productivity and how this can be leveraged to drive superior results and world-class performance has been developed and is presented below. It requires multiple approaches that are consistently applied at many levels in the industry, as envisaged by the productivity model in Figure 2. One off attempts to fix the problem simply will not work. There needs to be a long-term commitment to the issue so the new practices are embedded in the way people work.

The frameworks presented in this report are intended to enable a shared understanding of the hierarchy and in-

[1] Please note we are not looking directly at capital investment or innovation/R&D, even though they are important and have connections to labour productivity.

[2] An SME business is defined as, < 250 employees, a Small Business, <50 employees and Micro as <10 employees They can also be defined based on turnover and balance sheet, but size is used in this report.

[3] Putting Productivity First, (2008), New Zealand Treasury, Productivity Paper 08/01.

[4] A broad literature review of international best practice augmented the local research data that was gathered from an extensive set of interviews. The interviews were transcribed and analysed using a triangulation of techniques: Content analysis, Concept mapping and Grounded theory. These research techniques were utilised and combined to uncover an array of interdependent issues surrounding productivity barriers and potential. For the full report, see www.caenz.com.

[5] Soft systems methodology is essentially a 7-stage action learning cycle. Its use enables interventions in complex social situations with diverse stakeholders. See Checkland (2007) for further details.

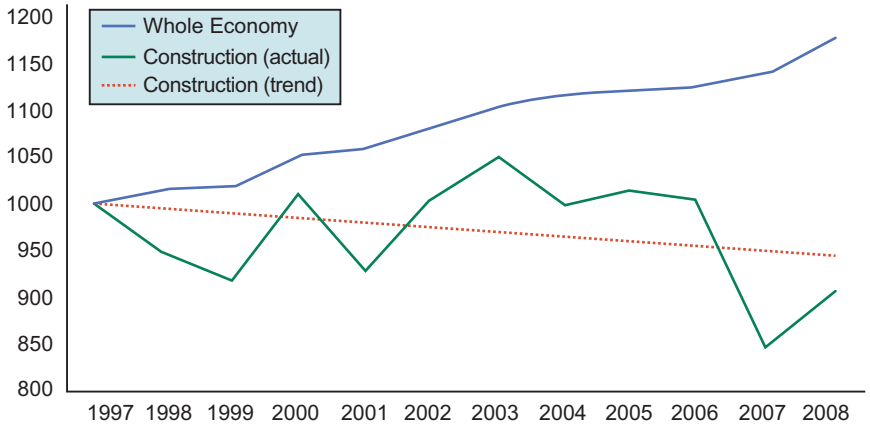

Figure 1: Labour productivity in general economy and construction compared (1997-2008) After Davis N., (2009) Construction sector labour productivity scoping report.

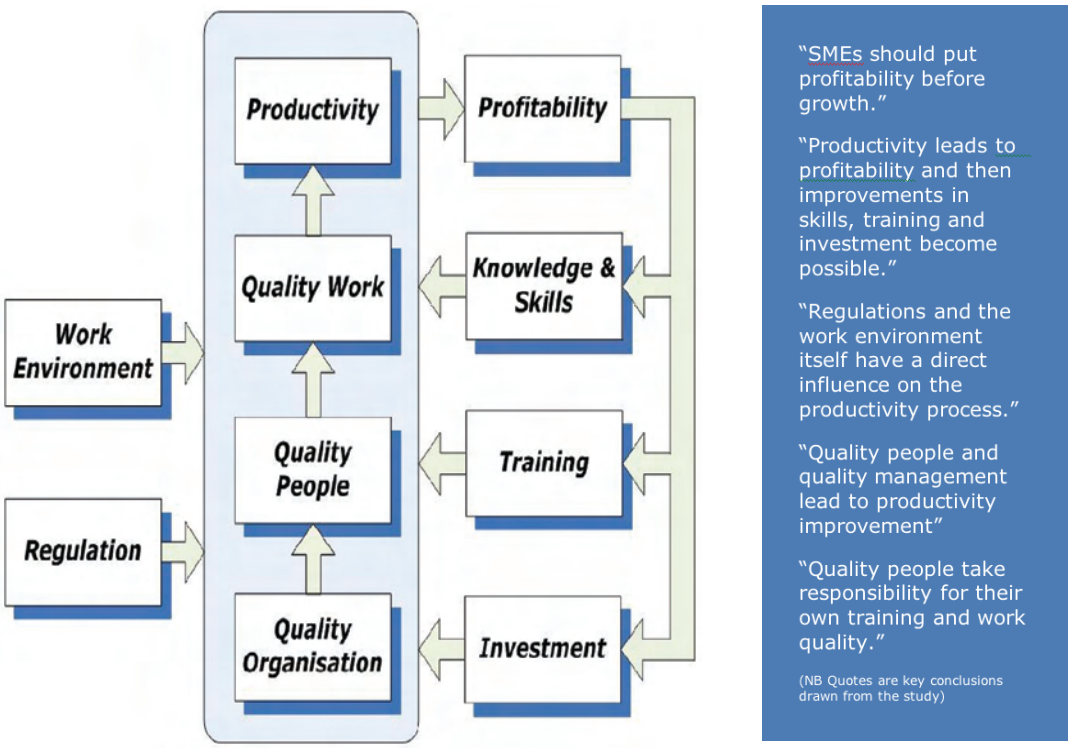

Figure 2: Productivity Model for the SMEs in New Zealand's Construction Industry

terplay of these issues and to guide intervention decisions, at whatever level. Training initiatives are also proposed based on the priority of needs of the practitioners and potency of their impact for unlocking potential or removing barriers to productivity.

A radically different approach and change in mindset is required to improve labour productivity in our industry and economy as a whole.

Unlocking the People Potential

Perhaps not surprisingly people are at the root of the productivity issue, but through a complex series of interconnections.

More than five hundred individual factors were derived during the course of the study: their structure and interrelationships[6] are summarised in Figure 3. Each factor is made up of multiple factors underneath, but these are not displayed for clarity. For example, the factor 'Communication' has seven second-tier factors attached to it.

The green coloured factors in the model are the key to understanding the most important issues relating to productivity:

- The way of working
- The way of managing
- Organisational issues
- Human factors.

It is worth noting that each of these factors are themselves highly interconnected, e.g. "The way of working" influences the "Way of managing" and "Human factors" and vice versa. Interestingly the only direct key influence on productivity is "The way of working". This is shown in detail in Figure 4.

Systemic Issues and Interventions

Most factors affecting productivity and possible interventions are related to people and their skill level, particularly generic management skills, project management ability and soft, people skills. This may be no great surprise as the H&S issue in construction industry reached the same conclusion years ago after decades of research. Below are a number of suggested interventions required in skills, management, training and most importantly mindset.

The way of working

Unlike manufacturing or agricultural industries, construction work is not very automated, modulated or repeatable, and physical working conditions are an issue. Un-

[6] An arrow between the nodes indicates a causal relationship whilst a line implies that two concepts are related and influence each other but with no direct causality.

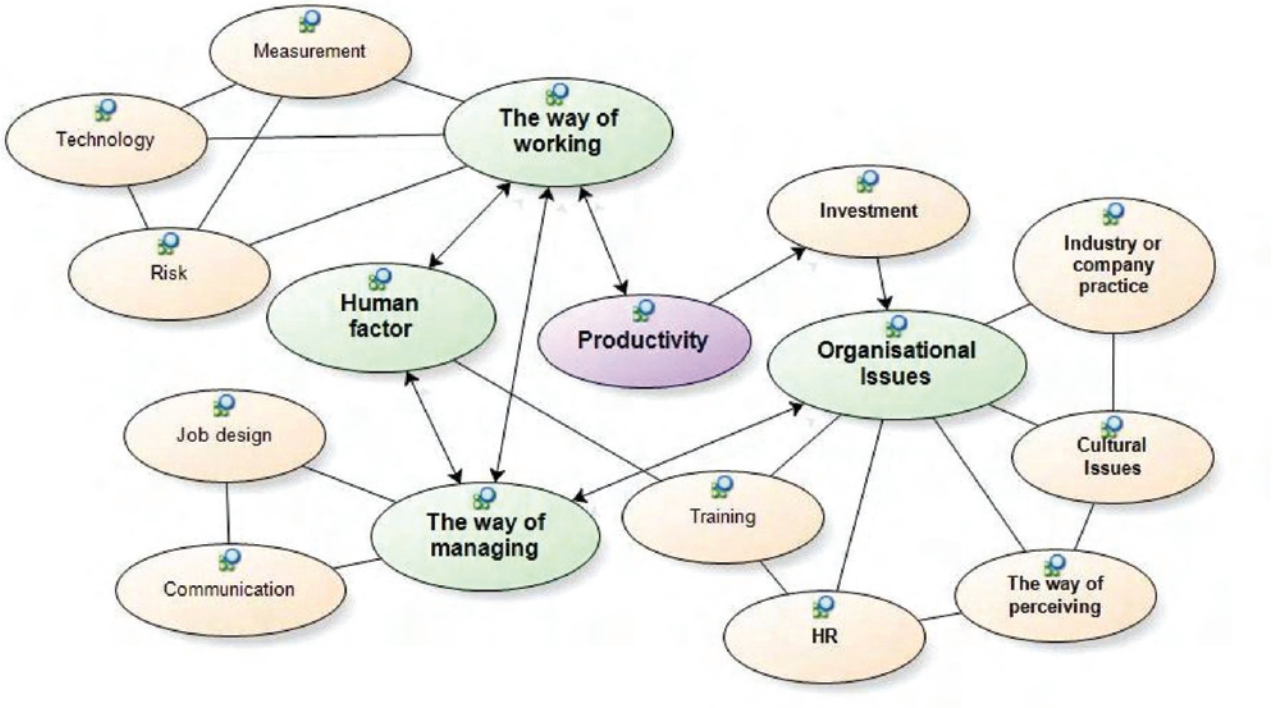

Figure 3: Model of interconnected people issues relating to Productivity

safe working conditions, accidents and physical site constraints all impact productivity.

Improvements could be achieved by simple planning, coordination, communication and knowledge sharing. Indeed good practice suggests that contingency planning should be in place so that work crews have other productive tasks to do, such as maintenance or health & safety activities should unavoidable delays occur.

Step changing productivity through the supply chain

An unproductive day on an infrastructure project site is unlikely to be caused by a single issue or individual. Suppliers, clients, contractors and subcontractors can all exert influences on the progress of a project and if any party fails to be productive, the overall productivity can be dragged down significantly. A key reason for this is that SMEs have minimal control over other parties, unlike a large integrated contractor with contract managers and long-term work streams. One option is to educate and promote the importance of supply chain management and in particular sharing information if necessary to help one part of the chain catch up so as to improve everybody's progress. By doing so, SMEs could recognise their importance and how their productivity can affect others, leading to a self-motivated productivity improvement.

It is perhaps the clients of infrastructure construction that hold the key to supply chain productivity, more than anyone else. Many industry reports, such as the Egan Report[7], have urged the adoption of a client led approach and recommend public clients should play a leading role in this. This will need a change to the way projects are procured, including the abandonment of lowest cost tendering. This may also help reduce the worst effects of boom bust cycles[8] too.

Human factors

Some of the key motivational factors raised in the interviews were extrinsic incentives such as wages, salaries and working environment, but also intrinsic concepts such as self esteem, public image, job satisfaction and future employment.

There was evidence that motivation and productivity was easily dragged down by a few employees' behaviour; drugs, alcohol, racial and gender prejudice were all contributory factors to a sense of a poor working conditions. Improvement in the working environment alongside recognition and non-financial motivation could dramatically improve productivity.

Organisational Issues

Enhancing project management competency

Project management is highly connected to productivity particularly time management, planning, quality, reduc-

[7] *Rethinking Construction* (1998), the report of the Construction Task Force, UK.

[8] *A Study into the Cyclical Performance of the New Zealand Construction Industry* (CAENZ, 2008).

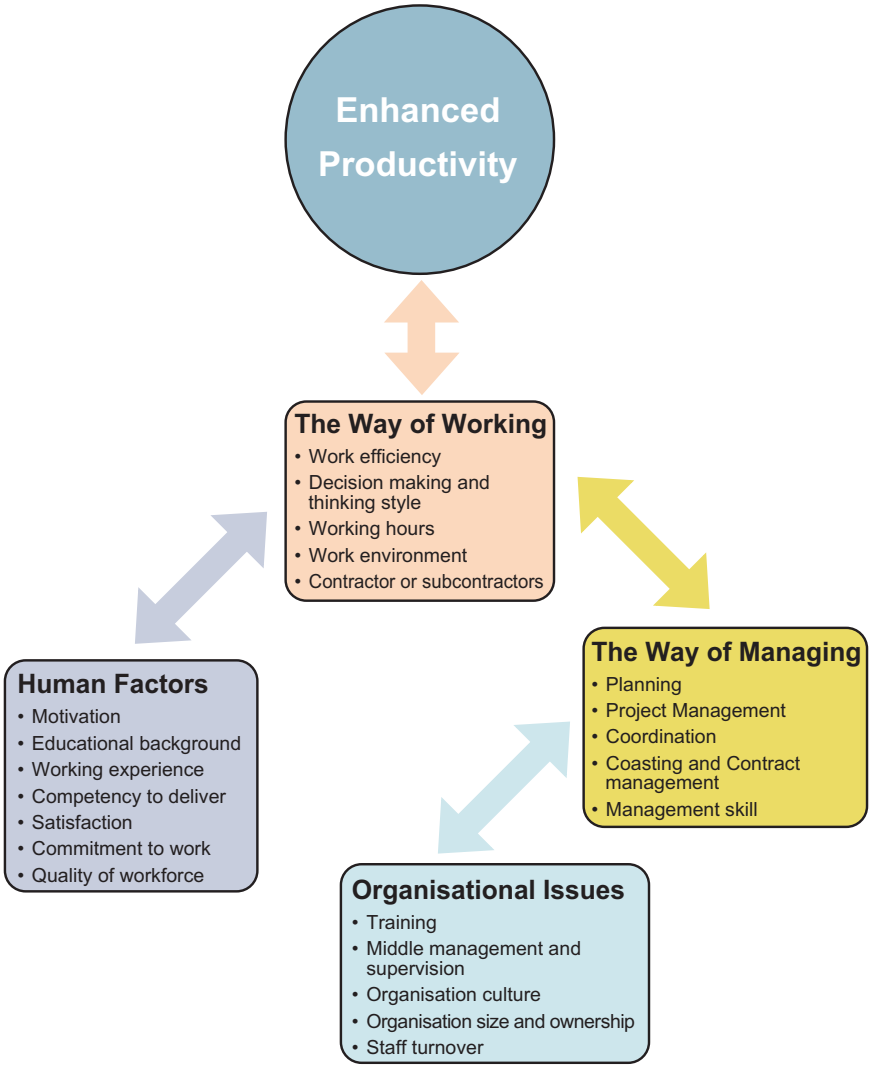

Figure 4: Diagram of the dynamic relationships between the key influences

ing waste, health and safety, and cost control. Many interviewees suggested that applying basic project management knowledge and techniques would be helpful in enhancing productivity. There are clearly different levels of project management skills required in SMEs from basic time management to more advanced quality concepts. A structured project management training programme would provide a solid foundation for improved productivity.

Benchmarking for better profitability and productivity

Some straightforward and easily benchmarked measures of productivity would be helpful to SME owners and managers such as:

1. Profitability
2. Value added/Employee
   (Turnover- cost of supplies)/No of Full-time employee equivalents
3. Turnover/Employee
   Turnover/ No of Full-time employee equivalents

These would allow for a simple positioning of how well individual SMEs are performing and to direct help accordingly. Using benchmarking processes as provided by CAENZ[9] would be beneficial, to track productivity on a business to business and possibly project to project basis. This would help identify issues of concern and motivate owners to seek support for access to better practice.

The way of Managing

From the interviews, the concept 'management' is closely coupled with four key skills groups:

- Generic management skills,
- Organisation and coordination skills,

[9] *The New Zealand Construction Industry National Key Performance Indicators Handbook* (CAENZ, 2005 - 2007).

- Interpersonal skills and
- Communication skills.

These key members of staff are often undervalued, poached by other industries and are part of the aging workforce. An emphasis should be placed on training a new generation of technically competent managers, whilst updating the capability of project and company managers who are currently employed by the industry.

This is a significant shift in thinking for trainers and SME owners who tend to focus on imparting technical skills on the job. Moreover, improvement in management competency cannot be achieved in the short-run as educational background and experience are also key determinants in management ability. However, this is a very potent and achievable intervention that could reap long-term improvements. There are also many additional linked benefits created by injecting generic management skills into the SME management including, improved motivation, communication, work quality and creating a better work environment to attract good, new recruits.

Training

From the research, training is a key influence and potent factor in changing the skills, mindset and managerial competencies across the productivity system.

A framework for management training across different levels is given in Figure 5, which incorporates the key training issues discussed above.

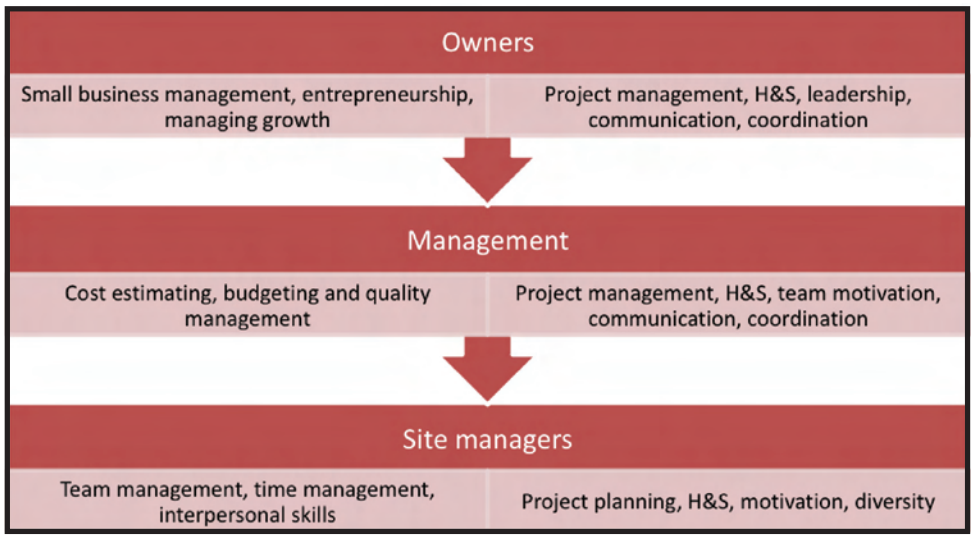

Figure 5: Framework for management training

Recommendations

To achieve sustainable productivity improvement the full set of recommendations given below need to be applied. A piece-meal selective approach will not deliver what the industry needs to break through the current downward cycle of underperformance. Improvement will take time, resources, commitment, alignment of opposing competitive forces and a new mindset which puts the SME construction company at the forefront of NZ's economic and social development.

Industry level actions

- **The role of clients**, especially those in public sectors, must lead in changing practices.
- **Better communications** across the industry sector. Information sharing regarding project proposals and future plans are crucial for SMEs to evaluate their capacity to make rational bids and assess their performance.
- **Quality** should be specified and properly assessed in bids and contracts.
- **Equality and pride** shall be reinforced in the industry.
- **Attracting young people** with better education background is important for future productivity improvement.
- Improve the **ease of mobility** between companies
- Provide a **clear career pathway** for employees.
- Industry and government need to promote the **role of entrepreneurship** and its value to the society and economy to encourage a new generation of construction related enterprises.
- Improve the **prestige of qualifications or certificates** awarded as incentives for training courses.
- **Training courses** should be more **experientially based**.
- Use modern **on-line learning** to attract young IT literate workers.
- **Targeted skills** should be better delivered in training courses. Training courses should be able to deliver the range of skills in an integrated way. See the competency framework attached.
- Develop an i**ntegrated supply chain approach** to infrastructure construction procurement.
- **Value-for-money** approach should be adopted in all procurement strategies.

Recommended Actions for SMEs

Improving the efficiency of the work itself

- Develop a **network** of reliable and trusted sub-contractors and partners.
- More **effective planning** in the delivery and placement of equipment and materials to avoid double handling and aid sequencing of work.
- **Pre-work** using pre-moulded materials, such as precast concrete and standardised products.
- Develop **manuals and/or working procedures** and circulate to workers.
- Use **IT systems**, communication and planning software.
- Use **downtime and idle time** better for maintenance of tools and equipment and web based training or tool box talks.
- Have a **backup plan or contingency** for bad weather or other delays.
- **Pricing strategy** should be reviewed by both contractors and clients.
- **Cost control** should not be overlooked by the SMEs.

Improving competency of people to deliver

- **Educating and training** employees can enhance the quality of work and productivity.
- Improve the level of **technical skills**. The SME construction industry should be better equipped with both specific and generic skills.
- **Diversity** is an advantage. Many participants reflect that the workforce in the industry is aging and it is becoming difficult to attracting qualified young people into the industry. There are very few females working in the industry and ethnic groups are not fully represented.
- **Workforce stability** needs to be improved. Although recruiting and dismissing employees is normal in business, a high turnover rate of staff can be harmful to workers, companies and the industry sector.
- **Support and supervision** are an integral part of competency to deliver. When an emerging situation occurs on site, managers should be able to provide instant support or intervention. Solving problems promptly can stop trivial problems escalating.
- **Teambuilding** is essential for employees to gain the feeling of belonging and hence commit more to work. Since a large proportion of SMEs in the construction industry are family owned, it is difficult for those employees who are not family members to feel they are integral part of the company.
- **Influences of peer workers** affect onsite productivity significantly. High absenteeism puts a strain on other workers resulting in low productivity and inertia.
- **Working stress** should not be overlooked by SME managers. Many interviewees mentioned drinking, smoking and drug abuse as endemic in construc-

tion; the cause for individual cases should be better understood.

- **Equality and pride** should be reinforced in the workplace. As reflected by interviewees, workers are more productive when they work in public areas, such as roads, because people can recognise the importance of their work and they have to work harder. It is their psychological pride that forces them to be productive.
- **Attracting young people** with better educational backgrounds is important for future productivity improvement.

Training in project management at all levels

- Develop and promote **learning skills** as this makes for good project managers.
- **Flexibility** is a powerful advantage for an SME when competing with larger rivals.
- **Communication** is necessary for good coordination.
- **Organisational skills** should be improved.
- Adopt common procedures and best practices for **planning**.
- **Contingency and uncertainty** planning needs to be encouraged.
- Improve **analytical skills**. Although experience is an integral part of project management, rational decisions should be based on analysis, instead of subjective perceptions.

Strengthen management skills for owners and key staff

- Improve SME manager's ability to **communication and coordination**.
- Managers should be trained in **how to motivate** employees effectively, and be shown different approaches.
- **Developing a clear business vision** is important for long-term development of the company.
- Train in **quality techniques** and **how to write** procedures and policies.
- Managers should learn about **proper delegation of responsibility** to employees.
- Training in **continuous improvement** and related techniques should be provided.
- Long-term **sustainability** should be adopted as a criterion for decision-making, not short-term profit.

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1 BACKGROUND OF THE RESEARCH

1.1 Background to the research – the productivity problem

We concur with the view that productivity is a multifaceted issue and that there is no single magic bullet for NZ's construction labour productivity. The approach to this study takes a holistic, systems approach to understand the interconnectivity of the issues and the interdependency of the possible interventions.

A recent Treasury report highlighted, as a priority, the need to improve New Zealand's low productivity. Construction accounts for approximately 10% of GNP, yet in common with many countries growth in construction productivity lags the general economy and other industrial sectors (see Figure 1), making it particularly important to target for improvement. Improvements in construction sector productivity would result in some improvement in infrastructure affordability in the long-run.

There is no official measurement of industry-level productivity within New Zealand, and only a few studies that estimate productivity of the construction sector, (Davis 2007). The studies that do exist are consistent with international research and paint a bleak picture of construction sector productivity against other industrial sectors since the late 1980s. Moreover, NZ productivity levels in the sector are poor relative to the construction sector in other countries. Indeed, Davis suggests that productivity levels in the construction sector in 2006 have not improved in the last 15 years and has underperformed comnpared to many other sectors in the economy between 1995 and 2004.

Figure 2 shows the relevant firm's labour productivity within each industry for several percentiles of the distribution. It illustrates that the construction industry does not have a wide distribution of labour productivity by the standards of a number of other sectors and importantly is the third lowest of any sector.

There are a variety of possible reasons for this, including factors related to regulation, capital investment, competition, innovation but this study has focussed on labour productivity which still remains a stubborn and misunderstood factor, particularly for New Zealand. Construction industry productivity measurement is itself at an early stage of development and there are significant measurement and data quality issues, particularly in the SME (small- to medium-sized) sector.

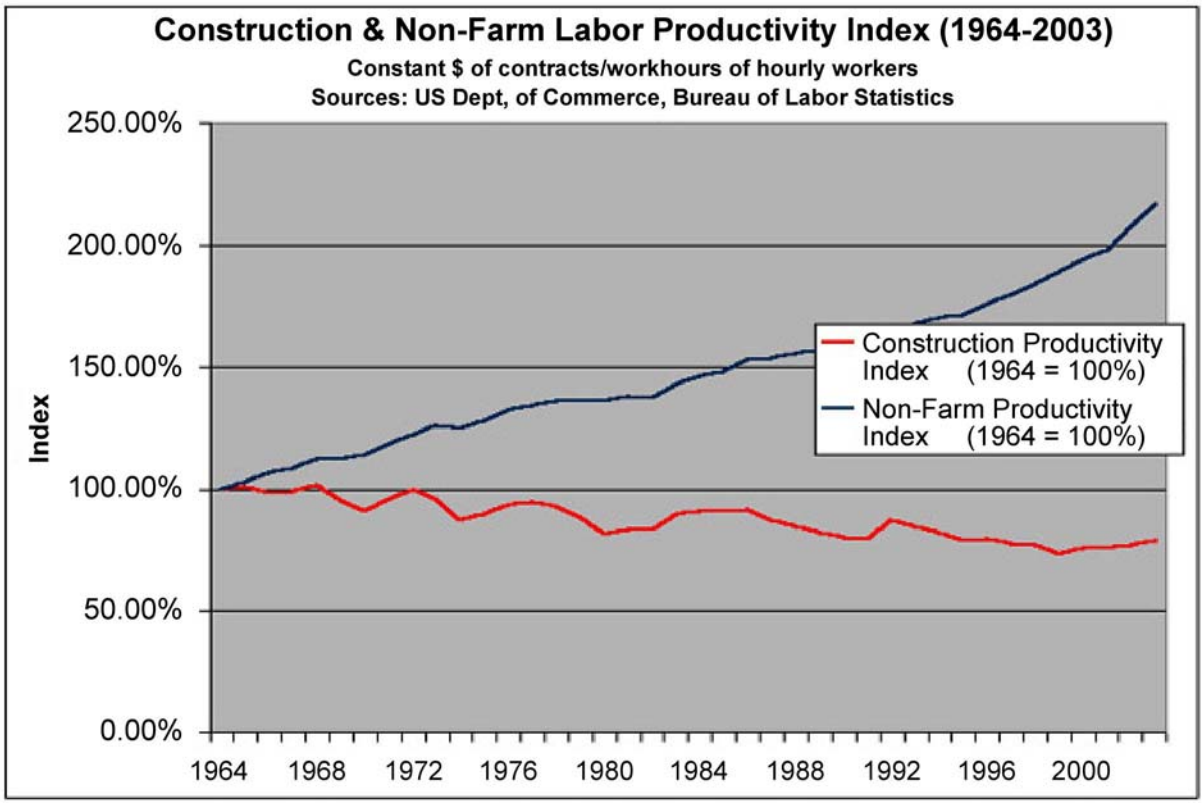

Figure 1: US Construction productivity lags other industrial sectors

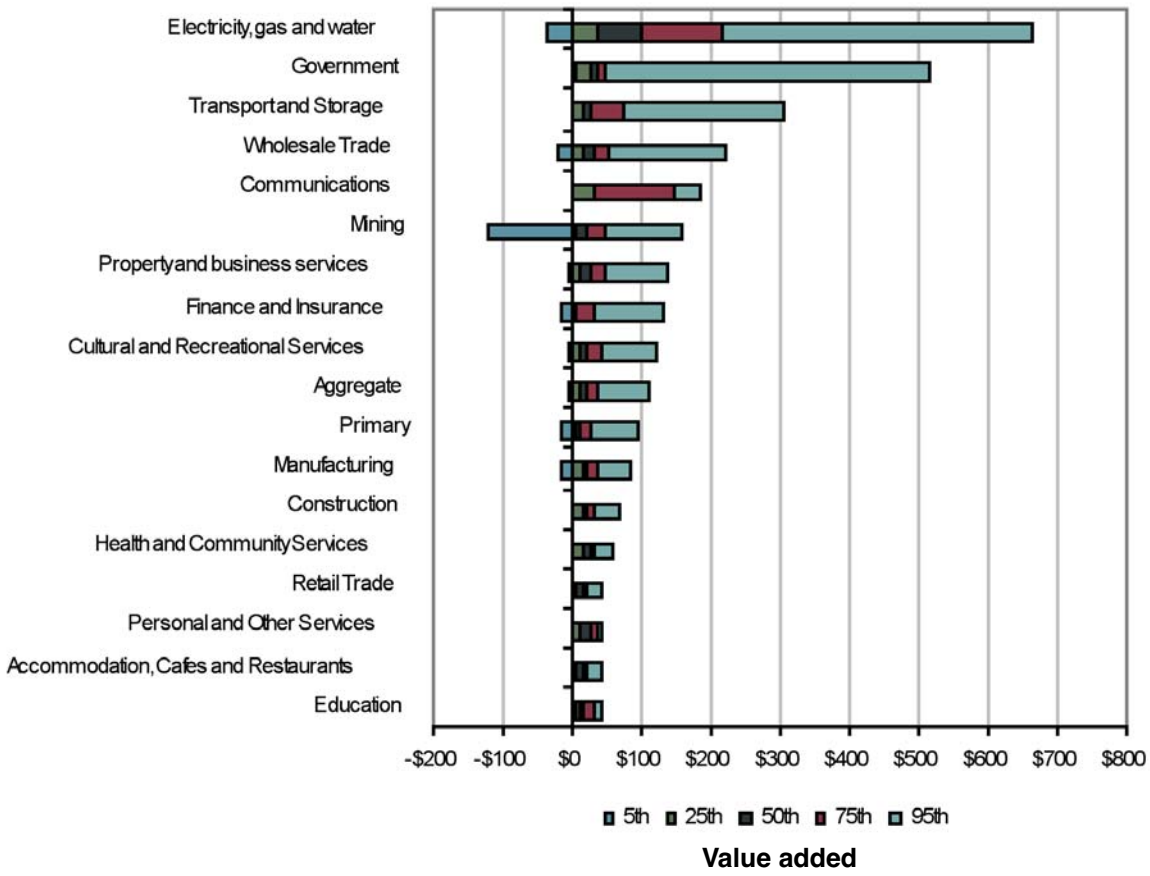

Figure 2: Distribution of Labour Productivity – NB The firm at the 95th percentile generates value added of $65 per hour worked compared with $0 per hour worked at the 5th percentile. Source: Davis (2007), Adapted from Law, Buckle and Hyslop (2006).

Ever since the Second World War various incentive schemes and time related studies worldwide have been conducted to tease out more output from construction workers. These were described by the renowned organisational guru Herzberg as mere 'kicks in the ass' in the productivity improvement process.

Couple this with the fact that most of the studies conducted on labour productivity have been done in large organisations and we start to see that there is a significant gap in understanding about what is happen ing in small and medium sized organisations in the construction sector. Yet, NZ, like most advanced economies, relies on SME's as the main engine of growth. Indeed, for most OCED countries over 95% of all enterprises fall below the large organisation definition of 250+ employees. In the UK, 99.9% of enterprises in the construction sector are SME's and they employ 84% of those in the sector and contribute to 67% of the sector turnover (BERR, 2007) Moreover, research from the European Union, shown in Figure 3 , suggests that the smaller the enterprise the lower the added value or productivity. Micro enterprises are less than 10 people; the average New Zealand construction firm size is 2.6, with general construction and site preparation rising to 3.5. (Source: NZ statistics)

1.2 Project objective

Our aim is to really understand what is holding back labour productivity gains in the NZ construction industry with a particular focus on the SME companies in the infrastructure construction sector. We hope to establish and communicate a more complete picture of the key drivers or road blocks, rather than snapshots of part of the problem. We intend to try to get under the surface of what is going on and identify what can be done to improve productivity for everyone. Please note that we are not looking directly at capital investment or innovation/R&D, even though they are important and have connections to labour productivity.

The aim of this study is to inform and help identify labour productivity areas that may be improved by the development and implementation of specific training courses by Industry Training Organisations (ITO).

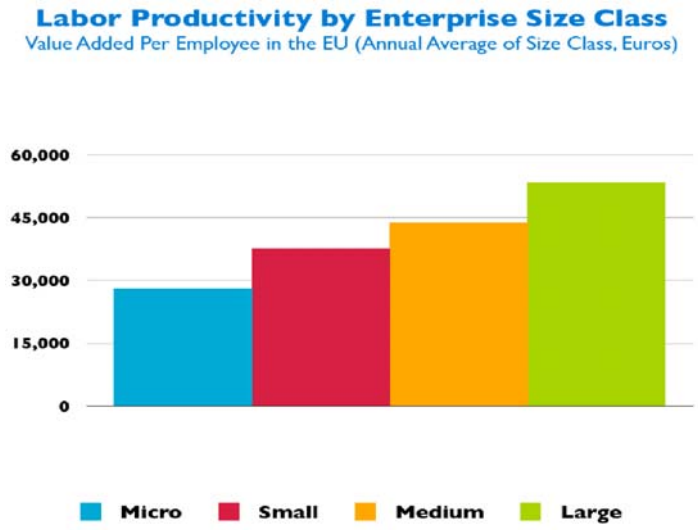

Figure 3: Labour productivity by enterprise size

1.3 The productivity challenge

Improving productivity is a major concern of any profit organisation as representing the effective and efficient conversion of resources into marketable products and determining business profitability. The benefits extend far out beyond the individual enterprise into society and the wider economy. Consequently, considerable effort has been directed to understanding the productivity concept yet real sustainable improvements seem elusive. This study has adopted a systems thinking approach that aims to really understand the problem by embarking on an extensive stakeholder consultation phase with over 50 individuals, including more than 30 interviews with infrastructure construction operatives working in SME organisations. The reporting of the process is split into two key stages:

Stage 1. The analysis and uncovering of the key influences and systemic issues in the SME construction sector, based on international research and the interviews/ workshops with key stakeholders. The analysis includes the interconnectedness of the factors affecting labour productivity. Recommendations and guidance are given to a range of interventions that are required to improve productivity in the sector.

Stage 2. Summary implementation guidance for the training and skills based recommendations generated from Stage 1. A broad competency framework is proposed to enable industry participants to self-benchmark themselves and staff, as well as provide guidance to ITOs with regards to training development.

This report covers stage 1 of the process with recommendations for stage 2. The competency framework is included with the Summary Report, available from the Infratrain and CAENZ websites.

2 LITERATURE REVIEW

2.1 Defining productivity

Productivity is generally defined as the ratio between total input of resources and total output of production.

Productivity = input / output

However, there are measurement difficulties with this simple ratio as input includes labour, materials, equipment, and overhead. Should labour then include all hours employed or just those paid for and recorded. Output is somewhat easier to measure and as it can represent the total monetary value of construction put in place; though for an SME working on a larger project this may not be that straightforward to ascertain. Productivity is often linked or mixed up with other measures such as efficiency (Rogers, 1998), which is commonly understood as reduced operating costs. In this study we are concerned with labour productivity specifically, though totally separating this from other influences such as investment, innovation and capital expenditure is not possible or helpful when looking at industry-wide interventions.

The OECD defines labour productivity as "the ratio of a volume measure of output to a volume measure of input". Volume measures of output are usually GDP (gross domestic product) or GVA (gross value added). The three most commonly used measures are: hours worked; workforce hours; and the number of people employed. These measures all have measurement issues as they also relate to qualitative measures including the quality of the labour, social norms and innovation. The main partial measures are:

Labour productivity: output per unit of labour used, or

$$\text{labour productivity} = \frac{\text{output}}{\text{input}} = \frac{\text{work completed}}{\text{workers employed}}$$

Capital productivity: output produced per unit of capital used, or

$$\text{capital productivity} = \frac{\text{output}}{\text{input}} = \frac{\text{value added}}{\text{capital employed}}$$

Time productivity (efficiency): output produced per unit of capital used, or

$$\text{time productivity} = \frac{\text{output}}{\text{input}} = \frac{\text{progress made}}{\text{total working hours}}$$

Single-factor productivity measures have been adopted as indicators for key input, such as government policy objectives, and they are relatively easy to measure and in common use. It should be noted that single-factor productivity can give biased understanding if its interpretation is not properly placed. For example, the labour efficiency can be significantly increased by injecting capital in the form of new technology and equipment. More than one factor can be included in the productivity understanding and this approach is often referred to as total factor productivity (TFP) or multi-factor productivity (MFP). Since TFP or MFP aims to provide insights into how a collection of determinants influence the productivity, it is in principle more holistic than the single factor approach.

$$\text{TFP} = \frac{\text{output}}{\text{total input}} = \frac{\text{O(t)}}{\text{F(K(t), L(t), T(t), ...)}}$$

When considering the construction sector productivity, particularly infrastructure and SME activity, the very nature of the work is important; it clearly cannot be compared to a controlled manufacturing industry environment. Uncertainty and risk spring from a multitude of factors that can potentially affect project success including site conditions, political environment and the weather. SMEs often face difficulty in maintaining a stable organisation due to the short term nature of construction jobs which undermines efforts to improve productivity by learning from past mistakes (Cottrell, 2006). The very nature of construction industry makes it is difficult to reach a concise or bespoke definition of productivity. In this sense, construction productivity is best understood from a holistic, multifactor perspective and Ellis and Lee (2006) provide a useful illustrative model (figure 4) for developing such a framework for the SME sector under consideration.

On the input side, labour, materials, equipment etc. all exert an influence on the progress of a construction project. Some inherent issues, such as weather, rework, planning and congestion act as inhibitors and can have a negative (if improved they can have a positive affect) impact on a project. However, the danger is that policy makers or management fads focus on such a single factor which ignores the interdependencies of the other influences (including additional factors not covered by Ellis & Lee). This leads to a partial but often unsustainable improvement in productivity, because the whole system tends to resort to a state of homeostasis (equilibrium) after a single temporal intervention.

Furthermore, the definition of construction productivity

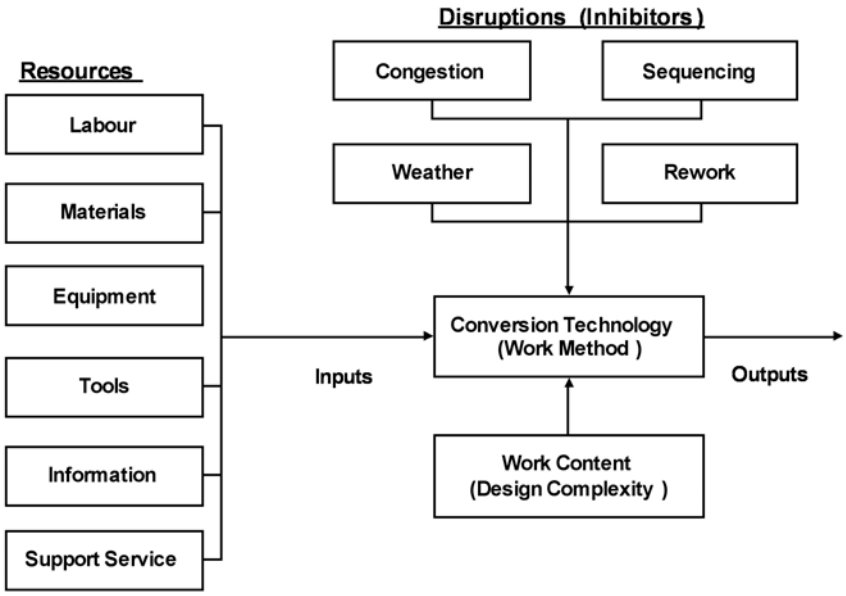

Figure 4: A model to understand productivity

is subject to both objective entities and subjective influences from people who undertake the investigation: consequently there are a different views and approaches of how to study and assess construction productivity.

2.2 Measuring productivity

The concept of 'no measurement, no management' is overwhelming in reductionist, scientific management literature and construction productivity is no exception, however due to the complex interactions between factors already mentioned this mantra is often unhelpful. As Einstein famously stated, 'what can be measured is not always important and not everything that is important can be measured'. One important contribution of this study is to gain an understanding of what is important to measure in productivity and then determine what and how to measure it. This is unlikely to be an easy or single measure and it might be that a few very simple high-level measures are all that is worth attempting. First we review the literature on the topic.

2.2.1 Difficulties in measuring productivity

Researchers have concluded that it is difficult to obtain a standard method to measure construction labour productivity (Olomolaiye, Jayawardane & Harris, 1998), because of project complexity and the unique characteristics of construction projects. The uniqueness and non-repetitive operations of construction projects make it difficult to develop a standard productivity definition and measurement. Furthermore, it is incorrect to assume that productivity is measured consistently and uniformly and that all published productivity values have the same basis of calculation, indeed we see that accounting and productivity terminology are confusingly interchanged.

Also, nearly all the measures assume that the worker's output remains constant. It is nearly impossible for productivity to remain constant for any activity or period of time particularly where people have been working long hours in less than ideal environments (Whiteside, 2006). There have been attempts to develop common definitions within a standard productivity system; however, those were not based on the consensus of academia and industry. We have reported some of the key approaches as some practitioners may find some of these suitable for their needs.

2.2.2 Approaches to measure productivity

Edkins and Winch (1999) identified three approaches to the measurement of productivity in the construction industry: macroeconomic studies, case studies and pricing studies. Conceptually, these are all related, as they implicitly or explicitly provide estimates of a production process, and can thus be linked to the framework set out here. The major differences between the approaches are the source of data, its level of aggregation, the boundary/definition of the production process and the completeness with which it is described (Edkins and Winch, 1999). In detail, case studies based productivity estimates on the performance of specific projects; macroeconomic studies calculate productivity based on highly aggregated data taken from the national accounts. The use of pricing studies to generate productivity estimates involves asking experienced professionals to provide qualitative information on performance measures and

drivers, and also resource inputs such as labour, material, and plant for projects based on drawings and specifications of a building, structure or task.

Alternatively, some researchers perceive productivity as the output potential of a production process conditional upon its inputs, so that we can investigate one or more factors for the measurement purposes.

2.2.3 Alternative approaches

Throughput measurement

In 'Viable Vision', Kendall argues that the more complex the situation the simpler the solution must be (Kendall, 2005). He argues that a better frame of reference is to consider 'throughput accounting'. In this management accounting approach decisions are taken on the basis of a simple financial model that considers the following measures of income and expense. Throughput accounting is not a commonly adopted approach but it is winning a strong base in a world consumed by cost accounting practice. (Hutagalung, 2003)

- **Throughput (T) = Revenue generated (value of work actually done) – purchased material cost.** Revenue is defined as the sum of revenue the system generates from the sale of its product or services. Purchased material cost is defined as cost of acquiring materials for the product or services rendered. Direct labour cost and overhead cost are irrelevant, and thus should be omitted from the calculation of either the purchased material cost or total variable cost. Unlike activity based management which considered that overhead cost can be managed to attain certain level of efficiency, throughput assumes that direct labour cost and overhead cost cannot be changed and thus it won't be worthwhile to spend much of our attention for such cost.
- In reality, project managers know that while material varies directly with volume (each additional unit produced requires additional raw materials), labour and overhead costs are often more stable. If the efficiencies proposed in the UK reports on construction efficiency are to be believed then there is scope for at least a 30-40% increase in throughput without using considerably more labours. By the same token these costs do not all go away simply because something can change on the project at short notice or hold up the planned flow of work.
- **Investment (I)** is the money tied up in the system. This is money associated with inventory, machinery, buildings, and other assets and liabilities. Inventory is valued strictly on totally variable cost associated with creating the inventory, not with additional cost allocations from overhead.
- **Operating expense (OE)** is the money the system spends in generating "goal units." For physical products, OE is all expenses except the cost of the raw materials. OE includes maintenance, utilities, rent, taxes and payroll.

Because this is more dynamic and holistic and removes factors that impact but over which the small business owner or project manager has little control it can help in determining overall productivity.

Relative measurement

An alternative approach is to apply an understanding of productivity vs project plan (budget). This is the route taken by many project managers when using earned value management (EVM) and indices such as schedule performance index and cost performance index (Wilkins, 1997). This approach essentially establishes the project programme baseline as the basis for the measurement and establishment of productivity. It ignores factors outside the project and is limited by the planning assumptions used. However, it benefits from being relevant, relative and – provided a few simple rules are defined and followed – can provide a baseline for project to project comparison. This approach was used in the UK to determine the Key Performance Indicators (KPIs) for 'Predictability of cost and time' (Constructing Excellence, 2008), and subsequently adopted by CAENZ in the 'New Zealand Construction Industry National Key Performance Indicators' (2005 - 2007).

Target-based measurement

Another approach to productivity measurement is to adopt a target value. This can be based on existing measurements of a product or process and a desired goal that is then derived or determined. There are many methods and approaches to achieving this. This is generally the domain of the strategy execution approaches put forward by the likes of Kaplan and Norton (2008). Approaches to goal setting and review vary from the simple (guesswork) to the complex (strategy mapping and six sigma measurement). Target-based approaches to measure and drive productivity are limited by the extent to which the individuals concerned are motivated extrinsically and their ability to achieve the desired performance.

In brief, various measurement methods are designed to provide insights into construction productivity and the applications of these methods depend on the context and the intention of the investigation. Moreover, if a productivity measurement aims to explore the concept from one or a few perspectives, the versatility of productivity measurement in effect reflects the fact that

various factors can exert influences on the issue of productivity and this has been mirrored in numerous researches. The following section will introduce how productivity is influenced by various factors.

2.3 Factors affecting productivity

2.3.1 The approaches to understand productivity factors

A variety of researches and studies have been committed to understand construction productivity and a considerable number of factors that can influence productivity have been identified and discussed. Basically, there are three prevalent approaches to categorise and hence understand those factors and they are demonstrated as follows.

The resource approach

Construction productivity can be simply understood as the relationship between input and output. In this regard, factors that may influence the construction input can affect the overall productivity. Well established economic theories would consider that the inputs into a construction project include capital investment, manpower, raw materials, machinery, and management efforts, all of which are essentially the resources. Therefore, the factors that can influence construction productivity can be traced from these five major sources.

The hierarchical approach

This school is based on the understanding of the nature of construction companies and their projects. From a systems point of view, a hierarchical approach is effective in understanding such complex issues as productivity. For simplicity, the construction productivity can thus follow the hierarchical structure of a company in the industry, namely industry level, strategic level, organisational level, project level, and individual level. Any factors that influence productivity can be allocated to one or multiple categories.

The case-specific approach

The advocates of this approach always argue that even though the approaches mentioned above can provide insights into construction productivity in an effective way, they may fail to be comprehensive enough for decision makers to deal with the very specific nature of a project. In this respect, the productivity factors in the construction industry shall be considered in the context of the case that is of interest. For example, as shown in Figure 5, Ellis and Lee depicted how project-based environment influences productivity and how to understand different productivity factors in a relative manner. In reality, this approach is widely adopted by practitioners and people are willing to feed their experiences regarding to one or a few factors back into daily practice and thus formulate their unique conceptual construct or model about productivity.

The approach adopted by this study

In order to draw a rich picture of the productivity issue, this report would adopt the latter two approaches in combination, in which case-specific factors that are drawn upon from previous researches and studies will be allocated into a pyramid structure that is based on Allan and Davis (2006).Considering the specific nature of this study, further two dimensions will be integrated and finally form the analytical structure, in terms of strategy, organisation, operation, project, and individual. Figure 6 exhibits how productivity factors can be allocated.

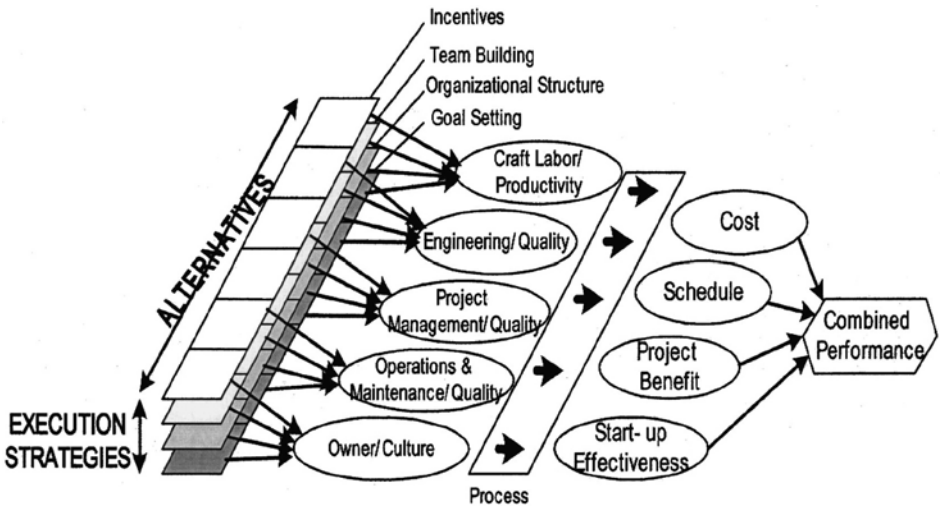

Figure 5: Adopted from Ellis and Lee (2006)

Figure 6: The hierarchy of productivity factors

It should be noted that a myriad of the productivity factors in the existing literatures, such as planning, can be found in more than one category and arbitrarily assigning them to certain layers in hierarchy can be misleading. In order to utilise its functionality, it is more reasonable to transform it as a benchmark to indicate certain properties of a productive factor and those properties can be perceived as the evidence for categorisation. The detailed application of this model will be demonstrated after presenting a brief summary of productivity factors.

2.3.2 Detailed description of productivity factors

A collection of factors

From a practitioner's viewpoint, there are numerous factors that can affect productivity. From a structured survey study, the construction workforce rated material and equipment shortages, change orders, weather, labour shortages, and turnover as the top five factors affecting the ability to produce work (Borcherding, 1978). Rojas and Aramvareekul concluded their researches by identifying the top 10 problems that are associated with construction productivity, including: lack of materials, incomplete drawings, incompetent supervisors, lack of tools and equipment, absenteeism, poor communication, short instruction time, poor site layout, inspection delay and rework (Rojas and Aramvareekul, 2003). In Australia, Doloi

Supervisor direction	**Foreman**
Inadequate instruction provided by supervisors	Lack of people skills on behalf of foremen
Not receiving directions due to size of the project	Unqualified linemen
Not receiving compliments for doing a good job	**Unfair Performance Reviews**
Not being notified of mistakes when they occur	Foremen not allowing crafts to work autonomously
Lack of goals for craft workers	Lack of construction knowledge on behalf of foreman
Communication	Lack of authority to discipline craft workers
Different languages spoken on a project	Lack of proper resource allocation
Disregard of crafts' productivity improvement suggestion	Lack of managerial and administrative support
Lack of 'big picture view on behalf of the crafts	Excessive paperwork
Craft worker importance	**Superintendent**
Lack of communication among site management	Lack of people skill on behalf of superintendents
Safety	Qualified superintendents
Shortage of personal protective equipment	Lack of experience on behalf of superintendents
Lack of site safety resources	Disrespect for craft workers
	Micro-management on behalf of superintendent
	Political/performance competitions within company
	Inconsistent safety policies established by different superintendents
	Different work rules by superintendents

Table 1: Factors affecting productivity (Dal et. al., 2007)

Tools and Consumables	**Labour**
Availability of consumables	Availability of skill training
Restrictive project policy on consumables	Jobsite orientation program
Availability of hand tools	
Viability of power tools	**Project Management**
Lack of power source for tools	Delay in work permits
Lack of extension cords	Out of sequence work assignments
Inexperienced tool room attendants	Absenteeism
Misplaced tools	Unreasonable project and milestones
Poor power tool quality	Disrespect for craft workers and foremen
	Layoff qualified craft workers
Material	Unawareness of onsite activities and project progress
Availability of material	Pulling people off a task before it is done
Poor material quality	Jobsite congestion
Availability of bulk commodities	Different pay scales for the same job on a project
Errors in prefabricated material	Different per diem rate
Difficulty in tracking material	Lack of incentive for good performance
	Material storage area too far from workface
Engineering Drawing Management	Insufficient size of material storage area
Drawing errors	Shortage of temporary facilities
Availability of drawings	Lack of coordination between the trades
Slow response to questions with drawings	Slow decisions
Drawing legibility	Incorrect crew size
Needed information not on drawings	Inappropriate vehicle traffic routes
	Lack of weather protection
Availability of Health and Safety Training	
Unqualified craft workers	**Construction Equipment**
Lack of pride in their work	Availability of crane or forklift
Lack of incentive to attend training	Availability of manlift
Demotivated craft workers	Waiting for people and/or equipment to move material
Less pay than the projects in a geographic area	Poor equipment maintenance
Craft workers' distrust in supervisors	Stow equipment repairs
	Improperly maintenance of power tools

Table 1: Factors affecting productivity (Dal et. al., 2007) (continued)

adopted AHP method, which is basically a decision-supporting technique to prioritise, and he ranked five specific productivity problems as: lack of materials, rework, absenteeism, shortage of tools and equipment (Doloi, 2008). Moreover, Motwani et al. reported five factors impeding productivity in the USA, namely, adverse site conditions, poor sequencing of works, conflicting drawings/lack of information, non-availability of tools and materials, and poor weather (Motwani et al., 1995).

After conducting a literature survey, Dai et al establish a list containing 9 productivity factors with the following ranking: (1) Material availability; (2) Tool availability; (3) Work redone; (4) Overcrowded work areas; (5) Inspection delays; (6) Foreman incompetence; (7) Crew interference; (8) Craft turnover and absenteeism, and (9) Foreman changes. It can be found that lack of materials is repeatedly identified as one of the most significant problems, followed by crew interference, rework, supervision delay, lack of equipment/tools and absenteeism. The reasons for the lack of materials are ranked in the following order: (1) lack of planning; (2) transportation difficulties within the site; (3) improper materials; (4) crew interference; and (5) extensive paper work (Dai et al., 2007). Table 1 exhibits detailed information of Dai et al's work.

Mojahed and Aghazadeh, on the other hand, adopted a

Factor ranking	Details
1. Skills and experiences of workforce	Skills and experience of workforce was chosen as the first driver of productivity. The qualifications may be easier and workers may enter the occupation with limited skills or experience. If a worker lacks the knowledge or skills required for performing a task, the timely performance of task would suffer which result in poor productivity or potential mistakes made in performing the task. Lack of attention to quality standards could also result in rework, which is another cause of productivity loss.
2. Management	Lack of competency by management at construction jobsite may lead to poor direction of workforce, de-motivation of workers, and poor coordination of subcontractors, which results in poor productivity. Managers may increase productivity through planning, proper selection, control and utilization of resources, and supply of information and feedback. Commitment to productivity must be demonstrated in actions.
3. Job planning	Effective planning of construction projects requires understanding of details, construction methods, and resource requirements. Construction tasks are not isolated. The relationship between construction activities and resources is intrinsic to the construction process. The respondents stated that the internal delay, which is usually caused by dependency between construction activities, where one activity cannot be started before the preceding activity is finished, happens at construction jobsites due to inadequate planning. In addition, it was revealed that the workforce productivity is negatively affected when a project schedule changes as a result of fragmentation of work activities, reassignment of crew members, and out-of-sequence work. Proper planning of all phases and components of work is necessary to ensure productivity.
4. Worker motivation	The lack of motivation or existence of demotivational factors could result in decline of workforce productivity. Motivational problems peculiar to large construction projects include: minimal knowledge about the project, lack of participation in decision making, inadequate communication and coordination between crews and supervisors, detrimental changes in the work, as well as supervision and manpower that reduce learning curve efficiency improvement. Some of the demotivational factors reducing workforce productivity include lack of adequate planning and materials, constant disruption of job assignment, unavailability of tools and equipment, overcrowded work areas and rework, unsafe working conditions, lack of recognition and training, and disrespectful treatment of workers.
5. Material availability	Extensive multiple handling of materials, improper storage of materials, waste due to negligence, obstruction of access to material storage area, extensive travelling time between material storage area and active worksite, long fabrication time and late deliveries are a few instances of how material arrived late to active construction jobsites and influenced productivity of construction projects

Table 2: Key productivity issues (Mojahed and Aghazadeh)

quantitative method to derive key productivity factors from a variety of issues and their findings can be summarised in Table 2.

Moreover, Chan and Kaka drew 59 factors through an intensive literature survey and their findings can be shown in Table 3.

However, the elicitation and ranking of productivity factors are not universal and they are dependent on time, geographical location, and specific industry sector. In the late 1970s, a survey conducted in the US found that material availability, proper tools, rework, overcrowded work areas, and interference between crews were the top five factors affecting the ability to produce work.

1	Supervision	21	Scheduling	41	Travelling time to work
2	Simplicity of building design	22	Availability of plant	42	Shift work
3	Level of site experience	23	Utilisation of plant	43	Size of components
4	Information flow	24	Working hour (include overtime	44	Uniqueness of building design
5	Communication with subcontractors	25	Specifications	45	Bonus schemes
6	Delivery	26	Quality requirements	46	Site administration duties
7	Availability of materials	27	Health and safety management	47	Welfare amenities
8	Congestion	28	Training investment	48	HCN HND
9	Prefabrication	29	Experience of planner	49	Short courses
10	Sequencing and interference	30	Turnover	50	Packaging
11	Standardisation	31	Level of pay	51	NVQS/SVQS
12	Procurement of materials	32	Construction technology involved	52	Degree/postgraduate qualifications
13	Availability of staff	33	Storage	53	Secondary school qualifications
14	Communication Within gangs	34	Modern apprenticeship	54	New products
15	Weather	35	Capacity	55	Building regulations
16	Resource allocation	36	Cost control	56	Construction skills certification scheme
17	Rework	37	Maintainability of plant	57	Investors in people
18	Communication with suppliers	38	Job prospects	58	EU directive on working time
19	Communication Within company	39	Health and safety	59	Equal Opportunities Act
20	Availability of components	40	Simplicity of plant and equipment		

Table 3: Productivity factors (Chan and Kaka)

Some of the identified major productivity factors in this study are skills and experience of workforce, motivation, and management which are different from proper tools, rework, and overcrowded work areas. Some others found that materials shortage, weather and site conditions, equipment breakdown, drawing deficiencies/ change orders, and lack of proper tools and equipment are the top causes of poor productivity in Iran. In Nigeria researchers found lack of material, inadequate tools, rework, instruction delays, and inspection delays are major problems impairing labour productivity. A survey of 27 medium and high-rise construction projects showed that the main productivity problems facing craftsmen were absenteeism, rework, and lack of material. In Canada, planning and scheduling, equipment, availability of working drawings, materials, and motivation were found to be major drivers of productivity. On the other hand, in a survey study of 34 project managers in Thailand, the factors ranking prominently as causes of non-productive time were lack of material, incomplete drawings, inspection delay, incompetent supervisors, and instruction time. Table 4 contains a brief summary:

As demonstrated in Table 4, there is a significant amount of literature and studies conducted in the field of productivity by identifying factors that can exert influences. In order to depict a rich picture, we endeavoured to outline a table that contains as many factors that may potentially influence productivity from a theoretical perspective. The output can be utilised as a checklist for practitioners to check whether they face similar productivity constraints. Furthermore, we adopted the hierar-

Country Ranking	Canada	Iran	Indonesia	Nigeria	Thailand	US (1970s)	US (2005)
1	Planning and scheduling	Material shortage	Absenteeism	Lack of material	Lack of material	Material availability	Skill and experience
2	Equipment	Weather and site condition	Rework	Inadequate tools	Incomplete drawings	Proper tools	Management
3	Working drawings	Equipment breakdown	Lack of material	Rework	Inspection delay	Rework	Job planning
4	Materials	Drawing deficiencies		Instruction delays	Incompetent supervisors	Overcrowded work	Motivation
5	Motivation	Lack of proper tools		Inspection delays	Instruction time	Interference between crews	Material availability

Table 4: Comparison of identified productivity factors from a variety of studies

	Strategy	Organisation	Operation	Project	Individual	Total
Number	65	157	204	257	106	397
Percentage	16.37%	39.55%	51.39%	64.74%	26.7%	

Table 5: Statistical description of productivity factors applied to the Figure 6 hierarchy diagram

	Strategy	Organisation	Operation	Project	Individual
Strategy	1	69.23%	36.92%	26.15%	20%
Organisation	28.66%	1	36.94%	33.1215	42.68%
Operation	11.76%	28.43%	1	78.92%	18.13%
Project	5.44%	20.23%	62.65%	1	19.84%
Individual	12.26%	63.21%	34.91%	48.11%	1

Table 6: Interrelationship between various tiers in the hierarchy structure

chy structure in figure 6 as the second dimension for readers to capture the essence of those factors in a more systematic way.

2.3.3 A statistical description of productivity factors

We have uncovered no less than 397 factors influencing construction productivity in the literature and have attempted to group these against the hierarchical model in figure 6 to make sense of the findings.

Based on the literature-based checklist of productivity factors, it can be found that each of the five tiers in figure 6 has a different level of entries. Moreover, as pointed out before, a productivity factor can be allocated to one or multiple tiers in the hierarchy structure, in that, the total number of productivity factors does not equal to the sum of individual categories. Table 5 contains a statistical description of those factors.

Several points should all be noted:

- A considerable amount of factors can influence the productivity of the construction industry. Even though the total number derived from current research is 397, we believe that there could be more added as it is unlikely to be an exhaustive survey of all the factors. These productivity factors can help practitioners extend their view of productivity factors.
- Project level productivity factors are the most significant. Key issues surrounding this area include scheduling, material, tools and consumables, drawing and etc.
- The second most significant area is all about a company's operations and the factors in this category is pretty similar to those at the project-level. The most noticeable difference is that the former integrates more concepts from management, whereas the project-level factors are adjacent to technical aspects.
- The third in categorical ranking is organisational factors that would affect productivity. In this category, factors are mainly about management, skills, training, and communication and so on. It can be found

that more soft issues are included, implying that companies cannot improve productivity without taking soft issues into account.

- The fourth tier is at the individual level, with such important factors as motivation, moral, skills, and etc. Compared with organisational factors, individual level factors do not involve much management topics and this is why its number is slightly lower.
- The last category is at the strategic level. However, this by no means indicates those factors are least important. On the contrary, they may be the most important ones for senior managers or policymakers to consider.

Regarding to the interrelationships between different tiers in the hierarchy structure, a brief statistical summary can be obtained as shown in Table 6. The logic in building the table is to help us capture a better understanding of how closely those tiers are related in terms of common productivity factors. For example, the tier 'strategy' has 45 common factors with the tier 'organisation', the relationship between strategy and organisation is 45/(the number of 'strategy' tier). It should be noted that such an arrangement is two directional as the values of a pair are not necessarily reciprocal.

In Table 6, column variables are the denominators and row variables are the numerators, in that, every cell in the table represents the degree of similarities between the corresponding row variable and column variable. For instance, the value of the cell in row 2 column 3 indicates 36.94% of all organisation factors are also in the group of operation.

In principle, the greater the percentage value is, the more similar two hierarchy tiers are. In the analysis, we found the operation and project are the most closely coupled concepts. This would indicate that if a manager identifies some productivity factors in one category, the other category is likely to be affected. Following this logic, we identified the top five closely coupled tiers, namely project-operation, organisation-strategy, organisation-individual, operation-project, and individual-organisation. Thus, it could be concluded that, from a literature's perspective, operational level and project level productivity factors are intimately related and they are, to some extent, similar to each other. This would indicate that efforts to improve any factor in one category are very likely to improve the other as well, so that, the improvement can be coordinated. On the other hand, the other three pairs all contain the concept of organisation, indicating that organisational factors are the core for improving productivity.

2.4 Summary

In this section we briefly reviewed the definition of productivity. In the simplest form, productivity is the ratio between the input and output. The complex nature of the construction industry determines that the input into a construction project is so diverse that it ranges from natural resources to working conditions, from human efforts to capital investment. On the other hand, the output of a construction project aims to meet client's requirement and thus involves people's judgment. In this sense, construction productivity is related to both objective entities and subjective influences and the understanding of this concept can cover different dimensions. In that, whilst productivity can be described by a single factor, such as labour or capital efficiency, multiple factors can provide a richer picture of the issue.

Without applicable measurement, the problems residing in productivity cannot be fully addressed and thus this section gives a brief review of existing productivity evaluation methods. Although reaching a generic and universal measurement of construction is to some extent unrealistic, this does not mean practical methods are unavailable. The single factor productivity measurement has various formats and can help decision makers capture insights into how one variable influences the overall productivity, whilst the total factor productivity measurement endeavours to provide more comprehensive information by integrating multiple factors into consideration. Recent development in productivity measurement, such as the throughput approach, relative measurement, and target measurement, aim to integrate, delivers alternative approaches for practitioners in the construction industry to investigate the productivity issue.

The majority of existing literature related to construction productivity has been devoted to investigating what factor(s) influence construction productivity and how they exert their influence. We have compiled a collection of those productivity factors which is extensive. We followed a hierarchic and case-specific approach to categorise those factors and constructed a hierarchy model for readers to understand the essence of productivity factor groupings. The importance of different levels of productivity factors, namely strategic issues, organisational issues, operational issues, project issues, and individual issues, has been elicited and decision makers can utilise this to benchmark their own organisation or project. Knowledge and information that is accumulated during this literature review formulates the basis of the theoretical foundation of this research and future data collection and analysis is based on work completed in this phase.

3 RESEARCH METHODOLOGY

Our philosophical approach to the research is a systemological interpretative perspective, in that we use systems thinking and systems tools to make sense of the data gathered from workshops and interviews s that have been conducted with selected stakeholders.

3.1 The Research Loop

Stakeholder viewpoints are invaluable in systems approaches as they can provide insights not easily uncovered by other techniques. So we conducted workshops and interviews with selected stakeholders to probe the barriers to productivity issues in NZ's infrastructure construction SME community. Whilst every interview was useful, there was diversity in the richness of the data gathered that did pose some methodological issues. The approach taken was predominately qualitative and the central approach used a grounded theory type of analysis coupled with a learning cycle adapted from Kolb's model (Kolb, 1985). See Figure 7 for details.

At the beginning of the learning loop, data has to be gathered and transcribed. Any memos, notes, or summaries made during this phase will be of paramount importance for the understanding of the contexts of each individual interview. The next stage is called '*reflective observation*' by Kolb, which in effect requires the analysts to capture a more specific understanding of the data. In order to do so, the analysts have to become intimately familiar with data and can put some orders to the data. The following stage is to grasp key concepts from the interview data. According to Kolb, a concept is '*a descriptor for an issue, movement, thought or pattern of words that would be recognisable particularly to* the researcher'. Then, the analysts transform the knowledge that is generated from the data to a format which can be accessed by others. At this stage the analyst needs to identify the emergence of patterns and to present it in a robust way. It should be noted that this should be a looped process, so that, the knowledge generated from data analysis should be feedback to the participants for reviewing.

3.2 Data gathering

All the interviews were undertaken between September and November, 2009 and in total there are 32 interviews with each spanning between 30 – 90 minutes. The interviewers have considerable experience in conducting face-to-face interviews and they had been given detailed instructions, question lists, and a checklist of productivity factors to aid the process. The interview process was recorded digitally, then transcribed and the transcripts were checked by the interviewers. It should also be noted that due to the confidentiality issue and ethical codes for conducting qualitative research, all contributors to this research remain anonymous. The output of this phase is a collection of fully properly transcribed interviews. A list of the interviews and transcripts are available on a separate indexed CD-Rom.

In addition to the interviews, two half-day workshops were undertaken. One was with senior managers and key stakeholders in the sector, from which rich-pictures and concept maps generated. The second workshop focussed on a set of practitioners from the SME sector, consisting of owners or senior managers of small construction enterprises. In this workshop a directed discussion around key productivity topics was captured and later mapped. The workshops were intended to give a

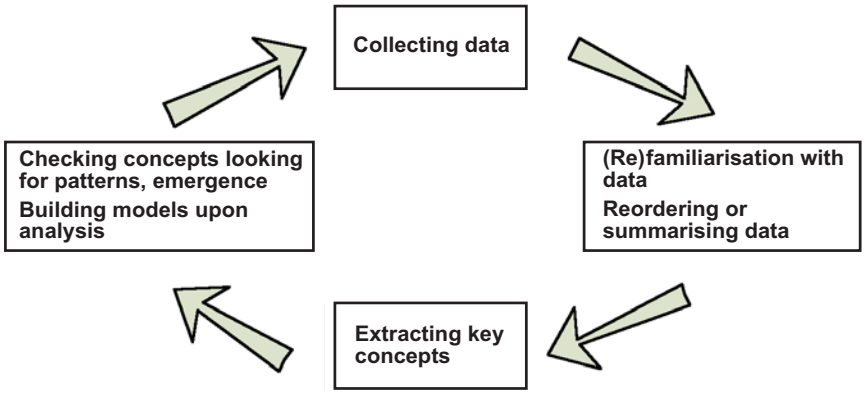

Figure 7: Ground Theory – Kolb's Learning Model (Kolb, 1985)

broad overview of the issues so that an appropriate set of interview questions could be designed. The output from the workshops was analysed separately as the context and questions were different to the interviews and may have invalidated the interview analysis results.

3.3 The Trinity in Analytical Methods Used

There are essentially three methods we used to analyse and triangulate the interview data, though in practice they overlap and supplement each other to some degree:

1. Leximancer analysis of the complete text for automatic generation of concepts and themes.
2. Grounded theory approach using NVivo software to code words and concepts for each interview, which build to form a hierarchy and from this a theory or framework emerges
3. Concept mapping techniques and analysis, developed by Eden and Ackermann using Decision Explorer software.

Each technique will be described separately below.

Leximancer is a piece of software designed for qualitative research and the analytical process is almost automatic. Leximancer scrutinises the text content of documents and then visually displays the extracted information in the form of concept maps which shows how the data is related. Essentially a word can be characterised by the words that tend to appear near it, and not apart from it. It is known that the appearance of a word is correlated with the appearance of certain other words, and this correlation has a range in terms of separation before or after the target word in the stream of text. The connections of different words produce a concept from the text and the connection of the concepts produces themes, see Smith & Humphreys (2006).

The main benefit of this process in this study is to give an overview or map of the whole area of analysis, so that we do not miss important areas in the more detailed analysis, which is easy to do. It provides a survey of the field and highlights trees, dips, hills and places of interest.

However, the efficiency of automatic analysis does not necessarily lead to robustness in the results and therefore the grounded theory analysis and concept mapping are needed to supplement the result generated by this automatic process. The following section will introduce how the researchers conducted those two analyses.

3.3.1 Coding

After gathering enough data through interviews, the next step is to code transcripts. With the view of creating comprehensive understanding of SME productivity in the context of NZ's construction industry, coding interview transcripts is of paramount importance. The researchers have selected an open and structured process to conduct the coding practice, in that, interviewees' transcribed articulations have been analysed sentence by sentence

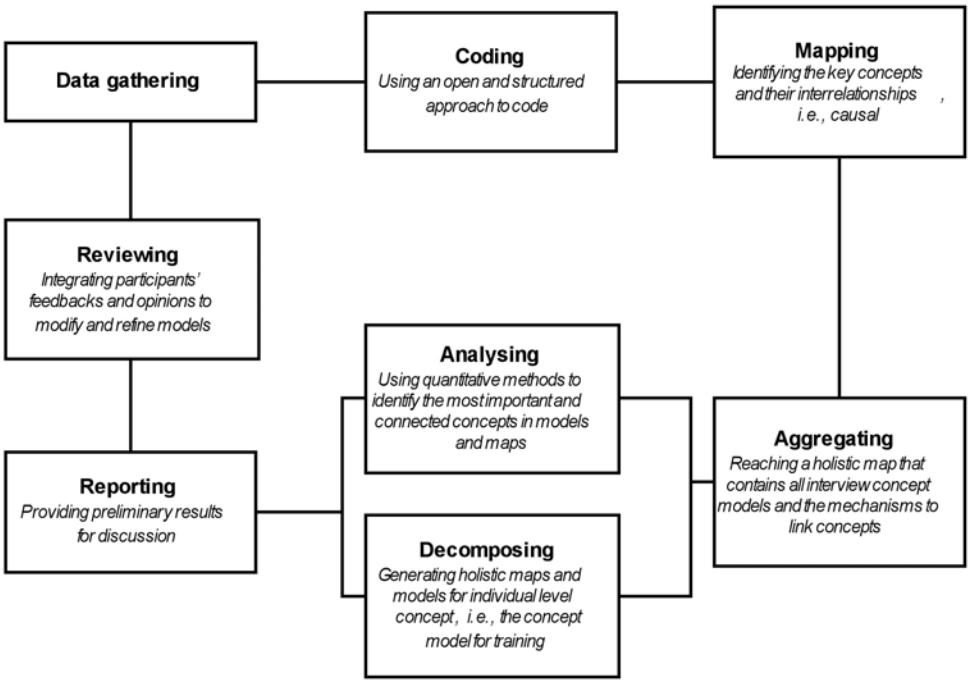

Figure 8: Data analysis procedure

so as to extract the themes or concepts the interviewees tried to express. In doing so, such themes or concepts are generalised and highlighted as key nodes in the QSR NVivo environment, which is a popular qualitative analysis software package and is adopted as the analytical tool for this project. Figure 9 exhibits an example of the NVivo interface on how to code the transcripts.

As can be seen in Figure 9, interviewee's verbal expressions are represented in the bottom left column and the nodes, which reflect the essence of individual concepts, are in the bottom right column. The coded concepts and sentences are highlighted in shadow brown and their corresponding nodes are stressed by strips on their right hand side. For instance, in the original transcript, the interviewee said that '*...productivity really comes down to sort of making sure you are well organise(d), you know you got a plan you go to and sort of making sure, thinking through...*'. This sentence reflects that in the interviewee's mind, the concept productivity is related to being organised, being well planned, and being considerate. In the coding practice, these concepts are highlighted and recorded as productivity, organisational skills, plan, and decision-making competency respectively. The interviewee's expression of determination, or the term 'make sure', is coded as assurance. All of the codes are highlighted with different colours.

The research accepts that the subtlety in every interviewee's sentences determines the richness of the final output and in this regard it is necessary to try to include as many nodes as possible. In order to do so, the knowledge summarised in the literature review and analysts' experiences are utilised to support this 'open coding' practice. However, since every individual interviewee can have diversified expressions regarding a single concept, it is very likely to create repetitive nodes during the coding process. Therefore, the analysts have used a structured approach to code transcripts, in which relevant nodes are combined into one. The result of this action is that all nodes in effect formulate a list and this list can be used as the benchmark to code new transcripts. Moreover, the structure of the list and interrelationships between nodes is the root of the grounded theory.

3.3.2 Mapping

At this stage, pair-wise relationships between nodes are identified and recorded for each individual interview. Specifically, it is the causal relationships between two nodes to determine the mechanisms of a concept map. Thus, we assign either positive or negative signs to every link. Furthermore, when multiple concepts formulate a closed circle, we can identify self-reinforcing loops and self-balancing loops, the former being able to feedback influences back to the loop and then propagate further influences, whilst the latter having the capability to counter the effect of itself to force the loop to balance at a certain state. After obtaining the information regarding

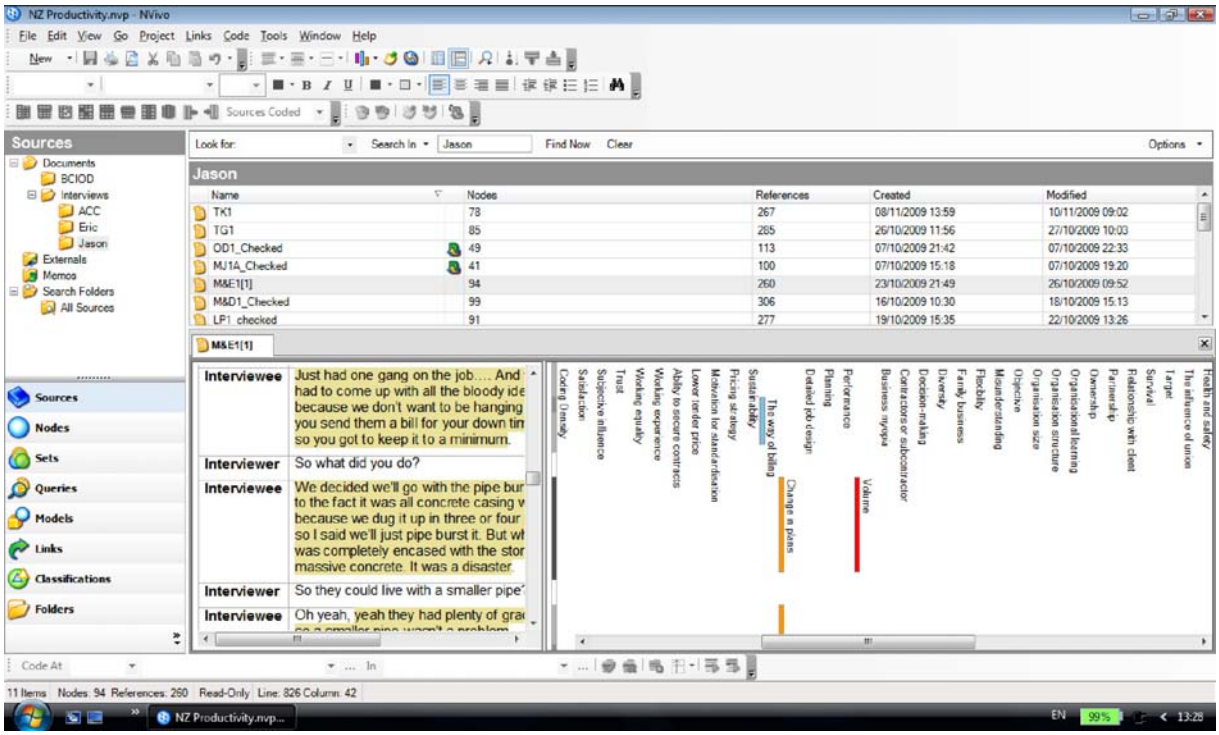

Figure 9: A NVivo screenshot for coding transcripts

every node and the relationships among them, a concept map can be arrived at. Having a concept map for every interview not only allows analysts to capture a view of the productivity issue, but also makes it possible for review purposes. In Figure 10 there is a sample concept map that is derived from mapping exercises. Detailed interpretation and application of concept map analysis will be found in later sections.

3.3.3 Aggregating

The 'aggregating' stage is simply to integrate all concept maps into a single map than can provide holistic views of the research topic. The basic method for reaching such a goal is to merge similar concepts from every individual concept maps and keep the links. During this practice, we have used the software Decision Explorer to aggregate concept maps.

3.3.4 Analysing/decomposing

The aggregated concept map is indeed too complicated to comprehend at the first glance. In fact there are more than 500 concepts collected and represented in different concept maps and such richness in information is beyond people's capability to comprehend and therefore it is necessary to run certain quantitative analyses to find the most important concepts and their mechanisms. We have used Potency Analysis and Centrality Analysis, which will be explained in later sections to elicit the most significant individual concepts.

With the knowledge of the potent concepts derived from interview data, we can then pick out the concepts that are associated to a common theme to develop specific models and we referred to this process as 'Decomposing'. In fact, those models are the ones that can reflect the specific nature and mechanisms of the construction productivity from a particular perspective. For example, we can extract concepts relevant to 'Training' or 'Management' to build a 'Training Model' or 'Management Model' for the sake of understanding sub-topics in details.

3.3.5 Reporting

Reporting the concept maps, the aggregate maps, the models of individual topic and etc in a formal document is important to circulate the research findings to audience. We have compiled the findings in this report.

3.3.6 Reviewing

The final stage of the data analysis process is to review the results and findings and feed them back to the report. This process is crucial in determining the validity of the findings as participants' inputs are always appreciated by the project team.

3.4 Summary

In this section we introduced the general process of collecting and analysing practical data. Generally the researchers followed a Kolb's learning cycle to design this qualitative research and by examining different analytical methods we determined to adopt a triad of techniques, in terms of Leximancer analysis, NVivo based grounded theory analysis, and concept map analysis.

Leximancer can process transcripts automatically and generate a map of key themes. In running this analysis, an overview can be obtained as guidelines for the general understanding of the investigated problem. However, the subtlety residing in interview transcripts might be lost during the automatic filtering process and thus the robustness and validity of its findings might be questioned by critiques. In order to supplement these minor loopholes, the researchers adopted grounded theory and concept map analysis as complementary.

According to the researchers' knowledge and experiences, the grounded theory analysis and concept map analysis can be conducted simultaneously with the same procedure and the results from the two are complementary. By considering the nature of this research, we designed a seven-step process to deliver reliable and robust results. That is, individual transcripts are coded in NVivo environment with a view to elicit the interrelationships between words and sentences. Then, the essences of interviews are modelled as analysed concept maps. Because of the quantity of data collected and the multifaceted nature of participants' perspectives, we aggregated every viable individual model together to formulate an aggregate one to include all participants' mental constructs and then decompose it with a view of understanding certain themes.

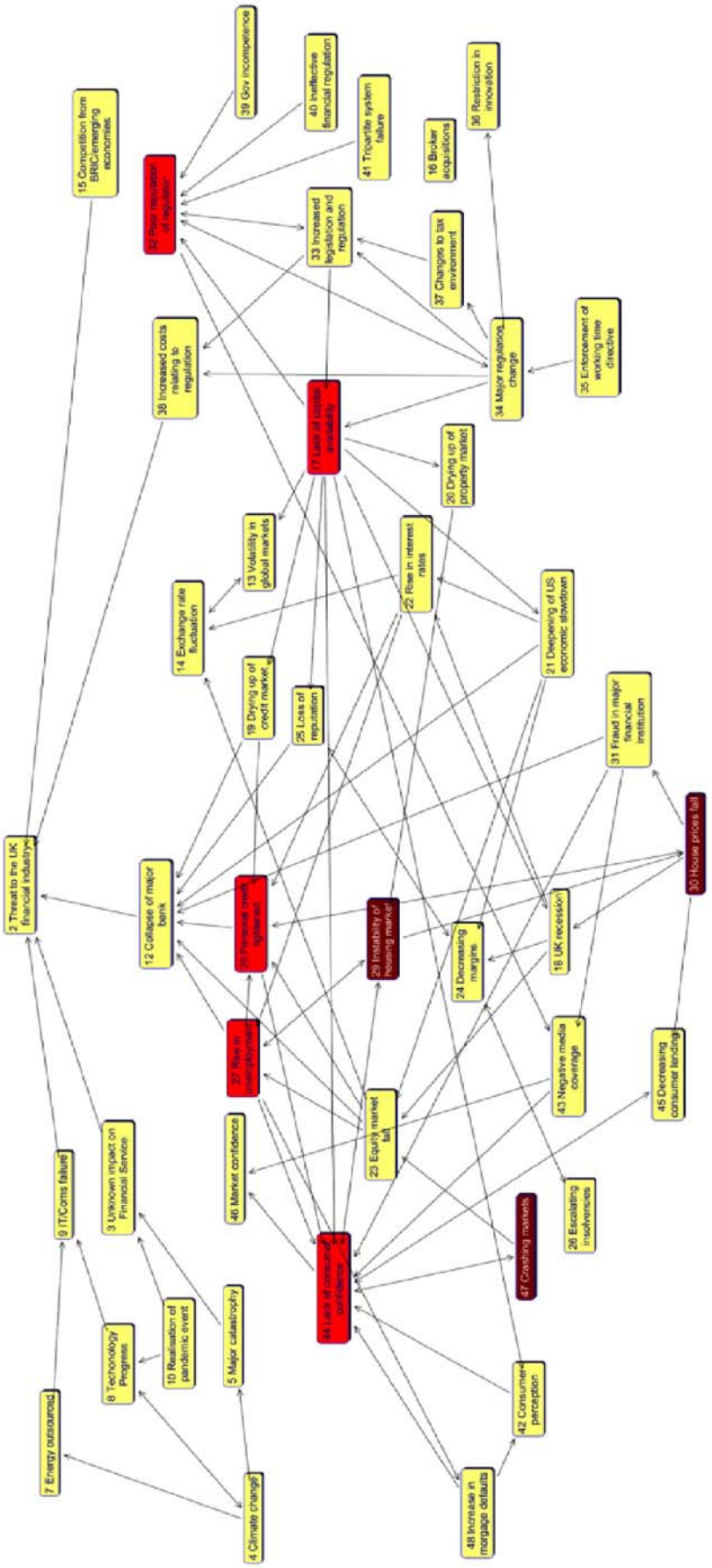

Figure 10: An example of a concept map

4 RESULTS AND DISCUSSION

4.1 The Results from Leximancer

All the interview transcripts have been processed into one analysis (see Figure 11), which shows the major themes relating to productivity.

One can see from Figure 11 that there is a direct connection between productivity and business, plant, cost, time, work and the job. Work is an important secondary theme, which is highly connected to people, money and staff. Training is also important as it is highly connected to projects, skills and management. What is interesting about training is that it is perceived (at least in the minds of those interviewed) as significantly related to productivity but somewhat separated from it. It is revealing that projects, management, skills and staff are grouped closely together but distant maybe because they are less tangible than plant, cost or time.

To explore this connection a little more we have carried out a pathway analysis to reveal exactly how the connection is perceived from training to productivity, this is shown in Figure 12.

The key pathway shown in Figure 12 is from training to productivity which is:

Training – Skills – People – Work – Productivity

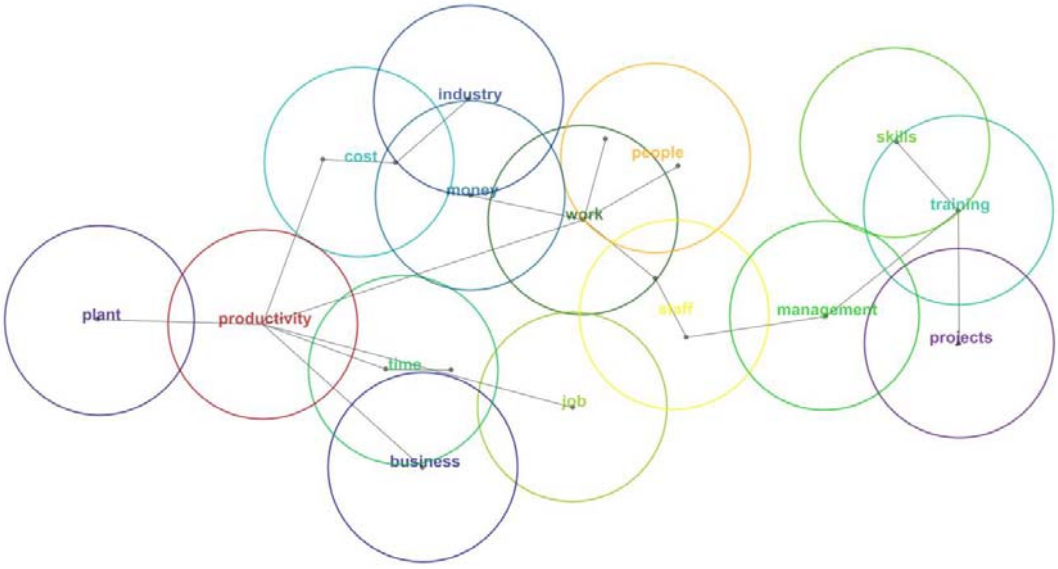

Figure 11: Leximancer analysis showing the key themes from all the interviews

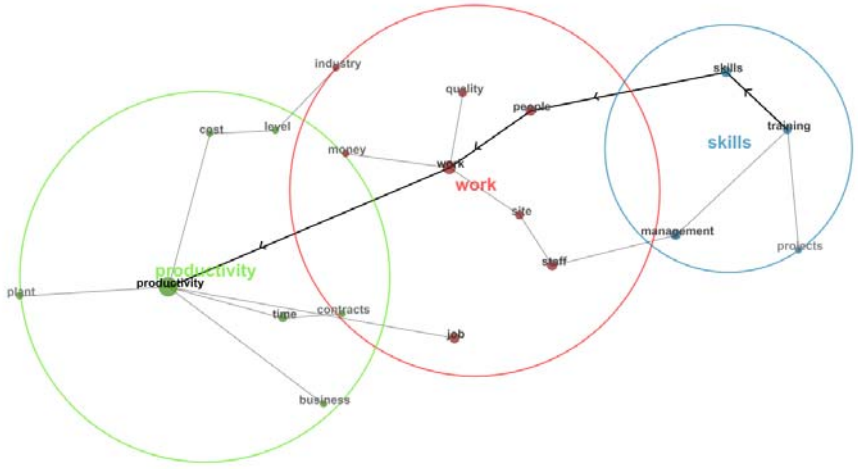

Figure 12: A pathway analyses

This pathway is important as it suggests that training should be designed to meet skills of people through work to achieve productivity. This may seem intuitive to those involved in training but is worth reinforcing here.

The themes in Figure 11 have been expanded to reveal six major themes, namely productivity, work, industry, business, plant and skills. This is shown in Figure 13 and the overlap between the themes is significant so from this diagram we can see that productivity is perceived as being more about business and plant than training.

We also ran an analysis on just the interviews from within a managed supply chain, to see if their world views of productivity were different. These maps are shown below in Figures 14 and 15.

Figure 14 shows all the key concepts that have emerged (which are the solid circles - the bigger the circle the more important it is) and the two central themes (the large circles labelled productivity and people). The dark directional line between productivity and training highlights the way that these two concepts are perceived to be linked by interviewees.

There is considerable similarity, to the overall maps with some additional interesting points:

1. Productivity is inextricably linked to people and indeed overlaps to a great extent in the minds of our interviewees.
2. Training is linked through: management – people – work – to productivity. Interestingly, skills is linked by a different pathway namely, skills- industry- people- work- productivity. It could be important that skills and training are perceived differently in this regard.
3. Productivity is seen as being closely related to money, work, hours, cost, contract, problems and plant, (indicated by the relative spatial position).
4. Training is seen as being closely associated with: experience, site, industry and management. Whilst skills is associated most with: management, people, doing and working.

Figure 15 provides a different view of the same analysis but this time the concepts have been suppressed and the thematic connections expanded. Now we can observe some of the key issues arising in the study: quality, important, money, job, work, companies, time, people, skills and training.

The location of the themes gives an overview of the associations for example; training is now seen as close to skills, people and time. Quality on the other hand is adjacent to other themes such as important, work and money, perhaps representing the classic quality, time, cost dilemma in construction projects and suggesting that money is seen as most important in relation to productivity.

4.2 A summary of key factors

4.2.1 Statistical summary

By analysing interviewees' transcripts, the researchers elicited the top-ranked factors that are related to productivity problems. Regarding to NVivo analysis, 519 factors have been mentioned by all participants and they

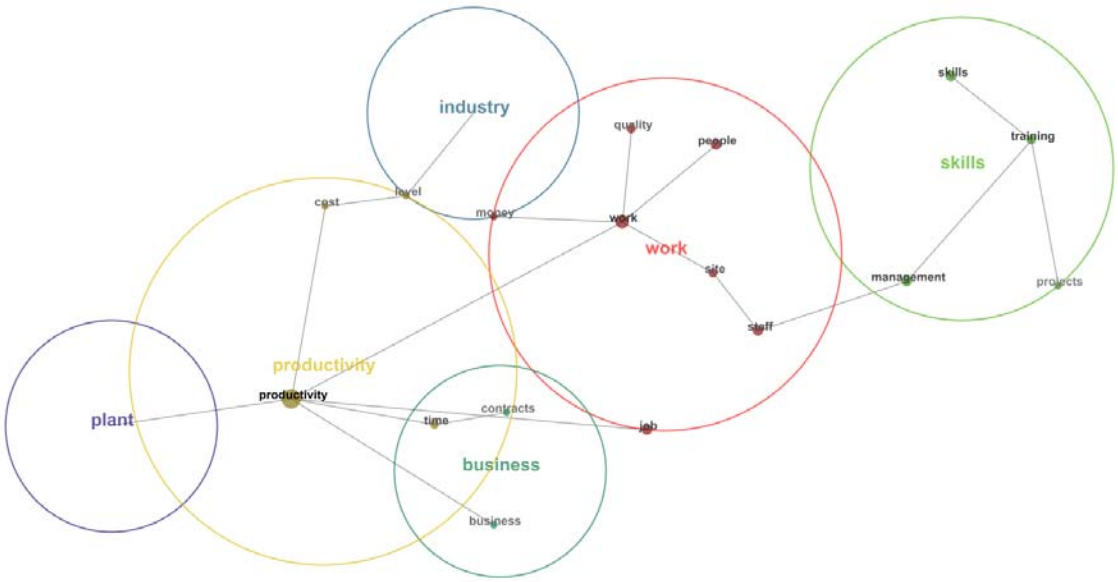

Figure 13: The six key themes relating to productivity and how they overlap

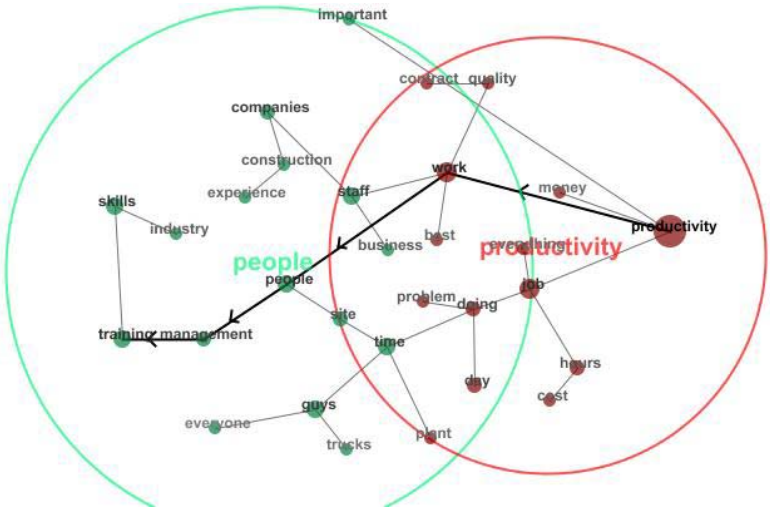

Figure 14: Leximancer map of the managed supply chain interviews

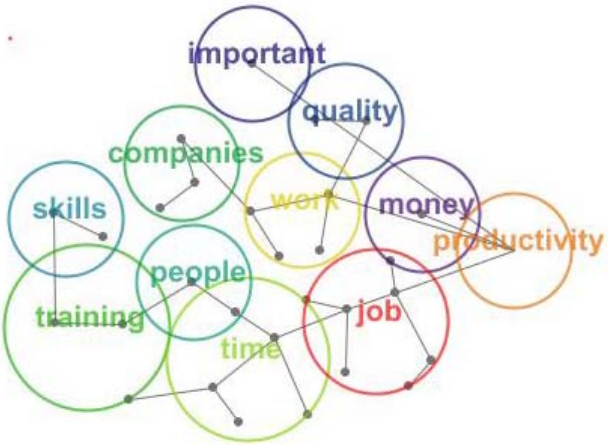

Figure 15: Managed supply chains

have been identified 6115 times by the researchers during the course of data analysis. The pie chart in Figure 16 shows how many times different individual factors are referenced.

As can be seen in the figure above, the number of references is skewed and thus not all factors are equally important for all participants. In fact, the average number of a factor being repeated by all interviewees is about 12 and only about 24% of the factors have reached or exceeded the average level, indicating that interviewees intentionally or intuitively emphasised on those important factors in their mental constructs. Therefore, it is necessary to elicit the relative importance of those factors and the research adopted a ranking approach to understand this.

4.2.2 The ranking of factors – a comparison

The ranking of a factor depends on how many times interviewees mentioned it. For example, the concept 'productivity' appeared 349 times in different recorded occasions and its number of references is higher than any others so that it is ranked as the top. The result of this statistical test is shown on the left half of Table 7. On the other hand, we have built concept maps for each individual transcript and aggregated them into a single model that allows for more advanced analyses. Considering the nature of a complex problem, the more connected a concept is, the more important it should be. In this sense, we tested the concept maps to find out how well a concept is connected to the others. The results are demonstrated on the right-hand half in Table 7.

The results demonstrated in Table 7 showed considerable similarities of key issues but also some important differences. Since the interviews are structured to investigate the productivity problem, the concept 'productivity' is ranked in the top positions. There are several

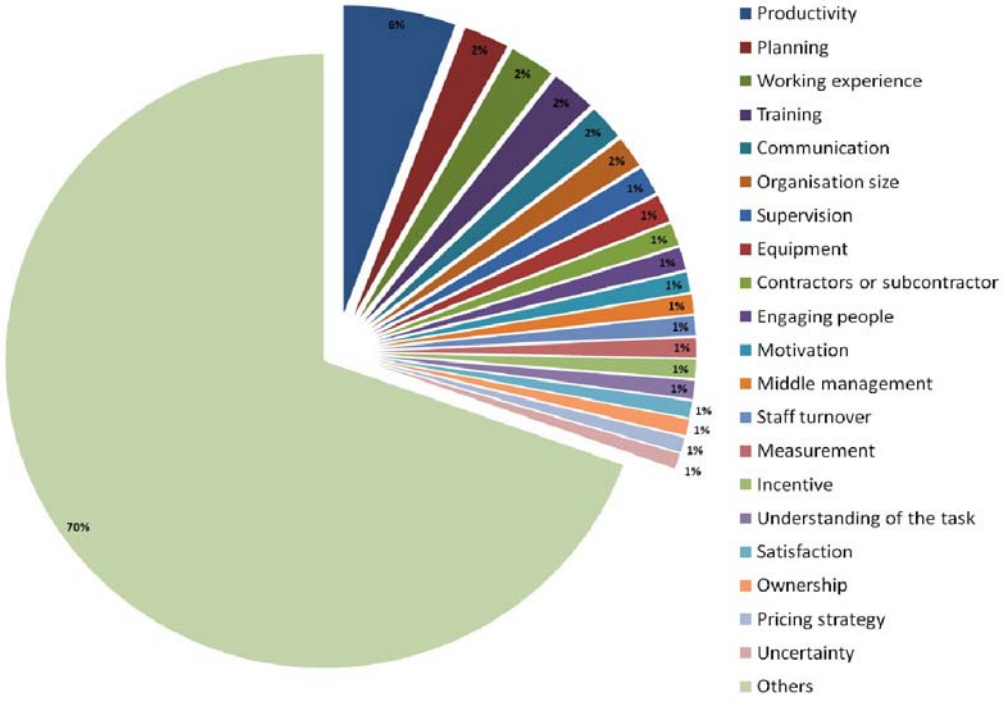

Figure 16: A pie chart of most frequently mentioned concepts

other factors namely planning, organisation size, training and working experiences, which are ranked in top 10 with both methods. Considering the analytical methods used in this research, these factors are considered well developed and recognised by participants as influential factors in the productivity problem.

On the other hand, the differences between the results cannot be ignored. Those top 20 factors from concept analysis that are not displayed in Table 7 include decision making (4), competency to deliver (7), work efficiency (8), organisation culture (9), project management (12), contract (13), relationship with clients (16), and profitability (17). A major reason for the differences is embedded in the fact that the frequency of a factor being mentioned does not necessarily mean it is well connected to all other concepts. That is, a frequently mentioned factor might only be related to a few, whereas a factor with less presence in transcripts may actually be well connected to many, leading to the differences in rankings. Also, it can be found that those top ranked factors identified by concept map analysis tend to be more general and intangible, i.e. culture issues, which are less likely to be mentioned in daily conversations.

This phenomenon is quite noticeable. For instance, the participants did not mention the concept 'middle management' sufficiently to make it in the top 10. However, the concept maps showed that it is the most connected concept as it links various loops and concepts that go beyond the understanding of a single person. The concepts of 'decision making', 'relationship with clients', and 'profitability' also belong to this category. Conversely, communication is frequently emphasised by interviewees but its connectivity ranking is relatively low. The reason might be that participants recognise communication as an issue yet don't see the pervasive influence beyond them individually.

Certainly the results shown in Table 7 can add new insights in the productivity problems when they are compared with the findings from the literature review.. Planning is regarded by both existing literatures and this research as a key factor that influences productivity. The significance of experiences and communication is also agreed by many sources. In other words, the research findings from this research can be partially validated by literature. However, not all top-ranked factors identified in the context of SMEs in the NZ's construction industry fit well to literatures. For example, only a small number of references emphasise the concept 'training' and 'organisation size', probably because of the focus on larger organisations. Also, the term training used in this research includes multiple facets, such as skills, and therefore this could lead to the differences in the top ranked factors when compared to literature. Finally, the variations in the top ranked factors only serve to provide a richer understanding of productivity problem from different perspectives and are not intended to falsify the validity of the results.

Top factors drawn from NVivo	No. of References	Ranking	Ranking in concept map analysis
Productivity	349	1	2
Planning	141	2	3
Working experience	141	3	10
Training	139	4	5
Communication	112	5	18
Organisation size	99	6	6
Supervision	90	7	20+
Equipment	87	8	20+
Contractors or subcontractor	71	9	15
Engaging people	70	10	20+
Motivation	63	11	14
Middle management	62	12	1
Staff turnover	62	13	11
Measurement	62	14	20+
Incentive	59	15	20
Understanding of the task	58	16	20+
Satisfaction	52	17	20+
Ownership	52	18	19
Pricing strategy	48	19	20+
Uncertainty	48	20	20+

Table 7: Ranking comparison of interview versus concept mapping

4.3 The Hierarchy Model – A Grounded Theory of SME Construction Productivity

The researchers collected more than five hundred individual concepts during the course of analysing interview data and their basic structure and general interrelationships are demonstrated in Figure 17.

In Figure 17, every node represents a collection of concepts. For example, in the node 'Communication' there are seven second tier nodes attached to it. It should be noted here that for this map the arrows indicate causal relationships whilst a line implies that two concepts are related. Furthermore, different colours have different meaning. The purple node, or the productivity node, is the core of the research and it is unsurprisingly located as the centre of the model. The green nodes symbolise key clusters, whereas the pink ones denote those that can be roughly allocated into different clusters. In specific, the way of workers do construction work is closely associated with equipments and tools, which are part of technology in the researchers' codes, and uncertainty plays an important role in daily work, leading to cluster it with risk. In practice, daily work is measured and supervised and thus this general group 'the way of working' is composed of measurement, risk and technology. Further, it is people who deliver construction products and they formulate another group to influence the way of working. As echoed by literatures and the results of Leximancer analysis, trainings and skills are related to human factors but with a noticeable distance. Moreover, when a group of people is gathered together with particular purposes, they should be managed and this would lead to a new group of concepts. As interviewees reflected, the most significant issues in this group is planning, which is also termed as job design, and communicating and coordinating people. At a macro level, more issues can be involved in and they are organised in surrounding of the organisation issues. In this general group, issues, such as training, HR, culture and etc, are included. Additionally, this model is not purely based on hierarchical understanding of different factors as the interrelatedness of issues determining the behaviour of the model is complex per se.

4.3.1 Linking literatures to the research findings

Figure 6 demonstrated how we have categorised the various influencing factors that are gathered in literatures into five tiers, in terms of strategy, organisation,

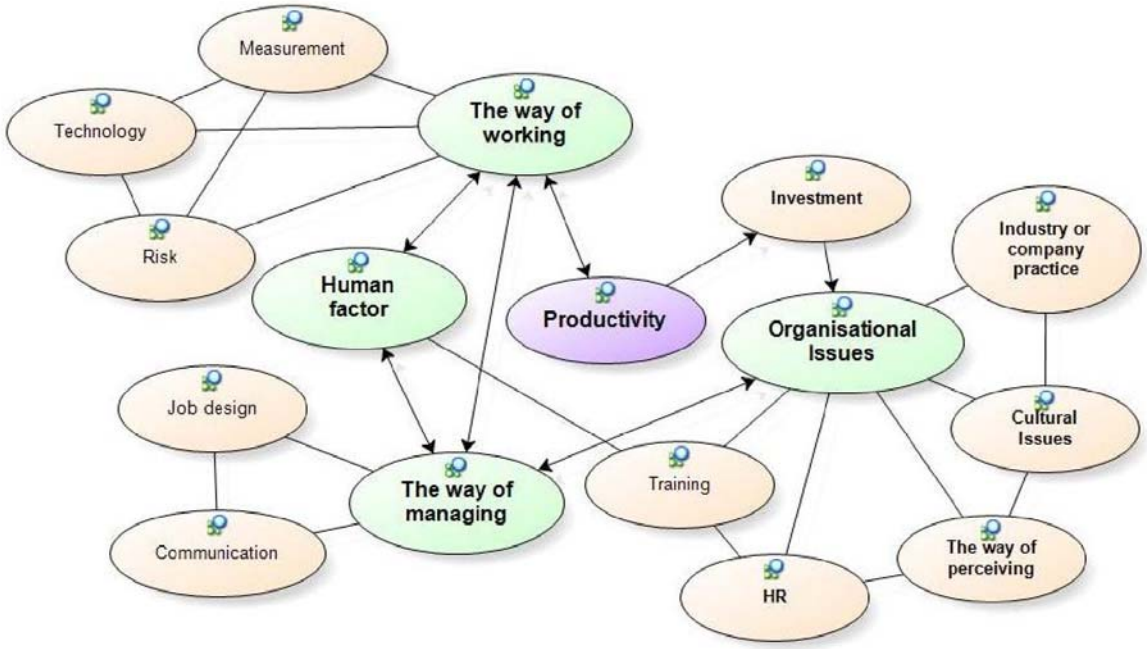

Figure 17: The factor model generated from NVivo analysis

operation and individual. However, we would reinforce the point that since most of the literature studies are not about the SMEs in the NZ's construction industry, that the comparison can only be utilised as general guidance to tackling the productivity problem.

However, by taking account of the interrelationships between different factors, which are shown in Figure 18, the research provides a basis to modify the general literature so as to relate it to the context of the SMEs in construction industry. In Figure 18, the links between literature and the preliminary research findings are shown.

The hierarchical structure created for the factors that are collected from the literature review is illustrated on the left-hand side of Figure 18. From a practitioners' viewpoint, those factors mentioned by academics as strategy or organisation are in fact interpreted as organisational issues. Further, when people in practice talk about 'managing', it is actually related to different levels in an enterprise. At a broad level, the organisation has to manage its staff, finance, etc; at operational level, managers take the responsibility for dealing with more routine requirements; at project level, project managers have to assure the delivery of a project. Moreover, when practitioners talk about work, they try to specify how to do a job, which can be reflected at operation and project level. Additionally, those topics in literature at individual level are talked as human factors by participants and the difference between researcher and practitioners' perceptions is insignificant. Finally, the concept group of 'productivity', which is the most frequently referenced in this research, covers all groups of factors that are elicited in the literatures and thus its range is the widest.

In general, we found that practitioners in the SMEs in NZ's construction industry hold a relatively unique view towards productivity problem when compared with their counterparts in other countries and regions. By considering the specific nature of the NZ's construction industry and practitioners' unique perspectives, our research proposes a holistic hierarchical model, shown below.

4.3.2 The hierarchical model

The first tier in the model in Figure 19, is termed Productivity. As discussed earlier the concept of productivity is complex and different people attach different meanings

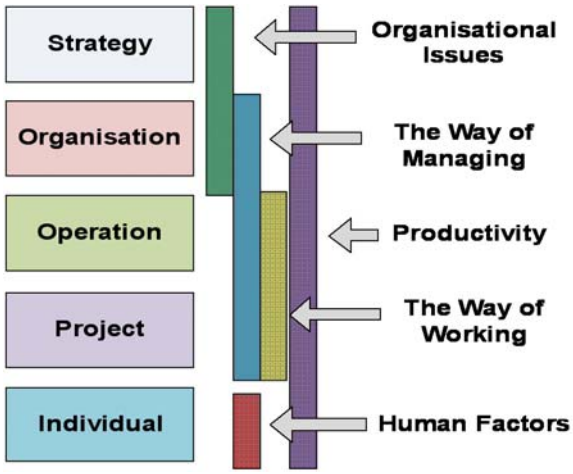

Figure 18: Linking literatures and research findings

to it. For contractors, productivity implies 'work efficiently and deliver in time', whilst clients expand the meaning to include 'the quality of construction output is an essential part of productivity'. On the other hand, health and safety (H&S) is thought to be an integral part of being productive and environmental issues become emerging concerns for both clients and regulators. These different perspectives demonstrate the complexity inherent in productivity.

The second tier or grouping of concept is Quality Work. For interviewees this means, the availability of tools and equipment; rework; human errors; changes to original plan; and disruptions. Management, a general and ubiquitous term dominating many interviews, can be partially located into this domain. Planning is of critical importance to the quality of work and without a good plan productivity can never be achieved in practice. Communication and coordination are also key to the quality of work, especially when multiple parties are involved in a project. Additionally, such factors as environment, working conditions, and project complexity can all be grouped in this category. The common attribute of this sort of factor is that they cannot be fully controlled by the workforce.

Quality People

Construction work relies heavily on human factors and quality people. The data analysis reinforces this argument and an emerging picture of how human factors affect the work can be suggested. Firstly motivation, which covers a wide range of more specific factors, is a key determinant for quality. The income level, financial incentives and bonuses exert considerable influences on workers' commitment to their jobs. Domestic and personal issues cause absenteeism and this has a ripple effect on productivity. On the other hand, team spirit seems to improve an employees' feeling of belonging and in turn this leads to commitment to their daily job, pride in the work and self-esteem.

Other important human factors are related to skills and experience. Construction work is partly based on trained skills and partly based on experiences that are accumulated through working. Without both there is a perceived drop in the worker's competency of doing quality work. Training is in turn linked to demographic attributes, such as education background, age, gender and ethnicity. Many interviewees agreed that diversity in workforce is important and that, workers with different and complementary skills can collaborate to create a desirable working climate to enhance productivity.

Figure 19: productivity hierarchical structure

Quality Organisation

The last tier includes concepts such as culture, organisation size and company policies which are essentially related to the concept of organisation. However, at this level there are two distinctive subgroups of factors, one being composed of issues inside the boundary of an organisation and the other being issues that are outside of a construction SME. Business vision, leadership, ownership of the business, corporate structure and so on determines the quality of an organisation. Many interviewees agreed that better employees are attracted to better organisations and vice versa. On the other hand, clients, government regulators, unions, agencies are all stakeholders and can also influence an organisation.

In summary, the hierarchical structure exhibited in Figure 19 is a revised version of the literature-based hierarchical model in Figure 6. It includes participants' insights into the specific nature of the New Zealand's construction industry. The model in Figure 17 helps to capture how productivity is influenced by various factors but it does not represent how these factors interact with each other. To understand these important linkages and mechanisms the research now focuses on the relationships between factors and attempts to create a model that can show the dynamic interactions between the key factors of productivity.

4.3.3 Dynamic Productivity Model for the SMEs in NZ's Construction Industry

The high level dynamic productivity model, which is grounded in the research data, is shown in Figure 20.

To explore the dynamics of the productivity problem, it is necessary to understand what influences productivity and how this in turn affects the other parts of the system.

A noticeable dynamic that negatively impacts the SME construction sector is that many companies are struggling to survive and they do not have enough resources to develop or grow, simply because of low profit margins. Without the adequate level of profitability a company is not sustainable and cannot improve, develop or

grow. They are more likely to fail and experience is lost and quality work is endangered. The sector ends up in, what one interviewee describes as 'a dog eat dog world'. This damaging self-reinforcing loop amplifies the effect of low profitability and needs to be broken.

As reflected by participants, various external forces can influence the productivity – work – people – organisation structure. Even if a company did its best within its own capability, productivity is still subjective to external factors that are almost impossible to manage by a single enterprise. A well organised sector on the other hand can moderate some of the worst fluctuations and influences, particularly if the clients and regulators can provide more transparency in the process of pricing, bidding and approvals.

Since the productivity problem is complex, especially when human factors are involved, it is unwise to expect a simple or one-off solution to enhance productivity. Instead of attempting to solve the productivity problem by addressing one or a few factors, a holistic intervention is needed.

4.4 Areas for Interventions

So far, participants' knowledge and insights have been generalised and summarised in the models culminating in the dynamic productivity model. One interpretation of this model is that the importance of five areas shall be recognised, in terms of the construction work, the workers, the project management, the management teams, and the view towards the industry.

4.4.1 The nature of the construction industry determines the level of productivity

Unlike manufacturing or agricultural industries, construction work is not very automated, modulated or repeatable, and therefore each individual project tends to have its unique issues and properties.

The physical working condition in the construction industry is an issue as workers are directly exposed to any adverse weather conditions, such as high temperature, relative high humidity, severe rain and wind speed. Also, unsafe conditions, accidents and physical site constraints all reduce productivity.

These physical and tangible influences tend to produce what both literature and our models indicate is that 'the availability of materials, equipment and tools is a direct constraint to improved productivity'. Some of this is due to capital investment but much of it is due to poor planning, coordination or communication. Indeed good practice suggests that if contingency planning is in place then work crews have other productive tasks to do, such as maintenance or health & safety activities.

4.4.2 Issues related to labour are key to enhance productivity.

Unsurprisingly, our research findings show that many factors that significantly influence productivity are closely related to labour issues, with motivation being probably the most central. Some of the key motivational factors raised in the interviews were tangible incentives such as wages, salaries and working environment, but also softer

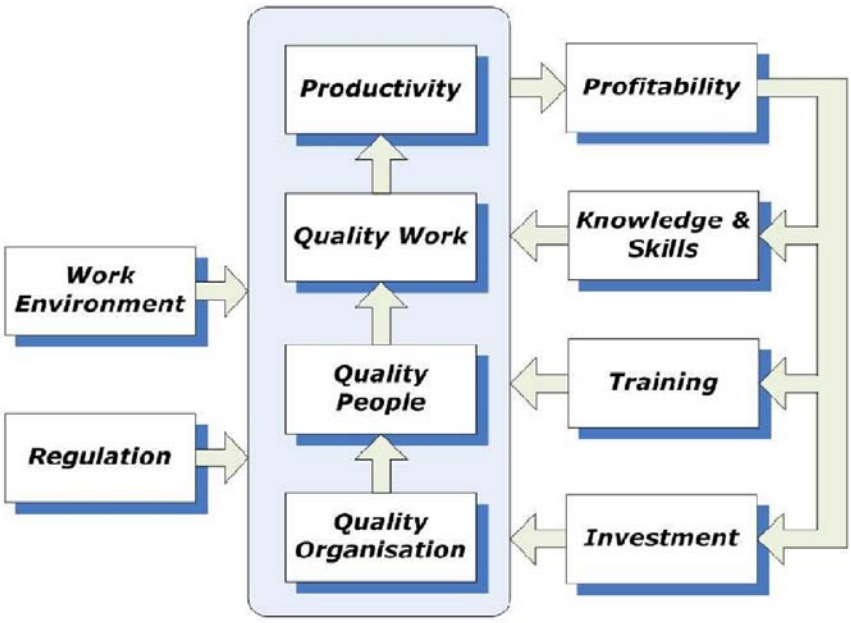

Figure 20: Dynamic Productivity model

concepts such as self esteem, public image, job satisfaction and the prospective future employment.

Furthermore, one common consensus from the construction industry is that the competency to deliver a project is determined by the quality of the workforce and the number of qualified workers can be assigned to this project. Historically, companies tend to employ more labour in booming periods and then lay off some workforce during the down cycle. This approach is widely adopted by companies even though managers do realise the fundamentals are unsustainable. This unpredictable nature of SME continuity of employment does impact the attractiveness of the sector to quality new recruits. Perhaps some scheme to easily transfer good workers between companies could be designed and managed by the industry.

There was evidence that motivation and productivity was easily dragged down by a few disgruntled or negative employees; drugs, alcohol, racial and gender prejudice were all contributory factors to a poor working environment.

4.4.3 Project management is essential in guaranteeing productivity.

Project management is highly connected to the concept of productivity in our models; the notions of planning time, quality, reducing waste, health and safety, and cost control. Many interviewees suggested that applying basic project management knowledge and techniques would be helpful in enhancing productivity. There are clearly different levels of project management required in SMEs from basic time management to more advanced quality concepts. A structured project management training programme would provide a solid foundation for improved productivity.

4.4.4 Enhancing the competency in the middle management can positively influence productivity.

In an SME, middle management plays a crucial role between the foreman and the owners. From the interviews the concept 'middle management' is closely coupled with a manager's generic management skills, organisation and coordination skills, interpersonal skills and communication skills. Helping these managers enhance their general management competency would significantly help solve many of the productivity problems. These key members of staff are often undervalued, poached by other industries and part of the aging workforce: so an emphasis should be placed on training a new generation of technically competent, whilst updating the capability of project and company managers who are currently employed by the industry.

This is a significant shift in thinking for trainers and SME owners who tend to focus on imparting technical skills. Moreover, improvement in management competency cannot be achieved in the short-run as educational background and experience are also key determinants in management ability. However, this is a potent and achievable intervention that could reap immediate improvements. There are also many additional linked benefits created of injecting generic management skills into the SME management including, improved motivation, communication, quality and creating a better work environment to attract good, new recruits. Poaching of good people from the industry will always be an issue, particularly with favourable salaries in Australia, but from a national perspective this provides benefits.

4.4.5 A supply chain view is required to overhaul productivity

An unproductive day on an infrastructure project site is unlikely to be caused by a single issue or party. Suppliers, clients, contractors and subcontractors can all exert influences on the progress of a project and if any party fails to be productive, the overall productivity can be dragged down significantly. A key reason for this is that SMEs have minimum control over other parties, unlike a large integrated contractor with contract managers and long-term work streams. One option is to educate and promote the importance of supply chain management and in particular sharing information if necessary to help one part of the chain catch up so as to improve everybody's progress. By doing so, SMEs could understand the importance and how their productivity can affect others, leading to a self-motivated productivity improvement.

It is perhaps the clients of infrastructure construction that hold the key to supply chain productivity, more than anyone else. Many industry reports, such as the Egan Report, have urged the adoption of a client led approach and recommend public clients should play a leading role in this. This will need a change to the way projects are procured, including the abandonment of lowest cost tendering. This may also help reduce the worst effects of boom bust cycles too.

4.5 Summary

Based on participants' insights and knowledge, the researchers have adopted Leximancer as the analytical tool to give an overview of the productivity problem.

In order to capture an in-depth and comprehensive under-

standing of productivity problem, we employed the grounded-theory to process data and built models based on the results. As demonstrated in section 4.3, factors that can affect productivity can be allocated into a hierarchical structure with four tiers. Firstly, productivity has multiple meanings and many factors, such as H&S, quality, cost, and etc, are integral part to the problem. Secondly, productivity is directly associated with construction work and thus quality work is the determinant to productivity. Thirdly, it is people who deliver work and thus they are linked to productivity via their work. Fourthly, organisations are formulated by people and how well people are organised and managed determine the productivity in a more delicate way.

The specific dynamics of construction productivity are reflected by participants' interviews and they are generalised in the model in Figure 19. The complex and dynamic nature of the construction productivity, as can be seen from the model, is determined by the involvement of various factors as well as the number of loops that link those factors. The core of different loops is essentially composed of productivity and profitability, the two being in a self-reinforcing loop. In that, an increase in productivity can lead to an increase in profitability, finally increasing productivity further. This is also valid when a decrease is identified in this loop. Work, people, organisation, and external parties are all involved in certain loops that are influenced by productivity and profitability.

The implication of the dynamic productivity model is significant to this research. The complex nature of the productivity problem requires people to think bigger. Also, expecting to solve this problem with one-off effort is unrealistic. Further, it indicates five areas that need improvement, in terms of the work, the people, the project management, the middle management, and thinking differently.

Regarding to the interventions needed to improve productivity, detailed rationales have been given in this section. However, due to the limitations of grounded theory, specific recommendation cannot be purely based on the generalised models that are illustrated in this section. The next chapter will demonstrate how to use concept analysis and dynamic modelling techniques to derive recommendations for interventions.

5 ANALYSIS

5.1 Linking grounded theory to concept maps

As stated in section 3.3, the research uses grounded theory and concept mapping methods simultaneously in the analysis phase, with three aggregated concept maps being produced based on more than thirty individual ones. Since every relationship mentioned by participants during the interview process has been recorded and then modelled in individual concept maps, the aggregated map enables us to analyse how factors influences each other. In such analysis, the non-linear relationships between factors can be exhibited and their influences to the whole system can be elicited. The number of factors and relationships collected during the interview process is extremely high and the resulting interactions map is very complex, so only the high-level map is presented here.

The analysis of the maps attempts to identify the key concepts and this is done by looking at a combination of the most connected and central nodes. From the key nodes it is then possible to identify the most potent nodes, which are the nodes that most influence those top key nodes. Indeed these become useful factors to look at for influencing the key factors and are often useful intervention points in the system as they have high leverage. (The term 'most' here indicates only a small proportion when compared to the whole population. In the analysis, we selected 5% as the benchmark to decide whether a factor is Key or Potent.) The key and potent factors are categorised into five areas in Table 8 below: these have been elicited and used in theory building in section 4.4.

The results are visually presented, with the key factors and their interrelationships being shown in Figure 21, and the most potent factors and their connections being exhibited in Figure 22.

The structure of the concept model in Figure 21 is considerably more complex than that in Figure 22 because of the number of connections and potential loops in the system of nodes. With the understanding of central key and potent concepts and their interrelationships, the researchers can explore the system of influence further by developing a systems dynamics model, shown in Figure 23. This model is complete in so much as it represents the system under consideration. The faint nodes represented by ‹node name›, is simply a way to portray connections without crossover lines and have no influence in the model. The direction of the arrows is important in this model as (A→B) means more of A will lead to more of B and less of A will lead to less of B. The –ve sign over an arrow (A$\xrightarrow{-}$B) means that more of A would lead to less of B.

Now that we have modelled the dynamics of the system we can revert back to the detailed analysis and in par-

Five areas for interventions	Key Factors	Potent Factors
The Work	Productivity, contract, profitability, cost, work efficiency, decision making, working hours	Thinking style, subjective influences
The People	Working experience, competency to deliver, motivation, incentive, satisfaction, commitment to work, quality of workforce	Education background, personal influence,
The Project Management	Planning, project management, contractors or subcontractors	Coordination, manager intervention, management skills, interpersonal skills
The Middle Management	Middle management and supervision	Hierarchy influences, manager influence, organisation policies
The Holistic View	Organisation culture, organisation size, staff turnover, training, ownership	Organisational skills, team building, training design, training course, social culture

Table 8: Key and Potent factors in SME productivity influences

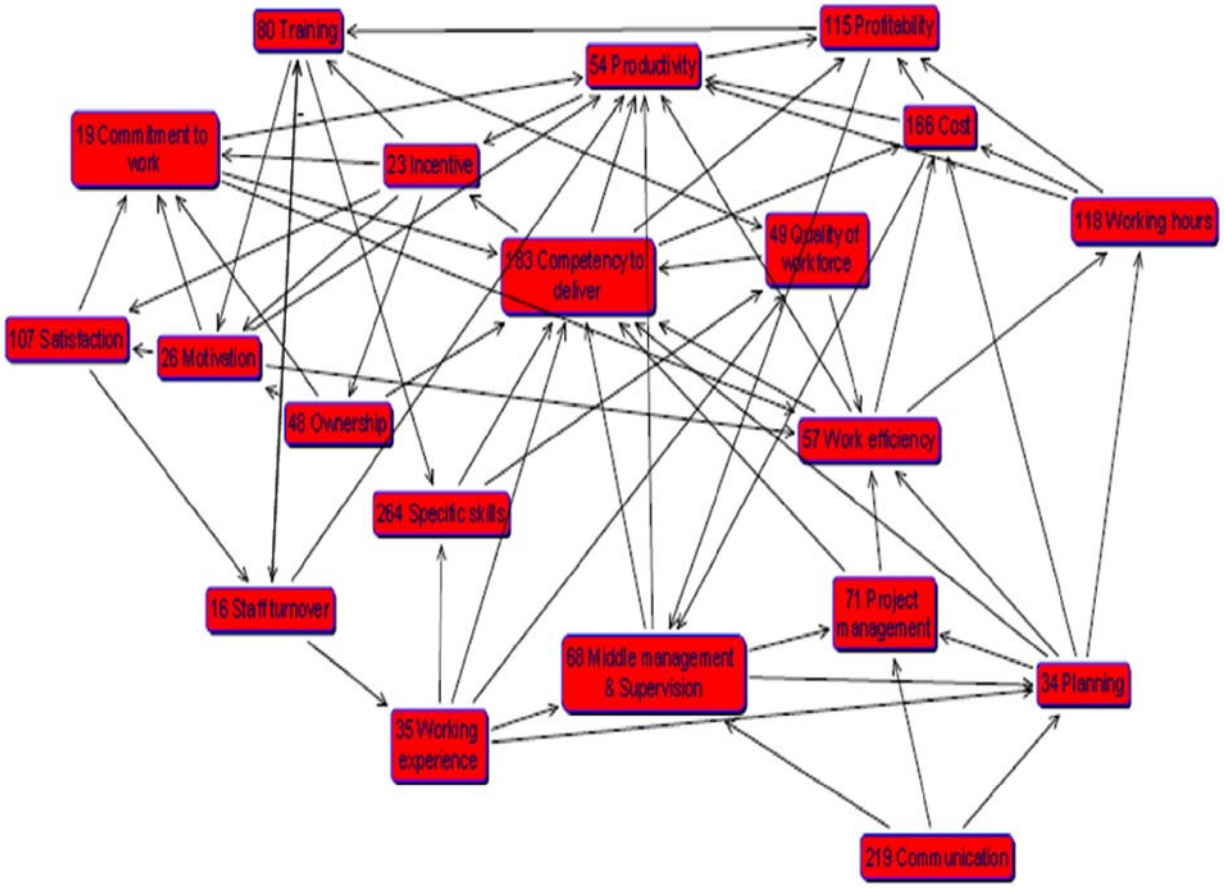

Figure 21: The Key factors in SME productivity influences

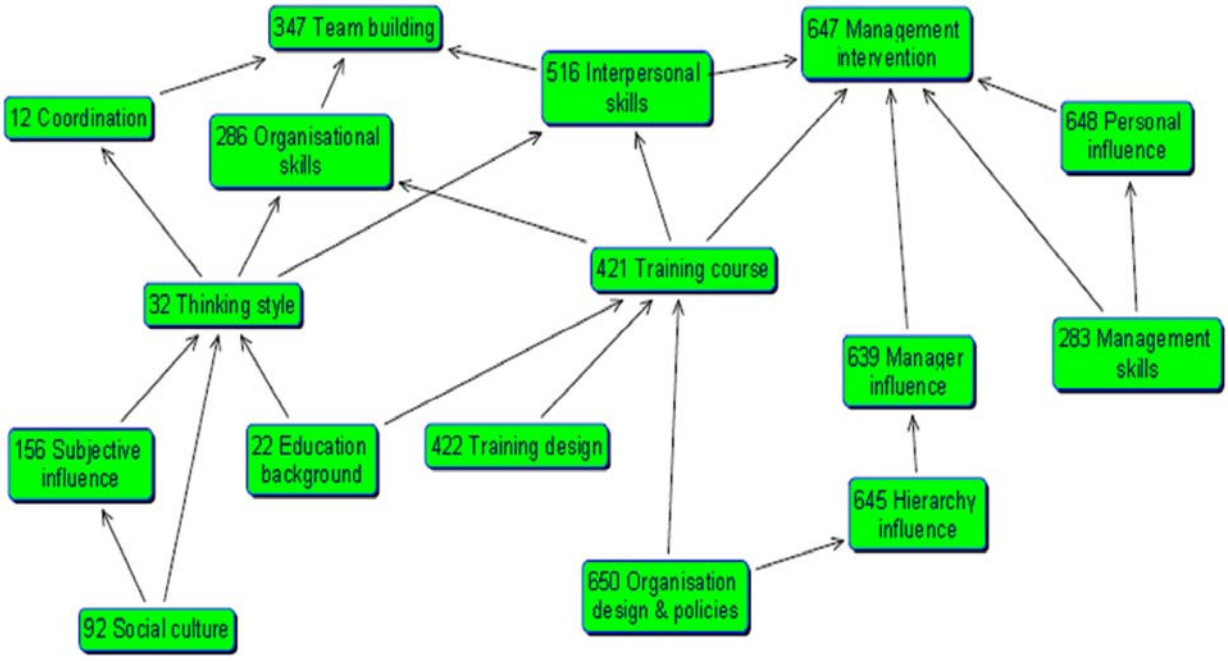

Figure 22: The Potent factors in SME productivity influences

ticular the key and potent nodes identified in Table 8 above, with a view to understand potentially important linkages.

5.2 The work itself

In this category, work efficiency, working hours, cost, contract and profitability are closely associated with productivity and we can identify several influential loops.

1. A higher productivity means a company has more competiveness and better reputation compared to others. Clients will contract projects to this sort of company and therefore they can win more contracts. With more contracts, a company can have more security and hence plan for the future better, leading to more work efficiencies. As reflected by many interviewees, uncertainty in construction industry prohibits SMEs thinking about a long term strategy and companies only focus on survival.
2. Productivity, cost, profitability, motivation, and work efficiency form a powerful feedback loop. That is, when profitability is low, the company has very limited resources to reward employees. Without sufficient incentives to keep them going, employees may not be satisfied with their work, especially when the physical working condition is taken into account, and hence the motivation level is lowered. In turn, they are not committed to work and so their efficiency is poor, leading to underperformed productivity. The consequence is that cost is higher and profitability is lower. In this regard, if this vicious loop keeps running, productivity will be in an ever decreasing trend until the company goes out of business.
3. Work efficiency, working hours, cost, profitability and motivation can form a self-reinforcing loop. This loop does necessarily involve productivity in the first place but does affect productivity in a long run. When work efficiency is low, which might be caused by human errors, rework, or bad planning, workers have to spend more time on a project and the project, leading to cost overruns and low productivity. Such a scenario has a double affect on labour – on one hand, they may get frustrated by long working hours or physical tiredness; on the other, they cannot get proper reward for their work, both making productivity lower and lower.

5.3 The people

It can be shown in Figure 23 that there are several loops involving people and productivity and by understanding them decision makers can make better intervention strategies. First of all, motivation, competency to deliver,

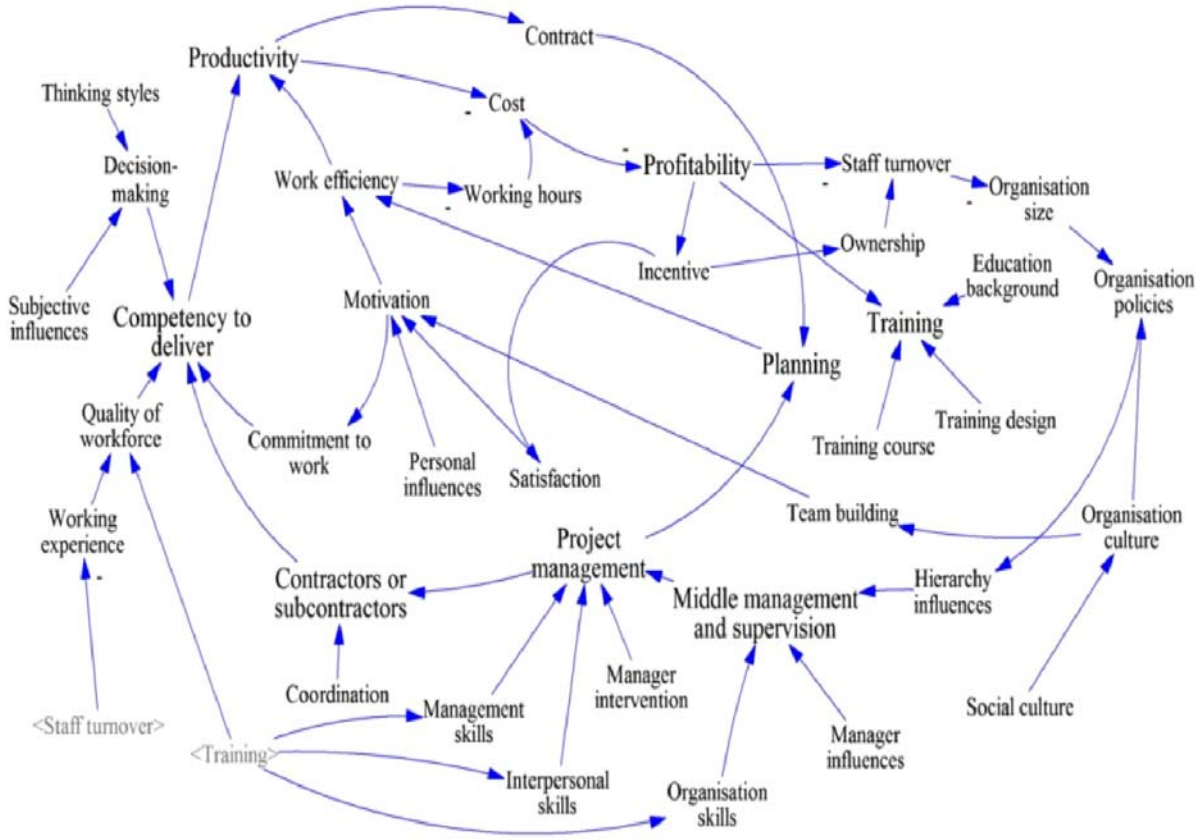

Figure 23: A systems dynamic model of SME productivity problem

productivity and profitability are in a positive feedback loop. That is, when people get motivated, they will commit more to their work, improving the overall competency to meet requirements. In turn, the productivity is overhauled and, as demonstrated in section 5.2, this will increase profitability. With more funds available, companies have more freedom to incentivise employees, making them more motivated. De-motivated employees are not likely to commit to work and hence cannot meet targets, thereby reducing productivity and hurting profitability further. The consequence is that the company cannot have enough resources for financial reward and the motivation level can be even lower.

Moreover, incentive, satisfaction, motivation are always in the same loop to influence productivity. This has profound implications for SME companies in that incentives are not the direct driving force for motivation and it is satisfaction that really matters. If a company has limited financial resource for incentives, it is possible to increase employees' satisfaction level by other means, e.g. team spirit.

Additionally, working experience, quality of workforce, productivity, profitability and staff turnover can propagate a single factor's influences back into the whole system. As agreed by most interviewees, construction work needs experience and such experiences are assets to a company. In other words, experience is part of the quality of the workforce. The longer an employee stays with a company, the more experience they accumulate and the higher quality work they produce. In this regard, if the quality of the workforce is getting better it could result in the company achieving a sustainable mode for development.

5.4 Project management skills

Project management is perhaps one of the most influential areas in productivity problems. It has been identified that equipping managers with sufficient project management knowledge can hugely enhance productivity. Generally speaking, the concept 'project management' can influence productivity both inside and outside of the boundary of an SME. Internally, when project management is improved, managers can have more options to plan a project better and thus enhance work efficiency. Then, those self-reinforcing loops involving productivity and profitability can take effect by amplifying the effect the positive signal caused by enhanced work efficiency.

One significant consequence of these loops is that the organisation can have more and more resources for training. In that, managers and employees can receive more knowledge and increase their levels of skills. With newly gained knowledge and skills, the project management ability is further increased and hence propagates the positive influences back into the system. However, this loop does not always stay positive as when the functionality of project management is deteriorated, the whole loop can drag the performance of the company further back.

In many cases, a project environment in construction industry indicates more multiple contractors or subcontractors are involved. In this sense, project management should deal with external stakeholders more effectively. If a company can handle external parties properly, its competency to deliver a task is improved. As a consequence, productivity can be elevated and better profitability is expected as a return. With more financial strengths, the company can sustain its employment structure by reducing the turnover rate of staffs. Moreover, it is easier to attract new employees, expanding the size of the organisation gradually.

Generally, the bigger the company is, the more powerful it is in controlling projects. That is, the company has more strength in managing a project and can go through another iteration of productivity-profitability-organisation size loop. This loop also indicates that if the company is in a weakening position, its project management ability can decrease further by the leaking of controllability. When it has insufficient stake to collaborate with other participants, it will go through an even faster track to lose competiveness and finally goes out of business.

5.5 Generic middle management skills

In the systems dynamic model in Figure 23, the concept 'middle management and supervision' is directly connected to the concept of 'project management', implying that company-level management is realised through daily project management practices and all loops that may influence project management can affect 'middle management and supervision'. Or, in other words, the concept 'middle management and supervision' uses 'project management' as an agent to influence the overall system. Therefore, improving 'middle management and supervision' can be very powerful. As shown in Table 8, several factors have already been identified as influential variables, such as hierarchical pressure. The concept map analysis reveals that there are more factors that could help decision makers improve management capability of their organisations, such as improving management skills and organisational culture.

5.6 The holistic view

The research results show that many issues are beyond the scope of those points mentioned above and a holistic approach is needed. As shown in Figure 22, the turnover of staff, training, and social culture exist as prominent factors that affect productivity indirectly. That is, if human interventions in these areas can make those factors evolve towards a desirable and benign direction, productivity problem can be solved gradually. In this sense, the researchers recommend the following three areas for decision makers to make change: staff turnover, training and supply chain management.

5.7 Summary

Following the analysis of participants' interview data, the themes reduced to five key areas for attention, namely: the work itself, the people, project management, middle management, and the holistic view, for specific recommendations for interventions. The complex mental constructs of participants have been modelled as concept maps and then the key factors were identified. We found that the most connected factors, or key factors are directly related to the low productivity symptom and the most potent factors provide interventions for change. Furthermore, a systems dynamics model was developed to aid the understanding of the interactions of the key factors.

6 RECOMMENDATIONS

There are four broad areas for improvement, and to reiterate these need to be implemented together for maximum possibility of success.

6.1 Improving the efficiency of the work itself

a) **Develop a network** of reliable and trusted sub-contractors and partners.

b) **More effective planning** in the delivery and placement of equipment and materials to avoid double handling and aid sequencing of work.

c) **Pre-work** using pre-moulded materials, such as precast concrete, and standardised products.

d) **Develop manuals** and/or working procedures and circulate to workers.

e) **Use IT systems, communication and planning software** more.

f) **Use downtime and idle time better** for maintenance of tools & equipment and web based training or tool box talks.

g) **Have a backup plan** or contingency for bad weather or other delays.

h) **Better communications** across the industry sector. Information regarding project proposals and future plans are crucial for SMEs to evaluate their capacity to make rational bid.

i) **Quality** should be specified and properly assessed in bid and contracts.

j) **Pricing strategy** should be reviewed by both contractors and clients.

k) **The role of clients**, especially those in public sectors, shall play leading roles in changing practices.

l) **Cost control** cannot be overlooked by the SMEs.

6.2 Improving competency of people to deliver

a) **Improve the level of technical skills.** This research suggests that workers in the SME construction industry should better be equipped with both specific skills and generic skills.

b) **Diversity** is an advantage. Many participants reflect that the workforce in the industry is aging and it is becoming difficult to attracting qualified young people into the industry. There are very few females working in the industry and ethnic groups are not fully represented.

c) **Workforce stability** needs to be improved. Although the recruiting and sacking employees is normal, a high turnover rate can be harmful to companies and the industry sector.

d) **Support** and **supervision** are an integral part of competency to deliver. When an emergimg situation occurs on site, managers should be able to provide instant support or intervention. Solving problems promptly can stop trivial problems escalating.

e) **Teambuilding** is essential for employees to gain the **feeling of belonging** and hence commit more to work. Since a large proportion of SMEs in the construction industry are family owned, it is difficult for those employees who are not family members to feel they are integral part of the company.

f) The **influences of peer workers** affect onsite productivity significantly. High absenteeism puts a strain on other workers resulting in low productivity and inertia.

g) **Working stress** cannot be overlooked by SME managers. Though many interviewees mentioned drinking, smoking and drug abusing are always associated with construction workers, the cause for this phenomenon is not well understood.

h) **Equality and pride** shall be reinforced in the industry and workplace. As reflected by interviewees, workers are more productive when they work in public areas, such as roads, because people can recognise the importance of their work and they have to work harder. Their psychological pride forces them to be productive.

i) **Attracting young people** with better education background could be a viable solution for productivity improvement.

j) **Educating** and **training** employees can enhance their quality and productivity.

6.3 Training in project management at all levels

a) **Flexibility** is a powerful advantage for an SME when competing with larger rivals.

b) **Communication** is necessary to good coordination.. Modernised IT system can help to enhance communication.

c) **Organisational skills** should be improved.

d) **Adopt common procedures** and best **practices** for planning.

e) **Contingency** and uncertainty **planning**.

f) **Improve analytical skills**. Although experience is an integral part of project management, rational decisions should be based on analyses, instead of subjective perceptions

g) **Develop and promote learning skills** as this makes for good project managers.

6.4 Strengthen middle management skills for SMEs owners and key staff

a) Improve SME manager's ability to **communication** and **coordination**

b) Managers should be trained in **how to motivate** employees effectively, and shown different approaches.

c) **Developing a clear business vision** is important for long-term development of the company.

d) Train in **quality techniques and how to write procedures and policies**.

e) The **number of employees** managed by a manager shall be reviewed and assessed.

f) Managers should learn about **proper delegation of responsibility** to employees.

g) Training in **Continuous improvement** and related techniques should be provided.

h) **Sustainability** should be adopted as a criterion for decision-making, not short term profit.

6.5 A holistic, multi-faceted, industry level approach is required

The turnover rate of staff depends on both sides of an employment contract, that is, the employer and the employee. Employers can sack an employee for diverse reasons, such as the position is redundant, long term poor performance, big mistakes, or disciplinary issues.

On the other hand, an employee may quit the company voluntarily, i.e. the pay is not as good as other employers or lack of interests in working with the company. No matter which scenario is dominant, the changes in employment structure are costly to both employer and employee. In order to reduce the impact of the instability in workforce from an employer's viewpoint, the researchers would address three areas, alongside with those recommendations for motivation and commitment, for decision makers to make interventions.

- **Reduce staff and worker turnover rate**
- **Ease the mobility** between companies
- Provide a clear **career pathway** for employees.
- Industry and government need to promote the role of **entrepreneurship** and its value to the society and economy to encourage a new generation of construction related enterprises.
- Improve prestige of q**ualifications** or **certificates** awarded as incentives for training courses.
- **Training courses** should be more **experientially based**.
- **Use modern on-line learning to attract young IT literate workers.**
- **Targeted skills** should be better delivered in training courses. Workers need specific skills to improve their efficiency; for managers, they need more management skills to cope with daily jobs, for business owners and key decision makers, they may need to improve their decision making skills. Project management skills, on the other hand, are essential for all people in the industry. Training courses should be able to deliver the range of skills in an integrated way.
- Attention should be paid to the **details of training design**.
- Develop **an integrated supply chain approach** to the infrastructure construction procurement.
- Construction shall seek better **relationships with clients**.
- **Value-for-money** approach shall be adopted in **procurement** strategies.

6.6 Summary

In summary, most the factors affecting productivity and possible interventions are related to people and their skill level, particularly in generic management skills, project management ability and soft, people skills. This is maybe no great surprise as the H&S issue in construction industry reached the same conclusion years ago after decades of research.

Much of the problem needs to sit at the feet of the burdened management and owners of SMEs. Training across the SME sector should focus on generic transferable management skills delivered at a site level. The improvement in the sector, industry, economy at large and society could be significant if sufficient resource is committed to a sustained multi-faceted intervention, including:

The SME owners should receive support to initiate this new training and associated initiatives.

New sets of competencies should be developed and training matched against these requirements. Intensive and on-line learning should test competency and individual and company should be rewarded for success.

- Best practice should be shared and extended.
- Apprenticeships to encourage new blood into the industry should be re-vitalised.
- Local and central government should seek value not lowest cost.
- There should be transparency in procurement and on-line advertising of contract progress and prices.
- Pride and quality should take prominence over price and productivity, the latter will take care of itself.

7 REFERENCES

Allan, N & Davis, J, 2006. *Strategic Risks - Thinking about them Differently, London*, Thomas Telford

Borcherding, J, 1978. "Factors which influence productivity on large projects", *Transactions of American Association of Cost Engineering*, 252.

CAENZ, 2005 - 2007. *New Zealand Construction Industry Key Performance Indicators,* New Zealand Centre for Advanced Engineering, Christchurch, New Zealand.

Chan, P & Kaka, A, 2007. "Productivity improvements: understand the workforce perceptions of productivity first", *Personnel Review*, 36, 564-584.

Constructing Excellence, 2008. *Construction Industry Annual Key Performance Indicators*, Constructing Excellence, London.

Cottrell, D,2006. "Contractor process improvement for enhancing construction productivity", *Journal of Construction Engineering and Management*, 132, 189-196.

Dai, J, Goodrum, P & Maloney, W, 2007. "Analysis of craft workers' and foremen's perceptions of the factors affecting construction labour productivity", *Construction Management and Economics*, 25, 1137-1150.

Davis, N, 2007. *Construction Sector Productivity - Scoping Report*, Martin Jenkins, NZ.

Doloi, H, 2008. "Application of AHP in improving construction productivity from a management perspective", *Construction Management and Economics*, 26, 839-852.

Edkins, A & Winch, G, 1999. *The Performance of the UK Construction Industry: An International Perspective*, The Bartlett School of Graduate, University College London.

Ellis, R & Lee, S, 2006. "Measuring project level productivity on transportation projects", *Journal of Construction Engineering and Management*, 132, 314-320.

Hutagalung, N, 2003. "Throughput accounting = end of traditional cost accounting and activity-based management approaches?", *Ingenious*, Vol. 1, No. 1, , 40-50.

Kaplan, RN, 2008. *The Execution Premium - Linking Strategy to Operations for Competitive Advantage*, Harvard Business School Press.

Kendall, G, 2005. *Viable Vision – Transforming Total Sales into Net Profits*, J Ross Publishing.

Kolb, D, 1985. *Experimental Learning*, Pearson, Englewood Cliffs, NJ.

Law, D, Buckle, B & Hyslop, D, 2006. *Towards a Model of Firm Productivity Dynamics*, New Zealand Treasury Working Paper 06/11.

Mojahed, S & Aghazadeh, F, 2008. "Major factors influencing productivity of water and wastewater treatment plant construction: evidence from the deep south USA", *International Journal of Project Management*, 26, 195-202.

Moselhi, O, Assem, I & El-Raayes, K, 2005. "Change orders impact on labor productivity", *Journal of Construction Engineering and Management*, 131, 354-358.

Olomolaiye, PO, Jayawardane, A and Harris, F, 1998. *Construction Productivity Management*, Prentice Hall, London.

Rogers, M, 1998. *The Definition and Measurement of Productivity*, Melbourne institute of Economic and Social Research Working Paper, 9/98.

Rojas, E & Arawvareekul, P, 2003. "Labour productivity drivers and opportunities in the construction industry", *Journal of Management in Engineering*, 19, 78-82.

Whiteside, J, 2006. "Construction productivity", *AACE International Transactions*.

Private Bag 4800, Christchurch 8140, New Zealand
P: +64 3 364 2478 F: +63 3 364 2069
E: info@caenz.com W: www.caenz.com

Horizontal Infrastructure Construction Company Competency Framework

The way of working	Productivity Competencies	Supervisor	Manager	Owner
Performance Measurement and improvement	Knowledgeable and use of KPI's and benchmarking	1	2	3
	Conduct a post-project review and financial appraisal	1	3	2
	Implement lessons learnt and new ideas	1	3	3
Health, Safety & Environment	Knowledgeable of applicable legislation & statutory approvals	2	3	3
	Knowledgeable & contribute to company HS&E policies/procedures	1	3	2
	Involvement in plant operations and maintenance	3	2	1
Procurement of materials and contract workings	Knowledgeable of basic contract law	1	2	2
	Understand the different tendering and selection processes	0	2	2
	Understand the benefits of relationships and key suppliers	2	3	3
	Understand risks associated with procurement	1	3	3
Strategic approach	Understand and contribute to the business objectives	2	3	3
	Engage effectively with stakeholders and customers	2	2	3
	Identify and rectify supply chain issues	2	3	2
Innovative	Identify and appraise new ways of working	2	3	2
	Implement trials to assess effectiveness of new ideas	2	2	2
	Treat problems as opportunities to learn	2	3	3

The way of managing	Productivity Competencies	Supervisor	Manager	Owner
Project Management	Develop a project execution plan and assess risks	1	3	2
	Efficiently & effectively select and allocate resources	1	3	2
	Select and prioritise issues on projects and between projects	1	3	3
	Assess and engage stakeholders and customers effectively	1	2	3
Planning and work scheduling	Identify and draw up a realistic work plan	1	3	2
	Knowledgeable of critical activities, key dates & contingency plans	1	3	3
	Assess progress during projects and identify schedule problems	1	3	2
	Assess how resource availability will impact upon time schedule	1	3	2
Cost Estimating	Compile a list of quantities & unit prices from drawings for projects	1	3	2
	Compare different costed approaches to help make decisions	1	2	3
	Articulate and apply the difference between cost, price & profit	1	3	3
Budgeting	Develop a budget for the business and monitor through the year	1	3	3
	Develop a budget for a project and us to monitor progress	0	2	2
	Assess actual costs against budget to measure performance & learn	1	3	2
Quality Management	Source, read and follow key processes and procedures for projects	2	3	2
	Knowledgeable of key elements of a QM systems for projects & SMEs	1	3	3
	Develop 'fit for purpose' QM procedures and implement	1	3	1
Communication & Information Management	Appreciate importance of the process 'who' requires 'what' and 'when'	1	3	2
	Provide effective communication to different people in different ways	1	2	3
	Identify the hierarchy of relevant providers of information	2	2	3
Project control	Appreciation of project start-up & final documentation requirements	1	3	2
	Apply document control procedures and quality control	1	3	2
	Report on progress and make interventions to improve	1	3	2
Team management	Ability to provide leadership and motivate the team	1	2	3
	Create & maintain a positive team culture	1	2	3
	Reflect on team dynamics and development and apply interventions	1	3	2
Coordination	Look across the business & projects for synergies and improvements	1	2	3
	Sequence tasks on a daily bases for minimum downtime & waste	2	3	1
	Share knowledge with suppliers & customers to provide extra value	1	3	2

Human factors	Productivity Competencies	Supervisor	Manager	Owner
Leadership	Give clear direction and relate to goals	1	2	3
	Appropriate delegation and timely decisions	1	2	3
	Recognise skills and abilities of others and give constructive feedback	1	2	3
Team Effectiveness	Know how to measure effectiveness and make changes to improve	1	2	3
	Involve team members in decisions to achieve & team goals	1	2	2
	Agree issues and methods with team for continuous improvement	1	3	3
Selection & Recruitment	Describe the job requirements and person specification	1	3	3
	Evaluate different legal ways of attracting potential employees	1	2	3
	Use different techniques to evaluate the interviewee for selection	1	2	3
Motivation	Effectively observe behaviours at work regards motivation	1	2	3
	Reflect on motivation theories & how needs might be satisfied at work	1	2	3
	Use rewards and incentives to motivate and seek effectiveness	1	2	3
Diversity	Knowledable of the benefits of diversity and pitfalls	1	2	3
	Encourage an equal voice and influence in team and project decisions	1	2	2
	Make explicit the differences and develop policies to ensure balance	0	2	2
Disciplinary & grievance procedures	Be knowledgeable of the main causes of conflict in the business	1	2	3
	Develop clear framework for dealing with grievance and record actions	1	2	3
	Develop & follow policies for tactful discipline & communicate them	1	2	3
Thinking styles & attitudes	Appreciate that people think in different ways	2	3	3
	Assess your own and others thinking styles & how this impacts work	1	2	2
	Appreciate how to manage & influence your thinking & attitudes	1	2	3
Interpersonal Skills	Assess how well you perceive other people and vice-a-versa	1	2	3
	Listening to and understanding other people	1	2	3
	Behaving positively that builds on this understanding	1	3	3
Time management	Appreciate the consequences of poor time management	1	2	2
	Assess major causes of your lost time and plan ways to minimize	1	3	2
	Develop ways to recognise & use difference in important and urgently	1	2	3

Organisational issues	Productivity Competencies	Supervisor	Manager	Owner
Learning culture	Appreciate that people learn different ways	1	2	3
	Assess ways that your own and others learning could impact work	1	2	3
	Implement methods to manage & influence your learning culture	1	3	3
Staff availability	Knowledgeable of legislation around employee absenteeism & records	1	3	3
	Assess causes of staff availability and take tactful mitigation actions	1	2	2
	Plan alternative ways of working or substitutes	1	3	2
Small business management	Articulate a clear vision & develop supportive behaviours and culture	1	2	3
	Develop ability to innovate and adapt to new situations	1	3	3
	Be able to develop a business plan and measure performance to it	1	2	3
Managing Growth	Realise pitfalls of growth through profitability, people and turnover	1	2	3
	Recognise key transitions required & support needed (Fin, HR, IT, Cash)	1	1	3
	Assess various exit strategies against personal goals and values	0	0	2

Competency Levels for Assessment

Each skill set and competence is assessed at the following levels:

0 – Not required/not tested

This reflects where a skill listed in the framework is not relevant.

1 – Awareness

Describes someone who is dependant on others for direction, is learning the skill and when facing something new or unusual has to refer to procedures, manuals, other team members etc., for guidance. You may only ever need awareness of particular skills, or may be gaining experience in the skill.

It is important to note that attending training does not automatically mean that your proficiency level will increase. Once you have received training you will need to reinforce what you have learnt by using the skills.

You may stay at this level for some time, training and other development activities will help, but it is experience of applying new skills that will develop your proficiency level. As people learn at different rates, there is no set time limit for your level to increase.

2 – Competent

Describes someone who can cope with standard problems/common situations, is competent at day-to-day application of the skill, and is able to present concepts, information and solutions.

At this level you can deal with most standard problems and will only need to refer to an expert for non-standard issues and problems. You will still be using a variety of development activities to increase your experience and proficiency level e.g. reading manuals, white papers etc. and on the job training. You will still go on training courses and these will probably be at an advanced level.

You will probably stay at this level for some time.

3 – Experienced

Describes someone who can cope with unusual/non-standard problems and issues, is aware of alternative options and approaches to situations, can guide or advise others in this skill and is able to look ahead and anticipate.

Training alone will not take you to an expert level. It is experience in the job, as well as using the skill and other development activities that will develop your proficiency level.

Not only are you capable but confident in applying the skill in ordinary and unusual situations. Others will seek you out for advice and you may be involved in coaching/mentoring activities.

InfraTrain New Zealand

CAENZ

Address for Correspondence
New Zealand Centre for Advanced Engineering,
Private Bag 4800, Christchurch 8140, New Zealand
P: 64 3 364 2478 **E:** info@caenz.com **W:** www.caenz.com