Defining New Productivity Measures for Service and Network-Based Firms

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Certification

This thesis is submitted in fulfilment of the requirements of the degree of PhD at the University of Technology Sydney Business School, Management Discipline Group. This represents the original work and contribution of the author, except as acknowledged by general and specific references within the dissertation.

I hereby certify that this thesis has not been submitted for a higher degree to any other university or institution.

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Abstract

Historically, productivity has been defined as a measure of an economic system's allocation of resources. However, because world economies have transitioned from agriculture and manufacturing to service and knowledge-based industries, and work practices from single firm production units to more networked organisations, the relevance and measure of productivity is debatable. Services differ from goods production, and the differences go beyond characteristics to the underlying logic of how value is created. The difficulties in qualifying and quantifying intangible inputs and outputs lead to the research question: how can productivity be measured for service and network-based firms?

The focus of this research is on the development of two contemporary models, namely the Service Enterprise Productivity in Action (SEPIA) and Networked Enterprise Productivity in Action (NEPIA) models, which address the gaps and limitations in current models and which area able to be operationalised.

As this research is at the forefront of productivity for service and network-based firms, it uses two methodologies. Data is collected from a set of heterogeneous firms operating in the Australian travel and tourism industry. Data envelopment analysis (DEA) is used for the SEPIA model, measuring inputs and outputs of three of the five stakeholders, namely customers, employees, managers, suppliers and shareholders. The inclusion of stakeholders positions productivity and the firm in a social domain. Consequently, social network analysis (SNA) is used to explore productivity measures for network-based firms—that is, service value networks.

The contribution from this research is the alignment of firm level data for service and network based firms with the existing methods of calculating productivity at an industry and economy level. In addition productivity for service firms is found to be multi-layered. New forms of efficiency have been identified, namely integrative efficiency and collaborative efficiency having particular relevance for service and network based firms. The SEPIA and NEPIA provide a framework and roadmap that can be used to further collaborative research into productivity, for service and network-based firms.

Dedications

In dedication to Jai Waters

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As I sit looking back in time, I recall the excitement and trepidation I felt when starting my PhD journey and there are many people to thank. First and foremost I would like to extend my thanks and appreciation to Dr Renu Agarwal for taking me on as a student. She provided me with the freedom to explore areas of interest, celebrated breakthroughs, tolerated frustrations and reminded me of the responsibility to contribute to knowledge. I would like to thank her for her guidance.

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List of Research Publications

Academic publications

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Book chapters

Randhawa, K & Scerri, M (2015), "Service innovation: a review of the literature", in R Agarwal, W Selen, G Roos & R Green (eds), *Service innovation handbook*, Springer, London. (in press).

Scerri, M & Agarwal, R 2014, "Service enterprise productivity in action (SEPIA)", in A Emrouznejad & E Cabanda (eds), *Service productivity handbook*, vol. 215, Springer, London.

Scerri, M & Dodangeh, J 2013, "Measuring supply chain integration from a technology perspective using multi-attribute decision making model", in D Nejati (ed.), *Frontiers of business, management and economics*, Brown Walker Press/ Universial Publishers, Florida.

Scerri, M & Agarwal, R 2012, "Evolution of production, transition to the value creation cube", in *Driving the economy through innovation and entrepreneurship: emerging agenda for technology management*, Springer, Bangalore.

Referred conference papers

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Agarwal, R, Sajib, S, Scerri, M & Selen, W 2013, "Capability building leading to innovation in service value networks–evidences from industry case studies", Paper presented to the *SMART Conference and Expo 2013*, Sydney.

Other academic and industry publications

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Baker, K & Scerri, M 2014, *Cradle coast destination management plan: towards 2020,* SEPIA Consulting, Sydney.

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Baker, K & Scerri, M 2012, *The integration of riverina regional tourism and regional development Australia-Riverina* Riverina Regional Tourism, Wagga Wagga.

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Scerri, M 2014, "A generalised approach to measuring service productivity", Paper presented at the *Early Researcher Workshop* to the *10th Asia Pacific Productivity Conference*, Brisbane.

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List of Abbreviations

ABS	Australian Bureau of Statistics
AQF	Australian Qualification Framework
ANZSIC	Australian and New Zealand Standard Industry Category
ATM	automatic teller machine
B2B	business-to-business
B2C	business-to-consumer
B2G	business-to-government
DEA	data envelopment analysis
FTP	file transfer protocol
G2C	government-to-citizen
GDP	gross domestic product
ICT	information communication technology
IO-VRS	input oriented-variable returns to scale
TCP/IP	transport control protocol/internet protocol
MS	mass service
NEPIA	Networked Enterprise Productivity in Action
OECD	Organisation for Economic Co-operation and Development
PS	professional services
RFID	radio frequency identification
SCOR	Supply Chain Operations Reference
SEPIA	Service Enterprise Productivity in Action
SF	service factory
SNA93	Standard National Accounts
SPM	Service Process Matrix
SS	service shop
USDOT	US Dictionary of Occupational Title
WTP	willingness to pay

Chapter 1: Challenges of Measuring Productivity in Service and Network-based Firms

> Productivity isn't everything but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker (Krugman 1977, p. 8).

1.1 Introduction

This chapter summarises the research objectives, motivation, contribution and methodology adopted for this research. It is structured into five sections, as outlined in Figure 1-1. Section 1.1 introduces the thesis; Section 1.2 presents the research objectives by introducing productivity and services, and the importance of service productivity to the Australian and world economies. Section 1.3 outlines the research motivation and aims. Section 1.4 presents the four contributions expected to be made by the research. Section 1.5 presents an overview of the methodology used. Finally, Section 1.6 outlines the thesis's structure.

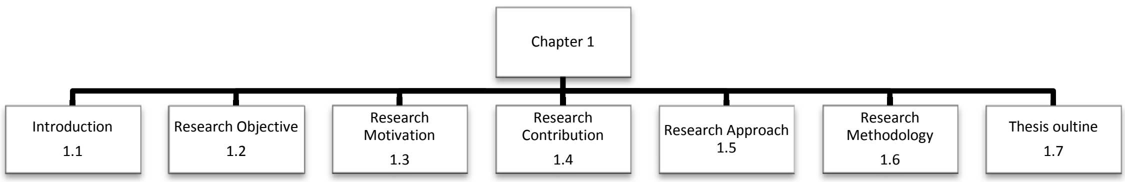


Figure 1-1 Outline of Chapter 1

1.2 Research Objectives

This thesis investigates productivity in service and network-based firms. Productivity is a key factor for economic growth, social benefit, welfare and living standards (Dolman & Gruen 2012; O'Mahony & Timmer 2009a; Timmer et al. 2007). Literature on macro and microeconomics defines productivity as the number of outputs that can be produced with any given number of inputs (Dolman & Gruen 2012; Solow 1956; Syverson 2011).

This definition originated at a time when production was principally physical and tangible in nature, with agriculture and manufacturing the mainstay of economies (Djellal & Gallouj 2013). The definition remains relevant when applied to easily quantifiable physical objects. However, economies of developed nations have transitioned from agriculture and manufacturing to service and knowledge-based industries, which are now the dominant sectors in terms of levels of employment and contributions to value added (Abe 2005).

The Australian economy is a service and knowledge-based economy. Service[1] firms contribute over 80 per cent to Gross Domestic Product (GDP), and employ over 85 per cent of the Australian workforce (McCredie & Bond 2012). Parallel to the rise in services has been a decline in productivity growth rates (Drucker 1991; McGratton & Prescott 2012). Green, Toner and Agarwal (2012) attribute productivity decline to a number of factors, linking innovation capability and the performance of firms, the role of employees and workplace organisation, and management practices as key factors in future productivity gains.

If these claims are correct, it is imperative to improve our understanding of productivity for service and network-based firms. The intangible nature of services makes them more difficult to quantify, and therefore measure (Gronroos & Ojasalo 2004; Gummesson 1998; Parasuraman 2002). Difficulties measuring service productivity are not only attributed to their intangible nature (Djellal & Gallouj 2013). Underpinned by service operations management literature, other aspects that contribute to the failure to measure service productivity adequately are attributed to the critical role of customer input (Sampson & Froehle 2006; Vargo & Lusch 2006a; Vargo & Lusch 2004), reliance on the intuition and experience of employees (Abe 2005) and the propensity and necessity of firms working in networks to deliver end-to-end services (Agarwal & Selen 2009; Gattorna 2010; Sampson & Spring 2012). Another concern is the unit of analysis when measuring productivity for service and network-based firms.

[1] Service sectors include financial (banking, insurance, securities, fund management), professional (accounting, legal, engineering, architecture), health, education, environmental, energy, logistics, tourism, information technology, telecommunications, transport, distribution, standards and conformance, audio-visual, media, entertainment, cultural and other business services. (Australian Services Round Table MOU with Australia 2009).

With these identified gaps and the stated importance of accurately measuring productivity, the research question is:

How can productivity be measured for service and network-based firms?

This research has four objectives. The first is to evaluate the current measures of productivity critically, in relation to service and network-based firms. The second is to develop a model (or a model) that addresses the identified gaps and weaknesses of our current understanding and application of productivity, hence enabling a more accurate means of measuring productivity for service-based firms. The third is to test and validate the new service productivity models with firms operating in the Australian economy. Because of the author's previous experience, firms operating in the Australian tourism, travel and hospitality industry are used. The fourth is to explore productivity measures, and provide an enhanced model that may be used for further research into measuring productivity of service and networked-based firms.

1.3 Research Motivation

This research was motivated by the phenomenon whereby the rapid rise in service and knowledge-based economies coincided with a decline in productivity growth rates. Service productivity models have been devised by scholars such as Schmenner (Schmenner 1986, 2004), Agarwal and Selen (2005), Parasuraman (2002), and Gronroos and Ojasalo (2004). They attempt to explain and measure service productivity at a firm level. While these models have provided insights into factors affecting service productivity, none has been put into operation to date.

The aim of this research is to provide a first attempt at operationalising productivity for service and network-based firms. Drawing upon literature from the fields of economics (Solow 1956), management (Taylor 1911), operations management (Schmenner 1986, 2004; Schmenner & Swink 1998), human resources (Hackman & Oldham 1976; Hackman & Oldham 1980; Kahn 1990), information technology (Kalakota & Robinson 1998; Swatman & Swatman 1991; Usipaavalniemi 2009), marketing (Parasuraman 2002; Vargo & Lusch 2004); and service science (Maglio et al. 2006; Spohrer & Maglio

2006a; Spohrer & Maglio 2006b; Spohrer et al. 2004) the research uses a holistic multi-stakeholder perspective. Two models are developed, which explain and operationalise factors affecting productivity for service and network-based firms. Using a common set of variables and units of measure, it is possible to measure and compare productivity across heterogeneous service network-based firms.

1.4 Research Contributions

This research makes four contributions in total: two theoretical, one methodological and two practical.

The first theoretical contribution is to the economics literature on productivity. Internationally, the Organisation for Economic Co-operation and Development (OECD) has sought to standardise productivity measures, using the KLEMS framework and database. KLEMS stands for capital, labour, energy, materials and services. The database has been adopted by the Australian Bureau of Statistics (ABS), and is the framework used to measure productivity at an industry and economy level. However, the KLEMS framework and database does not provide for firm-level data (Timmer et al. 2007). My contribution to the economics literature is the identification of new factors affecting the productivity of service and network-based firms. Further, the outcomes of this research extend the KLEMS conception of labour productivity found in the "*Output, input, productivity measures at the industry level: the EU KLEMS database*" (2009a) by acknowledging workers as discrete people, rather than an extension of machines. Intangible factors such as physical, cognitive and psychosocial attributes are attributed to the factors of labour productivity. These employee attributes incorporate the heterogeneous nature of employees and a measure of their intangible attributes. Customer input (C) and information communication technology integration (I) are also defined and operationalised, enabling KLEMS to become the KLEMS CI framework (capital, labour, energy, materials, service, consumer and information technology).

The second, theoretical contribution is to the literature on service operations management. Current models are Schmenner's (2004; 1998) Service Process Matrix (SPM), Agarwal and Selen's (2005) Service Cubicle, other models such as

Parasuraman's (2002) service quality and productivity conceptualisation, and Gronroos and Ojasalo's (2004) SPM, as a means of explaining service productivity at a service firm and network level. To date, however, no model has been operationalised. By adopting a network and a general systems view of the firm, and applying Boulding's (1956a) nine level general systems classification, I extend Schmenner's (1986, 2004), and Agarwal and Selen's (2005) Service Cubicle to develop two new models, hereafter referred to as the Service Enterprise Productivity in Action (SEPIA) and the Network Enterprise Productivity in Action (NEPIA) models. SEPIA incorporates the roles and contributions of key stakeholders such as customers, employees, managers, suppliers and shareholders (limited here to customers, employees and suppliers), and takes into account the enabling effects of information communication technology in determining new productivity measures. The NEPIA model, conversely, enables a whole network view, creating a means to measure and compare productivity of differently configured productive networks, and of firms occupying different positions within each productive network.

The third contribution is to the field of service science, through the establishment of a standard set of variables and units of measurement that can be applied across all service sectors. Service science is a new and contemporary field of study, and according to Abe (2005, p. 3) "the goal is to increase productivity of the service industry, promote innovation, and create greater validity and transparency when assessing the value of services". The use of a standard set of variables and units of measure enables a production frontier to be established and firm inefficiencies to be measured by the distance to the frontier. Thus, the development of the SEPIA and NEPIA models further extends service science and provides a framework for further research in the field of productivity for service and network-based firms.

The fourth contribution is a practical one to the field of management. Most management practices focus on cost savings, quality and resource allocation (Bannister 2001), making financial measures important. However, to focus on cost alone is to look at *what was*, focusing on financial projections examines *what ought to be*, rather than looking at *what is* (Carroll 2012). The use of contemporary definitions of service, the incorporation of modern business practices, and the use of standardised variables and units of measurement collectively facilitate redefining productivity measures for service and network-based firms. The SEPIA and NEPIA models include human and technical considerations, which capture structural, functional, compositional and behavioural elements into a set of measures. The list of measures is not exhaustive; rather, it is an attempt to highlight the importance of intangible factors in the measurement of service and network productivity. The SEPIA model measures intangible factors of service firms. These include customer choice, human capital accumulation, workforce diversity and supplier integration. The NEPIA model includes intangible factors resulting from firms operating in networks. These intangible factors are grounded in the social sciences, and are found in the firm's position within the network, thereby incorporating socially constructed factors such as popularity, influence and isolation, as factors of productivity.

The application of the SEPIA and NEPIA models provides managers of service and network-based firms with a new set of measures with which to assess firm performance. These measures enable the analysis and comparison of intangible aspects of an organisation, which can then be used for diagnostic and comparative benchmarking purposes. Further, comparisons across service industry sectors and service firms can now be compared, ultimately leading to improved decision-making and opportunities for innovation. This will enable decision-making to move away from the historic *what was* and *what ought to be* paradigm, to one based on current *what is* and *what could be possible* based on the intangible measures proposed in this research.

1.5 Research Approach

Service science is a new and emerging academic discipline (Zhao et al. 2009). Sarton (1959, p. 88) claims, "the most difficult thing in science, as in other fields is to shake off accepted views" and paradigms. Burrell and Morgan (1979), Frost (1980) and Gioia and Pitre (1990) claim that traditional approaches to theory building provide valuable but limited knowledge, as studies are too narrow (focusing on one theory and a single paradigm), and fail to take into account the multifaceted and complex nature of organisational realities (Gioia & Pitre 1990). The aim of service science is to discover the underlying principles of complex systems, by bringing together the human, technical and operational aspects (Spohrer et al. 2007) and to systematically create, scale and improve service operations (Spohrer 2007) .

In other, more established fields of science, models are an accepted approach to research (Simon 1957, 1969). Models are an essential part of intellectual activity, and require various skills and methods to produce in an insightful, reliable and useful manner (Bhushan & Rosenfield 1995; Silvert 2001). Models become artefacts that can be used in learning environments to aid the "understanding the dynamics of a complex system" (Silvert 2001, p. 261), such as service systems. The use of models includes assisting the assimilation of new concepts and in making sense of difficult, non-observable concepts (Griffiths & Tenenbaum 2009).

Productivity for service and network-based firms is examined using Winston's (1991) generalised modelling method.

1.6 Research Methodology

This research is primarily based upon operations research, which is concerned with "analysing complex problems and helping decision makers work out the best means of achieving some objective or objectives" (Heyer 2004, p. 1). To analyse the SEPIA and NEPIA models, I use a mixed method, with data collected from 14 organisations operating in the Australian travel and tourism industry. For the SEPIA model, the quantitative method used was data envelopment analysis (DEA), and the qualitative method of semi-structured interviews was used to validate the model. For the NEPIA model, I explored productivity measures quantitatively, using social network analysis at a whole-of-network level. Observation was undertaken, to validate the SEPIA and NEPIA models with contemporary business practices.

The focus of this research is the operationalisation of the SEPIA and NEPIA models, rather than the optimisation of each of the models.

1.7 Outline of the thesis

This thesis includes nine chapters (including the present one) and is structured according to the Winston's five stage generalised model formulation, which includes model formulation, data collection, optimisation of the model, validation and interpretation. Figure 1-2 provides an outline of how this thesis aligns each of Winston's stages. A summary of the remaining eight chapters is presented next.

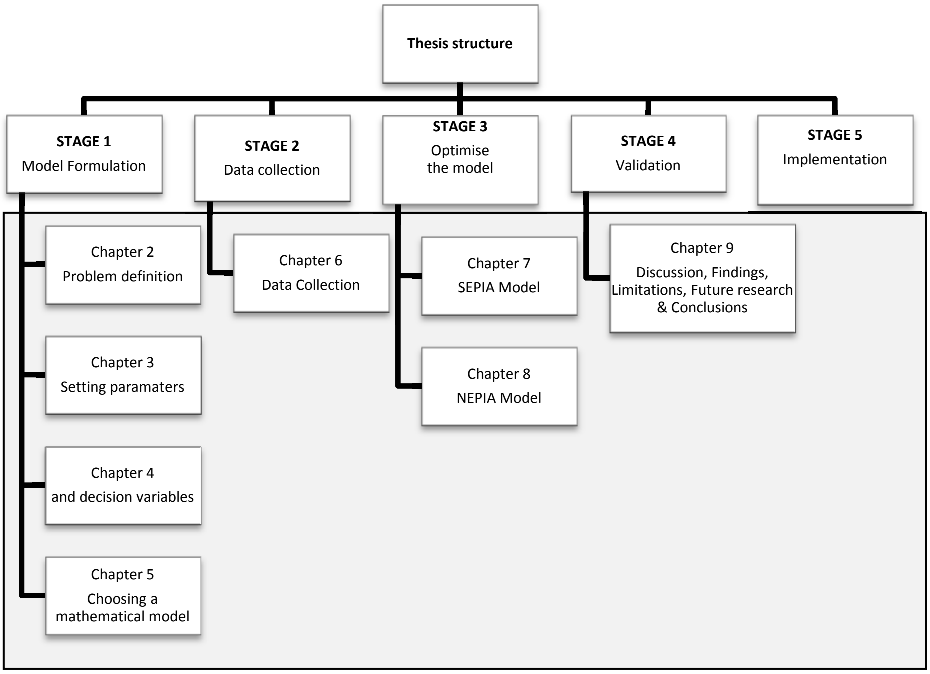


Figure 1-2 Outline of the thesis

Chapter 2 defines the research problem. A literature review on productivity, service, changing organisational operations, networks and existing service models is undertaken. The identified gaps in the literature define the research problem. In Chapter 3, Boulding's (1956a) nine levels general systems classifications are applied, to address gaps in the literature, and weaknesses of existing service productivity models. Two contemporary models are developed through this process, namely the SEPIA and NEPIA models. In Chapter 4, the decision variables and parameters for each of the models are defined and set. The selection of decision variables are derived from experience, academic literature and expert opinion. In Chapter 5, the use of DEA as the mathematical technique for analysing SEPIA is explained and justified. The use of SNA as the technique for conducting exploratory research of the NEPIA model is also presented. Chapter 6 provides an overview of the travel and tourism industry, and explains the data collection methods and processes, data preparation procedures and methods used to ensure the appropriateness of the data for each of the mathematical techniques. Chapter 7 details how data for the SEPIA model was categorised, analysed and the results presented. In Chapter 8, the solution for the NEPIA model is explored. SNA is applied to examine the application and appropriateness of the technique for measuring NEPIA productivity. Preliminary results are recorded and analysed. Finally, Chapter 9 details the key findings, limitations and opportunities for future research.

Chapter 2: Problem Definition: Productivity, Service and Network-based Firms

> It is largely the decisions made by individual firms in the Australian economy, and the interactions between them, that will drive productivity growth over coming decades (Dolman & Gruen 2012, p.12).

2.1 Introduction

Economics as a social science centres on the choices people make among a set of alternatives (Rittenberg & Tregarthen 2013)`. Specifically, economics attempts to understand the governing principles of production, distribution and consumption, through the mechanism of exchange. The explanations for which are expressed, generally, in terms market interactions at the macro level versus the individual firm, or household decisions, at the micro level (Manski 2000; Simon 1959). The focus of macroeconomics is on whole economies—issues such as aggregate production, consumption, savings and investments—and land, labour and capital are viewed as the traditional factors of production (Rittenberg & Tregarthen 2013). Conversely, microeconomics examines the interactions between buyers and sellers, focused more on consumers and the firm (Manski 2000; Rittenberg & Tregarthen 2013). Productivity is a specific area of economics, in which decisions made by individuals determine the allocation of scarce resources within a firm, industry, region or economy (Manski 2000).

In this chapter, the literature review takes a multi-disciplinary perspective. The review draws on the literature of economics (Boulding 1981; Smith 1976; Solow 1956), management (Porter 1984; 2000), human resources (Hackman & Oldham 1976; Kahn 1990), marketing (Gummesson 1998; Sampson 2000; 2010; Sampson & Spring 2012; Vargo & Lusch 2006b; Vargo, Maglio & Akaka 2008), information technology (Swatman & Swatman 1991; Usipaavalniemi 2009), and service operations management (Schmenner 1986; 2004). Existing models attempting to explain service productivity are also examined. Gaps in the literature and the weaknesses of existing productivity models are identified.

The aim of this chapter is to follow Winston's (1991) five stage generalised model formulation, to understand concepts underpinning the identification of parameters and decision variables that make up service productivity, as well as methods allowing the operationalisation of service productivity in mathematical terms. This will inform the development of the SEPIA and NEPIA models.

This chapter is organised into four sections. The structure illustrated in Figure 2-1. Section 2.1.1 reviews productivity, and how it is measured. The focus of Section 2 is on service. Section 2.2 describes how the evolution of production highlights the transition from agriculture and manufacturing to service and knowledge-based economies. Service is defined along with the changes in organisational structures as they evolved. Section 2.3 examines the role of customers, employees and the integration of suppliers in the service delivery process, using enabling technologies. Section 2.4 reviews current service productivity models, as evident from the extant literature and the limitations that prevented them from being operationalised.

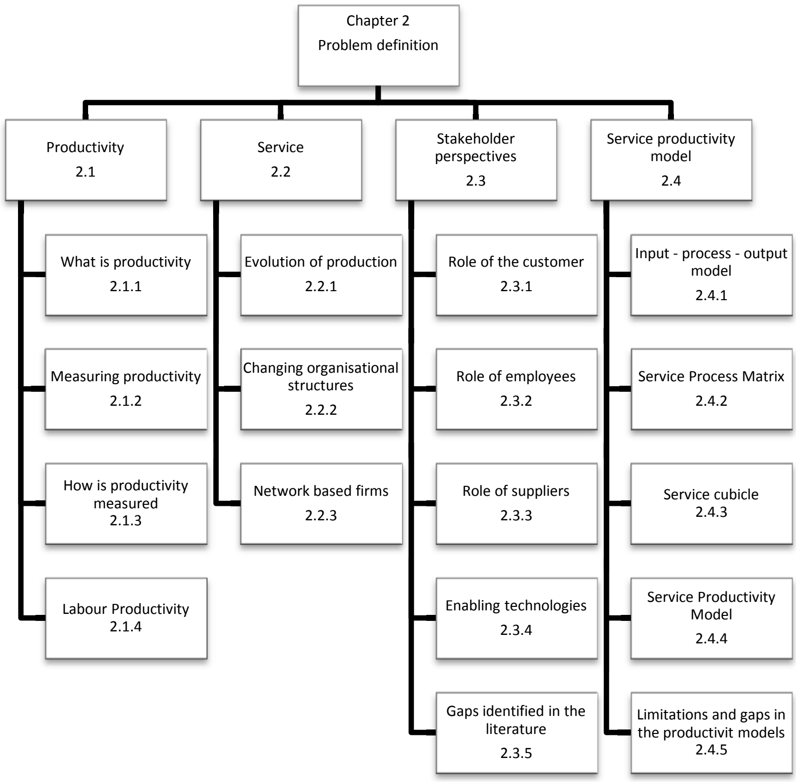


Figure 2-1 Outline of Chapter 2

2.2 Productivity

2.2.1 What is productivity?

Productivity is the area of economics that examines the allocation of scarce resources within an economy (Manski 2000), and can be applied at a macro/whole-economy level, or a micro, individual firm or consumer level (Djellal & Gallouj 2008; Robert et al. 2011). The economics literature defines productivity as the rate at which inputs can be converted to outputs (Syverson 2011). According to Dolman and Gruen (2012, p. 6), it is the "decisions made by individual firms in the Australian economy and the interactions between them, that will be a key driver of future productivity growth." Haltiwanger, Lynch and Mackie (2007) concur, claiming that it is data generated at the firm level that underpins the measurement, analysis and prediction of productivity at all other levels.

Productivity measures are important, as they are considered a determinant of economic growth and an indicator of living standards (Gretton & Fisher 1997; Schreyer 2001). In its simplest form, productivity is calculated by dividing the number of outputs produced by the number of inputs (Ahmad et al. 2003; Camus 2007; Coelli et al. 2005; Cook & Zhu 2008; Ospina & Schiffbauer 2006). Despite the importance of firm-level decision-making, there is a lack of firm-level productivity data, with productivity measures and most reporting occurring at industry and economy levels (Camus 2007). This limits the understanding and applicability of productivity at the micro level, thus inhibiting how firms approach and improve productivity (2007). Data collected from the Telstra Productivity Indicator 2012 report suggests that while 78 per cent of organisations participating in the survey consider productivity important, only 19 per cent of organisations measure productivity (*Telstra productivity indicator* 2012).

2.2.2 Drivers of productivity

The British Treasury Department identified investment, innovation, skills, enterprise and competition as five key drivers affecting long-term productivity (Camus 2007). Investment is a financial resource that may be in the form of money, or converted to other assets such as building, machinery and equipment, which aid production by lowering the levels of input required or enabling increases in output (Coelli et al. 2005). Conversely, innovation is the successful exploitation of new ideas, including the introduction of new technologies, superior designs, changing business models and management practices (Agarwal & Selen 2009; Bloom & Van Reenen 2007; Camus 2007; Mansury & Love 2008; Potts 2009). Skills are abilities that enable tasks to be undertaken (Hackman & Oldham 1980), and are defined by quality of work and the total number of hours worked (Camus 2007). Various scholars (Agarwal & Selen 2009; Lusch et al. 2009; Sampson & Froehle 2006) claim that it is the combined knowledge, capabilities and experience of the workforce, rather than skills alone, that have a cumulative, positive effect on productivity. Enterprise refers to the entrepreneurial capabilities required to combine multiple factors of production and new technological forms, which force firms to adapt and compete or exit the market (Agarwal & Selen 2009; Camus 2007; Romero-Martinez & Montoro-Sanchez 2008). Competition creates the incentives necessary to innovate and strive for the efficient allocation of resources (Agarwal & Selen 2009; Bloom & Van Reenen 2007; Dong et al. 2008; Ospina & Schiffbauer 2006; Porter 2000). The intangibility of many of these drivers makes them difficult to measure.

Two other factors of production found in the literature that affect productivity are geography (Jacobs 1969, 1984) and technology (Brynjolfsson 1993). The influence of geography on productivity manifests in two ways. The first is through the type, number and volume of natural resources available as inputs (Lawson & Dwyer 2002). The other factor is the attractiveness of a place, as attractiveness influences where managers locate their businesses. Access to infrastructure, speciality resources and co-location with complementary businesses are factors positively contributing to the attractiveness of a place (Porter 1984; Porter 2000). The co-location of businesses within the same geographic proximity is known in economics as agglomeration, or clusters. Porter (2000, p. 51) has defined clusters as a group of "inter-connected companies, specialist suppliers, service providers and firms in related industries and associated institutions in a particular field that compete and co-operate with each other." The productivity gains attributed to agglomeration include economies of scale, labour pooling, access to specialist skills and knowledge and technology spill over (Marshall 1890; Porter 1984). However, an alternate view is presented by Jacobs (1969, 1984) who claims that the benefits of co-location are provided through the diversity that arises through population increase.

Technology, or information communication technology (ICT), as an enabler is the key argument to being freed from geographic or location constraints (Freidman 2005; Therrien & Hanel 2005). Thus, the adoption of ICT is important in alleviating issues that may be caused by the tyranny of distance (Porter 2000). ICT-enabled organisations are better able to create connections and participate in more open and dynamic networks. Kalakota and Robinson (1998), Adobor (2006) and Lazzarini, Chaddad and Cook (2010) extend the benefits of ICT from the efficiency gained from ICT adoption to the integrative benefits able to be achieved by the acceleration of information and knowledge exchange, and being connected to differently configured networks. However, the differences in the availability and adoption of technology results in areas those have and use the latest technologies, and those that do not, creating a digital divide (Jimmerson et al. 2005; Pitelis 2009).

The link between geographic proximity, ICT availability and productivity is significant, given Australia's size (7,617,930 square kilometres) and disbursed population of 23.1 million. Glaeser, Kallal, Scheinkman and Shleifer (1992) show that people in regional areas are less productive than city-dwellers, attributing this to fewer opportunities for diverse interaction and exchange of ideas. However, not all scholars agree. For instance, Freidman (2005) argues that the availability of technology transcends time and place, and provides examples in which education and medical services are delivered virtually, with no requirement that the customer and service provider be co-located. Horowitz, Rosensweig and Jones (2007) discuss the necessity and preference in choosing to travel to obtain medical services, and the rise of medical tourism. Bhandari and Blumenthal (2013) discuss student mobility and Australia's 3.3 million international students as a growing phenomenon, highlighting the selection of location and preference for human interactions, despite the availability of virtual options. Therefore, where and how work is performed affects productivity.

2.2.3 How is productivity measured?

Productivity is currently the measure of the amount of outputs able to be produced for any given number of inputs. It is expressed in Equation 1 (Coelli et al. 2005).

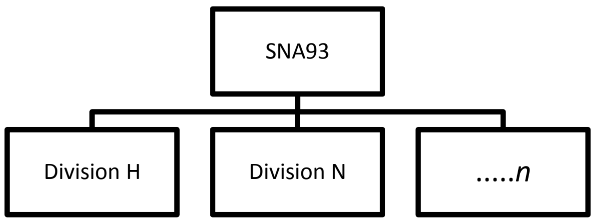
$$\text{Productivity} = \frac{\text{outputs}}{\text{inputs}} \qquad \textbf{Equation 1}$$

Productivity is often measured against a single factor of production, usually labour *or* capital. Where this is the case, the measure is referred to as single or partial productivity. Conversely, multi-factor productivity is where more than one factor of production is used to measure productivity, such as labour *and* capital. Total factor productivity measures the effects of all factors of production in the productivity measure (Coelli et al. 2005). While partial productivity may be easier to measure, it can be misleading if considered in isolation from other factors of production (Charnes et al. 1978b; Coelli et al. 2005).

Productivity is a priority for all nations, and attempts are being made to standardise the collection, analysis and reporting of productivity measures globally (Ahmad et al. 2003; O'Mahony & Timmer 2009a; Timmer et al. 2007). Work in this regard is led by representatives of 25 European countries, who have devised the capital (K), labour (L), energy (E), Materials (M) and Service (S), referred to as KLEMS model and database.

To date, 140 countries (including Australia) use KLEMS as the framework for measuring productivity at a meso (industry) and macro (economy) level (O'Mahony & Timmer 2009a; Timmer et al. 2007). A key benefit of KLEMS is the standardisation of 32 industry and 72 sub-industry groupings, which align to the Standard National Accounts (SNA93), illustrated in Table 2-1. The SNA93 is used to formulate other economic performance data, such as GDP, intermediate use of goods and services and movements of labour within the economy, and is a critical component in the assessment of the economic conditions of a nation (Jorgenson et al. 2010; O'Mahony & Timmer 2009a; Timmer et al. 2007).

Table 2-1 KLEMS framework aligned to national accounts

Economy	As defined by geographic boundary Include service and non-service sectors Linked to the Standard National Accounts (SNA93)				
Australian and New Zealand Standard Industry Category (ANZSIC) Codes					
KLEMS framework	Capital	Labour	Energy	Material	Services

The KLEMS framework and database is underpinned by the mathematics of production possibility frontiers. KLEMS calculates industry output, *Y* as a function of capital, labour, intermediate inputs and technology indexed by time *T*, expressed mathematically in Equation 2. Here, each industry is indexed by *j*.

$$Y_j = f_j(K_j, L_j, X_j, T)$$ **Equation 2**

Where:

Y = industry output

K = capital

L = labour

E = energy

T = time

j = industry index

A limitation of the KLEMS model is the absence of micro (firm) level measures. Inputs entering the production process are transformed and converted into finished products or services. According to Boyer and Verma (2010), the transformation process changes the nature of physical properties by changing the shape, fixing the dimensions, changing surface finishes or joining parts and materials. Once goods are transformed they become available as outputs, for household consumption. However, not all outputs are consumed by households. According to the ABS ("Productivity glossary" 2011), outputs consist of "goods and services that are produced within an establishment that become available for use outside that establishment, plus any goods and services produced for own final use." This established two classes of outputs: those consumed by external entities and those consumed internally by the firm. Contrary to this, Schreyer (2001) delineates outputs into three distinct types: outputs consumed by the end user (Business-to-Consumer B2C), outputs from one firm that become inputs to another firm's production process (Business-to-Business B2B) (referred to as intermediate inputs) and outputs produced for the firm's own use (Schreyer 2001). Figure 2-2 represents the KLEMS productivity model, showing the various input types defined by KLEMS and the output types defined by the ABS and Schreyer (2001).

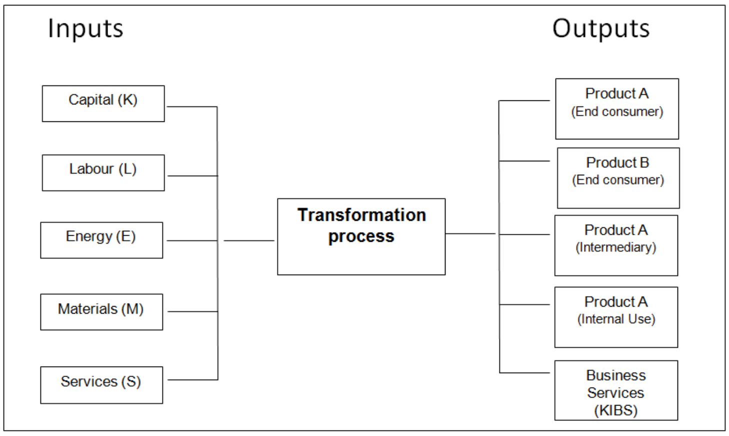


Figure 2-2 Multi-factor productivity

The current definition of output is limited by two basic assumptions. The first assumption that all outputs are tangible is flawed. It is noted by Lovelock and Yip (1996) in the service operations management literature and by Vargo and Lusch (2004), Ng (2008) and others in the service marketing literature that this is not the case with services, as inputs and outputs may be intangible. The second assumption is that outputs have value that customers are willing to pay for. A consequence of production may be the generation of unwanted and undesirable outputs (Cook et al. 2013; Cook & Zhu 2013). Not only do unwanted and undesirable outputs not hold value, they may actually detract from value. For example, air pollution is the unintended and undesirable output of industrial plants, the costs and effects of which are not currently factored into productivity calculations (Piercy & Rich 2009). This has implications when calculating productivity, as it exemplifies a situation contrary to an output maximising strategy (Coelli et al. 2005; Cook et al. 2013; Cook & Zhu 2008) and fails to take into account remediating effects.

2.2.3.1 Labour productivity

Labour is a key focus of productivity studies, as it remains the most important input into the production process. Given the importance of people in the delivery of services, it is pertinent to understand how labour productivity is measured and to identify limitations. According to Baumol and Bowen (1996), cited in Spohrer and Maglio (2006a, p. 7) "labour migrates from high productivity, low value portions of the economy to low productivity, high value portions of the economy." This is evidenced in the movement of labour from manufacturing to service industries (Baumol & Bowen 1996; Spohrer & Maglio 2006a). In its simplest form, labour is considered homogenous, and calculated as the number of workers multiplied by the number of hours worked (Coelli et al. 2005). This measure accommodates the structural changes occurring within the workplace, in which one in five employees in Australia are casual workers, rather than full or part-time employees (Pink 2011). Changes to the average work time, multiple job holdings and the role of self-employment are also reflected in the labour productivity measure (Schreyer 2001).

Measures of labour productivity are based either on a gross output method or on a value added index (Balk 2003). The gross output measure conceives of a production unit as an input-output mechanism, using capital, labour, energy, material and services to produce a quantity of outputs (Balk 2003; O'Mahony & Timmer 2009a; Timmer et al. 2007). An example is when measuring labour productivity as a single factor of production: the total number of hours worked is the input measure used to determine the gross output generated as a result of that labour (Balk 2003; Cobbold 2003). Labour productivity measured by gross output can be used at a production unit level, be it a firm, industry, region or whole economy (Balk 2003). The equation for labour productivity based on gross outputs is shown in Equation 3.

$$\text{Labour productivity based on gross output} = \frac{\text{Quantity index of gross output}}{\text{Quantity index labout input}} \qquad \textbf{Equation 3}$$

Conversely, the value added index is a method of calculating productivity that excludes the value of intermediate inputs. This approach separates the gross production function into primary and intermediate inputs (Balk 2003), and according to van der Wiel (1999) is more suitable to profit-maximising firms. As the value added approach is less dependent on change in intermediate inputs or degrees of vertical integration, it neutralises the effects of outsourcing, as it replaces labour from being a direct input to being an intermediate input, thereby reducing the use of direct labour (Cobbold 2003). In addition to the reduction in labour inputs, there is a reduction in value added (Schreyer 2001). The equation for labour productivity based on the value added index is shown in Equation 4.

$$\text{Labour productivity based on value add} = \frac{\text{Quantity of output and quality of output}}{\text{Quantity of input and quality of output}} \qquad \textbf{Equation 4}$$

While there are differences between the two methods discussed above, there are also similarities. The similarities relate to the joint influence of input factors on labour productivity, and the use of input factors other than labour, such as capital, technical and organisational efficiency. Each method is relatively easy to measure, interpret and compare. However, it is easy to misinterpret the results as technical changes or productivity improvements in the labour force.

The basic measure for labour is based upon the number of hours worked. Hours worked are categorised as *normal* hours, which relate to the negotiated hours an employee is contracted to work. This is in contrast to *actual* hours, which include overtime and absence due to annual leave and sick leave. The number of hours worked is regarded as a labour input into the production process, whereas wages and compensation are considered outputs (*Measuring Productivity: Measurement of aggregate and Industry level productivity growth* 2001). This is problematic when examining the treatment of business owners and the self-employed, as they often mistakenly use the return on capital as income. Where this is the case, the *common compensation* method is adopted, to attribute value per employee. Common compensation assigns the average rate per hour for employed workers, and to other entities such as business owners and the self-employed (Schreyer 2001). One of the limitations of this measure is that it treats labour as homogeneous. There is no distinction between the value addition of one hour's labour input of a surgeon and one hour's labour input of a fast food operator. There is no assessment of the effort, cognitive ability and emotional engagement and expertise required to perform different jobs.

2.2.4 Gaps in current productivity measures

Two problems exist in the way labour productivity is currently measured. The first is that the treatment of labour as a homogenous factor of production measured by time alone fails to acknowledge the whole person, and does not take into account the personal, cognitive or psychosocial aspects of workers. The second problem (detailed further in Section 2.3.1) is in relation to services, whereby customers act as a resource providing input into the service delivery process. Customers and their inputs are not currently viewed as a factor of production, and consequently their efforts are not included in current measures of productivity.

2.3 Service

2.3.1 The evolution of production

Production methods and the ways in which value is created have evolved over time (Boulding 1981; Stam 2007; Trist 1981). In the past, natural resources such as land, labour and capital were the resources bundles used by firms for production and the creation of outputs (O'Donnell et al. 2008). However, as the reliance on physical resources declines, moving towards intangible resources (Vargo & Lusch 2006a; Vargo & Lusch 2006b) such as knowledge and information (Drucker 1991; Drucker 1999; Hunter & Scherer 2009; Toffler 1981), changing the resource bundles required to create value.

The organisation of work is changing. Agriculture and manufacturing, once the mainstay of economies, were produced away from the market, stored, transported and delivered to customers in different geographical locations (Fitzsimmons & Fitzsimmons 2004). Today, the service and service delivery industries dominate employment and how value is created in developed countries, and is a focus for developing countries (Noland et al. 2012). However, our understanding of service is still in its infancy. According to Spohrer, Morris and Maglio (2004), the impact of the rise in services is so significant in terms of rates of growth and levels of employment that the vitality of nations is threatened unless services become more efficient and productive. Noland, Park and Estrada (2012, p. 1) agree, claiming, “the case for raising productivity in the service sector is overwhelming”, and acknowledge that achieving the gains will be difficult.

Toffler (1981) views the move from agriculture and manufacturing to service and knowledge-based work as having occurred in three waves. The first was the domestication of humankind, the move from nomadic hunting and gathering to domesticated farming and landowning. The second was the industrial revolution and Taylor's (1911) scientific management of production, in which characteristics of standardisation, synchronisation and maximisation became commonplace (Stam 2007). We are currently in the third wave, referred to by Toffler as the Techtronic age, in which resource integration becomes paramount. In direct contrast to the industrial age, knowledge work, de-massification, the breaking up of markets and marketing channels organising customers into diverse niches become the preferred operational model. The change in operational preference is accompanied by a change in strategy, where the focus now is on sustainability, waste minimisation and optimisation rather than a single maximisation focus. This is achieved through the application of alternate operating methods such as just-in-time production and delivery, demand chain management and lean manufacturing (Boyer & Verma 2010; Gattorna 2010).

Changes in the way work is performed can also be viewed from an organisational theory perspective. Taylor (1911) was the first to identify changes in the way work was performed through the division of labour. He viewed managers as intellectually superior to employees, and this intellectual superiority meant managers needed to take responsibility for workers and the work they performed. He also acknowledged that the contributions to production from managers differed from those of workers (2009; Stam 2007). The work performed by workers was essentially mechanistic, and their contributions viewed primarily as an extension to the machine. Research into the human contributions of work continued, including aspects such as behavioural and motivational factors that affect work (Hackman & Oldham 1976), work conflict (Follett 1918), the role and dynamism of the entrepreneur (Muller 2011; Schumpter 1942; Smith 2006) while studies from Csikszentmihalyi (1990), Nakamura & Csikszentmihalyi (2002), and Potts (2009) examine creativity and the impacts it has on work and workers.

In response to the changes in the way work is performed, organisations have also altered the way resources are accessed, configured and integrated. This is evident in the move away from permanent full-time employees to non-permanent, casual, part-time employees (Schreyer 2001), contractors, outsourced workers, freelancers or project-based virtual workers (Koukoulas 2013; Storey et al. 2005). This is made possible due to the differences between good production and service delivery (Vargo & Lusch 2004). Generally, services are geographically located in the same place as customers, and are more labour intensive than agriculture and manufacturing (Fitzsimmons & Fitzsimmons 2004). Additionally, there has been a rapid uptake of technology, reducing the dependence of fixed place locations (geographies) for service firms. For example, the automation of business processes enables work to be outsourced and conducted virtually. Increases in the levels of technology have also moved employers from reliance on the physical contributions of labour, to employees who possess a broad range of skills, knowledge and experience (Agarwal & Green 2011; Maglio et al. 2006). Today, work is organised around customers and services. Customers have also moved from being purchasers of goods to now being involved in the service delivery process, and are themselves a resource co-creating value (Sampson 2000, 2001; Sampson & Froehle 2006; Vargo & Lusch 2004; Vargo & Lusch 2006b; Vargo et al. 2008).

This section illustrates a number of changes that have occurred through the evolution of production, as economies move from agriculture to manufacturing to service and knowledge-based industries. To date, productivity measures have revolved around the allocation of resources related to the production of physical goods. However, as economies and production evolve, changes to the way work is performed and organised have occurred. These changes include increased reliance on service and knowledge-based industries, with an inherent focus on intangibles.

2.3.1.1 What is a service?

The previous section illustrated the evolution of production. This section further presents differences between goods production and service delivery, to define what a service is, before examining how resources are configured through changes in organisational structures and networked forms.

Boyer and Verma(2010) claim that goods are produced from large capital-intensive facilities require long lead times and are easy to measure in terms of quantity and quality. Goods production involves processes that enable firms to embed value (utility) into a product throughout the production process, after which goods are stored, transported, inventoried and made available for future use (Vargo & Lusch 2011). They postulate that firms producing goods look to maximise profits, and therefore “production efficiency should be maximised; thus the ideally tangible goods should be standardized, produced away from the market and inventoried until demanded" (p. 2). This results in the production and consumption of goods being asynchronous.

In contrast, services are characterised as intangible, heterogeneous, inseparable and perishable (Lovelock & Yip 1996; Sampson & Froehle 2006; Zeithaml et al. 1985). Gadrey and Gallouj (2002) present the view that the differences between the production of goods and delivery of services are relative to time, location and space. They observe that the market for services has short response times, and such services are generally delivered in local markets from small facilities. Further comparisons between goods and services were made by Vargo and Lusch (2004), who assert that the differences between the two go beyond the inherent characteristics. A different mind-set or logic is required to understand the complexities of the differences between service and goods production. Vargo and Lusch introduce the notion of a goods dominant logic and a service-dominant logic. Service is defined, by them, as "a process or the use of one's resources or competences for the benefit of another entity" (Vargo & Lusch 2004, p. 3). Their definition of service is based upon their ten foundational principles of service-dominant logic (Vargo & Lusch 2004, p. 7) which are:

1. Service is the fundamental basis of exchange.
2. Indirect exchange masks the fundamental basis of exchange.
3. Goods are a distribution mechanism for service provision.
4. Operant resources are the fundamental source of competitive advantage.
5. All economies are service economies.
6. The customer is always a co-creator of value.
7. The enterprise cannot deliver value, only offer value propositions.
8. A service-centred view is inherently customer oriented and relational.
9. All social and economic actors are resource integrators.
10. Value is always uniquely and phenomenological determined by the beneficiary.

A major differentiator between the production of tangible goods and the delivery of service processes relates to the role of the customer, as they are suppliers of input resources for services (Sampson 2010). In relation to goods production, customers select, pay and consume outputs, and there is no direct involvement in the production process. Once customers select goods and payment is made, ownership is transferred to the customer. The realisation of value by the customer is separate from the maker, with no direct feedback between the customer, maker and supplier of goods (Boyer & Verma 2010). Services, on the other hand, rely on customer inputs. Sampson and Froehle's (Sampson & Froehle 2006, p. 112) Unified Service Theory defines service as "processes wherein each customer supplies one or more input components for that customer's unit of production." This places the customer in a critical, dual role: that of a customer and co-producer. Customers supply raw materials in the form of themselves, their belongings or their information (Lovelock & Yip 1996), and are therefore co-producers of value (Lusch et al. 2008; Sampson 2000; Sampson & Chase 2010; Vargo & Lusch 2004; Vargo et al. 2008). Sampson's (2010) definition of service enables the comparisons of the value creation and transformation processes, rather than measuring unit of output. The customer-supplier duality of service is a key differentiator between the single directional flow of goods production and the bi-directional flow of value in the service delivery process.

Services can also be viewed as a system (Maglio et al. 2006), called service systems. Viewing service firms with a systems approach provides a more holistic view, as it includes the roles of participants, the identification of elements and relationships and gives visibility to the function or structure of the inter-connections (Trist 1981; von Bertalanffy 1968). Magilo and Spohrer's (2008, p. 14) definition of service systems describes them as "value co-creation configurations of people, technology, value propositions connecting internal and external service systems and shared information." While this definition includes elements of the system—such as people and technology—it fails to specify their relationship. Agarwal and Selen (2005) go part way in doing this in their conceptualisation of a Service Cubicle model. This model includes the degree of technovation, which positions the firm within a service value network, with technology being the means of connecting firms. This is discussed in more detail, with specific reference to productivity in service firms, in Section 2.2.

Noting that service offerings are culminated through increasingly collaborating firms, Agarwal and Selen (Agarwal & Selen 2011, p. 1169) define services in the context of a service value network, or a service system, as:

> the application of competencies (knowledge, skills and experience) of the stakeholders, whereby customers provide themselves, or provide significant inputs into the service production process and in the best case are transformed by the simultaneous consumption—the experience.

This provides specificity for some of the broader elements identified earlier by Maglio and Spohrer (2008). For example, Agarwal and Selen's definition specifies people as *stakeholders* and, therefore, it is possible to identify each of the stakeholders that contribute to (input) or expect returns (outputs) from the service delivery process. The marketing literature identifies customers as key stakeholders (Frei 2006; Sampson 2000; Sampson & Spring 2012; 2008); human resource literature considers employees and managers key stakeholders (Green & Agarwal 2009; Kahn 1990; Trist 1981); operations management considers suppliers (Gattorna 2010; Kalakota & Robinson 1998; Walters 2000; Walters & Rainbird 2007); and finance see shareholders as key stakeholders (Robinson 2013). The identification of stakeholders now makes it possible to assess each stakeholder role in the service delivery process. It also arms us with the ability to examine their relationships and the methods used to connect and interact with each other and with the firm.

2.3.2 Changing organisational structures

More service offerings are being made through a network of firms, wherein stakeholders transact or interact and become more involved in the operations of service firms, and changes in organisational structures of service firms have been observed (Cherns 1976; Sampson & Spring 2012; Trist 1981). According to Manzoni (2007), organisational structures are based on the volume of customers needing to be serviced and the number of employees and suppliers working together to meet their demand. In response to the interdependent relationships between customers, employees and suppliers, organisational structures are changing from highly structured and bureaucratic, to flatter and more organic (Cherns 1976; Mori 2011; Trist 1981). Additionally, the way that value is created is also changing, making it important to understand and respond to changing dynamics. Traditional roles and structures are being challenged as the boundaries of the firm become less defined and transparent (Thompson 2008a, 2008b).

Organisational structures are determined by their function and form (Manzoni 2007). This affects the ability of an organisation to respond to variability caused either by environmental uncertainty (Trist 1981) or customers (Parasuraman 2002; Schmenner 1986, 2004; Schmenner & Swink 1998). These changing dynamics alter the centrality of power and decision-making, which help distinguish different types of organisational structure (Manzoni 2007). Two such structures presented below are mechanistic and organic (Manzoni 2007; Trist 1981; Trist & Bamford 1951).

2.3.2.1 Mechanistic organisational structures

Mechanistic organisational structures are typically bureaucratic and hierarchical in form, and the workplace environment in such organisations is characterised by friendliness, kinship and neighbourliness (Manzoni 2007; Smith 1998). Work is divided according to functional areas, cost control being the main focus of management, and the organisation is dominated by collective consciousness (Manzoni 2007). The work environment is structured through formalisation, specialisation and standardisation (Burns & Stalker 1966; Child & McGrath 2001; Goffees 1985). This structure is prevalent in industrialised economies, in which production occurs on a large scale and involves standardised, pre-defined work practices and outputs that conform to pre-determined specifications.

A negative aspect of mechanistic organisational structure is organisational distance. This is the number of hierarchical layers between the points at which variability occurs, where and decisions can be made to control or address the variability issue. According to Chern's Principles of Socio-technical Design (1976, p. 7), "variance should be dealt with at source and should not cross any boundaries." Organisational distance implemented via organisations structured around functional areas (silo structures) increases the number of requests generated vertically between lower and higher levels of the organisation, as well as horizontally across departments, resulting in bottlenecks. As such, bottlenecks occurring across silo structures delay the decision-making process, introducing "red tape" (Walker et al. 2007), which results in slower reaction times and the organisation's limited ability to adapt to change (Burns & Stalker 1966).

2.3.2.2 Organic structure

Conversely, organic organisational structures are characterised by small cross-functional teams, with decentralised decision-making resulting in a capacity to adapt (Augusto 2007; Augusto et al. 2010). Social scientists define teams and groups as a collection of two or more individuals with a stable pattern of relationship between them. Teams share a common set of goals and perceive themselves as a group distinct from other groups or teams (Greenberg & Baron 2009; Owen 1996). Teamwork requires employees of organic organisations to possess a different set of skills from employees of mechanistic organisations (Owen 1996).

Good communication skills and being a generalist are characteristics of employees working in organic organisations (Manzoni 2007). The generalist nature of employees enables multi-skilling and contributions to different discipline areas, as required by the work needing to be performed. This provides flexibility in the jobs undertaken, and employees are able to facilitate free-flowing communication across a multitude of discipline areas (Murray 2002; Singh 2013). A study by Singh (2013, p. 41) shows that informal—or “grapevine”—communication leads to increased business performance and productivity, as well as generating other group cohesion and motivation benefits. Change also occurs more swiftly as a result of flatter structures, thereby reducing organisational distance.

The flatter organisational forms of organic organisations are more conducive to dealing with variability and uncertainty (Owen 1996). The reasons provided for this include lower levels of organisational distance, cross-functional communication across silo structures, and the ease in which information flows, enabling flexibility and adaptability (Agarwal & Selen 2008; Qureshi 1995). Clegg (2000) holds this true in his reconceptualisation and extension of these principles, and includes this point in the context grouping (Baxter & Sommerville 2000). Decision making in non-hierarchical organisations is often undertaken by self-organising teams, who use social connections to solve problems. Self-organising structures have been likened to tribal societies that operate by informal leadership, and are constructed through complex social structures and arrangements (Collister 2012).

The complexity of social structure is also seen in the formal (business) and social (informal) connections that people within organisations have with their external environment (Agarwal & Green 2011; Agarwal & Selen 2009; Gattorna 2010; Qureshi 1995). Here, relationships between customers, the firm and their suppliers described by Agarwal & Selen (2009) as organisational relationship capital was shown, empirically, to add value in the context of innovation in service value networks, and these relationships form the basis of how firms are connected.

2.4 Network-based firms

The changing organisational work patterns discussed in the previous section showed a flattening of organisational structure. Managers within organisations chose to create either a mechanistic and hierarchical organisation, or a more organic and team-based firm. However, the organic form and flattening of the organisation is also changing, as markets are viewed as economic and social networks (Jackson 2010; Qureshi 1995). The study of networks is not new, and has been an area of focus for engineers, computer scientists, social scientists, economists, managers and marketers (Basole & Rouse 2008; Hanneman & Riddle 2005). Networks are characterised by the purpose for which the network forms, and are defined as the connection of two or more people (actors) or entities. The links and connections between the entities become as important as the entities themselves (Gattorna 2010; Qureshi 1995). Networks form for a variety of reasons, but principally to connect places (geographies) (Gattorna 2010; Walters 2000), information technology communications and systems (Swatman & Swatman 1991; Usipaavalniemi 2009), business (Agarwal & Selen 2009; Gattorna 2010) or people (social) (Leonard & Onyx 2003; Onyx & Bullen 2000; Onyx et al. 2007; Putman 1995).

2.4.1 Networks via geographic proximity

The importance of geography to productivity was discussed in Section 2.1.2, and is found in the seminal work of Alfred Marshall (Marshall 1890). He argues, and Porter (1984) agrees, that organisations that cluster within the same geographic proximity do so to gain competitive advantages and productivity efficiencies due to agglomeration. Jacobs (1969, 1984) and Park, Burgess and McKenzie (1925) claim that the benefits of geographic proximity come from the human aspects of difference and diversity, creativity and innovations and spill over that occurs as a result of co-location. Kelly (1998) claims that businesses transacting over the Internet create a new economy, operating in a space rather than a place. According to Williams (2014), one third of the economy has moved into the digital, online space, and another third is expected to do so over the next two years. This is evidenced by the proliferation of industries making the move to an online space, such as banking and finance (Kalakota & Robinson 1998), travel and tourism (Jyh-Jeng Wu & Yong-Sheng Chang 2005), and more recently medical (Herrington et al. 2013) and educational services (Daniel 2012) moving into the online space.

2.4.2 Networks enabled via ICT

Conversely, ICT networks facilitate communication and information exchange between organisations across spatially dispersed locations and entities (Kalakota & Robinson 1998; Walters 2000). Friedman (2005) puts forward a view that information technology transcends time and space, making geography irrelevant. The technology enabling anytime, anywhere operation enables the formation and operation of networks in a virtual space. The benefits of virtual networks depend upon the degree of integration and collaboration, and the readiness to share information and knowledge on a whole-of-network basis (Agarwal & Selen 2006; Agarwal & Selen 2008, 2011; Van Dinther 2010). A study by Anderson, Lewis & Parker (1999) demonstrates the benefits of information sharing between organisations, where travel expense data exchanged between American Express, travel management companies and corporations enabled efficiency gains of up to 84 per cent to be realised by travel management companies. Studies of the efficiency of service value networks typically examine dyadic relationships. Service triads were not considered in this study, calling for research dealing with different network configurations with up to three layers in the supply chain (Benedettini & Neely 2012; Rathmell 1974) , service value networks (Norman & Ramirez 1993a) and service constellations (Holmstrom et al. 2010).

2.4.3 Networks enabled through business partnering

Business networks form around socio-economic activities with a view towards recognising, creating and acting on business opportunities (Andersson & Sundermeier 2013; Bengtsson & Kock 2000). Business networks have proliferated because of globalisation, changing market conditions and increasing competition (Hayakawa et al. 2010; Kimura & Ayako 2013). Types of business networks include, for example, supply chains, strategic alliances, joint ventures, supplier-producer collaborative distribution networks (Cravens et al. 1994), supply chains (Gattorna 2010), virtual organisations, business networks, smart business networks and service value chains (Ritter et al. 2004). Organisations are known to cooperate to increase market power, reduce costs and/or acquire new knowledge (Gulati 1998). This is achieved by integrating business processes and systems, and collaborating and sharing information (Agarwal & Selen 2009; Kalakota & Robinson 1998; Walter 2005).

Business networks, service value networks and supply chains in particular have evolved as new organisational forms, mainly to manage the flow of material, information and financial flows from raw material to the end consumer (Gattorna 2010; Kalakota & Robinson 1998; Walter 2005). Organisations such as Dell, Walmart and Zara have successfully integrated their supply chains. They have created a sustained competitive advantage through the adoption of advanced techniques such as postponement strategies, lean manufacturing and integrated business systems. Consequently, the competitive landscape is changing from one in which individual firms compete to one where competition occurs between entire supply chains (Kim 2010; Lee 2004). This view is supported by Gattorna (Gattorna 2010, p. 8) who states that:

> we must wake up to the fact that it is 'supply chain versus supply chain' from now on, rather than company versus company as in the past. Within a decade it will be networks versus networks.

The focus of many organisations, however, occurs on the dyadic level of intra- and inter-organisational connections, rather than taking a whole-of-network viewpoint (Randall & Farris II 2009). Karmakar (2004, p. 6) presents a different perspective for service firms, claiming that "instead of competing over links in the chain, service companies should compete for the chain itself." The modularisation of services enables organisations to "pick, plug and play" to combine and bundle service offerings, thus moving from slow moving business networks, to being agile, rapidly forming and constantly changing. This is enabled through the construction and integration of modular and interchangeable building blocks of software (Papazoglou 2008; Schroth & Janner 2007), enabling the creation of anyone, anytime, anywhere business processes despite different business processes or computer systems (Van Dinther 2010; van Heck & Vervest 2007).

2.4.4 Networks emanating from social contacts

Social networks exist and bring together members of a community who share common beliefs and values (Latour 2005; Potts 2009; Putman 1995). The connections between the actors/nodes in social networks represent relations and the relational aspects of the connections. Three connections have been identified: bonding, bridging and linking (Bullen & Onyx 2005; Onyx & Bullen 2000; Onyx et al. 2007; Putman 1995). Bonding links exemplify relationships between homogenous groups, and are built on trust and reciprocity (Zaheer & Bell 2005). Here, members know each other and share a common set of values. However, Onyx, Edwards and Bullen (2007) claim that where there is too much bonding, marginalisation and isolation may occur, resulting in disenfranchisement of some members from the group (Baker et al. 2011; Onyx & Bullen 2000). Conversely, bridging members overlap heterogeneous networks where they exist. Those in bridging positions gain access to resources from both networks and are, therefore, considered to be in an advantageous position (Burt 2000; Merton 1968; Onyx & Bullen 2000; Zaheer & Bell 2005). The advantage of bridging positions comes from access to information, ability to control flow of resources passing between the two networks and brokerage benefits, which can be converted to competitive advantage position (Burt 2000; Merton 1968; Onyx & Bullen 2000; Zaheer & Bell 2005). Finally, linking networks have a relationship mix and balance of relationships across all connections, as it provides a level of authority and power as they are not dependent on other nodes in the network, and are able to influence the network through the centrality of their position.

Customers are regarded as co-producers and co-creators and consequently affect the productivity of the firm (Sampson & Froehle 2006; Vargo & Lusch 2004). According to

Allam and Perry (2002) co-production is directly related to customisaton and expand the choices customer make. Co-production is seen as a chain of sequential bundles of operational activities grouped into three distinct processes; initiation and design, resource aggregation and processing attributes and the delivery and execution stage. Co-creation on the other hand is created as customers use the product or service (Vargo & Lusch 2006a; Vargo & Lusch 2004; Vargo & Lusch 2006b).

The dynamic and relational nature of the relationship between suppliers and customers is captured in the interactions between them (Chesbrough 2011; Edvardsson et al. 2010). These interactions between customers, employees and suppliers extend the role customers to that of innovator, value chain collaborators and resource integrators. Not only that Allam and Perry (2002) elaborate on the roles and activities performed by customers to also include strategic planning, idea generation to service testing and commercialisation. Scholars have also focused on leveraging the social wisdom of communal platforms (Nambisan & Baron 2009, 2010; Nambisan & Nambisan 2008) to interact with their customers, generate new ideas (Howe 2008; Surowiecki 2004) and extend their influence to their friends and broader social network Kaplan and Haenlein (2009). A trend ensues where attempts to engage their customers and their customers friends and social networks more broadly is being perused through the use of social media and social networking sites.

Social media and social network sites differ. Social media is defined by Kaplan and Haenlein (2009, p. 61) as a "*group of internet based applications that build on the ideological and technical foundations of Web2.0, and that allow the creation and exchange of user generated content*". Whereas according to Sullivan (2013) social media sites are virtual places where users gather to create, disperse and consume media where as social networking sites are built around connecting friend's family and like-minded people regardless of their physical location. Therefore the foci of social networking sites to build communities whom they wish interact.

Recommendations from family and friends remain the most trusted and influential advice informing consumer purchase decisions. However, online consumer reviews are now also a trusted information source and are widely used by consumers. Trip advisor offers over 70 million reviews and opinions on all aspects of travel and Ye, Law and Gu

(2009) found a relationship between online consumer reviews and business performance of hotels.

Crowdsourcing is the act of outsourcing a task to a crowd rather than a designating the task to an agent (an organisation, formal or informal team or individual) as is the case in outsourcing or sub-contracting (Howe 2008; Jeppesen 2010). Howe (2008) suggests that crowdsourcing works because of the absence of central authority (Huberman et al. 2008) and the collaborative and self-policing nature of the online community and that "given the right set of conditions, the crows will almost always outperform any number of employees – a fact that companies are becoming aware of and are increasingly attempting to exploit". According to Howe (2008) and supported by Ichatha (2013) crowdsourcing will dramatically change the nature of work and creativity as access to previously scarce resources become more abundant easier and cheaper to access. This will change what customers are willing to pay for, the consequences of which are not yet fully known or envisaged (Howe 2008). Not only that the motivations for solving problems by each of the agents may be driven by a need or desire other than money alone. Afuah and Tucci (2012) suggesting that ultraisms, building reputation, demonstrating skills or simply a desire to belong to a group drive participation in crowdsourcing activities.

2.4.5 Network structure

Networks are structured around nodes and the connections between them (Granovetter 1973, 1985), resulting in a variety of network configurations. Network configurations include linear networks—such as supply and value chains (Gattorna 2010; Porter 1985; Porter 2000). dyad, triads, hub and spoke, pendant, circle and constellations (Adobor 2006; Agarwal & Selen 2009; Tapscott et al. 2000; Venkatesh & Davis 1996). According to Granovetter (1973) the connections are represented by ties which may be strong, weak or absent. The configuration of the nodes and ties result in networks being either open or closed, and determine the ease with which organisations are able to enter and exit the network (Borgatti et al. 2013). Open networks are where ties are absent, leaving a space between nodes. Where this is the case the space between the nodes is referred to as a structural hole (Burt 2000, 2004). Structural holes leave an open space, in which organisations may take on a bridging role and connect the two unconnected nodes (Burt 1992, 2004, 2005; Choi & Kim 2008; Li & Choi 2009). Service triads are an example of a closed network, as agreements form the connections between nodes, which occur in a triangular fashion, leaving no open space between nodes. Triads have become more prevalent as organisations outsource specific operational functions (Choi & Kim 2008; Li & Choi 2009). These differently configured networks challenge many of the assumptions that have been formed around the operations of linear networks.

2.4.5.1 Position of a firm within the network

The position of a firm within a network is a structural property held by actors (firms) in the network, and is determined mathematically as the ratio between the number of connections the firm has to the total number of possible relationships (Adler & Golany 2001; Burt 1992; Harary 1969; Pfeffer & Salancik 1978). Firms holding a central position accrue advantage through early access to information, or an ability to filter and control the information flowing throughout the network (Borgatti et al. 2013; Burt 2004) Conversely, removal of a node from the network jeopardises the existence of the rest of the network, as its removal breaks the ties between other organisations, leaving them disconnected (Barros & Couto 2012; Burt 1987, 1992, 2005). Therefore, the firm's position within the network is indicative of the level of dependence, control and influence that can be exerted by the firm (Adler & Golany 2001; Freeman 1979; Pfeffer & Salancik 1978).

As discussed earlier, the social network literature discusses the level of embeddedness, rather than centrality, wherein network embeddedness refers to the structural nature of the relationships between two actors (Grewal et al. 2006). Empirical research into this area is relatively new. Zukin and Di Maggio (1990) claim that embeddedness is constructed through intangibles, and relates to cognitive, cultural, structural and political connections between actors. Wuchy and Uzzi (2011), on the other hand, refers to embeddedness as the quality of relational exchanges. Bogetoft et al. (2008, p. 1146) define structural embeddedness as "the structure of relationships around actors", and Gulati and Garigulo (1998) incorporate both positions within the network and the links and relationships between each of the actors, as the components forming the network structure.

2.4.5.2 Network performance

The different network structures make performance metrics and management difficult to establish and problematic to monitor. However, the Supply Chain Operations Reference (SCOR) model sets performance metrics across the whole supply chain and identifies performance metrics across different processes, enabling the identification of best practice. This provides a unified structure for supply chains that are driven by a plan, source, make, delivery and return (manufacturing) process. SCOR provides a set of guidelines for common manufacturing business problems. Additionally, performance metrics can be used to assess reliability, responsiveness, agility, costs and asset utilisation across the entire supply chain (Gattorna 2010; Lockamy & McCormack 2004; Walter 2005). Gattorna (2010) further develops outcomes from the SCOR model into a framework that defines four standard types of supply chain configurations, with each configuration suitable for different operations. These are: (1) continuous replenishment, where there is consistent demand that is managed through tight collaboration across supply chain participants; (2) lean supply chains, where tight collaboration with customers enables efficient management of predicable demand; (3) agile supply chains, enabling quick responses to unplanned and unpredictable demand; and (4) fully flexible supply chains and ability for the group of organisations to respond quickly to opportunistically manage yield. Each supply chain approach requires different business processes, organisational structures, human skills and competencies, information systems, partnering organisations and performance management and metrics to be configured differently. Conversely, service value networks currently lack any standardised vocabulary, metrics or an understanding of common business practices against which to identify, explain, understand or compare similarities and differences.

Changing organisational structures are reflective of the dynamic open systems environment in which businesses operate. The reliance on networks to extend market reach, deliver end-to-end services and share information and resources to achieve strategic goals is not yet fully understood (Walter 2005). According to *The social economy: unlocking value and productivity through social technologies* report by McKinsey Global Institute, there is the potential "to raise the productivity of the high-skill knowledge workers that are critical to performance and growth in the 21st century by 20 to 25 percent" (Hu & Cai 2004, p. 1). The study claims that these figures are achievable by "streamlining communication and collaboration, lowering barriers between functional silos, and even redrawing the boundaries of the enterprise to bring in additional knowledge and expertise in extended networked enterprises." (Hu & Cai 2004, p. 2). Latour (2005, p. 5) claims that a socio-technical view enables the social construction or reconstruction of workplaces from individual workers to groups and networks, what he refers to as "appropriate social aggregates".

The complexity[2] of operating environments being reliant on social arrangements is not the sole domain of intra-organisational structures; organisations are moving to operate in (socially) networked enterprises. Socially networked organisations have increased in the travel and tourism industry, among other industries, in the USA over the last five years. The introduction of home-based business models that support socially networked individuals working together as a conglomerate is increasing, and expected to continue doing so (Bowden 2007). This phenomenon is already being observed in the Australian travel and tourism industry, with an increase in home-based travel agents whose business is reliant on personal connections and word-of-mouth referrals (Speakman 2011). Ward (1973) claims that these types of social networks rely on cooperation and collaboration with customers to evolve and survive. The roles of stakeholders—customers, employees and suppliers—is now examined.

2.5 Stakeholders

2.5.1 The role of customers

Customers participate in the service delivery process (Sampson 2000, 2010; Vargo & Lusch 2004; Vargo et al. 2008). Gersuny and Rosengren (1973) showed that customers take on one of four roles: customers can be a resource (Smith & Ng 2012), co-worker (co-producer), buyer or beneficiary (user) or co-creator (Edvardsson et al. 2010; Gersuny & Rosengren 1973; Smith & Ng 2012; Vargo & Lusch 2004; Vargo et al. 2008). Sampson (2012) describes situations in which inputs received from the customer are substitutes for physical goods. He claims that customers also perform the role of component supplier, employee, design engineer and product manager, as well as

[2] Complexity can be conceptualised as the number of elements and their interconnectedness (Rajagopalan, Rasheed & Datta 1993)

providing quality assurance and inventory management. Further, customers are positioned as competitors in the emerging sharing economy (Buczynski 2013; Sampson & Spring 2012). However, it is unlikely that this is the case in all situations, as the level of participation varies between customers and contexts (Ng 2008). The participatory role of customers in the service delivery process raises questions about how customers participate, and the levels and breadth of participation. Despite these questions, customers are inextricably involved in the service delivery process, and consequently have an impact on the use of a firm's operation, resources and, ultimately, productivity (Ordanini & Pasini 2008).

2.5.1.1 Customer participation and variability

The level of customer participation differs for manufacturers and service firms. Manufacturers produce goods with no direct customer involvement (Boyer & Verma 2010). Firms pre-determine product specifications and subsequently establish a production process to make and deliver goods to meet or exceed customer expectations (Boyer & Verma 2010). Service firms, on the other hand, differ in that customers are heterogeneous and their involvement in the service delivery process leads to variability. Each customer has specific needs and requirements, and the quality of their input may differ. Variability is described by Cherns (Cherns 1976, p. 7) as an "unprogrammed event, which critically affects outcomes." Service delivery becomes increasing complex with the introduction of customer variability, requiring managers to make decisions on the degrees of customer-introduced variability that will be accommodated (Schmenner 2004; Schmenner & Swink 1998). Managers seek to control variability of materials and processes, in an attempt to predict whether the outputs of the production process meet required specification (Morris & Johnston 1987). However, given that service delivery and consumption occur simultaneously, reducing variability is not always possible as customers may disrupt core operations with their unpredictable behaviour (Frei 2006). The simultaneous nature of service requires employees to consider and make decisions on the appropriate strategies to minimise customer variability without sacrificing efficiency or the quality of the customer experience (Frei 2006).

Customer variability occurs because of the type of input or the service delivery approach. Morris and Johnston (Morris & Johnston 1987, p. 14) claim that variability is a result of the type of operation a firm sets up. They posit that the type of operation is established based upon whether the input type is predominantly a good, information or a person. Conversely, Lovelock and Yip (1996) take a service delivery approach, suggesting that service is the result of tangible acts on people, intangible acts on intangible things, tangible acts on physical possessions and intangible acts on peoples' minds, which ultimately results in service performance.

Customer variability and the level of customer interaction affect firm performance (Schmenner 2004). Frei (2006) and Sampson (2000) examine customer actions that cause variability, and determine how these actions arise. Frei (2006) attributes customer variability to five factors: (1) the time that customers arrive, which can be predicable or random; (2) customer requests that relate to their individual needs; (3) customers' varying capability to perform tasks necessary to receive services; (4) the level of effort customers are willing or able to expend on tasks; and (5) customers' subjective preferences about what they want or how they should be treated. Organisations attempt to control customer variability by attempting to group or categorise customers into homogenous niches, or make decisions about whether to combine and make available complementary products or services together for a single price, a process called bundling and unbundling in the marketing literature (Guiltinan 1987; Klein & Jakopin 2013; Paun 1993).

Decisions on when to bundle depend on the market and the ease in which customers are able to combine services. According to Paun (1993) and Klein and Jakopin (2013) , three types of bundling strategies exist: pure bundling, unbundling and hybrid or mixed bundling strategy. The decision on when to bundle and which bundling strategy to adopt is dependent upon how mature the market is, the ease of doing so and level of risk customers are willing to take to co-create their own service offering (Paun 1993). Klein and Jakopin (2013) provide an example of each of the bundling strategies in the telecommunications industries, where the telephone and access to call and data downloads are bundled and sold in one transaction, or are able to be purchased separately. Interactions between customers and frontline employees who make decisions on whether to offer bundled or unbundled service offerings is one strategy used by frontline staff to accommodate or reduce customer variability (Heskett et al. 1994).

Accommodating customer variability through service bundling and unbundling, however, may lead to competitive advantage. Porter (2000) claims that learning to manage customer variability enables a firm to differentiate their service offerings from other firms'. The differentiation, according to Paun (1993), Guiltinan (1987) and Klein and Jakopin (2013), is provided through the organisation's bundling strategy and the price and cost advantages that can be achieved. Conversely, Brotherton and Coyle (1990) and Morris and Johnston (1987) claim that reducing variability in service offerings is difficult to achieve, and may not be a preferred strategy. Recent studies by Kannan and Proence (2010) demonstrate that firms that relentlessly pursue strategies that reduce customer variability leave themselves blind to the sort of differentiation that can be converted into competitive advantage and revenue generating opportunities, and hence improve productivity through value creation.

Degrees of interaction between customers and employees are distinguished according to context, and whether a customer is co-producing or co-creating value (Ng 2008). Service-dominant logic makes this distinction primarily on how value for the firm is realised. Under service-dominant logic, co-production is achieved when customer involvement realises a company's value proposition (Ng et al. 2008; Smith & Ng 2012). This is in contrast to value co-creation, is achieved through how the customer uses a product or service. Norman and Ramirez (Norman & Ramirez 1997, p. 8) comment that:

> a better way to define where value lies is to recognise that it arises in the way customers use the product or service on offer. Value is determined by the value creating potential provided for the customer in their business or their home. This means that value is not determined by what the supplier achieves in its own business but by what it helps the customer to achieve.

Customers move beyond co-production to co-creation when organisations are able to gain insights beyond those available from traditional market research approaches, such as focus groups and interviews (Edvardsson et al. 2010; Kannan & Proence 2010) . Gronroos (Gronroos 2011a, 2011b) states that encouraging variability is a way of engaging customers in the transactions of business, thereby establishing and creating long-term customers through the provision and extension of service offerings beyond the point of consumption (Simar & Wilson 2000). In doing so, the firm becomes more customer-centric, and new customer interfaces and interactions are made available (Berger et al. 2005; Gronroos 2011a). Agarwal and Selen (2011) refer to this as ESO, where customers input and their knowledge is considered fundamental to value creation.

The assumption that customers input is always positive is disputed in the literature with cases showing some customers deliberately violate widely held norms in service exchange (Best & Luckenbill 1994). Customers have been referred to as problem customers (Bitner et al. 1994) or aberrant customers (Fullerton & Punj 2004), deviant customers (Moschis & Cox 1989), misbehaving customers (Toglet 2001), dysfunctional customers (Fisk et al. 2010; Harris & Reynolds 2004) and unfair customers (Berry & Seiders 2008) and jay customers (Lovelock 2001). According to Lovelock (2001, p. 73) jay customers are those that “act in a thoughtless and abusive way causing problems for the firm, its employees and other customers”. Lovelock (2001) classifies jay customers as thieves, rule breakers, the belligerent, vandals, family feuder and deadbeats, Berry & Seiders (2008) propose a model illustrating the severity and frequency of harm, Yagil (2008) identifies three type of customer misbehaviour and Zemeke and Anderson (1990) propose a “customer from hell” typology. However, all scholars agree that this dysfunctional behaviour negatively affects the service experience for other customer and employees (Dallimore 2007).

The negative effects of dysfunctional customers on employees is reported to be the cause of e stress (Dallimore 2007), burnout (Ben-Zur & Yagil 2005), absenteeism (Gradey, Dicter & Sun 2004) and high turnover (Yagil 2008). The frequency of the abuse is also a determinant of an employee’s job (dis-) satisfaction. Grandly 2004 reports some US service workers fall victim to dysfunctional customer behavior at least 10 times per day, whilst front line retail staff in the UK were subjected to verbal abuse every 3.75 days and acts of violence every 15 days to 31days (Voss et al 2004). In contrast Fisk et al (2010) suggests dysfunctional customer behavior is not all bad and suggests the number of service jobs increases as jobs are created to control and monitor dysfunctional customers. They also provide examples where the implementation of electronic security systems also supports employment and potentially creates new industries and expertise. However the view that dysfunctional behviour has detrimental effects on the service experience of other customers and employees is more widely represented in the academic literature (Fisk et al 2010; Grandly 2004).

In summary, customers will continue to play an increasingly important and active role in the service delivery process. The degree and methods of customer interaction implemented by a firm affect the organisational structure, the work performed by employees and ultimately organisational performance. Managers make decisions on whether to reduce or accommodate customer variability, based on the volume and types of customer input. Reducing customer variability may result in higher levels of productivity, while accommodating customer variability may result in increased value and competitive advantage. This leaves organisations with the dilemma of how to deal with the polarity of reducing customer variability (inputs) and accommodating customer variability (maximising outputs), both of which directly affect a firm's productivity.

2.5.2 The role of employees

The importance of employees and the work they perform is of interest to economists and managers, as labour is a key and costly factor of production (Boyer & Verma 2010; Coelli et al. 2005). Studies of how work is performed have been examined from a number of perspectives. In particular, human resource and operations management literature provides insight into individuals' work (Hackman & Lawler 1971; Hackman & Oldham 1976), work teams (Cherns 1976; Katzenbach & Smith 2003), collaborative networks (Agarwal & Selen 2011; Agarwal et al. 2014) and management (Green & Agarwal 2009). The evolving definitions of service have also recognised, and place a considerable emphasis on, the role of people and competencies used to create value in the service delivery process (Agarwal & Selen 2009; Agarwal & Selen 2011; Maglio & Spohrer 2008; Spohrer & Maglio 2006a; Spohrer et al. 2007; Spohrer et al. 2004; Vargo et al. 2008) and the dynamic nature of the relationships between individual employees, work teams and collaborative networks. The contributions of employees to the productivity of service and value-based firms are paramount to this research, and discussed below.

Taylor's (1911) study of the principles of scientific management was critical in highlighting the differences of how and by whom work is performed. This study made an important distinction between the roles of managers and workers. Managers were considered intellectually superior, and therefore able to take responsibility for decision making and controlling their own work as well as the work of others (Stam 2007; Taylor 1911; Trist 1981). Workers were seen to perform routine tasks, working in unison with machines (Stam 2007). Taylor linked cooperation between workers and managers as a key enabler of productivity and prosperity, claiming that "maximum prosperity can exist only as the result of maximum productivity" (1911, p. 2), and that this could be achieved "through the close, intimate, personal co-operation between management and the men (workers)" (1911, p. 10). The role of management was to apply work approaches, which have clearly defined laws, rules and principles. Hence, production methods that supported standardisation, specialisation, synchronisation and maximisation were established, widely supported and promoted (Toffler 1981). However, Taylor still regarded workers as a critical factor of production:

> in the past the man has been first; in the future the system must be first. This in no sense, however, implies that great men are not needed (1911, p. 1).

Apart from managers determining the best way to perform a task, Taylor emphasised the need for careful employee selection and training. He said that the responsibility of management also extended to the removal of poorly performing workers, and ensuring appropriate rewards and remuneration were given to high performing workers. This point has special significance in light of the current productivity debate in Australia, and the results from the "*Management matters—just how productive are we?*" report, which showed Australian management to be weak in the areas of people management, especially relating to addressing poor performers and retaining high performers (Green & Agarwal 2009). The focus on the way work is performed, rather than the human aspects of workers, is evident in the management of many Australian firms (Agarwal & Green 2011).

Studies focusing on human behaviour began in the mid-1900s (Campion & Thayer 1987). Mayo's findings from the Hawthorne Studies showed the effects of groups on an individual's work, and that social aspects of work were often more important than monetary incentives. Trist, Bamforth and Emery (1951) undertook studies in response to declining productivity, despite the introduction of new machinery in long coalmines. These studies identified new ways of working with workers self-organising into small autonomous work groups. The term "socio-technical systems" was introduced to represent the need for social (human) and technical aspects of work to be jointly optimised. Despite these significant findings on the importance of work teams and social aspects of work, studies continued with the individual as the unit of analysis and the focus of studies.

2.5.2.1 Job Design

In this context, Hackman and Oldham (1976) make a significant contribution with their Job Design Theory and Job Characteristic model, in that they define the role of employee beyond physical efforts. They identify three key variables: (1) the psychological state of employees has an effect on their internal motivation; (2) the characteristics of the job affect the psychological state of the individual; and (3) employee attributes affect how a person will respond to complex and challenging tasks. Their studies demonstrate that motivation has a positive impact on productivity, with skill variety (ability to use different skills and talents), task identity (identifiable piece of work), task significance (impact of work performed on others), autonomy (degree of freedom) and feedback (effectiveness of performance) being key contributors to an individual's potential motivation and, therefore, performance. However, studies of individual workers within the work group or organisational context show that high levels of employee engagement deliver greater benefits than motivation (Marciaro 2010).

Motivation is driven largely by external factors, and is seen as opportunistic, delivering short-term and variable results. Conversely, employee engagement is considered to be employees' possession of a positive attitude and commitment to the long-term success of the organisation and achievement of its goals (Marciaro 2010). According to Robinson, Perryman and Hayday (2004), employee engagement is a measure of the employee's effort at work. Engaged employees are more able to remain focused on the big picture and have a positive attitude. This in turn increases their productivity and capacity to work with others to deliver superior customer service and produce a positive work environment (Gibbons 2007; Lockwood 2007; Schaufeli et al. 2002). However, a contradictory view is that of Marciaro (2010) and Wagner and Hartner (2006), who see employee engagement as an outcome of good leadership and a demonstration of management's ability to understand and deliver the basic needs of employees, provide support, and teamwork and growth opportunities. This enables a positive work environment for employees, especially frontline employees, enabling them to be fully and emotionally engaged in servicing customers. Employee engagement is the link between management leadership, employee satisfaction, customer satisfaction and loyalty and business growth and profitability. This link is described by Heskett et al. (1994) as the service profit chain.

The importance of frontline employees to firm performance is significant in determining the firm's human resource and customer service strategy. Engaged and empowered employees act on a firm's decision on whether and how to reduce or accommodate customer variability (Frei 2006; Skaggs & Galli-Debicella 2012; Trist 1981). Managers must choose one of four adoption strategies:

1. classic adoption, embracing customer variability;
2. low-cost accommodation, which seeks to provide options to accommodate customer variability but requires some accommodation and changes from the customer (trade-offs);
3. classic reduction, which includes requirements for customers to make bookings or appointments, the use of yield management to smooth demand and the provision of limited service offerings; and
4. uncompromised reduction, based on the relentless pursuit of standardising service offerings (Frei 2006).

Once an adoption strategy is chosen, implementation decisions are made. According to Heskett et al (1994, p. 1):

> successful managers pay attention to the factors that drive profitability, in this new service paradigm: investment in people and technology that supports front line workers, revamped recruitment and training and compensation linked to performance for every employee at every level.

The importance of socio-technical systems (that is, the way people and technology are utilised) is highlighted in Heskett's quotation and in the literature (Gattorna 2010; Kalakota & Robinson 1998; Usipaavalniemi 2009). However, optimising performance across human and technical systems is a challenge for managers (Heskett et al. 1994; Heskett 1986). Maintaining human interactions while leveraging advanced technologies requires reengineering of front office processes (Rayport & Jaworski 2004; Walters 2000) and provides an opportunity to reconceptualise and redesign service offerings. Tax and Stuart (Tax & Stuart 1997) claim that reconceptualising services from a systems perspective is required, rather than simply automating services as they currently exist. Scholars such as Donnelly, Berry and Thompson (1985) and Lovelock and Yip (1996) proposed new service classifications, which include new services, modifications to existing services, services that enable market expansion or market extension and services that support diversification. These classifications are consistent with Carmen and Langeard's (1980) strategic perspective of new services being multi-site, multi-segment or multi-service, with technology identified as the enabler in connecting sites, segments and service components.

2.5.2.2 Impact of technology on work

Changes in service design and the implementation of new technology require new skills and knowledge to operate new systems and adapt to new ways of working (Tax & Stuart 1997). However, changes in the skills required may apply not only to the need for new skills. There may also be a need for existing skills to be available in different proportions from the numbers available in existing production systems (Kelly & Lewis 2003). Despite the number of workers, in today's work environment workers are expected to be "literate, numerate, have analytical capabilities, well-honed interpersonal skills and emotional intelligence" (Rayport & Jaworski 2004, p. 3). Additionally, a set of higher order skills are identified by Agarwal and Selen (2009) as essential to strategic goal setting and when managing interactions with customers. These higher order skills include entrepreneurial alertness, strategic foresight and systemic insight. These findings fit with the definition of services, as the "application of competencies, skills, knowledge and experience" (2011) and demonstrate a move away from physical work towards a knowledge economy. The importance of competencies is reflected in the US Dictionary of Occupational Title (USDOT), which now provides a table listing the competencies, skills and knowledge required to perform tasks, as well as a scale of the complexity of skill categories.

The complexity of skills grouping is consistent with Morris and Johnston's (1987) view that organisational operations are set up according to whether the input is information, person or a good. The USDOT categories are also based upon data, people and things. Further, cross-industry analysis enables skills to be grouped more generically into motor, interactive and cognitive skills (Kelly & Lewis 2003; Wolff 1995). The analysis of USDOT and skills grouping shows that people working with data require higher cognitive skills, while people working in roles relating to others require interactive skills, and those working with things or physical goods require motor skills (Kelly & Lewis 2003). The shift in skills is only one aspect of skills requirement. Traditionally experts (specialists) were trained in a narrow, discrete knowledge domain, such as business and management, computer science and information systems or economics and social sciences. Multi-disciplinary training has resulted in people with generalist skills. However, an emerging skills profile and one that service organisations are showing a preference for is specialisation in a specific domain accompanied with broad general knowledge across disciplines (Macaulay et al. 2010; Spohrer et al. 2004). Considering all service sectors include IT processing within their domain, IT skills are a key focus for service sector employees, and will determine the likelihood of adoption, ramp up and ultimately productivity gains through technical efficiency (Tamkin 2005).

Combinations of technology and human interactions between employees, customers and suppliers change the organisation of work. Emery (1959, p. 1) suggests that "top-down bureaucracy is beginning to give way to an emergent non-linear paradigm, which is based on discovering the best match between the social and technical systems of an organisation", while Tapscott and Caston (1993, p. 10) caution that the "traditional organisation is in deep trouble." Trist (1981) was one of the first scholars to recognise the change in working patterns, acknowledging an increase in the use of small autonomous work groups. This phenomenon resulted in workers being eager to adopt new concepts and try new ways of working (Trist 1981). For these small work groups to be effective, communication, collaboration and exchange of information within and between groups and organisations (within the network) is required. Zhao et al. (2008) identify nine service relationships requiring management: organisation to people; organisation to software; organisation to organisation; people to organisation; people to software; people to people; software to organisation; software to people, and software to software. However, Gentile, Spiller and Noci (2007), Hyer, Wemmerlov and Morris (2009) and Webster (2004) all claim that cooperation between people is more difficult to achieve than coordination of tangible things. This leaves management with the challenge of shifting from a focus on coordination to how to foster and maintain cooperation among individuals and groups (teamwork) within the organisation and across the social systems (that is, the network).

In summary, employees contribute more than time and physical labour to the service delivery process. However, current productivity measures fail to incorporate the intangible contributions of employees, such as competencies, knowledge, skills and experience(Agarwal & Selen 2009), levels of enagement with customers or employees or other non-tangible aspects that may improve productivity or the quality of work (2012). The importance of technology as an enabler of business and social change is discussed next.

2.6 Enabling technology

The adoption and implementation of ICT enables organisations to connect with customers and suppliers (Kalakota & Robinson 1998). This creates networks as organisations begin to connect with each other, with ICT facilitating the flow of information between customers, organisations and suppliers. Given that information is a key input to services, the data formats and level of integration vary considerably in quality, ultimately affecting a firm's productivity (Swatman & Swatman 1991; Usipaavalniemi 2009).

Interactions and information exchanges within and between internal and external environments occur in continuous, dynamic ways (Boulding 1956a; Swatman & Swatman 1991; von Bertalanffy 1968). Therefore, technology serves as an enabler, connecting intra and inter-firm functions and processes (Bowersox 1990; Hayes & Wheelright 1979; Kalakota & Robinson 1998). Technology adoption has been driven, primarily, by rational efficiency, promising access to new markets, cost reductions, resource sharing, business process re-engineering and other performance benefits (Tsikriktsis et al. 2004). However, over time, a firm's connections with its customers and suppliers has moved from primarily transactional—such as providing access to product and pricing information—to relational—whereby the use of information "informate", that is information generated as a result of technology use or automating business processes (Zuboff 1985), allows organisations to understand, predict and anticipate the behaviour of customers and suppliers (Kalakota & Robinson 1998). Strategic imperatives, such as joint planning activities and product and market development became more prevalent, increasing the need for intra and inter-firm collaboration. This leads to increased productivity, and in turn higher levels of innovation (Agarwal & Selen 2009; Gattorna 2010; Schniider & Bowen 1995).

Business processes are a set of pre-defined activities, largely data or information dependent, to be organised sequentially, with a focus on delivering specific outcomes (Osterman 2000). Integration of business processes across organisations is the primary driver of ICT adoption, because it increases productivity by eliminating non-value add activities, such as the re-keying of data (Hayes & Wheelright 1979; Kalakota & Robinson 1998). Improvements in ICT have enabled business processes to be integrated from the point of sale to service providers across multiple organisations (Dick & Basu 1994; Shun 2004; Yang & Peterson 2004). Resources such as people, material, energy, equipment and procedures are organised and combined in a logical flow irrespective of the organisation in which they reside. Examples of successful end-to-end business process integrations, many of which were implemented at the expense of suppliers, include Walmart, Nokia, Zara, Dell, Toyota and Proctor and Gamble (Randall & Farris II 2009). Further, ICT enables services, largely information dependent, to be connected with transactions occurring across organisations, electronically and in real-time (Kalakota & Robinson 1998). This is important, as organisational boundaries blur, enabling service value networks to form as business processes are connected.

Firms often couple information sharing with business process improvement (Lee & Whang 2000; Usipaavalniemi 2009). Kaipia and Hartiala (Kaipia & Hartiala 2006) argue that the connection between information processes and business process improvement is rarely made or considered, while McAdam and McCormack (McAdam & McCormack 2001) claim that it is rarely exploited. Regardless, all business-process based management techniques advocate identifying, documenting and process mapping information flows for all core business processes, with a view to determining potential improvements (McAdam & McCormack 2001). The delivery of improvements is claimed by changing the order of the organisation in which activities is performed, enabling straight-through processing, resulting in a more efficient business operation.

Bachi and Skjoett-Larsen (Bachi & Skjoett-Larsen 2003) identify organisations that have achieved high levels of inter-firm integration by taking a process-oriented view of their operations. Business process mapping and other visualisation tools and models enable processes; value added activities and data integration requirements across different domains, and the illustration of distributed systems, irrespective of boundaries or borders, leading to greater understanding (McHugh et al. 1995; Usipaavalniemi 2009). These types of tools also aid technology adoption and collaboration (Ng et al. 2009; Sampson & Spring 2012).

Collaboration is a capability that firms can and should develop. Agarwal and Selen (2009, p. 238) claim that it is a dynamic skill developed when collaborating with partners, linked to innovation. They state that collaborative innovation is:

> a dynamic skill that is developed when collaborating with partners and consists of an ability that evolves within individuals or groups; it is an ability to come up with innovative ideas, which gives partnering organizations the capacity to introduce new services, new or modified processes, new or modified operating structures, new ways to market products or services, or ideas through the integration of capabilities and resources in an urge to incite innovation.

This highlights the need to extend the boundaries of the firm to include capabilities and resources from partnering organisations, which enable productivity gains through enhanced value creation that can be made possible only through collaboration between partnering organisations. Consequently, inter-firm collaboration is becoming increasingly important to the successful implementation of ICT projects, enabling innovation and in turn affecting productivity.

Changes to work practices, organisational structures, business models and new skills are driven by technical innovation (Lee et al. 2003; Tamkin 2005). The Internet and other technologies—such as mobile wireless and cloud computing—are enabling services to be embedded in physical goods, thereby creating intelligent systems (Osterman 2000). Kleinrock (2003, p. 4), a computer network engineer, stated:

> as of now, computer networks are still in their infancy. But as they grow up and become more sophisticated we will probably see the spread of computer

> utilities, which, like present electric and telephone utilities will service individual homes and offices across the country.

Intelligent systems are now becoming a reality and enabled, as hardware maintenance and software are run as a service rather than considered a product. ICT was once purchased, run and managed internally. Improvements in ICT connectivity, computer processing capability and distributed application development enable users to access computing processing capabilities and applications from anywhere, anytime, according to their requirements (Armbrust et al. 2009; Randhawa & Scerri in press; Scerri 2014). The development of cloud computing, embedded technologies and the investment in smart infrastructure enables organisations to change their business models, detect, predict and correct failures in the operations of physical goods, remotely monitor and provide technology dependent services (Dolman & Gruen 2012).

As the cost of computer microprocessors decreases and their operation speed increases (Moore's Law), smart technologies are becoming a reality (Manzoni 2007). Unobtrusive radio frequency identification (RFID) tags are being embedded in physical goods enabling remote activation with information transmission possible (Boyer & Verma 2010; Gattorna 2010; Kalakota & Robinson 1998; Norman & Ramirez 1993b). Current uses of RFID include automatic, real-time, individual tracking to manage inventory at the item level more effectively. New ICT service models are making computer applications more accessible, affordable, scalable and mobile (Berger et al. 2005; Scerri 2013; Scerri & Agarwal 2011) a trend expected to continue. It is predicted that the number of consumer goods embedded with such technologies will increase, raising concerns of privacy and data ownership (Norman & Ramirez 1993b).

New ICT service and deployment models are being introduced into the marketplace and changing the way firms organise and manage their ICT (Dikaiakos et al. 2009). Service models include Software as Service, Platform as a Service and Infrastructure as a Service (Zhang et al. 2010). Each service model provides organisations with the ability to maintain or relinquish control of application development, configuration and/or management, hosting environments, security and access controls, operating systems, storage and networking components (Mell & Grance 2011). Deployment models are determined by who has access, ownership and management rights, as well as the location of cloud infrastructure (Mell & Grance 2011). The ability to select how service offerings are assembled, reassembled and deployed is what Agarwal and Selen (2009) call plug and play business models.

The use of technology to share information, integrate and re-engineer business processes and systems has improved productivity. Firm boundaries blur as value is co-created through coordinated efforts between customers, employees and suppliers. The rise of the Internet, self-service and mobile technologies enable organisations to open their systems to customers. Multiple organisations align and connect the delivery of a core competence with the ultimate aim of delivering efficient and valuable end-to-end processes, *the service*. Thus, changing the flow and network structures of organisations from predominantly supply driven to demand driven, recognising the input and increasingly important role of customers in the service delivery processes.

2.7 Productivity paradox

Questions surrounding the value of ICT and ICT investment can be found in the literature. Authors such as Brynjolfsson (1993), Hitt and Brynjolfsson (1996), Lucas (1993) report positive relationships between ICT and productivity, whilst Strassman (1990), Dos Santos (1993) and Byrd and Marshall (1997) provide evidence that such relations do not exist. The ambiguity and inconsistencies linking ICT investment to productivity was referred to as the productivity paradox by Brynjolfsson (1993) with he claims it is caused by measurement errors, lags, redistribution and dissipation of profits and mismanagement are key causes to the paradox (Brynjolfsson 1993, p. 76) is discussed next.

Traditional measures of the relationship between inputs and outputs fail to account for non-traditional sources of value (Brynjolfsson 1993). Given that the transformation of inputs into outputs is a function of the work system it is recognised that attempts to optimize productivity for neither a technical or social system alone will result in the sub-optimization of the socio-technical whole (Trist 1981). Strausmann (1990) found that the correlation between IT investment and changes in productivity are sub-optimal when compared to profitability or stock returns. Gordon & Bailey (1988) and Noyelle

(1990) agreed and suggested that consequences for the service sector were even more significant given the reliance on the use of ICT. Denison (1989) also put forward a case that demonstrates that output statistics can be unreliable. Managers described that the benefits of IT increase in quality, variety, customer service, speed and responsiveness (Brynjolfsson 1993), measures which are not accounted for in productivity statistics or in accounting numbers (Brynjolfsson 1993). There was also a general consensus among the literature that the effects of technical and IT investments are not immediate and therefore the time lag between investment and realisation of productivity gains needed to be better understood.

Time lags are used to predict when investments are likely to yield results. Time in relation to technology take-up (number of people using) and technology ramp up (levels of usage) is a key variable in the determination of return on investment and realisation of productivity gains. Levels of technology take up and technology ramp up are indicators of technology diffusion, the time it takes for a technology to be accepted by individuals, organisations and society in general. Rogers (1962) theory of technology diffusion groups and categorises people into one of 5 phases of adoption. These five phases are: innovators, early adopters, early majority, late majority and laggards. These phases support the notion that benefits of technology are realised over time and increase with the number of users adopting the technology (Rogers 1962).Rogers work categorised users in aggregate while Mick &Fournier's (1998) unit of analysis was the individual.

Personal characteristics such as cognitive ability, behavioural and emotional characteristics affect the speed at which an individual is able to adopt and embrace technology. Zeithaml, Berry & Parasuraman's (1985) work also examined individuals with specific reference to their motivations and inhibitors of selecting a particular technology. These motivation and inhibitor constructs were further developed into a Technology Readiness Index (TRI) and applied in a business context with employees (Walczuch et al. 2007; Zeithaml et al. 1996) and customer's alike (Chen & Zhu 2004; Reinders et al. 2008). It is worth noting similar results and findings applied for both employees and customers. Trist (1981) and Potts (2009) claim that aggregation of the individual findings rather than segmenting individual actions as was the case with Rogers, reflect part of the social system. Trist (1981) claims *the technological choices* *made by a society are critical expressions of its world view. As new technologies develop, new societal possibilities may or may not be taken up"*(Trist 1981). This quote gives causality to the fact that some technologies may never be accepted by society and therefore productivity gains may never be realised.

The societal and shared nature of technology means the benefits are distributed among many actors (Hamel 2001). Importantly the benefits of technology may be dissipated among many actors and may not necessarily be reflected in the results of the organisation making the investment (Barratt &Konsynski 1982). An example of this is where benefits of technology are delivered to the customer or buying organisation through reduced search costs. The result of which is increased competition and renewed drive for product and business model innovation. IT enables business model innovation and changes to organisational structures work becomes less limited on the temporal and special constraints of a purely physical work environment (Hannula & Lonnqvist 2011). Hence IT enables organisations to create virtual trading environments and in doing so hasten the process of disintermediation and re-intermediation of functions of the firm. Firms use virtual environments access cheaper labour or resources that are not accessible within the firm boundaries through the outsourcing of non-core functions (Barratt & Konsynksi 1982; Hannula & Lonnqvist 2011; Chen & Shing 2010). The new operating model creates a more complex operating environment.

2.8 Productivity shortcomings for service and network-based firms

In this section I have reviewed the literature on productivity, service, networks, customers, employees and enabling technology. I have identified a number of shortcomings in productivity, and how it is applied in a contemporary business environment in which the predominant industries in the Australian economy are service industries, and in which the productive unit has moved from a single firm to groups of organisations, configured in differently configured networks.

The first limitation is the inconsistency in definition, meaning and application of the term "technology" in economics and business. The economic definition of technology is a surrogate term for "know-how" (Boulding 1981) or any unexplained factor of production resulting in increased productivity (Coelli et al. 2005). This differs from the business definition of technology, viewed specifically as ICT (Kalakota & Robinson 1998; Swatman & Swatman 1991). While economists refer to technology or technical change, in the broader context, business applies the specific meaning of ICT, which may not necessarily be the case. Technical efficiency in an economic context refers to changes in management, information technology, business models and innovation or any other unexplained factor.

The second limitation is the time lag between the conception of productivity and newer and more contemporary ways of conducting business. Productivity and productivity measures were established during industrialisation, where manufacturing and goods production were economic mainstays and easily to quantifiable. However, it has been shown that the evolution of production has changed the way that value is created, with an increasing reliance on intangible factors, not currently incorporated in any productivity measures.

The third limitation is with the KLEMS framework. The productivity measures that do exist, and that are incorporated into the KLEMS framework, are applied at an industry and economy level (O'Mahony & Timmer 2009a; Timmer et al. 2007). The measures and reported outcomes are of little relevance to business and do not educate them about productivity improvements at a firm level.

The fourth limitation relates specifically to labour productivity and its current measure. Time alone no longer captures the contributions made by employees. The literature identifies skills, knowledge and experience, as well as levels of engagement, as key contributing factors to employee productivity, thereby acknowledging the individuality and heterogeneity of employees.

The fifth limitation is that customer input is excluded from productivity measures. It is now widely accepted that customer (end consumer) input into the service process is a necessary factor of production, one that affects a firm’s productivity (Sampson & Spring 2012; Sampson & Froehle 2006; Vargo & Lusch 2004). However, customer input, or its effects, are currently not measured nor included in any productivity measure.

The sixth limitation also relates to the customer and their willingness to participate in the service delivery process and contribute to the value creation process (Botsman & Rogers 2010). Current productivity measures do not include productivity gains because of peer-to-peer and collaborative consumption, whereby customers trade or share the use of goods and services with each other (Buczynski 2013).

The seventh limitation is in the application of the firm as a unit of analysis. Firms are viewed as the main unit of production (Fitzsimmons & Fitzsimmons 2004). In the past, managers made decisions on how production would occur, and these decisions were built into the production processes through the use of machinery and other fixed assets (Stam 2007). However, with service delivery, decisions are made by each of the stakeholders with simultaneous exchanges and interactions during the service delivery process (Sampson 2012; Sampson & Spring 2012). Stakeholders come together and are organised in different configurations to deliver end-to-end services. Consequently, it is difficult to segregate and assign the value of inputs and outputs to a single firm in a network. This challenges the existing notion of the firm being the unit of analysis for service and network-based firms.

The eighth limitation relates to the way information technology contributes to service productivity. While it has been identified that technology adoption increases productivity in the long run, specific components such as data, access and mechanisms supporting data exchange between systems (integration) are not yet specified as productivity measures despite being key factors of productivity (Kalakota & Robinson 1998; Swatman & Swatman 1991; Usipaavalniemi 2009).

The ninth limitation relates to production networks being viewed predominantly as linear supply chains (Gattorna 2010; Walters 2000). However, other non-linear network configurations exist, and have not been adequately explored in respect to measuring productivity. As a result, suppliers and customers who form an important part of the network structure are not yet incorporated.

Finally, the tenth limitation is the conflicting view of the importance of geography to productivity. Krugman (1991) places the importance of geography on the physical endowments of a place, while Porter (1985; 2000) claims that it is the concentration of people and organisations that allow the benefits of agglomeration and clustering to emerge. Conversely, Friedman views geography as irrelevant to productivity as information communication technologies enables organisations to operate in a space rather than a place (Freidman 2005). However, geography affects productivity, as evidenced through access to new markets, transportation costs and outsourcing of production to overseas countries (Redding & Sturm 2008; Redding & Venables 2004). It is important to understand the net impact of these decisions on productivity at the firm, network, industry and economy levels. Next, service productivity models are examined to understand the current gaps and limitations that have prevented the operationalisation of these models.

2.9 Existing service productivity model

In this section, existing service productivity models are discussed. According to Simon (1957, 1969), models offer an opportunity for groups of people to think collectively about complex problems. Different people are able to work individually or collectively on parts of the problem, and combine their knowledge with others in a logical and consistent way. The common input-process-output model of productivity is presented before introducing three models that attempt to explain service productivity at an enterprise level. The three models included are Schmenner's (1986, 2004) Service Process Matrix (SPM), and the application of the Theory of Swift Even Flow, to describe how productivity in service firms is achieved; Agarwal and Selen's Service Cubicle (2005), which theoretically shows that causality of productivity increases with the degree of technovation adopted; and Gronroos and Ojasalo's (2004) SPM, which incorporates a dynamic element of productivity. This section concludes with the identification of gaps in each model.

2.9.1 Input-process-output model

Productivity and a firm's operations are shown in Figure 1 as being directional and linear. Raw materials enter a firm as inputs, passing through the firm's operations while undergoing a transformation process, and exit as an output with value embedded in the physical good.

Figure 2-3 Linear depiction of productivity and firm production

Other process models have been developed, which attempt to explain the variability of productivity between different organisations' operations. Specifically, Hayes and Wheelwright's (1979) Product Process Matrix suggests that production processes evolve from a job shop towards batch processes and assembly lines, and the processes become more efficient, capital intensive, less flexible and fixed into a continuous line operation (De Myer & Vereecke 1996).

2.9.2 Schmenner's (1986; 2004) Service Process Matrix

Schmenner (1986) developed the SPM by overlaying Hayes and Wheelright's (1979) Product Process Matrix onto service operations. The SPM is illustrated in Figure 2-4 and includes four quadrants, representing possible operational models for service firms. These are Service Factory (SF), Mass Service (MS), Service Shop (SS) or Professional Services (PS). The organisation's operations are represented specifically as one plot point positioned in one of the four quadrants. The horizontal axis (X-axis) of the matrix represents an internal (organisational) view of the degree of customer interaction and customisation. The vertical axis (Y-axis) represents the degree of labour intensity, being the ratio of the cost of labour to plant and equipment. The measures, or degrees, on each axis are shown simply as high and low.

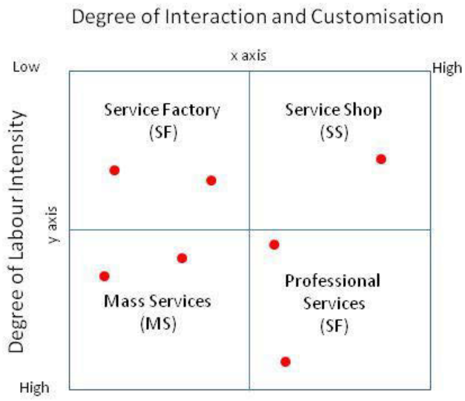


Figure 2-4 SPM (Schmenner 1986, p. 25)

Schmenner's (2004) SPM includes the application of the Theory of Swift Even Flow and a productivity diagonal. The Theory of Swift Even Flow states that "productivity increases as the speed of materials (or information) increases and variability decreases" (Schmenner 2004, p. 1). The productivity diagonal illustrates the movement of productivity as production moves from the bottom right corner of the matrix to the top left corner, resulting in the name change of the two axes, as shown in Figure 2-5.

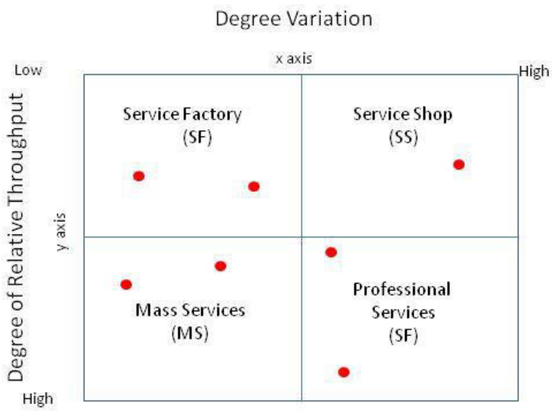


Figure 2-5 SPM (Schmenner 2004 p. 339)

There are limitations with each of Schmenner's (1986, 2004) SPM models. First, the measures of low and high are subjective and do not provide sufficient clarity to plot the organisation's operations accurately on the matrix. While the dots illustrated in Figures 2-4 and 2-5 represent an organisation's operation, they also highlight the second limitation. Service organisations typically have multiple operating models rather than one fixed model. This limits the ability to operationalise the SPM.

2.9.3 Agarwal and Selen's (2005) Service Cubicle

Agarwal and Selen's (2005) Service Cubicle framework extends Schmenner's (2004) SPM by incorporating technology as an enabler and causal factor of productivity, forming the Service Cubicle. The Service Cubicle includes a 'z' axis, which operationalises technology through the degree of technovation. This modification is significant as the use of technology enables an organisation to communicate with external partners at a local and global level. The inclusion of the third axis fundamentally changes the structure of the framework, from a two-dimensional matrix to a multi-dimensional cube, as illustrated in Figure 2-6. Examples provided by Agarwal and Selen (2005) make the distinction between front and back office operations, thereby positioning the organisation in a service value network. This provides the potential to develop the model further.

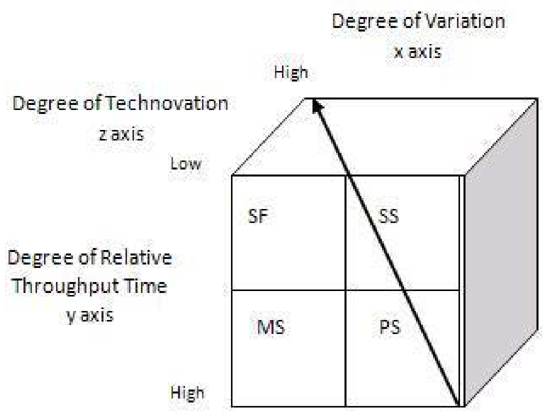


Figure 2-6 Service Cubicle (Agarwal & Selen 2005)

However, despite this value addition, the Service Cubicle inherits the same limitations of Schmenner's (2004) SPM, and therefore has not been operationalised.

2.9.4 Gronroos and Ojasalo's (2004) SPM

The open systems nature of service productivity is acknowledged in Gronroos and Ojasalo's (2004) Service Productivity Model. They argue that productivity is influenced by demand, recognising and incorporating customers and customer input as a factor influencing service productivity. Low levels of demand result in the underutilisation of the resources of a service provider, which negatively affects service productivity. This leads to the introduction of the concepts of "internal efficiency" and "capacity efficiency" (Gronroos & Ojasalo 2004, p. 417). Internal efficiency relates to how efficiently service provider resources—such as personnel, technology, systems, information and time—are configured. Capacity efficiency relates to how internal resources are managed in response to variations in demand. Additionally, recognition of how customer interactions with service providers affect service provider productivity introduces the concept of "external efficiency" (Gronroos & Ojasalo 2004, p. 417). Customer inputs and interactions—such as the quality of information received during the use of self-service facilities and complaints—are examples of customer inputs that directly affect service provider productivity. Consequently, service productivity is expressed in Equation 5:

Service productivity = *f (internal efficiency, external efficiency, capacity efficiency)* **Equation 5**

The service productivity model presented by Gronroos and Ojasalo (2004) incorporates a systems model with customer input and participation as factors influencing productivity. However, it fails to incorporate the bi-directional, dynamic nature of the interactions between the customer and service provider, nor does it recognise the customer-supplier duality. This is evident in the illustration of the model retaining a linear input-process-output form. Another limitation in the model is the representation of the service provider. The model shows inputs into the service delivery process generated by a single entity. However, services are often the result of the connections and integration of multiple service organisations.

A comparison of the models highlights a number of critical factors, summarised in Table 2-2. Agarwal and Selen (2005) and Gronroos and Ojasalo (2004) allude to or include the entities external to traditional firm boundaries as key aspects of input and/or output points for service firms, and place the organisation with a system environment. Gronroos and Ojasalo (2004) conceptualise service productivity as a factor of internal, external and capacity efficiency. While this model incorporates the customer, firm and supplier inputs and outputs, it remains a conceptual model with no measures specifically defined or tested. The consideration of inputs from the customer are included in

Gronroos and Ojasalo (2004), Schmenner (2004) and Agarwal and Selen's (2005) Service Cubicle, and the importance of suppliers' input into service production is evident in Gronroos and Ojasalo's (2004) SPM, and Agarwal and Selen's (2005) Service Cubicle. Technology as an enabler is absent from Schmenner's (2004) models, yet included in Gronroos and Ojasalo (2004) and Agarwal and Selen (2005).

Table 2-3 Existing service productivity model comparison

Characteristic	SPM Schmenner (2004)	Service Cubicle Agarwal & Selen (2005)	Service Productivity Gronroos & Ojasalo (2004)
Objective measures (operationalised)	X	X	X
Multiple operating environments	X	✓	X
ICT	X	✓	✓
Multiple input and output points	X	✓	X
Network as the unit of analysis	X	X	X
Impact of suppliers	X	X	✓
Inclusion of multiple points to increase service productivity	X	X	X

2.9.5 Weaknesses of existing SPMs

In this section, four weaknesses of existing service productivity models preventing them from being operationalised are discussed.

The first weakness is the assignment of measures as low and high. The low-high measures found in Schmenner's (1986; 2004) SPM and inherited in Agarwal and Selen's (2005) Service Cubicle are subjective, and therefore prevent the accurate plotting of the organisation's operations on the matrix.

The second weakness inherent in Schmenner's SPM (1986; 2004) and Gronroos and Ojasalo's (2004) Service Productivity model is the assumption that an organisation has a single mode of operation. This is not always the case. Agarwal and Selen (2005) illustrate that multiple modes of operation are evident in the banking sector, in which customers have the choice of transacting with tellers or through automatic teller machines (ATMs). The operations for each are fundamentally different. Another example is full service airlines, where three classes of travel are available on flights. Each class of travel has a differing fare, cost base and conditions of travel, to appeal to different customer segments.

The third weakness, the assumption of a single input point and a single entry output point, is found in Schmenner's (1986; 2004) SPM and Gronroos and Ojasalo's (2004) SPM. Agarwal and Selen's (2005) Service Cubicle introduces examples in which interactions with customers occur through a front office (one input point), while transactions with suppliers are facilitated by technology, taking place through a back office, thereby dispelling the notion of single entry-exit points.

The final weakness is the assumption that decisions affecting firm productivity are wholly within management control. Schmenner's (1986; 2004) SPM seeks to control customer variability through the application of the Theory of Swift Even Flow, which states that "the more evenly and more swiftly materials flow through a system the greater the productivity." Kalakota and Robinson (1998), Agarwal and Selen (2005), Walter (2005) and Gattorna (2010) and others recognise that the locus of production no longer lies with the boundaries of a single firm, but in the nexus of relationships between a variety of parties all contributing in some way towards the production function. This view should be incorporated into new service productivity models and subsequent productivity measures.

In this chapter, productivity and how it is currently measured were reviewed. This was followed by showing the evolution of production that brought to light a number of fundamental changes that have occurred in business, and the way in which resources are allocated and used. Next was a discussion on how organisations are structured, work is performed, the role of customers and employees and the enabling effects of technology. Then, the complexity of measuring how productivity production moves from individual workers in firms to teams operating in networks was highlighted. Also identified was the fact that the economy and value creation is moving from a reliance on goods and physical artefacts, to intangible factors and experiences. As services require interaction between customers, employees, managers, suppliers and shareholders, the boundary of the firm needs to be extended because inputs and expectations of outputs (value) all ultimately affect the firm's productivity. This is, and continues to be, hastened as the use of technology becomes more commonplace. Ten limitations found in the literature, and four gaps identified in the existing models, inform the development and operationalisation of the next generation productivity models for service and network-based firms.

Chapter 3: Setting Parameters: SEPIA and NEPIA Model Development

> The most difficult thing in science, as in other fields is to shake off accepted views (Sarton 1959, p. 88).

Chapter 2 identified limitations and weaknesses in the literature and current service productivity models. In this chapter, a more holistic view of service productivity based on general systems theory is brought together. I use Boulding's (1956) nine level system classification to build on Schmenner's (1986; 2004) SPM and Agarwal and Selen's (2005) Service Cubicle, to address each of the identified limitations and weaknesses and develop the next generation service productivity models, namely the SEPIA and NEPIA models. These new models are more contemporary and reflect evolution in the way work has been performed and organised, enabling limitations and weaknesses to be addressed.

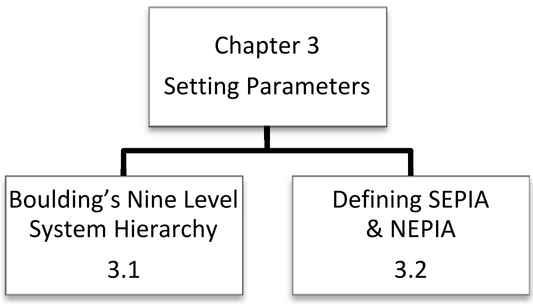


Figure 3-1 Outline of Chapter 3

Models are important to the development of theory (Simon 1957). They offer an opportunity for groups to think collectively, combining their knowledge in logical and consistent ways to solve complex problems (Manzoni 2007; Simon 1957). Consequently, research efforts may be coordinated into a central, open and generic framework, enabling the development of dynamic systems and simulation modelling. As such, models are used to represent relationships between variables, visually creating an image that Boulding (Boulding 1956b) claims determines behaviour. Next, we discuss Boulding's nine level system hierarchies, and the development of the SEPIA and NEPIA models.

3.1 Boulding's nine level system hierarchy

Kenneth Boulding was an evolutionary economist who helped define and shape general systems theory (Jackson 2000; Rapoport 1986). According to Boulding, knowledge is created not only by understanding the nature of the parts, but also the interrelations between them and the relationship with a system and the environment as a whole. Boulding was not the sole contributor to general systems theory. Von Bertlanftany (von Bertalanffy 1968) is credited as its grandfather. He developed a set of general principles applicable to all systems. Boulding took a different approach, permitting the emergence of patterns and structures to emerge, allowing him to arrange them empirically in a hierarchy of complexity. In Chapter 2 I showed the evolution of production has resulted in changes in the way work is performed and has moved to a more complex environment. I also developed insights into the weaknesses of extant models which attempt to address service productivity as I explore how such weaknesses may be addressed in a theoretically defensible manner. In this section I use Boulding (1956a) nine level classification system, (see Table 3-1) to organise the explication of the SEPIA and NEPIA models in a structured manner which both contextualised each model and affords insights gained from Boulding's theory to be incorporated into the development of the models

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Table 3-1 Boulding's (1956) Nine level system heirachy

Level	Boulding's nine levels
1	Framework and static models are where theories begin
2	Clockwork, includes a systematic analysis and introduces dynamics and motion which affect the steady state
3	Thermostat level introduces feedback into the system
4	Interactions begin to occur with the external environment
5	Genetic-social is where different geo-types and division of labour occur
6	Animal level introduces specialist information receptors and information is to be sent and received, reorganized and knowledge created
7	Human level is added which includes human characteristics and perspectives
8	Symbolic of behavior and units of the systems are defined by the role in the social organisation rather than the individual. The inter-relations, content and meaning of messages are important
9	Transcendental level Includes the ultimate and the absolute which sometimes remain unknown

This classification shows the developmental stages of a system from a static framework to a fully dynamic, interactive, multi-element system. According to Jackson (2000), Boulding uses the hierarchy to point out gaps in our knowledge. Jackson emphasises Boulding's view that there is a lack of adequate systems models above level 4 (Jackson 2000; Rapoport 1986). The key problem in predicting system behaviour at higher levels of complexity is the intervention of "the image", the depiction of each of the models into the chain of causality (Boulding 1956b).

The development of the SEPIA and NEPIA models are described next, and summarised in Appendix 1. I begin with Schmenner's (1986) SPM at Level 1 (static), because the model is static in nature. With the introduction of the Theory of Swift Even Flow that shows the productivity diagonal from the bottom right corner to the top corner, Schmenner's (2004) SPM is aligned to Level 2 (clockwork, including motion). This movement through the system is reflected in the change of the X-axis from the degree of labour of intensity to the degree of relative throughput. Agarwal and Selen's (2005) Service Cubicle aligns with Levels 3 (thermostat) and 4 (interactions with the external environment). Given the importance of the evolutionary process of production, highlighted in Chapter 2, and drawing on literature and my own industry experience, I show the evolutionary development of the SEPIA model, which evolved through the development of the Value Creation Cube at Level 6 (animal level) to the SEPIA model, which includes stakeholder interactions and relationships, and aligns with Level 8 (behaviour). However, the focus of the SEPIA model is still a single firm view, requiring further development to incorporate networks of varying sizes and configurations. The NEPIA model resolves this. It is aligned to Level 9 (transcendental) and recognises that there are many unknowns yet to be identified and considered from a productivity perspective.

3.1.1 Level one

Boulding (1956a) suggests that the development of theoretical models begins with frameworks that are static in nature, and probably already in existence. In this research, I begin with Schmenner's (1986) SPM, which is static in nature. This Matrix was predicated on the Process Matrix, with its origins in manufacturing and industrial production. The SPM includes quadrants that describe operations in relation to the production of manufactured goods. An organisation's operations are illustrated as one plot point on the matrix. This represents an organisation's operations as static and operating in one of four modes: SF, MS, SS and PS. The horizontal axis (X-axis) of the matrix represents an internal (organisational) view of the Degree of Customer Interaction and customisation. The vertical axis (Y-axis) represents the degree of labour intensity, being the ratio of cost of labour to plant and equipment. The measures or degrees on each axis are shown as high and low.

3.1.2 Level two

The second level of system classification is referred to as clockwork. This level includes systemic analysis of the dynamics of the system, and where motion affects the steady state. Schmenner's (2004) contributions to the SPM include the application of the Theory of Swift Even Flow and the productivity diagonal. The Theory of Swift Even Flow states that "productivity increases as the speed of materials (or information) increases and variability decreases" (Schmenner & Swink 1998, p. 112). The productivity diagonal illustrates the movement of productivity as production moves from the bottom right corner of the matrix, representing degrees of customer interaction and customisation and high degrees of relative throughput, to the top left back corner of the cube.

3.1.3 Levels three and four

The third level of the system classification incorporates the control mechanism, so is often referred to as the thermostat level. The fourth level is that of a self-maintaining structure. Agarwal and Selen's (2005) contributions to Schmenner's SPM incorporate the development through these two levels. Their first contribution is the identification of technology as a causal factor and an enabler of productivity. Technology becomes the control mechanism enabling communication and feedback within the organisation. Technology is also considered an enabler of productivity, allowing the organisation to move operations up the productivity diagonal. In doing this, Agarwal and Selen include a third axis, the Z-axis, which represents the degree of technovation. The inclusion of the third axis fundamentally changes the structure of the framework, from being a 2x2 matrix to a three-dimensional cube.

The weaknesses of Schmenner's (2004) SPM and those inherited in Agarwal and Selen's (2005) Service Cubicle were highlighted in Table 2.1.

3.1.4 Level five

The fifth, sixth and seventh levels are where the SEPIA model begins to emerge and transform our understanding of productivity for service and network-based firms. The SPM and Service Cubicle are inanimate objects. The transformation of the model from the Service Cubicle to the Value Creation Cube occurs at the genetic-societal level, level 5. Boulding (Boulding 1956a, p. 204) describes level 5 as the "division of labour among cells with differentiated and mutually dependent parts." The introduction of the human elements of customer, employee, manager, supplier and shareholder is symbolic of this division of labour, each differentiated in their role and contribution to the system, yet mutually dependent for the systems to operate and exist.

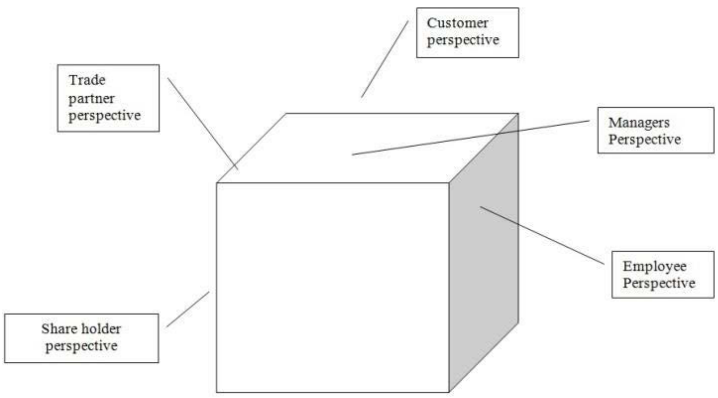


Figure 3-2 Value Creation Cube

3.1.5 Level six

The sixth level is characterised by increased mobility, teleological behaviour and self-awareness. The humanisation of the Service Cubicle incorporates the assignment of customer to axis X, employee to axis Y and supplier along axis Z. Extending the notion of human elements further to the inclusion of all stakeholders contributing to the production process needs to be represented in the model. Therefore, three changes are made to the model. The first change is the acceptance that managers, while still employees, have a different role and function in the production process from workers (Green & Agarwal 2009; Taylor 1911). The identification of the differences between the role and functions of manager and workers was first brought to light in the scientific study of work by Taylor (1911). Since then, the separation of roles and functions has continued to be a prominent feature of organisational theory, strategic management, human resource and management literature (Porter 1984). Therefore, it is deemed necessary to acknowledge the same in the representation of both employee (worker) and manager in the model. Further, as shareholders provide capital, they too are stakeholders and should be represented. (Coelli et al. 2005; Timmer, O'Mahony & van Ark 2007).

3.1.6 Level seven

The inclusion of all five stakeholders, customers, employees, managers, suppliers and shareholders in the model is representative of the seventh level. In this, the human element is considered separate to the system, with self-awareness and the ability to utilise specialist language and symbols. Another fundamental change is made to the models during the humanisation process, and along with each of the roles comes specific behaviour in response to stimuli. The stimulus allows the structuring of information into the image. Boulding (Boulding 1956a, p. 204) claims:

> it is not a simple piling up or accumulation of information into the image…sometimes the information hits some kind of nucleus of the image and a re-organisation takes place with far-reaching and radical changes in behaviour in response to what seems like a very small stimulus.

The radical change to the image, with the inclusion of the stakeholders, is that each stakeholder is represented on each of the planes, rather than the focus being on the axis, as illustrated in Figure 3-2. The customer is represented on the back plane, suppliers on the left plane, shareholders on the front plane, employees on the right of the plane and managers on the top plane. The conceptualisation of the model in this way is also illustrative of the multi-disciplinary nature of the organisation, and need for a more interdisciplinary area of study (Boulding et al. 1993). For example, the interactions between the organisation and customer are grounded in the marketing domain (Sampson 2000, 2010; Sampson & Froehle 2006; Vargo & Lusch 2004; Vargo et al. 2008); suppliers grounded in operations and supply chain management (Gattorna 2010; Kalakota & Robinson 1998; Walters 2000; Walters & Rainbird 2007); employees in human resources (Hackman & Lawler 1971; Hackman & Oldham 1976; Kahn 1990; Storey & Kahn 2010); shareholders in finance; and managers in strategic management, human resource and management literature (Agarwal & Selen 2011; Agarwal et al. 2014; Green & Agarwal 2009; Porter 1984, 1985; Taylor 1911).

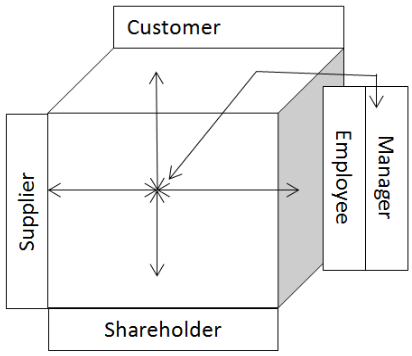


Figure 3-3 SEPIA model in development

However, the incorporation of IT as an enabler first introduced by Agarwal and Selen (2005) requires reincorporation. Examination of the marketing literature illustrates that organisations provide different customer interfaces, which provide customers with a choice of how, where and when they communicate with the organisation (Frei 2006; Heskett et al. 1994). ICT enables the integration of information sharing and data, systems and processes between the organisation and suppliers (Kalakota & Robinson 1998; Swatman & Swatman 1991; Usipaavalniemi 2009). Therefore, customer interface and supplier integration become fundamental components of the system and model.

3.1.7 Level eight

The eighth level is the formation of the SEPIA model representation. The SEPIA model incorporates the social system with the introduction of human characters. According to Woodward (2008), the complex nature of human emotion can be illustrated through the content and meaning of messages, the nature and dimensions of the value system and subtle symbolisation of art, music and poetry. The artistic representation of the SEPIA model transforms the cube from the original model, showing productivity as a single point, to being more dynamic, multi-dimensional and convergent. Hence, through the SEPIA model, I define service productivity as the aggregate of decisions made by each stakeholder as they converge to determine firm-level productivity. This challenges the productivity maximisation strategies of the past. As each stakeholder seeks to maximise their productivity, firm-level productivity is the optimisation of productivity between all stakeholders. Therefore, it is necessary to extend the boundaries of the firm to include customers, employees, managers, suppliers and shareholders, as illustrated in Figure 3-3, ensuring alignment, coordination and integration across stakeholders (Agarwal & Selen 2009; Gattorna 2010). This is fundamental to the definition of service productivity.

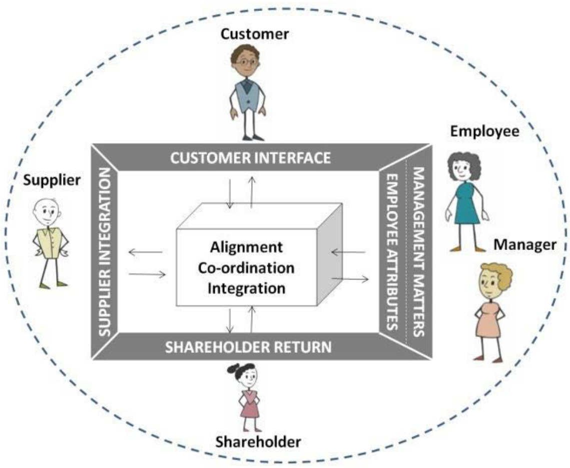


Figure 3-4 SEPIA model

3.1.8 Level nine

The ninth level is referred to as the transcendental system and exhibits systematic structure and relationships, with ultimates, absolutes and unknowns forming part of this level (Boulding 1956a). This is represented in Figure 3-4, in which the SEPIA model illustrates the possible relationships between two or more firms in a network structure, thus forming the NEPIA model. The NEPIA model includes the connection of multiple firms (the SEPIA model represents a single firm). The focus of the NEPIA model then becomes the relationships and inter-connections between two or more firms. The relationship between two firms (dyadic relationship) is typically represented by a single line with or without arrowheads (Adamic 2013; Borgatti et al. 2013) to detail the connection and directional flow. However, the NEPIA model shows that the connection between two organisations may be structured differently. The literature identifies four key types of structural relationships: alignment (Agarwal & Selen 2008; Gattorna 2010; Walters & Rainbird 2007), bonding, bridging or linking (Baker, Onyx & Edwards 2011; Leonard & Onyx 2003; Onyx & Bullen 2000). These variances in dyadic relationships are included in point 2 of Figure 3.4 of the NEPIA model, as each will have a different impact on a firm's productivity.

The NEPIA model is a network bounded by the organisations that constitute a productive unit; that is, the combination and configuration of organisations required to deliver end-to-end value. Point 3 of Figure 3-4 shows the network of three organisations; that is, a service triad, operating within a larger network. The existence and impact of sub-systems and differently configured networks—such as service constellation (Norman & Ramirez 1993a; 1997) and service molecules—are defined in this research as services relying on the connection of multiple hubs from two or more different environments (industries). This is where the delivery of end-to-end services relies on cross-industry collaboration and network connections. For example, a consumer making a payment for an air-ticket requires collaboration and communication with the travel and tourism industry and banking and finance sectors. These are not included in the illustration of the NEPIA model in Figure 3-4.

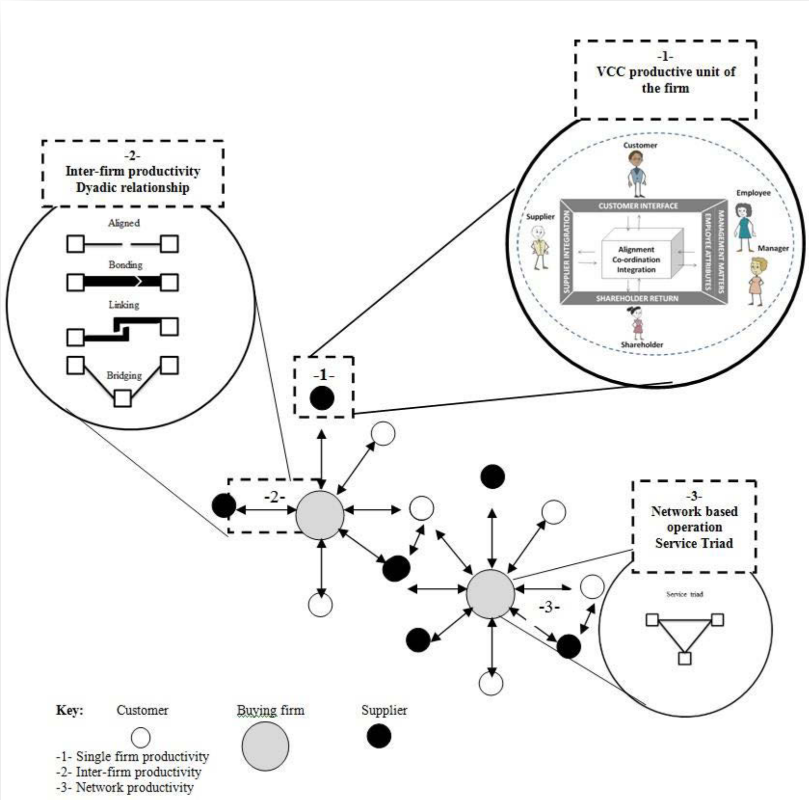


Figure 3-5 NEPIA model

3.2 Paradigm shift

The extension of the existing service productivity models to incorporate the human elements of each of the stakeholders is a radical departure from the firm being viewed as the decision-making unit. This is significant, as Boulding (Boulding 1956b, p. 6) claims that "behaviour depends on the image", and that images are a reflection of the structure of knowledge, built up from past knowledge and experiences. As knowledge is introduced or hits an image, one of three outcomes is likely: the image *remains unchanged,* as seen in the transition from the Product Process Matrix to the SPM; the image changes in "some regular and well defined way by what may be described as a simple addition" (Boulding 1956b, p. 7) as seen in the Service Cubicle with the addition of the "z" axis, and the change of image from a matrix to a cube. There is sometimes a radical and revolutionary change in the image when knowledge "hits some sort of nucleus or supporting structure…and the whole thing changes in quite a radical way" (Boulding 1956b, p. 8).

According to Burrell and Morgan(1979), management and organisational studies, like other fields of inquiry, are anchored in particular paradigms. A paradigm is a general way of thinking that reflects and reinforces basic assumptions and beliefs (Kuhn 1970; Lincoln 1985). Burrell and Morgan (1979) present four multi-paradigm perspectives to theory building, claiming that traditional approaches to theory building have been predicated in one major paradigm, therefore limiting our understanding of organisational phenomena inconsistent with alternate approaches of seeking theory construction (Gioia & Pitre 1990). One of the four paradigms presented by Burrell and Morgan (1979) is the radical structuralism approach, which, according Gioia and Pitre (1990), embodies change and transformation at a macro societal class, or industry structure level.

The development of the models through Boulding's nine-level hierarchy classifications, and the incorporation of theories and perspectives from different disciplines, does radically transform the image of the models and our view of productivity for service and network-based firms. While this was not intentional, the radical changes to the structural elements of the image, the process and the outcome are aligned with "the goals of the radical structuralist theory approach which is to understand, explain, be critical and act on the structural mechanisms that exist in the organisational world" (Gioia & Pitre 1990, p. 589), and as such is more representative of contemporary business practices. Table 3-1 highlights the deficiencies in the existing models, identified in the literature, and the illustrates how the SEPIA and NEPIA models address the identified gaps and liberate productivity for service and network-based firms beyond the tangible and physical elements to the intangible and relational elements incorporated in the SEPIA and NEPIA models. These are representative of the changes occurring with the transition of the economy from agriculture and manufacturing to service and knowledge-based. Benson (Benson 1977) suggests a rethinking of the data in light of the changes and refinements of viewpoints, which may involve recasting boundaries to encapsulate a broader context.

Table 3-2 Gaps of existing service productivity models addressed in the SEPIA and NEPIA models

Gap in the literature	SPM	SC	SePr	Addressed by	SEPIA	NEPIA
Definition of service includes stakeholders	x	x	x	Includes customers, employees, managers, suppliers and shareholders, and therefore satisfies the contemporary definition of service	✓	N/A
Single direction input-transformation-output model	x	x	x	All interactions are bi-directional, with each stakeholder including inputs and outputs, thereby addressing	✓	✓
Employees are heterogeneous	x	x	x	Recognition of the difference between employees and managers	✓	N/A
Firm as the unit of analysis	x	x	x	Firms do not make decisions, people do; therefore, data collection and unit of analysis is at the human level	✓	X
No customer inputs	x	x	✓	Customers and customer input are included	✓	✓
Single firm no longer the "productive unit"	x	x	x	Firm is positioned within a service value network, with different network configurations highlighted	N/A	✓

In this chapter, Schmenner's (2004) SPM and Agarwal and Selen's (2005) Service Cubicle were positioned as the first four levels in Boulding's (1956) nine level systems hierarchy. The development of the SEPIA and NEPIA models was the result of iterative changes at each of the remaining five levels. The result was a radical and transformative paradigm shift, which is more representative of contemporary business practices. The variable selection and rethinking of the data, as suggested by Benson (1997), is discussed next in Chapter 4, as the variables for each of the stakeholders included in the study are selected.

Chapter 4: Variable Selection

> Count what is countable, measure what is measurable and what is not measurable, make measurable Galileo (1954-1642).

This chapter is organised into three sections, as outlined in Figure 4-1. Section 4.1 introduces the standard measures used in operations management, and provides the grounding for the units of measure used in the SEPIA and NEPIA models. The examination of the SEPIA and NEPIA models are distinct. Section 4.2 discusses the variable selection for the SEPIA model, which includes customer interface, employee attributes and supplier integration. Section 4.3 presents an overview of commonly used variables that may be applied to network analysis, and that will be applied to explore the NEPIA model.

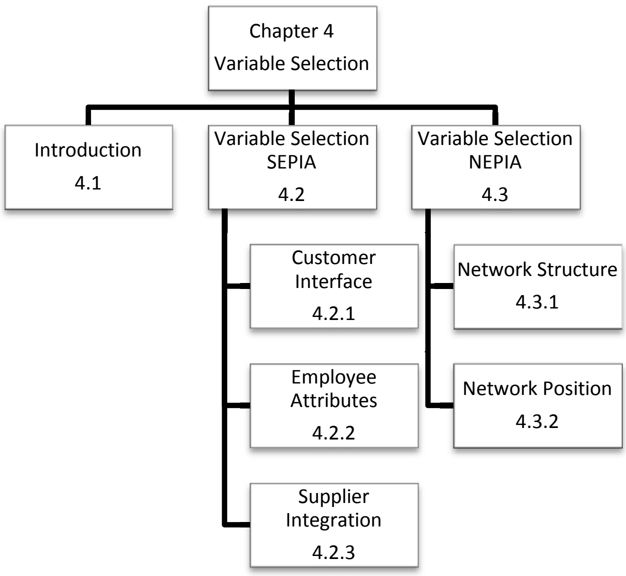


Figure 4-1 Outline of Chapter 4

4.1 Introduction

The choice of variables requires justification. According to Avkiran (2006), variables may be selected by reviewing academic literature and using expert opinion. He suggests that managers possessing in-depth knowledge of the business may use their "expert knowledge" to validate or nominate suitable variables. Once the variables are selected, it is necessary to determine whether they are inputs or outputs and to identify the appropriate unit of measure (Morita & Avkiran 2009).

The identification and measure of physical goods makes them easily assignable as inputs or outputs. However, the task becomes problematic where inputs and outputs are intangible and may be viewed from different perspectives. Gillen and Lall (1997) recommend a simple approach that can be used in cases where it is difficult to distinguish inputs from outputs, using less-preferred factors as inputs and desirable outcomes as outputs. This general view is also supported by Cook, Wade and Zhu (2013), who state that the fewer the inputs and the more the outputs, the better. Another suggestion provided by Morita and Avkiran (2010) is the use of statistical approaches to determine the optimal combination of variables when there are a large number of variables from which to choose.

Standard measures in operations management are volume, value, time and cost (Fitzsimmons & Fitzsimmons 2004; Gattorna 2010). However, in this research the measures used for the SEPIA model are limited to volume and value. The reason for this is twofold. First, the relationship between time and service delivery is different from that in manufacturing, where a major focus is to reduce time (Schmenner 1986; 2004). Some service firms seek to engage customers in the service delivery process for as long as possible, rather than lessen the time consumers spend in the service delivery process (Kumar et al. 2010). For example, a telecommunications company that charges customers for calls by the minute is likely to seek ways for customers to use the service as often and for as long as possible. The second reason relates to the exclusion of cost. While cost impacts price efficiency (Coelli et al. 2005), this is not a specific focus of this research. Rather, the main focus is the identification of intangible factors affecting the productivity of service firms. Consequently, volume and value are deemed sufficient to demonstrate the intangible factors of productivity for service and network-based firms.

Volume relates specifically to the number of customers. Value has two components: a financial value, which represents the customer's willingness to pay, and an intrinsic value, which is subjective and differs between customers (Ng 2008). In this research, the financial value paid for the service is used as a proxy for the intrinsic value for the customer (Ng 2008). Limiting the measures to volume and value for the SEPIA model enables the simplification of the model, to gain an understanding of the dynamics between the different variables and stakeholders.

Further, the same variables (namely volume and value) are used to define the relational ties between the customer, firm and suppliers for the NEPIA model. Supply chain management uses materials, information and financial flows to measure the movement of resources between organisations (Gattorna 2010; Kalakota & Robinson 1998; Walters & Rainbird 2007). Here I define service value networks through people flows (both customers and employees) in addition to material, information and financial flows. This is a reflection of the real world with the flow of tourists (Leiper 1989; Yang & Wong 2013), patients (Haraden & Resar ; Miro et al. 2002), students (San Pedro et al. 2008; Shah & Burke 1999), and customers more generally (Gelenbe 1991; Tretyak & Sloev 2013).

4.2 Justification for excluding managers and shareholders

The SEPIA model includes five stakeholders namely customers, employees, managers, suppliers and shareholders; however the study only includes customers, employees and suppliers, the justification of which is explained next.

Schmenner's (1986) Service Process Matrix includes two axis, the first represents the amount of customer contact and the ensuing interactions and the level of customisation (y axis is labelled the Degree of Interaction and Customisation). The second axis represents the employee in so far as it seeks to measure the Degree of Labour Intensity. In 2004, the labels of the each of the axis changed; however, what remains is the link to the actors that the axis seeks to measure. Later Agarwal and Selen (2005) introduce a third axis, the degree of technovation. Here, they position this axis and therefore technology as the "back office" interface to suppliers. Hence, customers, employees and suppliers (represented by the ICT connection) are included.

In addition, an examination of the management literature shows the London School of Economics (LSE) and McKinsey & Co have management practices which links the quality of management and the performance of firms (Green & Agarwal 2009). Shareholders provide capital and are not directly involved in the working or the organisation. Hence, the framework for this research is such that customers, employees and suppliers (through the use of technology) are the stakeholders included in the study. Due to the limited time available to conduct this research and the desire to explore productivity for network based firm's managers and shareholders are excluded from this study.

4.3 Variable selection SEPIA model

To operationalise the measures for service productivity using the SEPIA model, a review of academic literature from a multi-disciplinary management perspective is conducted. The identification of a standard set of variables across each of the three stakeholder groups included in this research, and how they align with the functions within the organisations and the management discipline from which the variables are selected, is illustrated in Table 4-1. Customer interface variables are assigned by reviewing marketing and operations management literature, employee attributes through reviewing human resource literature, and supplier integration through the review of operations management and ICT literature. While outside the scope of this research, it is anticipated that the finance and accounting literature will inform the variable selection for shareholders and management, and human resource literature the variables for managers. The variable selection for the customer interface, employee attribute and supplier integration are determined next.

Table 4-1 SEPIA model management literature and stakeholder alignment

Firm (ANZSIC code)	Marketing	Human resources	Operations management	Information communication technology	Finance	Management
SEPIA model (stakeholder decision making and resource integration)						
	Information technology enabling data and information sharing between processes, systems and stakeholders					
Stakeholder	Customer	Employee	Supplier	All stakeholders	Shareholder	Manager

4.3.1 Customer interface

Customers and customer input into the service delivery process are critical and a precondition to the commencement of service delivery processing (Sampson 2010). Customers provide themselves, their belongings or their information as input into the service delivery process (Lovelock & Yip 1996). The input from customers resulting from their behaviours was also acknowledged as a factor affecting the performance of the firm (Best & Luckenbill 1994; Lovelock 2001; Berry & Seiders 2008). Given the limitations of earlier models and assumptions about a single operating model, I incorporate different operating models through the variable selection for the SEPIA model, and use the number of customers (volume), without behaviour discrimination and customers' willingness to pay (proxy for value) flowing through the firm and service system.

Marketing and operations management literature states that the heterogeneous nature of customers causes customer variability (Lovelock & Yip 1996; Ng et al. 2008; Ng 2008). While not explicitly stated, the point of intersection between the customer and the service firm (customer interface) is the point at which service firms reduce, accommodate or manage discrepancies in customer variability. Customer variability is visible in the choices customers make and the behaviours they exhibit (Lovelock 2001). In this research the focus is on the decisions customers make, rather than their personal or behavioural characteristics. Specifically in relation to what a customer buys, when they buy, whom they buy from, where they buy, why they buy and how they buy.

Consequently, managers respond to customer variability and make decisions on when, to whom, where, why and how to offer services. Further, the decisions made by customers inform the service offerings, service design and subsequent service operations management decisions (Arlbjorn et al. 2011; Boyer & Verma 2010).

Real-time decision making around these variables influences service productivity, which is directly affected by the ability of the employee to deliver the service and the customer's acceptance and response to interactions with employees. This is the nature of the customer-supplier duality of service delivery. The underlying premise of these decision variables relates to:

(1) what services to offer;
(2) when to offer services;
(3) where to offer services;
(4) who to offer services to;
(5) why to offer services;
(6) how much the customer is willing to pay for the service(s).

The implications of these decisions form the customer interface construct, which I define as having six decision variables:

(1) service complexity (Roth 2001);
(2) access;
(3) service interactions (Roth & Menor 2003);
(4) customer channel (Kalakota & Robinson 1998; Wilson 2009);
(5) customer loyalty (Heskett et al. 1994);
(6) price as a determinant and proxy of customers' willingness to pay (Ng 2008).

Table 4-2 shows each of the decisions made by the customer and the firm at the point of customer interface. Each customer makes all six decisions for each service transaction.

Table 4-2 Customer interface decision variables

Decision	Customer	Service firm	Decision variable
1	What services do I want to buy?	What services does the firm offer?	Service complexity
2	When do I want to buy the services?	When to offer the service?	Access
3	Where do I want to buy the services?	Where does the firm offer services?	Customer service interactions
4	How will these transactions occur?	How do the transactions occur?	Customer channel
5	Whom shall I buy services from?	Who buys our services?	Customer loyalty
6	What am I willing to pay for the services?	Will the firm accept what the customer is willing to pay?	Customer willingness to pay

Figure 4-2 illustrates the customer interface construct. The choices available to customers are the result of the decisions made by service firms. These service offerings may be the result of management decisions at the service design stage, or during interactions with employees of the firm during the service delivery process. The customer interface decision variables highlighted in Table 4-1 are illustrated in Figure 4-3. The number of customers (volume) and the effects of the choices they make at the point of customer interface now enable the incorporation of customer variability as a factor affecting service productivity.

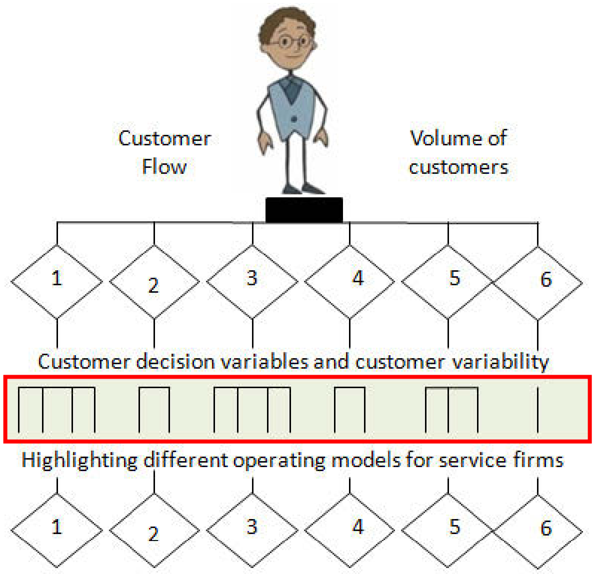


Figure 4-2 Customer interface, customer and service firm decisions

Each decision variable is discussed in more detail next.

4.3.1.1 Service complexity

Service complexity addresses the question of *what services to offer*. Service complexity is the way that service firms deal with customer variability and are able to customise service offerings in accordance with customer requirements. In this research, the definition of customisation provided by Srinivasan, Andersen and Ponnavolu (2002, p. 42), "the ability to tailor services and the transactional environment to individual customer requirements", is adopted. This construct defines the way that service firms select the range of service components and relevant service providers. Schmenner's (2004) SPM, Agarwal and Selen's (2005) Service Cubicle and Roth's (2001) P^3 Service Design Matrix link product (service), customer variability and interactions with low-high levels of complexity. Roth's (2001) P^3 model also includes customer knowledge as a factor contributing to service complexity. The inclusion of customer knowledge as a determinant of service complexity further clarifies the possible levels of complexity. In this research, service complexity is defined as the number of service providers and the types of service components combined to deliver one end-to-end service process. This definition is also in line with the definition of service bundling and unbundling, discussed in Section 2.2.1 (Brueckner et al. 2013; Guiltinan 1987; Kohlborn et al. 2010). Customers will select the service provider and the service component types based on their needs and level of knowledge required to process the purchase. The more complex the service the greater the level of customer/employee knowledge required. Figure 4-3 illustrates service complexity as a matrix, showing the four combinations together with the possible scores, used in this research to identify each of the levels.

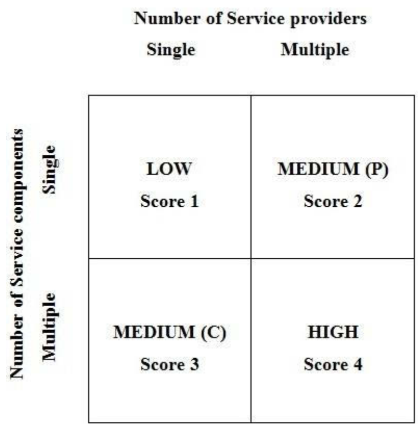


Figure 4-3 Service complexity matrix

The four service complexity level scores are described as:

- Score 1, Low: Single service provider, single service component; requires a comparatively low level of customer knowledge, as they are required only to know about and evaluate the service propositions from one service provider and component.
- Score 2, Medium (P): Multiple service providers and a single service component require a medium level of customer knowledge as there is a requirement to know about multiple service providers providing the same type of service component. For example, where accommodation is deemed a service component and the customer purchases multiple nights of accommodation from multiple accommodation providers (such as Hilton Hotels, Accor Hotels or Best Western Hotels), a higher level of knowledge is required to compare and differentiate between the brands, and to coordinate activities between each component to ensure correct check-in and check-out dates are booked, and that there are no overlaps or gaps between the two. Therefore, a medium level of knowledge is required, as the fundamental information provided is the same across organisations.

- Score 3, Medium (C): Single service provider and multiple service components also require a medium level of customer knowledge. An increase in the number of purchases (albeit different types of service components from a single provider) entails familiarity with the organisation, the user interface and the combination of service components. An example is where a traveller purchases a pre-packaged tour with multiple service components. The single service provider has selected, secured and made combinable different service components, and made them available to the customer as a purchase from a single service provider. An example is where Creative Holidays provides customers with the ability to purchase multiple service components, such as air transportation, accommodation, transfers and day trips. A medium level of knowledge is required as the tour wholesaler absorbs or combines the supplier variances, therefore reducing service complexity for the customer.
- Score 4, High: Multiple service providers and multiple service components require a high level of customer knowledge. Customers are required to deal with the complexity of combining and coordinating activities between the service providers, as well as having knowledge of and understanding how to apply the terms and conditions of each service provider. An example of high level service complexity is demonstrated in Jetstar offering flight bookings and hotel and/or hostel bookings, car hire and insurance. However, rather than being combined as one service offering, the customer makes separate decisions for each service component and each is processed as an individual service offering. Jetstar simply leverage their brand and provide access to the different service components without the integration of service components in any manner.

4.3.1.2 Access

Access addresses the questions of *when to offer services*. Consumers choose to avail themselves of services offered by the firm at different times. Conversely, firms decide which hours they will operate based on hours of the day, time of year, holiday season, availability of staff and the combination of technical and human resource configurations. For example, some service firms providing full service facilities are available for customers to contact them and access their services 24 hours a day, seven days a week, 365 days a year, while other firms may provide services between nine in the morning and five in the evening, Monday to Friday, excluding public holidays.

4.3.1.3 Customer service interactions

Customer service interactions address the question of *where to offer* services. Geographic proximity and the levels and combination of human and/or technology contact are key to Roth's (2001) P^3 models. The P^3 model defines proximity as being geography dependent and being either onsite (same geographic location) or offsite (different geographic location). Roth and Menor (2003) classify customer service interactions broadly, as either face-to-face or face-to-screen, thereby defining the point of interaction rather than geographic proximity. Froehle and Roth (2004) refine this by determining how interactions occur. These may be technology assisted, human assisted or a combination of both. In Figure 4-4, the point of interaction and the means of interaction are combined to determine four possible constructs. These are an adaptation of Froehle and Roth's (2004) five customer contact archetypes.

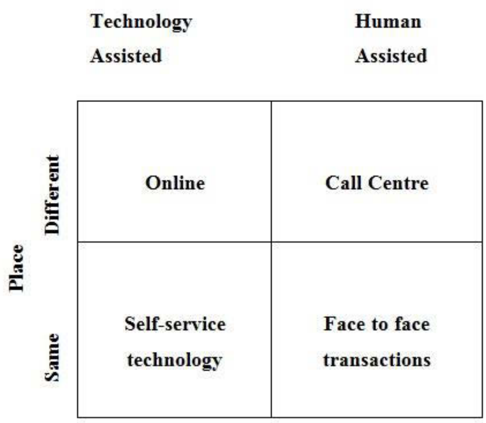


Figure 4-4 Customer service matrix

Adapted from Froehle and Roth's (2004) five customer contact archetypes.

The four possible customer service interactions used in this research are:

- *Online transactions*: technology assisted transactions that occur where the customer interacts with service providers in a different place and space.
- *Self-service transactions*: technology assisted transactions that occur in the same place as the service provider; for example, service transactions such as the self-

service checkout at a supermarket, check-in kiosk at the airport or an ATM in a bank (Froehle & Roth 2004).

- *Call-chat centres*: human assisted transactions that occur where the interactions between humans are synchronous; however, the customer and human assistance are located in different places, such as a telephone call centre, or where assistance is provided via e-mail or online chat sessions (Froehle & Roth 2004).
- *Face-to-face transactions*: human assisted transactions, where humans are located in the same place; commonly termed face-to-face transactions (Froehle & Roth 2004).

4.3.1.4 Customer channel

Customer channel refers to *how* transactions occur between the service provider and the end consumer. End consumers may transact directly with the service provider. These transactions are known as B2C transactions. Alternatively, end consumers may purchase services through an agent or affiliate, in which the purchase transaction is considered a B2B transaction. The implications of this construct are such that B2C and B2B transactions often differ in pricing, cost and/or volume dimensions. Other customer channels identified in the literature are Business-to-Government (B2G), such as where corporate travel agents make bookings on behalf of a government department; Government-to-Citizen (G2C) transactions, relating to payment of taxation fees due; and Peer-to-Peer, such as eBay or PayPal transactions (Boyer et al. 2002; Kalakota & Robinson 1998). This research anticipates that the nature of transactions will include B2C, B2B and B2G.

4.3.1.5 Customer loyalty

Customer loyalty addresses the question of *who to offer services to*, with service quality and customer loyalty being inter-linked. Customer loyalty has been recognised as a path to profitability and service quality drives customer loyalty (Srinivasan, Andersen & Ponnavolu 2002). Customers who enjoy the service experience are likely to become repeat and loyal customers (Heskett et al. 1994; Ng et al. 2008; Su et al. 2011). Loyal customers repurchase different services from the same service provider at different times and in different contexts (Anderson et al. 1999; Heskett et al. 1994; Ng 2008).

Additionally, loyal customers also express satisfaction with services provided by referring friends, relatives, colleagues and others within their social or business networks (Dick & Basu 1994; Hall et al. 2009; Heskett et al. 1994; Yang & Peterson 2004).

The impact of customer loyalty on firm performance is considered by many companies as a source of competitive advantage (Kim et al. 2012; Porter 1984, 1985). Increased customer loyalty is evidenced by increased revenue, reduced customer acquisition costs and lower costs of serving repeat customers, resulting in higher profits. Potential antecedents of customer loyalty include customer satisfaction, switching costs and customer value. Customer satisfaction is a determinant of customer loyalty—customers remain loyal if they feel they are receiving greater value than they would from a competitor (Gummesson 1998).

The literature identifies loyal customers as those who have been referred and those who have purchased products or services in the past and who repurchase from the same provider. In this research, I measure the number of new customers as an input into the service delivery process, and the number of referred and repeat customers as a proxy of service quality and therefore an output measure.

4.3.1.6 Customer willingness to pay

Customers' willingness to pay is defined as the maximum amount a buyer is willing to pay for a service (Ng 2008). Customers must perceive the value they receive from the good or service as greater than or equal to the amount they are willing to pay for it.

From the firm's perspective, *price* addresses the question of *why to* offer services. Organisations exist for different reasons. Some are profit driven while others are not-for-profit (Coelli et al. 2005). For-profit organisations determine success by the customer's willingness to pay for the service, and the price is a reflection of the value (output) they are able to create.

In this research, the output variables for customers is defined as the willingness to pay for the service provided (Ng 2008), and customer loyalty measured by the number of repeat and referred customers to the organisation. For information on input and output variables and measures, refer to Table 3-2; for the list of variables and sources, refer to Table 3-3.

4.3.2 Employee attributes

The human resource management literature review demonstrates that the role of the employee in the production process has changed over time. Various studies show that individual employee attributes contribute to productivity (Green & Agarwal 2009; Hackman & Lawler 1971; Hackman & Oldham 1976; Kahn 1990; Taylor 1911). These personal attributes include physical contribution (Taylor 1911), employee engagement (Kahn 1990; Wilson 2009) and cognitive attributes, such as the accumulation of skills, qualifications and experience (Tamkin 2005; Taylor 1911; Wolff 1995; Wolff 2002). Despite this, current measures of labour productivity continue to be based on the number of workers by the number of hours worked. However, it is necessary to consider the whole person and all the attributes of each employee.

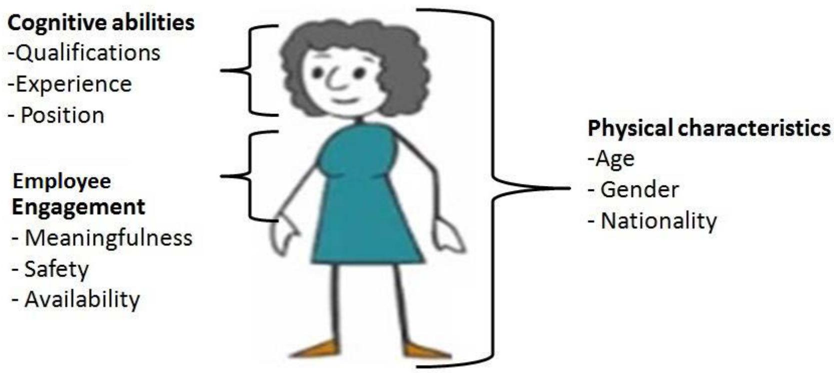


Figure 4-5 Employee attributes, taking into account the whole person

In this research, I include the employee's physical and cognitive attributes and psychosocial factors (employee engagement) as measures of their input into service productivity. Each is discussed in detail, next.

4.3.2.1 Physical characteristics of employees

Employee physical characteristics are many. While each factor is highlighted in the literature as a contributing factor of individual productivity, measures and levels of importance remain obscure (Koopmans et al. 2011). In this research, I limit factors relating to employee physical attributes to age, gender and nationality. Combined, these employee attributes are able to represent the level of cultural and workforce diversity. A culturally diverse workforce relates to cultural differences present in the workplace. This has also been identified as a positive contributor to productivity (Avkiran 2006; Koopmans et al. 2011).

- *Age:* the literature indicates that there is correlation between the age of a person and their individual levels of productivity (Wolf 1974). Physical and mental ability decreases as age increases (Skirbekk 2003; van Ours & Stoeldraijer 2010). Numerical and reasoning abilities are viewed at their highest when people are in their 20s and 30s (Avolio & Waldman 1994; Gomez & Hernandez de Cos 2006; Molinero et al. 2008); verbal fluency peaks at 53, and workers in their 30s are the most productive and hardworking (Skirbekk 2003).
- *Gender:* gender has an impact on the productivity of the individual as it relates to their area of employment (Skirbekk 2003).
- *Nationality:* nationality is used in this research to identify cultural diversity in the workplace, rather than examining productivity at an individual level. However, the literature shows different nationalities possess different work ethics, and diversity has a positive effect on productivity (Hamilton et al. 2004; Park et al. 1999).

4.3.2.2 Cognitive abilities of employees

Cognitive abilities reside in the brains of each individual (Koopmans et al. 2011; Stewart et al. 2009). These are intangible assets, which an organisation cannot own (Edvardsson 1997). Wolff's (2002) research into the causality of stagnant service sector productivity uses the mean years of schooling and the number of knowledge workers, defined as knowledge producers and knowledge users, to determine the measure of knowledge of workers. In this research, I adopt the level of education, as identified by qualification level, rather than the mean number of years of education, as a measure of knowledge.

- *Qualifications* are a quasi-measure for skills and knowledge. Qualifications attained provide a standard and unambiguous measure is based on the number of years of schooling. The Australian Qualification Framework (AQF) criteria will be used to measure level of qualification (*Australian qualfications framework* 2013).
- *Experience* relates to the number of years employed and the number of years in a job. This will be used as the measure for experience. The AQF provides an equivalency measure for the number of years experienced in a job with relevant qualification (*Australian qualfications framework* 2013).
- *Position* within the organisation. Taylor (1911) made the distinction between worker and manager and identified them as important attributes of how work is conducted, and ultimately of productivity. Since then, other worker classifications have been created. In this research the 2009 ABS 1220.0 Australian and New Zealand Classification of Occupations codes were used to determine an employee's position within their organisation.

4.3.2.3 Employee engagement

Employee engagement is where people harness their physical, cognitive and emotional being when performing their work (Kahn 1990; Koopmans et al. 2011; Sullivan et al. 2013). Employee engagement is changeable, depends on the workplace (Coffman & Gonzalez-Molina 2002; Crepton et al. 1998) and is considered a reflection of leadership from top to bottom (Townsend & Gebhardt 2007). Kahn's model proposed that three psychological conditions must be evident in the work environment for employee engagement. These are meaningfulness, safety and availability. Meaningfulness is where workers feel that their work affects others. Safety develops as a result of trust and a feeling of supportiveness. Availability is where workers have the physical, emotional and psychological means to engage in their tasks at any given point (Kahn 1990). Empirical evidence shows that engaged employees are more efficient, provide higher levels of customer service and are more productive (Loehr & Schwartz 2003). A survey questionnaire, developed by Wilson (2009) and validated with frontline service providers, will be used in this research. A copy of the survey instrument is included in Appendix 2.

The output measure for employees is a derivative of the remuneration and any related incentive payment received by an employee. Individual employee remuneration was not collected in this research, as the focus is the operationalisation of service productivity, rather than the optimisation of productivity.

4.3.3 Supplier integration

Supplier integration is a key element in supply chain efficiency and service value networks' abilities to deliver end-to-end services (Agarwal & Selen 2006; Gattorna 2010; Kalakota & Robinson 1998). Achieving effective integration includes alignment of goals and objectives at a strategic level; coordination of activities and integration of systems at a tactical level; and integration of data, information and processes at an operational level (Bowersox 1990; Gattorna 2010; Usipaavalniemi 2009). Operational efficiency is achieved through the integration of data, information and processes (Bowersox 1990; Gattorna 2010; Usipaavalniemi 2009), underpinned by data integration. According to Usipaavalniemi (2009), Swatman and Swatman (1991) and Kalakota and Robinson (1998), data integration is determined by data structures, the mechanism used to transfer the data between organisations or systems and whether the data is available in real-time or not.

4.3.3.1 Data structures

Data structures provide a means of managing, storing and organising data efficiently and are key to information sharing (Black 2009). Data is hierarchical in nature with the smallest unit being a data element. Data elements should be named, have a unique meaning or value and be indivisible (Swatman & Swatman 1991). A collection of data elements create a data record which has a fixed number of elements organised in a specific sequence and are indexed according to name and referred to as a data field. Data elements, data fields and records form the basis on how data is structured and stored in databases. Data records also have a unique record identification number (Record ID) to unambiguously identify the record within a database.

Data may be structured as follows:

- *Unstructured* data requires a human to read, interpret, understand and apply the data in a specific and intended way. In order for the data to be used by others it requires re-keying or uploading and transfer between systems (Deshmukh 2006; Swatman & Swatman 1991).
- *Semi-structured* is a means of achieving data integration with the exporting of data in flat files, such as.csv or.txt or tab delineated formats (Clifton & Thuraisingham 2001).
- *Data standards* such as XML define the data and describe how it should be structured. XML is a data interchange format that allows real-time data exchange between dissimilar systems, applications and independent platforms.

The time required to interpret the data is dependent on the level and degree of human and/or technical interpretation. In this research, standardised data is considered of higher quality because of the interoperability it affords and the ability for organisations to align their operations with their suppliers.

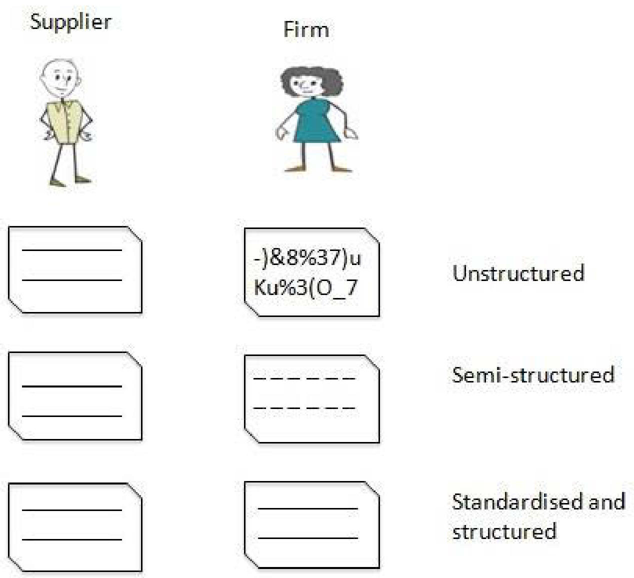


Figure 4-6 Data structures between suppliers and the firm

4.3.3.2 Data transfer mechanism

Communication mechanisms provide the ways that data can be transferred between organisations and systems. Communication may be offline, online, automated through file transfer protocols or enabled in real-time through various technologies, such as transport control protocol/Internet protocol. A brief presentation of each is provided next.

- *Off line,* such as mail or telephone.
- *Online* use of e-mail (Kalakota & Robinson 1998; Swatman & Swatman 1991).
- *File transfer protocol (FTP)* enables third parties access to file services. FTP functions provide the ability to control the connection as well as file management such as upload, download, rename and delete (Postel & Reynolds 1985).
- *Transport Control Protocol/Internet Protocol (TCP/IP)* controls the communication of data in packets across the Internet and specifies the interoperability between systems (Kalakota & Robinson 1998; Microsoft 2011).

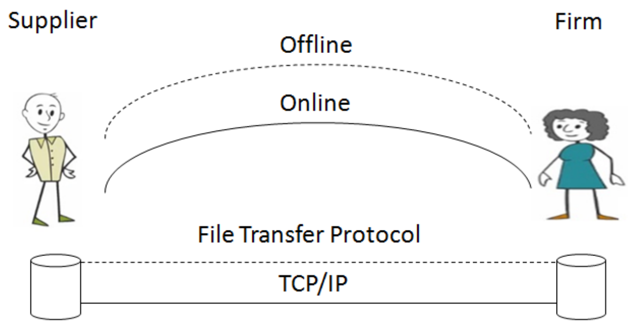


Figure 4-7 Data transfer options between suppliers and the firm

Data transport mechanisms are representative of the different forms of technical connectivity between organisations. The general view is that the greater the level of connectivity and automation, the better the quality of the data exchange. More automated procedures and exchanges reduce the level of manual intervention and therefore reduce the propensity for human error or misinterpretation. An increase in the usability of data increases the levels and speed at which integration is possible, thus increasing productivity.

4.3.3.3 Availability of data

The availability of data relates to the timeliness of when the data is available for use between users (Kalakota & Robinson 1998). It is generally regarded as an indication of the level of business process integration existing between parties. The greater the level of data availability, the greater the realisation of benefits such as integration, increased standardisation, reduced bull whip effects, improved controls and reduction in manual intervention of data, each of which leads to improved productivity (Guston et al. 1995; Kalakota & Robinson 1998). Availability of data relates to two key components: the time the data is available and the way that data requests are managed. Data may be in real-time (synchronous) or with time delays (asynchronous). Each data availability component is presented next, with the relevant categories as applied to this research.

- *Synchronous* data exchange is where data is available to multiple parties at the same time:

    -*Real-time updates*: where information is transported between multiple systems simultaneously or upon data entry.

    -*Shared systems*: extra-nets and cloud computing enable system sharing. Trade partners all access the same system enabling remote data entry by third party partner organisations.

- *Asynchronous*: where a time delay between the point at which data is captured from one party to another, and the data is transmitted for use by the partner or third party provider. Data exchange measures used are illustrated through industry examples:

    -*Ad-hoc*: data is sent sporadically. For example, pricing updates are sent only when prices change.

    -*On request*: data is sent only when requested. For example, inventory updates may be requested when inventory levels fall below a certain threshold.

    -*Pre-defined times*: transmission of data is sent at pre-defined times and coordinated to align with specific business processes. For example, payment files loaded into electronic banking systems occur at four pm daily, to coordinate with a five pm bank cut-off time.

The Theory of Swift Even Flow (Schmenner 2004) states that the more evenly and swiftly information flows through a system, the greater the productivity. The measures outlined in the availability of data relate to the volume of information and the timeliness of the flow of information between organisations, systems and processes. Therefore, implicit in this is that the availability of data is expected to affect the productivity of an organisation and its suppliers.

In this research, the flow of information will be based on the volume of customer information flowing between organisations. The volume of customers will be the number of customers the information flowing pertains to. The measure of supplier integration will revolve around the number of customers' information processed by each method. For information on input and output variables and measures, refer to Table 4-2; for the list of variables and sources, refer to Table 4-3.

Table 4-3 Summary of variables and sources used for the SEPIA model

Theoretical construct relating to the decisions managers of service firms make	Dependent variables	Independent variables	Source and amendments
Customer interface *What services to offer*	Service complexity	Low Medium P (Provider) Medium C (Components) High	Schmenner (2004) customer variability access; Roth (2001) P^3 service design matrix; incorporated product (service complexity) and service delivery as the means of dealing with customer variability, and incorporated customer knowledge as the means to measure complexity based on the number and types of service providers, and service components required to satisfy needs
When to offer services	Access to services	Business hours Outside business hours	Time is a common measure, with time of day, number of days and days in the year generally used. However, this research uses time as determined by the business' *normal trading hours as defined by the business*. That is, when the business is open for trading and whether customers seek to communicate with them during business hours or out of business hours
Where to offer services	Customer service interactions	Online Self-service Call-chat Face-to-face	Roth (2001) P^3 service design matrix; Froehle & Roth (2004) customer contact archetypes. Incorporated the (geographic) proximity of onsite and offsite—changed the description to be same location or different location. Use of the technology assisted and human assisted models holding the polarities to create a service interaction matrix and interpret the combined effects of place and technology used to define four service interactions types
How these transactions occur	Customer channel	Business-to-consumer Business-to-business Business-to-government	Kalakota & Robinson (1998) and Boyer, Hallowell & Roth (2002) each provide a list of various buying segment types. The use of business-to-consumer and business-to-business transactions are sufficient for this research, as they allow the determination of transactions that are consumer transactions versus intermediate transactions, those where outputs from one organisation are not "consumed" by the end consumer, rather they are used as inputs into upstream supplier services
Who to offer services to	Customer loyalty	Repeat customer Referred customer New customer	Heskett et al (1994) and Lam et al. (2007) incorporate repeat, referral and new customers

How much the customer is willing to pay for the service	Willingness to pay	Gross amount paid Cost of service	Ng (2008), Sherman & Zhu (2006) and self-developed through industry experience; gross payment, payment for services and cost of services
Employee attributes	Physical characteristics	Age Gender Nationality	Avolio & Waldman (1994) and Gomez & Hernandez de Cos (2006) relates to the use of age. Age brackets are defined by those used by the ABS. Gender taken from Skirbekk (2003)
	Cognitive abilities	Qualification Experience	Taken from Wolff (2002), identified years of schooling and years of experience as a causal factor for service productivity; *Australian qualifications framework* used as the measure of schooling and qualifications and the determinant of the equivalency of years of work experience with skill level
	Psychosocial	Employee engagement	Taken from Kahn (1990). Survey instrument taken from Wilson (2009), used with no amendments
Supplier integration *What data to share*	Data structure	Unstructured Semi-structured Data standards	Taken from Swatman & Swatman (1991); Clifton & Thuraisingham (2001). Redefined terminology using data structure as the basis to differentiate various levels and provide unambiguous means of classifying data formats
How to share it	Data transfer mechanism	Offline Online FTP Transport Control Protocol Internet Protocol	Taken from Swatman & Swatman (1991); Postel & Reynolds (1985); self-developed based on industry experience
When to share	Availability of data	Synchronous Real-time Shared systems Asynchronous Ad-hoc On request Pre-defined	

Table 4-4 Summary of the variables for the SEPIA model

			Input		Output
	Dependent variable	**Categories**	**Volume**	**Value**	
Customer interface	Service complexity	Low	X		
		Medium provider	X		
		Medium component	X		
		High	X		
	~~Access to services~~	~~Business hours~~	~~X~~		
		~~After business hours~~	~~X~~		
	Customer service interaction	Online	X		
		Self-service	X		
		Call-chat centres	X		
		Face-to-face transactions	X		
	Customer channel	Business-to-consumer	X	X	
		Business-to-business	X	X	
		~~Business-to-government~~	~~X~~	~~X~~	
	Customer loyalty	New customer	X	~~X~~	
		Referred customer			X
		Repeat customer			X
	Customers' willingness to pay	Gross amount paid			
		Amount paid for service			X
Employee attributes	Physical	Age	X		
		Gender	X		
		Nationality	X		
	Cognitive abilities	Qualification	X		
		Experience	X		
		Position	X		
	Psychosocial	Employee engagement	~~X~~		
		Remuneration			~~X~~
		Incentive			~~X~~
Supplier integration	Data structures	Unstructured	X		
		Semi-structured	X		
		Data standards	X		

	Data transfer mechanisms	Offline	X	X	
		Online	X	X	
		FTP	X	X	
		Transport Control Protocol/Internet Protocol	X	X	
	Availability of data	Real-time	X		
		Shared systems	X		
		Ad-hoc	X		
		On request	X		
		Pre-defined times	X		
		Revenue			X
		Volume of customers			X

Legend – ~~X~~ indicates which variables were not applicable to the organisations in this study.

4.4 Management literature, stakeholder and SEPIA variable selection aligned

The variables for each of the stakeholders included in this research were obtained by conducting a multi-disciplinary review of management literature, as seen in Table 4–5. The yellow cells highlight the variables selected for each stakeholder, with the SEPIA model integrating the decisions made by each of the stakeholders into a firm-level productivity measure.

Marketing literature was used to determine the variables from a customer perspective, and captured at the point where the customer interfaces with the firm. The literature showed that the whole person and employee attributes are important to productivity in service and network-based firms, hence the extension of the variables used to measure labour productivity moves beyond the number of employees and number of hours worked. Operations management literature informs the variable selection for supplier and supplier integration. Supplier input dependent upon the number of service providers, the types of services provided and the technology and level of integration used to ensure the flow of information between each stakeholder.

Table 4-5 Variable selection aligned to stakeholder and management discipline

Firm (ANZSIC mode)	Marketing	Human resources	Operations management	Information communication technology	Finance	Management
SEPIA model (stakeholder decision making and resource integration)						
Individual	Customer	Employee	Supplier	Connection	Shareholder	Manager
Construct	Client interface	Employee attributes	Supplier input	Supplier integration	OUT OF SCOPE (Future research)	
Variables	Service complexity	Physical	Service providers	Data		
	Customer interface	Cognitive	Service types	Access		
	Customer Channel	Engagement	Technology	Integration		
	Customer loyalty					
	Willingness to pay					

4.5 Variable selection NEPIA model

The study of network productivity is in its infancy, and this research makes an attempt to explore the notion of network productivity in social context. Granovetter (1973, 1985), Salancik (1974) and Walter (2005) recommend using social network analysis as a tool to link micro and macro levels of social theory and Borgatti, Everett and Johnson (2013, p. 1) suggests social network analysis can be used in economics to examine "who sells to whom". Thus, laying the foundations for how resources are allocated, used and integrated across organisations to provide end-to-end service delivery. It is in this context that social network analysis is an appropriate tool in which to link the SEPIA intra-firm productivity , dyadic inter-firm productivity and the NEPIA whole of network productivity models. Consequently, the selection of variables for the NEPIA model is taken from academic literature on social networks.

In this research, the SEPIA model examines the effects of information convergence within organisational bounds intra- (albeit extended boundaries), while the NEPIA model examines inter- organisational productivity taking in the the whole network. I use social network analysis to examine the information flow based on the financial (value) and booking (customer) data from customer input to service delivery, and this underpins the primary measure of network productivity.

The unit of analysis and variable selection for the SEPIA model recognises the role each stakeholder (customer, employee and supplier) plays in the decision-making process and their participation in the service-delivery process. The inclusion of these three stakeholders has three effects. The first is that productivity is placed firmly in a social domain, as each stakeholder has a human element (Wiig 2003). According to Wasserman and Faust (1995), the study of social networks focuses on the relationships between actors rather than the entities themselves. Therefore, the relationship or the *space between two entities* becomes the focus and the unit of analysis in social networks, rather than physical quantities, as is currently the case. This is a profound paradigm shift from our current understanding of productivity and associated measures.

The second effect is the extension of the boundary of the firm. Traditional theories on firm boundaries share an implicit assumption of the firm as a unitary actor, aligning transactions with organisational forms in search of efficiency (Dobrajska & Larsen 2014). However, the inclusion of these three stakeholders challenges this assumption, as each stakeholder (customer, employee and supplier) makes decisions to serve their own interests and seeks to maximise their own efficiency. This requires service firms to respond to externalities in real-time (Eisenhardt 1989; Tushman & Nadler 1978; Walter 2005) and their capacity to do so is dependent on the social context in which they are embedded (Galaskiewicz & Zaheer 1999; Gulati 1999).

The third effect is the positioning of the firm within a network. Studies on social networks imply that the position of the firm within a network can be the basis on which inimitable and non-substitutable values are created, through network structure, network membership and tie modality and, as such, provide access to critical resources (Gulati 1999; Gulati et al. 2000). This, in turn, affects the flow of information, the level of dependence and influence the firm has on the rest of the network (Borgatti, Everett & Johnson 2013). In this research, I explore the network structure of the firms' position within the network as determinants and measures of network productivity.

4.5.1 Network structure

Network structure refers to the configuration of relationships that make up a network (Zukin & DiMaggio 1990). The ties between nodes represent the flow of information bounded by the customer and the customer input, the employees of the firm to the supplier. Granovetter (1973, p. 1361) presents a case where he argues the strength of the ties may be strong, weak or absent and their strength of interpersonal links is determined by the amount of time spent, the level of emotional intensity, intimacy (mutual confiding) and reciprocity.

Recent studies show a firm is able to improve performance by cooperating and sharing information with customers (co-creating value) (Lusch, Vargo & Tanniru 2009; Lusch, Vargo & Wessels 2008; Ng, Nudurupati & Tasker 2010) and other entities (suppliers) in the network (Agarwal & Selen 2009; 2011b; Gattorna 2010; Kalakota & Robinson 1998). Granovetter's (1973) measure of tie strength at a dyadic level is described for interpersonal ties are not directly transferrable to business relationships. Instead Powell (1990), Uzzi (1996), Rowley et.al (2000) suggest factors such as interaction frequency, level of resource commitment, equity arrangements, licensing, patenting and marketing agreements and the exchange of detailed proprietary information each contribute to the strong ties in business relations.

According to Gulati (1998) and Provan, Fish and Sydow (2007), the informational value flowing throughout the network is a result of how densely or sparsely connected the network is, and the benefits that accrue to the organisation as a result of the position it holds within the network. Therefore, network density, defined as the number of actual ties in a network (compared to the total number of possible ties) becomes a key measure of productivity for network-based firms (Burt 1992; Hanneman & Riddle 2005; Harary 1969; Pfeffer & Salancik 1978).

4.5.2 Network position

The position of a firm within the network determines the benefits likely to accrue to the firm, and is a result of how central the firm is in the network. The centrality measure of a firm is defined by the number of connections (ties) the firm has to other firms (nodes) in the network. There are conflicting views in the literature about the extent of the benefits that accrue due to the centrality of the firm's position within a network. On one hand, firms in a central position benefit because they are able to access information and resources through their position, while on the other firms in a central position bear the cost of coordinating communication and activities between firms in the network (Gargiulo & Benassi 2000; Leana & Van Buren III 1999; Podolny & Baron 1997). However, the common view is that strong, cohesive ties results in increased trust, in turn facilitating the exchange of information, creation of obligation and imposition of sanctions for those failing to abide by social norms (Burt 1987; Coleman 1998; Das & Teng 1998). An alternate position is that firms in a broker position with access to heterogeneous networks benefit from information diversity, which provides the broker with the opportunity to "facilitate transactions between other actors lacking access to or trust in others" (Marsden 1982, p. 202).

Studies examining negative aspects of a firm's position within a network include avoidance (Labianca et al. 1998), hindrance and adversarial relations (Sparrowe et al. 2001), and issues related to industry fragmentation (Provan et al. 2007). Additionally, scholars recognise the position of isolation and there is general agreement that they gain or provide little benefit and may find themselves disenfranchised and lose connection to the network over time (Burt 1992; Onyx & Bullen 2000; Onyx et al. 2007).

Social network analysis is grounded in graph theory, mathematical structures used to model the relations between two or more objects (Pinheiro 2011). It was discussed in Section 2.4.5 that network density is a measure adequately describing how the network is structured. The firm's position within the network is determined by the degree of centrality. Four factors measure centrality, listed in Table 4-6 (Borgatti et al. 2006; Borgatti et al. 2013).

- *Degree centrality* measures the number of ties the given organisation has access to.
- *Betweeness centrality* measures the number of nodes requiring traversal to reach other nodes, and is indicative of intermediaries (Provan, Fish & Sydow 2007).

- *Closeness centrality* measures the distance between nodes with central organisations having short paths to all other organisations in the network (Provan, Fish & Sydow 2007).
- *Eignvector centrality* is the measure of the number of nodes adjacent to each other, with each node weighted by level of centrality. This measure is an indication of how popular or risky a node holding a central position is, and the level of impact to the whole network should this node be removed (Borgatti et al. 2006).

Table 4-6 Variables to be applied to the NEPIA model

	Construct	Measure	Source	Role grouped as collective customer, DMU firm, suppliers (nodes)	Ties Interactions (volume of customers)
NETWORK STRUCTURE	Network density	Number of ties in the network proportional the total number of possible ties	Taken from Burt (1992); Hanneman & Riddle (2005); Harary (1969); Pfeffer & Salancik (1979)		X
NETWORK POSITION	Degree centrality	Number of ties a given node has	Borgatti, Everett & Johnson (2013); Wasserman & Faust (1994)		X
	Betweeness	The number of nodes requiring traversal to get between two node sets	Borgatti, Everett & Johnson (2013); Provan, Fish & Sydow (2007)	Customer DMU firm Suppliers	X
	Closeness	Distance between other nodes	Okamoto, Chen & Li (2000); Borgatti, Everett & Johnson (2013); Provan, Fish & Sydow (2007)	Customer DMU firm Suppliers	X
	Eignvector (popularity- measure of risk)	Number of adjacent nodes to each other with each node but weight by its centrality	Borgatti, Everett & Johnson (2013)	Customer DMU firm Suppliers	X

Placing productivity in a social domain and using the standard measures of social network analysis opens the way for the effects of social phenomena such as trust (Currall & Inkpen 2002; Galaskiewicz & Zaheer 1999; Zaheer et al. 1998); power (Emerson 1962) and friendship (Tichy et al. 1979) to be used as factors influencing productivity for network-based firms.

The NEPIA model is exploratory and covers the connections between and across industry sectors.

In this chapter, the selection of variables for the SEPIA and NEPIA models is informed by a multi-disciplinary review of academic literature and the researcher's prior experience. The variables for the SEPIA model are determined by the roles of each stakeholder, limited in this research to customers, employees and suppliers. Customer inputs and outputs are determined by six decision variables that occur as customers interface with the firm. Employees are viewed holistically, including physical, cognitive and psychosocial aspects. The link to suppliers is determined by enabling technologies and the integration of technology is defined by data structures, transfer mechanisms and synchronicity of communication between the organisation and their suppliers. The inclusion of stakeholders (humans) places productivity in a social domain, thus the variables for the NEPIA model is associated with social network analysis. The measures for the whole of network NEPIA model includes the structure of the network-based on the density of the network, the firm's position within the network (centrality) and thethe firms level of embeddedness within the network.

The next chapter examines selection of mathematical techniques to explore the SEPIA NEPIA models.

Chapter 5: Selecting Mathematical Techniques

"*measurement is key to science and is the basis of shared objectivity*"

(Spohrer 2014 p.2)

The study of micro firm-level data from different perspectives gives rise to a deeper analysis of productivity (Avkiran 1999; Manzoni 2007) and captures the dynamics and interplay between variables. However, a lack of firm-level data has inhibited the alignment of productivity measures from a firm to an industry and economy level (Morita & Avkiran 2009; Nataraja & Johnson 2011; Peacock et al. 2001). The definition of service productivity used here is "the result of the aggregate of decisions made by each of the stakeholders," and is based on transactional data generated by the inputs and actions of three out of five of the stakeholders. Given that the inputs and actions of the stakeholders are the determining factors of service productivity, the appropriate unit of analysis for defining inputs and outputs for service firms is the stakeholder level as depicted in the SEPIA model in Figure 5-1.

Using decisions made by each of the stakeholder groups is a novel approach to examine firm productivity. It captures the dynamism of the interactions that occur between stakeholders as well as stakeholders and the firm, rather than viewing the process as fixed in a production unit. Extending the boundary of the firm to include stakeholders consequently shifts productivity to the social domain. This is a profound paradigm shift in our understanding of productivity and associated measures. Ultimately, the SEPIA model presents an opportunity to enrich the study of productivity by defining variables and establishing units of measure that enhance the study of micro-level data from different perspectives.

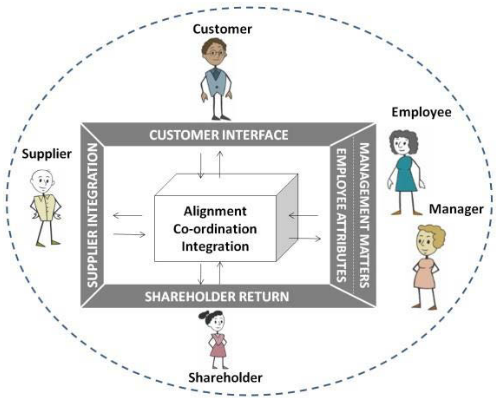


Figure 5-1 SEPIA model

The literature also acknowledges that firms do not operate in isolation; rather, service firms operate in differently configured networks to create value and deliver end-to-end services to customers (Dominici 2008; Gattorna 2010; Green & Agarwal 2009). The NEPIA model places service firms in a network and the inclusion of stakeholders in a social network. This is the basis on which productivity for network-based firms is explored in this research.

This chapter is structured into four sections as illustrated in Figure 5-2. Section 5.1 reviews frontier analysis. Frontier analysis enables the visualisation of an efficiency frontier for decision-making units included in a study. The distance of inefficient firms from the efficiency frontier is also estimated. The mathematical techniques for the SEPIA and NEPIA model are estimated separately. In Section 5.2, DEA is presented as a viable mathematical solution to measuring productivity for service firms. Section 5.3 examines alternatives to DEA, and provides justification for its selection. Section 5.4 explores the use of social network analysis as an appropriate method for measuring network productivity at a whole-of-network level.

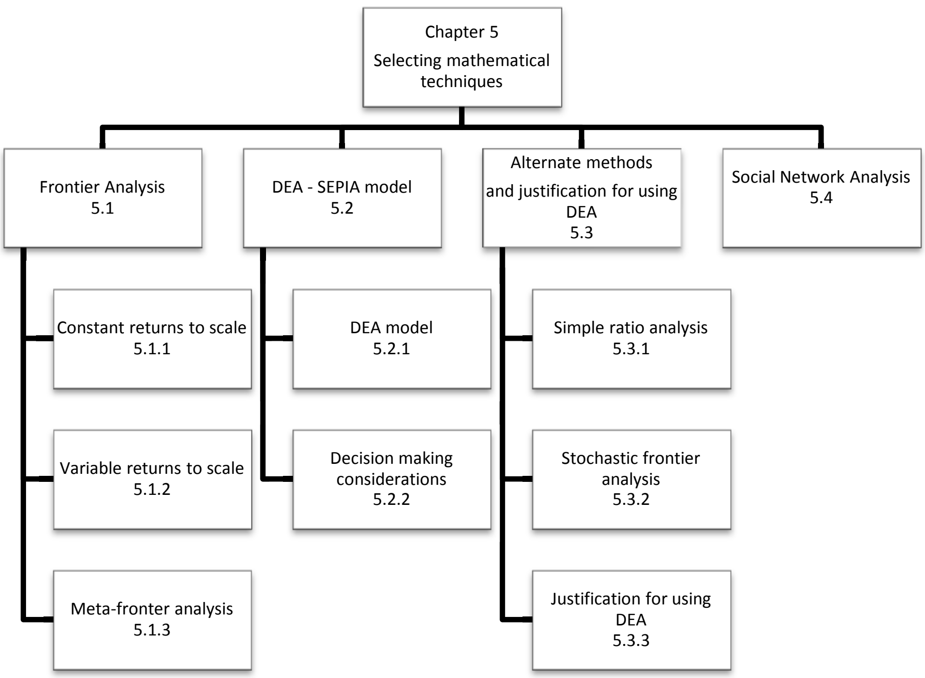


Figure 5-2 Outline of Chapter 5

5.1 Frontier analysis

The most common approach to estimating levels of productivity and efficiency for firms assumes homogeneity among decision-making units. In DEA, decision-making units represent any business operation, process or entities under examination (Zhu 2014), and are based on the assumption that all firms have access to the same production technology (O'Donnell et al. 2008). The production technologies available to firms are referred to as “technology sets”, and these differ depending on the physical, human and financial stock available to them (O’Donnell, Rao & Battese 2008, p. 231). Under these assumptions, a single frontier is created, restricted by the available technology set. Next, three examples are provided, the first showing a frontier exhibiting constant returns to scale, the second showing variable returns to scale, and the third example uses meta-frontier analysis that relaxes the assumption of decision-making homogeneity-bounded technology sets.

5.1.1 Constant returns to scale

A simple example showing the benefits of frontier analysis and highlighting the characteristics of a frontier exhibiting constant returns to scale using the data is found in Table 5-1, for service providers SP1 through to SP5.

Table 5-1 One input and one output exhibiting constant returns to scale

Points	SP1	SP2	SP3	SP4	SP5
Input (x)	12	2	4	10	11
Output (y)	8	2	4	4	3

A constant return to scale model assumes a proportional relationship between inputs and outputs. The efficiency frontier for constant return to scale is depicted in Figure 5-2 showing the service providers (SP1 through to SP5) plotted on a graph. A frontier showing a constant return to scale has a distinguishing feature; a change in inputs results in a proportional change; a change in outputs results in the frontier being a straight line (Coelli et al. 2005). Organisations that sit on the frontier are considered efficient, and those located below the frontier are inefficient—that is, they show an ability to increase the quantity of their outputs by using the same number of inputs, or they produce the same level of outputs using fewer inputs. In Figure 5-2, service providers SP2 and SP3 are efficient and SP1, SP4 and SP5 are inefficient. SP4 uses $x10$ units of input to produce $y4$ units of output. The green arrow highlights the point where $x10$units should be able to produce $y10$ outputs, also referred to as output augmentation (Cook & Zhu 2013). Alternatively, SP4 should be able keep the same level of output unit ($y4$) and reduce the number of input units used from $x10$ units to $x4$ units, depicted in Figure 5-1 by the red arrow. Frontier analysis, when used as a benchmarking tool, also serves to identify the closest peer among the set of peers analysed, that can be used for comparative purposes (Cook & Zhu 2013). Figure 5-3 indicated that the SP3 is the closest peer to SP4, and therefore the most appropriate peer to use for comparison.

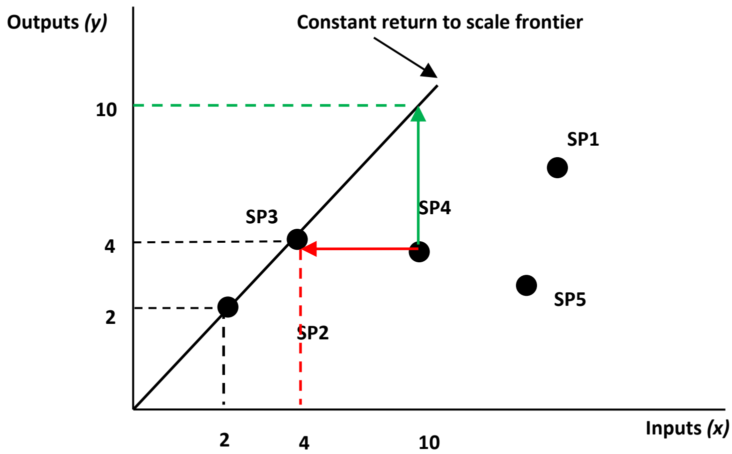


Figure 5-3 Conceptualisation of constant return to scale frontier

In contrast, variable returns to scale and a change in the number of inputs do not result in a proportional change in the number of outputs produced. Variable returns to scale are discussed next.

5.1.2 Variable returns to scale

The data for SP1 through to SP5 shown in Table 5-2 is used to highlight the characteristics of a frontier exhibiting variable returns to scale.

Table 5-2 One input and one output exhibiting variable returns to scale

Points	SP1	SP2	SP3	SP4	SP5
Input (x)	12	2	4	10	11
Output (y)	8	2	4	4	3

Variable returns to scale frontiers are created in segments by linking each of the efficient service providers. The frontier is formed with lines connecting each segment with a different gradient (Coelli et al. 2005; Cook & Zhu 2013), and the slope of the line indicates either an increasing, constant or decreasing return to scale, as shown in Figure 5-4.

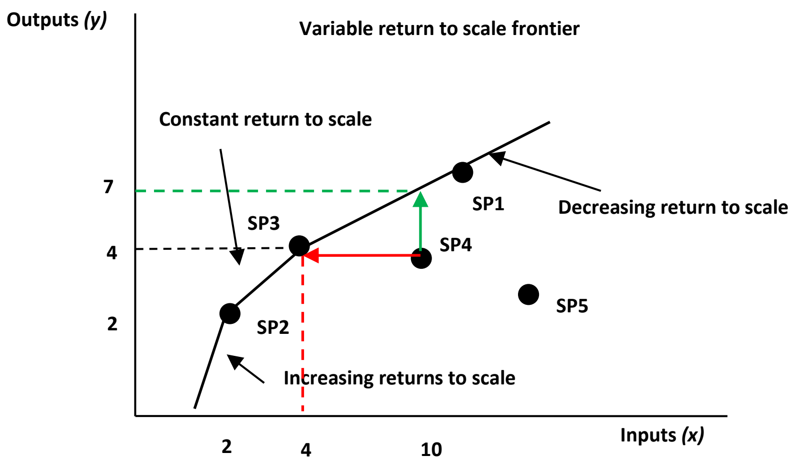


Figure 5-4 Conceptualisation of variable return to scale frontier

According to Cook and Zhu (2013), the calculation of it is necessary to sum the lambda ($\sum \lambda_j$) weight values to calculate whether the return to scale is increasing, constant or decreasing. The lambda weights are discussed in more detail in Section 5.2.1. However, if the summation of the lambda weights is less than 1 ($\sum \lambda_j$<1), then the decision-making unit exhibits increasing returns to scale. Increasing returns to scale indicates that a change in inputs yields a proportionally higher increase in outputs (quantity or quality). Efficient service providers that have a sum of lambda score equal to one (λ_j =1) exhibit a constant rate of return. If the summation of the lambda weights is greater than 1 ($\sum \lambda_j$>1) then the decision-making unit exhibits a decreasing return to scale.

Decreasing returns to scale indicate that a change in input produces a decrease in the level of output.

The above illustrates a simple one input, one output example. However, the calculation becomes more complex when multiple inputs are used to produce multiple outputs. The notation in Section 5-1 frontier analysis is based on the assumption that firms are homogenous and have access to the same technology set. However, if organisations in the sample operate in different environments, they have access to different technology sets. Such technological heterogeneity is attributed to the social, physical and economic environments in which the firms operate (Coelli et al. 2005). Where this is the case, meta-frontier analysis may be used. This is discussed next.

5.1.3 Meta-frontier analysis

The technology available to firms is dependent on the environment in which they operate. The choice of resources (technology sets) made by organisations differs, and is restricted to the physical, human and financial stock available to them. Consequently, the configuration of resources is subject to the available machinery, quality of labour and resource endowments of the area in which they are located, as well as the regulatory and environmental constraints that prevent organisations from selecting from the full range of available input-output combinations (O'Donnell et al. 2008). To accommodate such differences, Battese and Rao (2002), Battese, Rao and O'Donnell (2004) and O'Donnell et al (2008) developed meta-frontier analysis. This allows for the evaluation and comparison of the efficiency of firms operating in different environments. Meta-frontier analysis involves estimating different frontiers for groups bounded by "restricted technology sets and where the restrictions are derived from the lack of economic infrastructure and/or other characteristic of the production environment" (O'Donnell et al. 2008, p. 232).

The efficiency of individual production units can be assessed relative to the group frontier in which it belongs. According to O'Donnell, Rao and Battese (2008) the distance between the firm and group frontier identifies areas of improvement that may occur within an individual firm, and are as described in Sections 5.1.1 and 5.1.2. Additionally, the production environment for each group can be assessed by measuring the distance between the group frontier and the meta-frontier. This is referred to as the technology gap ratio, and its distance is illustrated in Figure 5-5 by the blue arrow (O'Donnell et al. 2011; O'Donnell et al. 2008). The technology gap ratio requires changes to the environment in which the firm operates, for firms to catch up, which may require government intervention or government programmes (O'Donnell, Rao & Battese 2008).

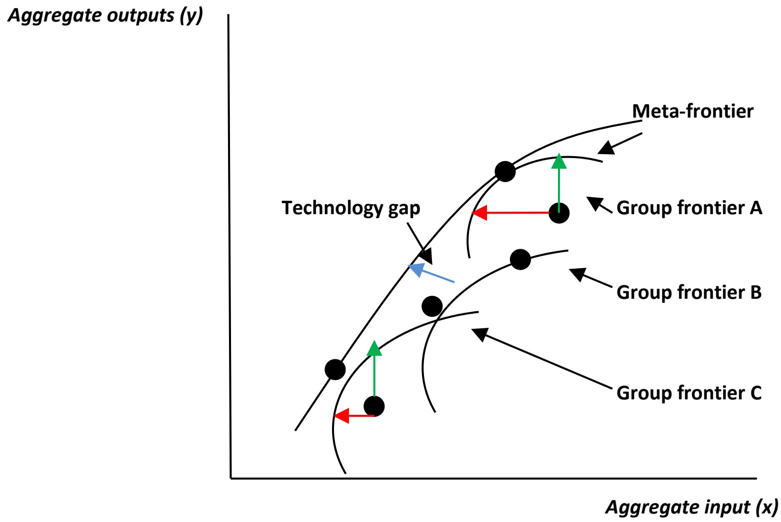


Figure 5-5 Meta-frontier and group frontiers

Examples of meta-frontier analysis examining decision-making units operating under different technology sets are found in the literature. For example, Rao, O'Donnell and Battese (2003) apply meta-frontier analysis to organisations operating in different geographical areas to illustrate inter-regional productivity differences. Naceur, Ben-Khedhini and Casu (2011) examine banks operating in different markets. Bartual, Garcia-Martin and Garrido (2012) test meta-frontier analysis across franchise firms operating in different service sectors, using financial measures.

5.2 DEA–SEPIA model

DEA is a mathematical programming technique used to measure the relative efficiency of decision-making units that use multiple inputs to produce multiple outputs in a single integrated model (Charnes, Cooper & Rhodes 1978; Cook, Tone & Zhu 2013). DEA is non-parametric and there is no need to specify the functional relationships between the inputs and outputs. (Coelli et al. 2005; Cooper et al. 2011; Cooper et al. 2006; Lai et al. 2011). DEA as a solution was first presented in Farrell's (1957) seminal paper, in which he describes how DEA can be used to calculate efficiency when multiple inputs are used to produce one output, and where the relationship between them are proportional (Cook et al. 2013; Farrell 1957; Manzoni 2007; Ray 2004). However, it was not until Charnes, Cooper and Rhodes (1978b) extended the formulation to cater to multi-factor productivity and exhibit variable returns to scale that DEA began to gain wider acceptance (Charnes et al. 1978b; Ray 2004). DEA has a number of available models and orientations, and therefore may be adapted to various conditions.

5.2.1 DEA models

The selection of DEA models depends on what the analyst is looking to achieve, and therefore clarity about the purpose of the study is important (Avkiran 2006; Cook & Zhu 2013). According to Zhu (2013), the model selection is based on a model orientation and a model type. A model may have either an input or an output orientation. Input-oriented models seek to minimise the input set for a given level of output (Cooper, Seiford & Zhu 2011). Conversely, the output orientation maximises the potential output for a given set of inputs. The model type determines whether a constant return to scale or a variable return to scale is assumed. A constant return to scale produces a frontier in a single line, and is where the input-oriented efficiency scores are reciprocal to the output oriented score. Variable return to scale is where an increase in input does not result in a proportional change in output (Coelli et al. 2005; Cook & Zhu 2013; Emrouznejad et al. 2010; Emrouznejad & Witte 2010). Lee, Yen and Othman (2011) present nine DEA models that have been applied in a variety of situations. Each model is listed in Table 5-1, with a brief explanation of its features and the authors attributed to each.

Table 5-3 Nine DEA models (adapted from Lee, Yen & Othman 2011)

Model	DEA models	Explanation	Authors
1	CCR Model Input oriented with constant return to scale	Input oriented with constant return to scale	Charnes, Cooper & Rhodes (1978)
2	BCC model Variable return to scale	Variable return to scale	Banker, Charnes & Cooper (1984)
3	Multiplicative model	Replaces the piecewise DEA frontier to a Cobb-Douglas (=log linear) frontier	Banker & Maindiratta (1986)
4	Additive model	Identifies input excess and output shortfalls	Charnes et al. (1985)
5	Cone ratio model	Link with multi-criteria analysis	Charnes et al. (1989)
6	Assurance region model	Includes *a priori* information, such as expert opinion, opportunity cost to restrict the results to the single best performing DMU	Thompson, et al. (1990)
7	Super-efficiency model	Gives efficiency scores by eliminating the data on the DMU to be evaluated	Andersen & Petersen (1993)
8	Two stage model (Network DEA)	Inputs and outputs are shared between two stages of production	Cook & Zhu (2013); Fare & Grosskopf (2000) ; Fare, Grosskopf & Whiitaker (2007)
9	Dynamic DEA	Model showing effects of different periods, including carryover effects	Tone & Tsutsui (2014)

The output measures used in this research are indicative of the value that each customer assigns to the service and level of customer loyalty that accrues from interacting with the organisation. The subjective nature of both variables means that a change in the number of customers (inputs) will result in a disproportionate change in the outputs of value and loyalty as customers. Therefore, an input-oriented variable return to scale model is chosen for this research, the mathematical representation of which is expressed in Equation 5-1.

$$\theta^* = \min \theta$$
subject to
$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{io} \qquad i=1,2,\ldots,m;$$
$$\sum_{j=1}^{n} \lambda_j x r_j \geq y_{ro} \qquad r=1,2,\ldots,s; \qquad \textbf{Equation 5}$$
$$\sum_{j=1}^{n} \lambda_j = 1$$
$$\lambda_j \geq 0 \qquad j=1,2,\ldots n;$$

(Cook & Zhu 2008, p. 37)

Where DMU*o* represents one of the *n*DMUs under evaluation and x_{io} and y_{ro} are the *i*th input and *r*th output for DMU*o,* respectively. λ_j are the unknown weights, where *j=1* …, n corresponds to the DMU number.

5.2.2 Decision-making unit considerations

Consideration of the selection, characteristics and number of decision-making units to include in the study is important. The literature implies that decision-making units should be homogenous and that the number included is relative to the number of inputs and outputs (Avkiran 2006; Coelli et al. 2005; O'Connell & Warnock-Smith 2013). According to Haas and Murphy (2003), the assumption of decision-making unit homogeneity is based on three conditions: the decision-making units should be engaged in the same process; the applications of the input and output measures should apply equally; and lastly, decision-making units should operate under the same conditions.

Instances of the application of DEA where decision-making units are homogenous are plentiful, and can be found across a number of service industries including agriculture, manufacturing and financial services (Abbott et al. 2011; Avkiran 2006), health (Rouse & Swales 2006)and education (Abbott & Doucouliagos 2002; Lau et al. 1991; Ray 2004). Specifically, DEA has been applied in the travel and tourism industry (Sigala 2004; Wober 2001, 2008) with examples from transportation (Adler & Golany 2001);

accommodation (Sigala 2004; Wober 2008); airlines (Lee & Worthington 2010), and retail travel agents (Fuentes & Alvarez-Suarez 2012; Sellers-Rubio & Nicolan-Gonzalbez 2009).

However, studies exist in which the decision-making units are non-homogenous. These include Fizzel and Nunnikhoven's (1993) comparison of private and non-private nursing homes; Zhu's (2000) application of DEA, comparing the financial data of Fortune 500 companies with decision-making units in the study from different industry sectors; Haas and Murphy's (2003) examination of the performance of municipalities' solid waste recycling and disposal channels; Ray's (2004) study of the performance of public schools across different socio-economic groups; and Atici's (2012) assessment of agricultural farms in Turkey. Zhu's (Zhu 2000) study is of particular interest as it is the first in which decision-making non-homogeneity is the result of firms belonging to different industry sectors. This research follows Zhu's precedent. Mentioned previously in Section 5.1.3, meta-frontier analysis has been used to study heterogeneous DMUs, where heterogeneity is the result of DMUs operating under different technology sets.

The number of decision-making units to include in any study is a topic of interest (Avkiran 2006; Haas & Murphy 2003). Some literature suggests that there is a correlation between the number of inputs and outputs and the number of decision-making units included in the study. Haas and Murphy (2003) argue that the level of discrimination between efficient and non-efficient units is dependent upon this. They recommend using large numbers of decision-making units, as the larger the population the better the discriminatory power (Haas & Murphy 2003). However, there is little consensus, as Boussofiane, Dyson and Thanassoulis (1991) suggest the number of decision-making units should be a multiple of the number of inputs and outputs, arguing that this enables flexibility in the assignment of weights to input and output values. Golany and Roll (1989) specify that the number of decision-making units should be twice the number of inputs and outputs, while Bowlin (1998) recommends three times the number of inputs and outputs. Dyson et al. (2001) provide an alternate view, suggesting two times the product of the number of inputs and outputs. The lack of consensus remains, and DEA models have been created to help overcome the decision-making unit data set size issue (Andersen & Petersen 1993; Doyle & Green 1994; Rousseau & Semple 1995).

Golany and Roll (1989) caution against using a large number of decision-making units. Another downside to using large numbers of decision-making units is the requirement for more complex computations (Golany & Roll 1989; Haas & Murphy 2003). Cook and Zhu (2013) posit that the number of decision-making units may be immaterial as DEA is a frontier-based linear programming technique based on optimisation, not a statistical regression model. They explain that DEA focuses on individual performance rather than performing statistical regression analysis, where the average behaviour of each decision-making unit is estimated. Hence, it is meaningless to apply the sample size requirements of regression analysis to DEA. In this research I have taken the latter view, given the main aim of this research is the operationalisation of the SEPIA model rather than its optimisation. My research includes a sample of 14 decision-making units.

Weaknesses of DEA found in the literature revolve around two topics: the non-statistical nature of DEA, and its susceptibility to noise. While there are conflicting viewpoints on whether DEA has sufficient statistical properties, the ability of DEA to enable robust hypothesis testing is also questioned (Bogetoft et al. 2008). Bogetoft and Otto (Bogetoft & Otto 2011) claim that DEA is considered a non-statistical approach, and does not easily allow for true hypothesis testing. However, Banker and Nataraja (Banker & Nataraja 2011, p. 272) disagree, arguing that “DEA is a full-fledged statistical methodology, based on the characterisation of the DMU efficiency as a stochastic variable.” Regardless of DEA’s level of statistical credibility, this limitation is minimised as Bogetoft and Otto (Bogetoft & Otto 2011, p. 155) state “that interesting insights can arise from the use of DEA models without the heavy use of statistical testing.” Therefore, this is not considered a weakness here as in this research there are no hypotheses being tested.

The second limitation stems from DEA’s susceptibility to noise. Noise is a measurement error, limiting the accuracy or generalisability of the results. Management error, equipment failure, errors in measuring variables in the model, management incompetence and external environmental factors may be the cause of statistical noise (Fried et al. 2002). A number of proposals have been suggested to identify the impact that statistical noise has on results. These include using a three-stage DEA and stochastic frontier analysis approach (Fried et al. 2002), adjusting inputs and outputs upwards or adding a new variable, AdjFactorNoise, with the percentage of upward adjustment (Avkiran 2006). According to Fried et al. (2002), using the three-stage approach enables the identification of noise resulting from endogenous and exogenous factors.

5.3 Alternate methods and justification for DEA

This section considers two mathematical methods used in economic analysis that are potential alternatives to DEA. These are simple ratio analysis and stochastic frontier analysis.

5.3.1 Simple ratio analysis

Simple ratio analysis is a possible alternative to DEA. Ratio analysis is the comparison of two variables, one input and one output, and does not involve mathematical programming to organise the ratios into aggregate measures (Manzoni 2007; Peacock et al. 2001). The selection of variables depends largely on the availability of data and the intended breadth of analysis, as the full range of interactions between all inputs and outputs are not taken into consideration (Manzoni 2007). Therefore, under conditions where multiple inputs are used to produce multiple outputs, it is likely that multiple ratios will be required to adequately complete the analysis. According to Lewin, Morley and Cook (1982) the comparative assessment of performance becomes increasingly difficult where a decision-making unit ranks highly on some measures and low on others. In these situations, it is not possible to calculate ratios unless a relative weighting or adjustment is assigned to each variable (Zhu 2014).

The use of ratios on their own is not a true indication of performance (Coelli et al. 2005; Johnson & Jones 2004). According to Johnson and Jones (2004), ratio analysis requires a point of comparison and depending on the complexity of variables and the number of decision-making units used may not accurately reflect the potential productivity of an operation. The determination of the impact each variable has on efficiency may require the use of other statistical methods, such as regression or variance analysis (Peacock et al. 2001).

In general, simple ratio analysis is a viable option given the ease with which it can be calculated and results interpreted (Manzoni 2007). However, a study by Lewin, Morley and Cook (1982) found DEA to be superior to ratio analysis on two fronts. First, DEA was able to compare all input and output variables and determine which combinations of inputs and outputs were most efficient. Second, DEA was also able to find the source(s) or inefficiency and identify the closest peer DMU among the data set that should be used to measure the comparative efficiency of purposes. According to Haas and Murphy (2003), other benefits of DEA are the identification and measure of causal relationships between variables, the detection and measurement of the impact of new technologies and production relationships. Further, Boussofiane, Dyson and Thanassoulis (1991) claims that DEA is also able to assist with resource allocation decisions, target setting, identification of efficient operating practices and strategies and monitoring changes in efficiency levels over time.

5.3.2 Stochastic frontier analysis

Stochastic frontier analysis is an alternative frontier estimation method that employs advanced econometrics techniques. Stochastic frontier analysis assumes a functional form for the relationships between inputs and outputs (Coelli et al. 2005). The functional form is specified even if the parameters of the function are unknown, which makes the computations more difficult (Coelli et al. 2005). Methods to test efficiency may be either parametric or non-parametric. Different algebraic forms give rise to different models, such as linear, Cobb-Douglas, quadratic, normalised quadratic, translog, generalised Leontief and constant elasticity of substitution (Coelli et al. 2005; Manzoni 2007).

Stochastic frontier analysis constructs a smooth parametric frontier, which may show an inappropriate technology. The stochastic frontier analysis model can be divided into three components: a deterministic component (usually reflecting diminishing returns to scale); a factor attributed to measurement error (noise); and a component highlighting inefficiency (Coelli et al. 2005; Jacobs 2000). A distinct advantage of using stochastic frontier analysis is the ability to deal with statistical noise, i.e., measurement errors. However, two distinct disadvantages are the volume of data required to draw meaningful conclusions, and the smoothing of the parametric frontier resulting in inappropriate technology assumptions.

5.3.3 Justification for using DEA

DEA is described in Section 5-1, and, as with any mathematical model, has strengths and weaknesses. These are presented with the justification for using DEA.

There are a number of advantages to using DEA over other methods. First, DEA has been extensively used for benchmarking and productivity analysis across a wide range of industries, with examples of its application in service industries provided in Section 5.1.3. The second advantage is that the non-parametric nature of DEA means that there are no preconceived structures requiring imposition on the data (Coelli et al. 2005). Therefore, it is possible to determine and construct the data structures in accordance with the needs of the analyst (Coelli et al. 2005; Cook & Seiford 2009; Cook & Zhu 2008). The third advantage is that there are no requirements for DEA to have *a priori* knowledge or assignment of weights for the model. Where weights are not specified, the results presented are legitimate, albeit conservative (Avkiran 2006; Coelli et al. 2005).

Additionally, DEA has been found superior to both ratio analysis and regressions using peer-to-peer analysis. DEA incorporates multiple inputs and outputs into the numerator and denominator of the efficiency ratio (Avkiran 1999; Fitzsimmons & Fitzsimmons 2004; Manzoni 2007), and therefore is seen to complement simple ratio analysis (Oral, Kettani & Yolalan 1992). DEA uses individual peer-to-peer comparisons, rather than statistical regression averages, which may be irrelevant to the decision-making unit (Cook & Zhu 2013; Manzoni 2007).

The comparison and benchmarking of individual decision-making units allows the efficient identification of decision-making units. Further, DEA is able to specify closely performing peer decision-making units as well as highlighting specific areas of the business that require improvement. Consequently, DEA can be used as a decision support tool (Avkiran 2006; Coelli et al. 2005; Cook, Tone & Zhu 2013).

Twelve strengths of DEA are presented below (Charnes et al. 1994, p. 8):

1. The focus is on individual decision-making units, in contrast to the population averages.
2. Each decision-making unit has a single aggregate measure for the utilisation of input factors (independent variables) to produce desired outputs (dependent variables).
3. DEA can simultaneously utilise multiple inputs and outputs, each stated in different units of measurement.
4. Adjustments can be made for extraneous variables.
5. Categorical (dummy) variables can be included.
6. Computations are value-free and do not require specification or knowledge of *a priori* weights of prices for the inputs or outputs.
7. There is no restriction on the functional form of the production relationship.
8. DEA can accommodate judgement when desired.
9. DEA can produce specific estimates for desired changes in inputs and/or outputs for projecting DMUs below the efficient frontier onto the efficient frontier.
10. Results are pareto-optimal.
11. The focus is on revealed best practice frontiers rather than central tendency properties of frontiers.
12. It satisfies strict equity criteria in the relative evaluation of each decision-making unit.

Lastly, DEA software is available, which removes the computation complexities enabling the implementation of DEA without knowing the algebraic form of the relationships between inputs and outputs, or having to assign weights (Coelli et al. 2005; Manzoni 2007). These features make DEA more accessible to business managers, and therefore more likely to be adopted as a decision support tool if the model is seen to be realistic and useful (Manzoni 2007).

5.4 Social Network Analysis–NEPIA model

Networks are a result of a number of nodes connected together by ties, interactions and relationships (Borgatti et al. 2013; Granovetter 1973, 1985; Leonard & Onyx 2003). The importance of networks gaining access to valuable resources and providing opportunities and risk was discussed in Chapter 2. Social network analysis examines the entire structure of a network or sub-groups and constituents. Nodes can be individuals or groups of individuals sharing common characteristics (Borgatti et al. 2002; Borgatti et al. 2013; Knoke & Yang 2008). According to Scott, Baggio and Cooper (2008), two characteristics differentiate social network analysis from other methodologies. The first is the focus on the relationship that exists between the actors, and the second is the emphasis on the interactions between organisations (actors), rather than a focus on what happens within the organisation (intra-organisation), which is examined in this research in the SEPIA model.

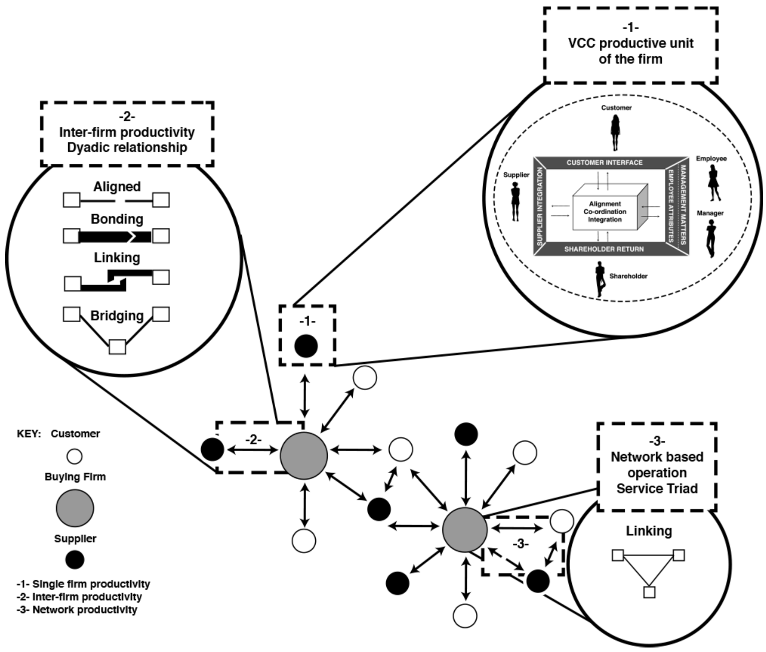


Figure 5-6 Whole-of-network nodes, ties and relationships

There are a number of advantages of using social network analysis to explore productivity for network-based firms. First, social network analysis enables studies to be performed on multiple levels, namely the individual (customer, employee and supplier), node or firm level (as indicated by -1 in Figure 5-4), sub-group, either a dyadic (indicated by -2 in Figure 5-4), triad (indicated by -3 in Figure 5-4), or another yet-to-be specified configuration or the whole-of-network, illustrated in the NEPIA model. Configurations may be based on collectives, defined by the analyst such as customers, organisations or specific network configurations, for example dyad, triad, pendant, circle, hub and spoke or whole-of-network, as is the case in this research. The whole-of-network includes customers, firms and suppliers connected by customer, information and financial flows across each entity. In addition to the virtual grouping of nodes, it is possible to position each node on a geographic map using geo-location data. This provides the opportunity to determine the importance of geography or location to network productivity.

Social network analysis is a suitable additional tool to DEA, as DEA assigns an efficiency score to the decision-making unit (aggregate of individual stakeholders) (node) for a single entity or organisation (SEPIA model) whilst social network analysis examines the relations, interactions and flows that eventuate from those decisions and is able to capture the relationships, interactions and flows across the whole network (NEPIA model). Social network analysis in this context may provide causality or an explanatory power based on social phenomena to productivity for service and network-based firms (Ying & Xiao 2012). Additionally, taking a social network approach contributes to knowledge of productivity that occurs as a result of organisations working together in different network configurations or a whole of network level where organisations transcend geographic or industry boundaries (Borgatti et al. 2013).

Data visualisation is another strength attributed to using social network analysis, and is a mechanism for interpreting abstracted data into a schematic form. The effective use of data visualisation tools enables a qualitative understanding that can be clearly communicated and is easier to interpret (Freidman 2008). According to Borgatti, Everett and Johnson (2013), constructing a visual representation of network data is one of the first things most people do, as it highlights what people do rather than what they say. A network diagram consists of a set of points representing nodes and a set of lines representing ties. Colour, size and shape can also be used to communicate information about the nodes and the relationships between them (Borgatti, Everett & Freeman 2002). UCINET's NETdraw function uses three criteria that are optimised simultaneously to graphically map the network. The first criterion is based on the path distance between nodes. The second criterion is that nodes should not appear too close together. The third criterion implements a preference for equal length lines, making it easier to identify symmetries while obscuring interpretability (Borgatti, Everett & Johnson 2013). There is also flexibility where nodes in the network may be positioned in a specific formation by the analyst, or alternatively, NETDRAW will create a random graph where the network formation is based upon a probability of distribution of the network. Social network analysis provides a suitable approach in which to explore the area of network productivity, and in future research incorporate aspects of social phenomena.

In this chapter I presented the choice of mathematical techniques used in this research. First, an overview of piecewise frontier analysis was provided before discussing DEA. DEA was presented, showing the various available models and orientations. Special consideration to the decision-making units was discussed, due to the contradictions found in the literature in relation to the need for homogeneity among the decision-making units and the perceived need for a mathematically calculated sample size. Limitations to DEA were put forward before examining alternate methods of analysis, followed by the justification for using DEA as the mathematical technique for the SEPIA model. The mathematical technique recommended to explore the NEPIA model (whole network study) is social network analysis. An overview of social network analysis and the visualisation tools used to graph the network provides the mechanism for productivity for service and network-based firms to be positioned in the social domain. Other methodological considerations were examined, specifically the use of survey questionnaires for the collection of employee engagement data and the use of semi-structured face-to-face interviews with experts in the field for model validation.

Chapter 6: Data Collection and Preparation

Consistent with the fourth stage of Winston's (1991) generalised model formulation, this chapter describes how data was collected and prepared. In Section 6.1, the unit of analysis is defined and the reason for the selection of the Australian tourism, travel and hospitality industry explained. Section 6.2 describes the data collection processes used to collect qualitative and quantitative data from retail travel agents and accommodation providers. Section 6.3 explains the data preparation methods for SEPIA using DEA, and NEPIA using SNA, and is treated separately. This section also discusses specific data requirements and file formats for each.

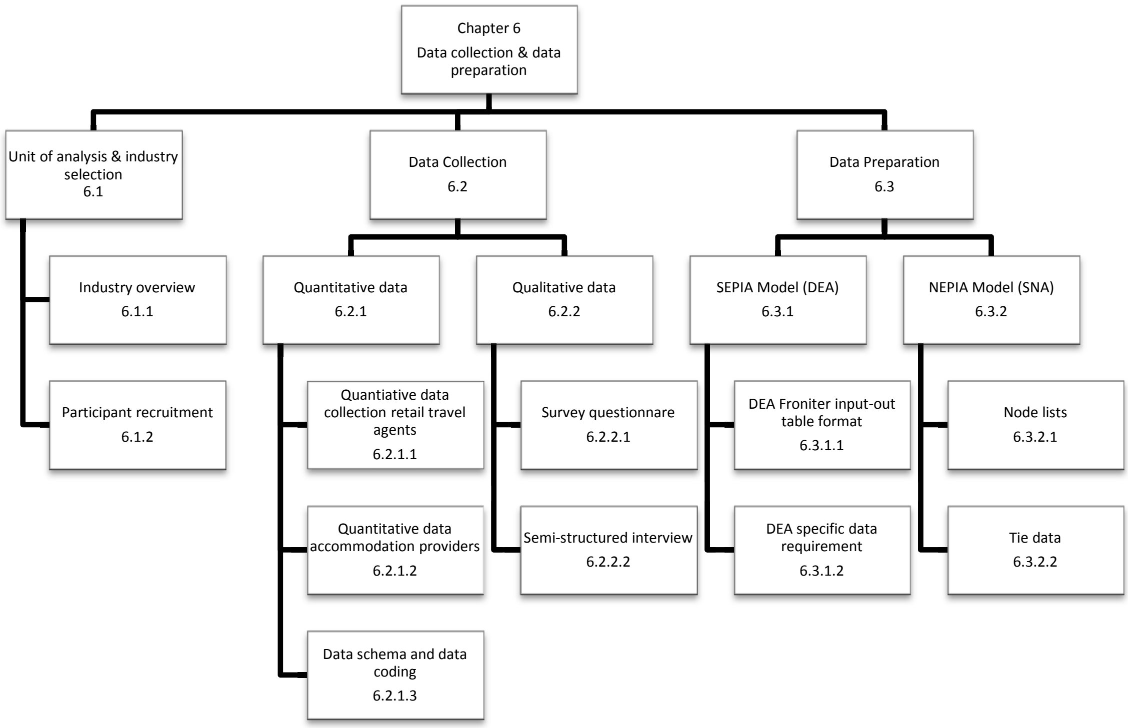


Figure 6-1 Outline of Chapter 6

6.1 Industry selection and unit of analysis

Data was collected from 14 organisations operating in two sub-sectors of the Australian tourism, travel and hospitality industry, namely the retail travel agent and accommodation sectors. The reasons for the focus on the Australian tourism, travel and hospitality industry are fourfold. First, the tourism, travel and hospitality industry is a key service industry in Australia, with significant issues around measuring productivity. Unlike other service industries, which are aggregated under one Australian and New Zealand Standard Industry Category (ANZSIC) code, the tourism, travel and hospitality industry is found across multiple ANZSIC codes. The second criterion used for inclusion of organisations in the study was to exhibit an element of non-homogeneity, hence the inclusion of two sub-sectors belonging to the same industry sector. Third, the researcher has experience in the tourism, travel and hospitality industry, and has an understanding of the underlying processes, systems, technologies and knowledge to interpret available data. Lastly, DEA and SNA approaches have both been successfully used to analyse data in the travel and tourism industry, as evidenced in the previous chapter (Avkiran 2006; Basole & Rouse 2008; Scott et al. 2008; Sigala 2003, 2004, 2008).

6.1.1 Industry overview

The tourism, travel and hospitality industry is a key service industry in Australia. The industry is recognised as the highest exporter of services and enables the distribution of visitors and income ($26 billion) to regional and remote parts of Australia (*Australian tourism export council annual report* 2013). The issues related to measuring productivity for service and network-based firms already identified in the literature apply to the tourism, travel and hospitality industry. Additionally, measuring and interpreting productivity at economy and industry levels remains difficult, as various sectors of the industry are fragmented across four different ANZSICs (see Appendix 2). The industry is also undergoing significant change in a number of areas, identified in the Service Skills Australia 2013 Tourism, Travel and Hospitality Environmental scan (*Tourism, travel and hospitality environmental scan* 2013). These issues include growth in some industry sectors, resulting in skills shortages in a number of occupations and/or geographic locations; the adoption of online and mobile technologies by customers is leaving some businesses struggling to keep up with the changes in technology; changing source markets from English speaking countries to non-English speaking countries requires a more diverse and multi-lingual workforce, and the economic dependence on tourism, travel and hospitality in many parts of regional and remote regions of

Australia.[3] The variables in the SEPIA model provide measures for customer choice, workforce diversity and technology diffusion, and go partway towards measuring the impact these changes have on the productivity for service and network-based firms.

6.1.2 Participant recruitment

Three criteria were used to recruit participants. The first was that each organisation had to operate in Australia; the second was that they had to operate in a service industry defined as a service by the Australian Service Roundtable, and finally, there needed to be a level of heterogeneity among the participant organisations, and this was determined by the ANZSIC they belonged to.

Three information sessions were scheduled and held between 15 February 2012 and 31 March 2012. The first information session was held at UTS Business School. An invitation was sent to 25 organisations operating in the Australian market. Nineteen of these operated in the tourism, travel and hospitality industry, and four in the education industry, specifically the vocational education and training sector. The second information session was presented to ten members of the New South Wales Backpacker Association, who attended the February 2012 monthly meetings. The third information session was presented to six retail travel agents belonging to a franchise group and who collaborate on a number of projects.

At the conclusion of each presentation, attendees were invited to participate in the research. Of the 41 organisations that attended the presentations, 17 accepted and signed the letter of consent to participate in this research (see Appendix 3). These included 16 organisations from the tourism, travel and hospitality industry and one from the education sector. Of these 17 organisations, three did not proceed for various reasons, leaving 14 organisations willing to participate in the research, all of whom operated in the Australian tourism, travel and hospitality industry. Of the 14 participating organisations, three were retail travel agents (ANZSIC Division N group 722) with

[3] Regions of Australia economically dependent on tourism are central Northern Territory (NT), Phillip Island (VIC), the Whitsundays (QLD), Snowy Mountains (NSW), West Coast Tasmania (TAS), East Coast Tasmania (TAS), Spa Country (VIC), Kangaroo Island (SA), Tropical North Queensland (QLD) and Lakes Region (VIC).

street or shopping centre offices located in the Sydney metropolitan area. The remaining 11 organisations were all accommodation providers (ANZSIC Division H group 44), operating in various tourist locations throughout Australia. Therefore, all criteria for inclusion in this research were met.

6.2 Data collection

This section discusses the quantitative and qualitative methods used to collect data from three retail travel agents and 11 accommodation providers participating in this research. The data was collected from multiple data sources and mapped to the SEPIA variables using a coding schema. The data collection and data coding processes are discussed next.

6.2.1 Quantitative data and data collection process

Quantitative data is numeric and used in research to uncover truths and principles in the form of relationships among variables or phenomena (2009). Productivity is the relationship between the number of inputs used to create outputs, and at a firm level is often derived using transactional data (Coelli et al. 2005). According to McGilvray (2008) and Watmough, Polovina and Andrews (2013), transactional data is the record of the internal and external events that take place as a result of an organisation conducting business. Transaction data is also secondary data by definition, as secondary data is collected for a purpose other than its analysis (Gray 2009; Szabo & Strang 1997), and therefore may need to be coded to the SEPIA variables. Transactional data is appropriate for use in this research, as the record of events and interactions that take place between customers, employees (as representatives of the firm) and suppliers. The transactional data was re-coded and used to quantify customer and supplier inputs and customer value and loyalty as output values. In this research, transactional data collected during the period 1 January to 31 March 2012, from each of the participating firms. This is an appropriate period as it is a standard quarterly reporting period, often used for comparative time series analysis. The collection of data for retail travel agents and accommodation providers is discussed next.

6.2.1.1 Quantitative data collection from retail travel agents

Data collection from retail travel agents required a minimum of two field visits to each agent. The purpose of the visits was to examine and collect data on various aspects of the business systems used across their business operations. Information on the business system, the purpose and function the system performed and the data stored in each system was examined. A sample set of relevant transactional data was collected from the three retail travel agents. This included an extract of booking and payment data, in addition to the number of employees and the hours of operation.

6.2.1.2 Quantitative data collection from accommodation providers

One visit to the head office of the accommodation providers was made, as all 11 accommodation providers belonged to a conglomerate, and consequently all used the same business systems and processes. After an introduction by senior management endorsing the research and authorising the data collection, contact was made with their operations manager and a technology provider, who provided access to their management reporting system in order for the researcher to access the required data. Quantitative data was available electronically. Monthly data was downloaded for each of the accommodation properties in.txt format, and imported into Excel (.xls) format.

6.2.1.3 Data schema and coding

A data schema is a high level specification of the relationship between two data sources (Alexe & Tan 2013; Cate et al. 2012). Schema mapping constitutes the basic building blocks in data standardisation, exchange and integration and is a non-trivial and time intensive process (Alexe & Tan 2013). In this research, data was collected from multiple sources from non-homongenous organisations operating in different ANZSIC codes, and mapped to the SEPIA data schema. This mapping process was the first step in operationalsing, standardising and generalising data and operations (Cate, Dalmau & Kolaitis 2012).

The sample source data was reviewed to ensure that it was able to be mapped to the SEPIA variables of service complexity, customer interactions, customer channel, customer loyalty and customer willingness to pay, as outlined in Chapter 4. A procedure for mapping and converting data from source files to SEPIA schema and file format required by DEA frontier input-output tables was defined and documented. Additionally, it was necessary to break down the customer's willingness to pay by service component, in order to attribute value to each service component. It was confirmed that the data provided by each firm was able to be used as intended in this research. Following this, an additional field visit was made to each of the retail travel agents, to collect the full data set for the period 1 January to 31 March 2013. Data from two of the travel agents was provided electronically, data from one was provided in printed hard copy form and collated data was entered into the spreadsheet by the researcher.

The data for all 11 accommodation providers was downloaded by the researcher by accessing the accommodation provider report messaging system. The data provided from monthly reports aligned with the SEPIA variables of customer channel and customer loyalty, and therefore the data found in these reports was used. All monthly reports for each property downloaded were in.txt format and required importing into Excel. Data stored in web tour booking systems was also provided electronically, by technology provider. This data was received electronically in.xls format. A summary of the organisational data is provided next, before describing how each of the SEPIA variables was quantified.

The data needed to be interpreted by the researcher in order to be assigned to an appropriate categorical variable. This brings into question the reliability of data and data coding. Epstein and Martin (Epstein & Martin 2004) suggest that reliability in this sense is "the extent to which it is possible to replicate a measurement, reproducing the same value (regardless of whether it is the right one) on the same standard for the same subject at the same time" (Epstein & Martin 2004, p. 1). They recommend developing a coding scheme that accounts for the values and variables, and to assign the values methodically during the coding stage. According to Shenton (2004), data coding is the analytical process in which data is transformed into an understandable form. Implicit in this process is the preparation of guidelines on how to interpret data and to ensure it is assigned to only one category.

Consequently, a coding schema was developed for each of the variables included in the SEPIA model. A sample of the schema is shown in Table 6-1, and the full schema is available in Appendix 4. The coding schema details the construct, value label, variable code, value and definition. Adherence to the definition and assignment of the codes ensures the interpretation is unambiguous and mutually exclusive, so that only one value can be assigned to each variable under consideration (Shenton 2004). Customer details were entered into a spreadsheet, with codes entered directly into Excel for each of the following variables: service complexity, customer interface, customer channel and customer loyalty.

A sample of 20 observations was provided to two student researchers with no prior knowledge of the research or variables, to ensure assignment of values was consistent with the assignments coded by the primary researcher. The interpretation and assignment of value for all 20 observations across both student researchers were consistent with the primary researcher.

Table 6-1 SEPIA service complexity coding schema

Construct	Value label	Variable code	Value	Definition
Service complexity	Service complexity low	SC1	1	One service type, provided by one service provider
Service complexity	Service complexity medium (type)	SC2	2	Multiple service types, provided by one service provider
Service complexity	Service complexity medium (provider)	SC3	3	One service type, provided by multiple service providers
Service complexity	Service complexity high	SC4	4	Multiple service types provided by multiple service providers
Customer interaction	Customer interactions Self Service	CI-Self	1	Online transactions
Customer interaction	Customer interaction Face to Face t	CI-FF	2	Transactions occurring in a face to face environment
Customer loyalty	New customers	CLNew	1	New customers
Customer loyalty	Referred customers	CLRef`	2	New customers that identified they were referred to the organisation
Customer loyalty	Repeat customers	CLRep	3	Customers who had purchased services from the organisation more than once
Customer channel	Business to business	CCB2C	1	Transactions with end consumers
Customer channel	Business to consumer	CCB2B	2	Business transactions occurring with third parties who are not the end consumer
Willingness to pay	Value for s	WTP	N/A	Sum of the transaction values

The input measure for each of the variables was the count (volume) of the number of customers assigned to each of the variables recorded by organisation. These measures were then entered into an Excel spreadsheet in the input-output format specified by the DEA software used to conduct the analysis (see Appendix 5).

6.2.2 Survey questionnaire

A survey questionnaire was administered to employees of both retail travel agents and accommodation providers, to determine employee attribute and engagement levels.

Additionally, model validation is a key component of model building (Winston 1991), and Golany and Roll (1989) and Landry, Malouin and Oral (1983) suggest face-to-face structured or semi-structured interviews to gather and compare opinions and predictions from experts. The method and data collection process for each is discussed next.

6.2.2.1 Survey questionnaire

Survey questionnaires are a way of systematically collecting information from a large sample. When administered online they may be suitable for a geographically-disbursed population, and to collect data anonymously (Gray 2009). Rea and Parker (2005) and De Vaus (2002) claim that data from surveys can be used to describe, compare and explain knowledge on attitudes and behaviours, while Fink (2002) endorses using surveys to examine associations between social, economic and psychological variables and behavioural elements, as is the case in this research.

In this research, the SEPIA model incorporates employee attitudes and psychosocial factors, as measured by the level of employee engagement. As such, the use of a survey questionnaire is considered an appropriate data collection method for this research.

6.2.2.2 Employee engagement of retail travel agents and accommodation providers

Employee engagement data was collected using a valid employee engagement survey instrument (Wilson 2009). The instrument was developed after careful consideration of three existing and popular employee engagement surveys: the Gallop Organisations Q12 instrument (Thackray 2001), the Decision Wise Engagement Survey ("Decisionwise leadership intelligence, employee surveys", 2007) and the Baldrige National Quality "Are we making progress" Program (2007). The construct of employee engagement in the literature is placed in two domains. The first domain is in the management and leadership domain where the level of employee engagement is viewed as a leadership capability and where managers are able to communicate strategy and inspire staff to be focused and present at work (Thackray 2001). The second domain is the human resource literature where the level of engagement is the result of the human strength and optimal functioning (Seligman & Csikszentmihaly 2000). Wilson's survey instrument assumes the second domain, where positive engagement is counter to burnout and differs according to the employees demographics, gender, office location, position within the organisation and years of service, that is, of factors directly related to the employee rather that the leader or manager(Schaufeli & Bakker 2004; Schaufeli et al. 2002). The employee engagement construct in the SEPIA model aggregates the level of engagement of individual employees and not the level of engagement that results from effective leadership or management. This survey instrument was appropriate for use in this research for three reasons, first the instrument was designed specifically for use in the service sector where which involves high levels of customer contact. The second is the instrument examines employee engagement of the individual rather than employee engagement which results from leadership or management and lastly because it is a measure of the positive value creating elements rather than seeking to measure the negative.

In this research, the survey instrument was amended in two ways. First, additional questions were added to record the *agreement to participate* data, and to collect information on the physical and cognitive attributes of employees The second amendment was to collapse all eight questions in the employee engagement instrument into one question, presented as eight statements. According to Gray (2009) and De Vaus (2002), survey questionnaires that are simple, well laid out and easy to complete are more likely to get a high response rate. See Appendix 6 for the final survey instrument used for this research.

The employee engagement survey passed the Cronbach Alpha reliability test (Wilson 2009), tested for reliability in 2009. The pilot Cronbach's Alpha score was 0.73, and the score for the administered survey in this case was 0.798 (Wilson 2009). Typically, a Cronbach Alpha reliability score of 0.7 is considered adequate for reliability (Cronbach 1951; Nunnaly 1978; Sellitz et al. 1976). Wilson (2009) developed a survey based on three psychological conditions of engagement identified by Kahn (1990): meaningfulness, safety and availability. The survey instrument passed a valid reliability test, and as the amendments were minimal it was considered suitable for this research.

The survey was administered using Survey Monkey, and piloted with two researchers and two students to ensure the layout and structure of the questionnaire was easy to understand and follow. The same employee engagement survey was sent to retail travel agents and accommodation providers. An e-mail was sent to the manager of each retail travel agent, and the operations manager of the accommodation provider with a link to the employee engagement survey. The manager was responsible for forwarding the e-mail to staff for completion. A call was made to a staff member from each location to ensure the e-mail was received. The e-mail contents included a brief overview of the research aims and the purpose of the survey, as per the UTS Ethics approval number 2012000423 (see Appendix 7).

6.2.3 Qualitative data semi-structured interview

Models require validation, and seeking expert opinion is an acceptable approach to model validation (Golany & Roll 1989). One approach recommended by Golany and Roll (1989), and supported by Landry, Malouin and Oral (1983) for model validation is the use of face-to-face interviews with experts. Interviews and convergent validation processes are commonly used approaches for gathering and comparing opinions and predictions from experts in the field (Landry, Malouin & Oral 1983). Interviews are conversations between people; in this case, the researcher and the expert. Questions may be structured, semi-structured or unstructured. Structured interviews are where questions are posed to respondents and responses recorded on a standardised schedule. Semi-structured interviews are non-standardised, although the interviewer has a list of questions or issues to be dealt with. The use of semi-structured interviews does not limit the responses from respondents in the same way that structured interviews do, as researchers may vary the order and direction of the interview based on the responses (Gray 2009). Therefore, the use of semi-structured interviews will provide the researcher with a list of questions to cover, but not limit the discussion to those specific questions. The list of questions used can be found in Appendix 8.

6.3 Data preparation

Data preparation was conducted in three phases. The first phase examined the results from the employee engagement survey. The second phase included transferring the measures assigned to each variable category to an Excel file format, in order for the

DEA to operate. The third phase included checking the data in the DEA formatted file against specific criteria required for DEA to operate correctly (Sarkis 2007).

6.3.1 Employee engagement survey results

The employee engagement data was downloaded from Survey Monkey in Excel format. A review of the data revealed three major anomalies. First, the accommodation provider had a higher than expected number of staff with different nationalities. A call to the operations manager confirmed that they used a large number of interns, often international students and backpackers, many of whom were not employees as their work was undertaken in exchange for free accommodation. Therefore, the survey was not sent to them. The second anomaly related to qualifications: the international staff who participated in the survey had studied overseas, and it was not possible to directly match their education with the AQF levels. The third anomaly was that some data on staff nationality and age provided by one travel agent was known by the researcher to be false. Together, these anomalies cast doubt on the validity and reliability of the employee attribute data set. Therefore, the decision was made to exclude this whole data set from the analysis. Additionally, it was not seen as critical to the research as the inclusion of customer and supplier data that contributes to the dynamic relationship of service productivity.

6.3.2 DEA file format

All transactional data for each organisation was available in or entered into Excel. Additional columns were added for each of the variables

During the data coding process, each variable was assigned a code. Using the pivot table function in Excel, the data was organised into the DEA input and output table format by using the COUNT function for service complexity, customer interaction, customer loyalty, customer channel and customer willingness to pay, where the SUM function on the value of commission recorded against each transaction. The results are found in Table 6-2.

Table 6-2 Customer data formatted into input and output tables for DEA

Vari-ables	Service complexity			Customer interaction		Customer loyalty			Customer channel		Willingn-ess to pay
DMU	SC1	SC2	SC4	CI-Self	CI-FF	CL New	CL Ref	CL Rep	CCB2C	CCB2 B	WTP
AA1	74	10	45	0	131	114	0	17	131	0	83000
AA2	55	11	111	0	177	127	0	50	127	0	54421
AA3	369	139	520	0	1028	369	0	0	1028	0	20727
PA1	33740	0	203	14690	19050	31951	1166	623	28546	5194	1026880
PA2	24622	0	270	15620	9002	21588	3034	0	18329	6293	774515
PA3	64266	0	504	27470	36796	56439	7526	301	49158	15108	1811384
PA4	11647	0	338	5359	6288	11193	446	8	9648	1999	470725
PA5	8891	0	180	5190	3701	6780	2109	2	6073	2818	320009
PA6	10167	0	258	4880	5287	5862	4273	32	7603	2564	213933
PA7	25132	0	271	13894	11238	19710	5355	67	22382	2750	638423
PA8	38474	0	382	19418	19056	34097	4316	61	30679	7795	1256749
PA9	94516	0	125	44892	49624	85056	9192	268	58877	35639	2011709
PA10	73091	0	356	41047	32044	45479	27204	408	43604	29487	2616952
PA11	153866	0	93	10413	49683	130513	23273	80	141670	12196	4892109

6.3.3 DEA specific data requirements

DEA has specific data requirements. Consequently, the aggregated data must be examined for missing data, non-negative values and data magnitude.

6.3.3.1 Missing data

DEA assumes the availability of numerical data for each input and output. However, in reality, some decision-making units may have missing data due to human errors or technical problems. Consequently, there are different approaches reported in the literature for mitigating this problem. One such approach is to exclude the decision-making units with the missing data from the reference set (Coelli et al. 2005; Kuosmanen 2002, 2009). However, the elimination of the decision-making units decreases the reference set, and therefore increases the efficiency scores of the other decision-making units. No decision-making units in this research had missing data, and therefore no specific treatment of the data was required.

6.3.3.2 Non-negative values

Cooper and Rhodes' (Charnes et al. 1978a; Charnes et al. 1989) CCR model requires all data to be non-negative for all input and output values (Iqbal Ali & Seiford 1990). However, in some situations, some data sets may have negative numbers; therefore, the treatment of negative numbers should be considered. According to Sarkis (2007), a common method of dealing with negative values is to add a positive constant to the relevant inputs and outputs. The elimination of negative numbers alone will distort the data, as the data for inputs should reflect the characteristic that smaller values for inputs are better, and larger numbers for outputs are better.

According to Emrouznejad et al. (2010), three DEA models that can incorporate both positive and negative numbers have been developed. He cites a directional-range distance model (Portela et al. 2004), a modified slack-based model (Sharp et al. 2006) and a semi-oriented radial model (Emrouznejad et al. 2010). In this research there are no negative numbers; however, there are zero values, which some scholars treat as a non-negative number (Sarkis 2007; Thompson et al. 1993).

The treatment of zero values as non-negative is not universally shared. Ramanathan (2003, p. 44) states that "the decision variables are non-negative, that is they can be either zero or positive." In this research, the Encyclopaedia Britannica (2014) definition of non-negative is used: "a real number, greater than or equal to zero" (http://www.merriam-webster.com/dictionary/nonnegative accessed 23 January 2014). Consequently, in this research, no specific treatment of the data was required.

6.4 NEPIA model—data preparation for social network analysis

The transaction (booking, ticketing and payment) data collected for DEA analysis was reassessed for its suitability to change the unit of analysis from a single firm to a whole-of-network analysis using SNA. The data was suitable, but required reformatting to comply with the file format specified by UCINET and NETDraw software. UCINET and NETDraw software was used to conduct SNA analysis. The VNA file format allows the user to store network data (node and tie), as well as node attributes and information on how to display them (Borgatti et al. 2002; Borgatti et al. 2013).

The node attribute data in the.VNA file is textual data that enables the analyst to read the file. Customers are aggregated and represented in the data as one (customer) node, and organisations (the decision-making unit and suppliers) are each represented as a node. Each node is assigned an attribute that specifies their function within the network, either customer (end consumer), retail travel agent, agent selling accommodation services, accommodation provider or supplier. Specific details are listed in Appendix 10.

Transactional data (booking and payments) represented the tie data. The direction of the payment determined the direction of the tie. To establish the tie level data, an additional column was inserted, labelled "from". This enabled the creation of the "from to" tie data for each organisation. Inclusion of the tie measures enables the data to be dichotomised (Borgatti, Everett & Johnson 2013). A pivot table using the "from" and "to" data with the sum of the customers represents the volume of customer flow between the nodes (agent to supplier) and the sum of the value, representing the money flow. Given that the data reflects the operations of the real transactions, there was no missing data, and the data is assumed to be accurate.

Each of the nodes (organisations) was coded to ensure anonymity based on their role in the network and attributes, agent or supplier, and whom they serviced. Data formatting conventions were observed, where rows contain data on the FROM nodes, and column data contains data on the TO nodes. The data was then reformatted using the UCINET.VNA file format. Node data included the name of the node and any unique attribute assigned to the node, as shown in Appendix 11. Only the links that actually existed were transferred, rather than all possible links.

In conclusion, this chapter has outlined how the data was collected and formatted in the specified file format, as outlined by DEA frontier and UCINET and NETDraw software. The data was also checked for omissions, non-negativity and data magnitude. The files were formatted and ready for use in DEA frontier for the SEPIA model, and UCINET and NETDraw for the NEPIA model.

The next two chapters cover the data analysis and results for the SEPIA model in Chapter 7, and the NEPIA model Chapter 8.

Chapter 7: Data Envelopment Analysis of the SEPIA Model

In this chapter, the analysis of the customer interface decision variables of the SEPIA model is performed using DEA. The chapter structure is illustrated in Figure 7-1. In Section 7.1, a revision of the SEPIA model and the customer interface variables is provided. Additionally, the rationale for the use and selection of DEA software is provided. In Section 7.2, an analysis of the customer interface variables is discussed and a test plan prepared.

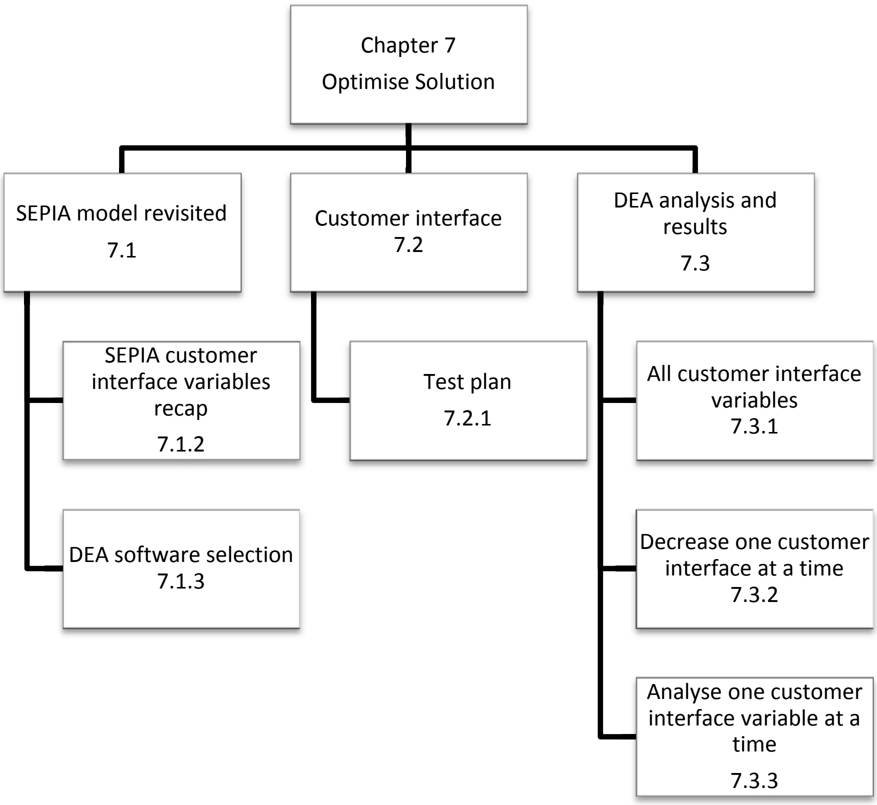


Figure 7-1 Outline of Chapter 7

7.1 Introduction

The SEPIA model represents a single service firm. The boundary of the firm is extended to include inputs from customers, employees and suppliers, used to create value. The literature review (Section 2.3.1) illustrated the role of the customer and their involvement in the service delivery process. Sampson and Froehle's (2006) Unified Service Offering places customer input as a necessary precondition to the commencement of the service process. As a result, customer input becomes a key factor of productivity, and one not yet incorporated in productivity measures. In this section, I review the SEPIA customer interface variables and determine which DEA software to use in this analysis.

7.1.1 SEPIA customer interface variable

The customer interface variable was described in Chapter 4 as the point at which a customer interacts with an organisation, and the specific customer interface decision variables are provided in Table 4-1. The six decision variables are service complexity, access, customer service interactions, customer channel, customer loyalty and customer willingness to pay. In this research, access and when to offer services is not included in the customer interface variable; rather, it is incorporated in the number of hours employees worked.

Table 7-1 SEPIA customer interface decision variables

Decision variable	Categories	Code	Input	Output
Service complexity	Low	SC1	Y	
	Medium	SC2	Y	
	Medium	SC3	Y	
	High	SC4	Y	
Customer interface	Self-service	CI-Self	Y	
	Face-to-face	CI-FF	Y	
Customer channel	Business-to-consumer	CCB2C	Y	
	Business-to-business	CCB2B	Y	
Customer loyalty	New	CL-New	Y	
	Referral	CL-Ref		Y
	Repeat	CL-Rep		Y
Customer willingness to pay		WTP		Y

A key motivation of this research was to enable the SEPIA model to be accessible to business managers. The use of DEA software removes the algebraic complexities; this approach has been used to conduct the analysis in this research.

7.1.2 DEA software selection

The goal of this research is to operationalise productivity for service and network-based firms. A number of DEA software programs were assessed using Barr's (2004) analysis. This included the DEA models available, features of the software program, platform interoperability, user interface, reporting, documentation and support, testing and availability. DEA Frontier was selected because of the user interface with Excel, the ability of the software to perform a vast range of DEA models, including multi-stage processing (network DEA), measuring and decomposing productivity changes using the Malmquist index,[4] bootstrapping and sensitivity analysis were key considerations (Cook & Zhu 2013; Sherman 2006).

7.2 Customer interface analysis

7.2.1 Test plan

The coverage of test plan includes the customer interface decision variables. The variables identified as inputs and outputs identified in Table 7-1 are listed. The DEA model used to the customer interface variables is an input oriented-variable return to scale (IO-VRS), as discussed in Chapter 5.1.1. The test plan includes running the model six times, removing one variable at a time, sequentially. Table 7-2 indicates which variables are included and excluded for each model number.

[4] The Malmquist index, unlike other indexes, allows the decomposition of efficiency changes into productivity growth (best practice frontier improvements) and efficiency growth (changes relative to the best practice frontier) to measure productivity change (Emrouznejad & Witte 2010).

Table 7-2 SEPIA customer interface test plan

		Inputs				Outputs		
Model number	Model orientation	Service complexity	Customer interaction	Customer channel	Customer loyalty	Customer willingness to pay	Customer loyalty (Ref)	Customer loyalty (Rep)
1	IO-VRS	Y	Y	Y	Y	Y	Y	Y
2	IO-VRS	Y	Y	Y	N	Y	N	N
3	IO-VRS	Y	Y	N	Y	Y	Y	Y
4	IO-VRS	Y	N	Y	Y	Y	Y	Y
5	IO-VRS	N	Y	Y	Y	Y	Y	Y
6	IO-VRS	Y	Y	Y	Y	N	Y	Y
Test one set of variables at a time								
7	IO-VRS	Y	N	N	N	Y	Y	Y
8	IO-VRS	N	Y	N	N	Y	Y	Y
9	IO-VRS	N	N	Y	N	Y	Y	Y
10	IO-VRS	N	N	N	Y	Y	Y	Y

When an input-oriented variable return to scale (VRS) model is run using DEA frontier three, separate results are produced, as illustrated in Figures 7-2, 7-3 and 7-4, highlighting the efficiency results, slack results and target results, respectively. Each is discussed next.

7.2.2 SEPIA Customer interface analysis using DEA

7.2.2.1 Efficiency analysis for customer interface model 1

In order for decision-making units to be truly efficient, two conditions must be met (Zhu 2013). The first is that the efficiency score must equal one, and the second is that there should be no slack. Where only the first condition is met, the decision-making unit is referred to as “weakly efficient” (Zhu 2000). This case may arise where multiple inputs are used. Where this is the case, the firm sits on the efficiency frontier but is able to reduce one or more of the inputs. The efficiency scores from running an input-oriented VRS model, which includes the entire set of customer interface data (Model 1 in Table 7-2), are shown in Figure 7-2.

The DMU number represents the decision-making unit, the DMU name column is the name of each individual decision-making unit, the input-oriented VRS efficiency column shows the efficiency score for each decision-making unit, the benchmark column shows the efficiency score of the closest decision-making unit and the decision-making unit name. Where there is more than one decision-making unit that can be used for comparative purposes, they are listed on the right of the preferred peer decision-making unit.

7.2.2.2 Results for efficiency analysis for customer interface model 1

The organisations that are efficient and sit on the efficiency frontier are shown in Figure 7-2 to have an input-oriented VRS efficiency score of one. These firms are AA1, AA2, PA1, PA4, PA5, PA6, PA7, PA9, PA10 and PA11. Inefficient firms that have an efficiency score less than one are AA3, PA2, PA3 and PA8, as their efficiency scores are 0.30894, 0.95715, 0.83266 and 0.92980, respectively. The closer the score is to one, the more efficient the firm. In this example, AA3 is the least efficient firm, as their efficiency score is only 0.30894. This result indicates that DEA could successfully discriminate between efficient and inefficient DMUs across heterogeneous firms, using the customer interface variables of the SEPIA model.

DMU No.	DMU Name	Input-Oriented VRS Efficiency	Benchmarks			
1	AA1	1.00000	1.000 AA1			
2	AA2	1.00000	1.000 AA2			
3	AA3	0.30894	1.000 AA1			
4	PA1	1.00000	1.000 PA1			
5	PA2	0.95715	0.868 PA5	0.066 PA10	0.066 PA11	
6	PA3	0.83266	0.261 PA1	0.309 PA4	0.310 PA10	0.120 PA11
7	PA4	1.00000	1.000 PA4			
8	PA5	1.00000	1.000 PA5			
9	PA6	1.00000	1.000 PA6			
10	PA7	1.00000	1.000 PA7			
11	PA8	0.92980	0.744 PA4	0.152 PA10	0.104 PA11	
12	PA9	1.00000	1.000 PA9			
13	PA10	1.00000	1.000 PA10			
14	PA11	1.00000	1.000 PA11			

Figure 7-2 Efficiency frontier for customer interface data

DEA may also be used to benchmark decision-making units. The benchmark column in Figure 7-2 highlights the benchmark score and the comparative peer. The comparative peer is the best firm or firms to which inefficient firms can be compared. DMU–AA1 can be compared to AA1, while PA2 can be compared with three peers, PA5, PA10 and PA11. The benchmark scores next to each of the peers indicated the distance between the firm and the comparative peer on the frontier. Figure 7-3 provides a visual representation of the efficiency frontier for PA5. However, the visualisation is not to scale, illustrating how the distance from PA5 to comparative peer differs, and the score is indicative of the distance between PA5 and the comparative benchmarked peer.

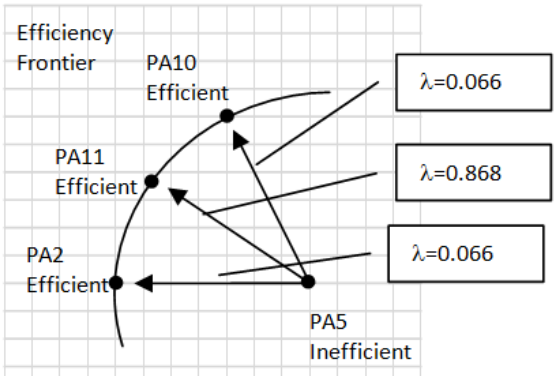


Figure 7-3 Frontier analysis of results for PA5 (not to scale)

To distil where the inefficiency occurs it is necessary to examine the slack. This is done next.

7.2.2.3 Slack

The DEA result also generates the amount of slack that each DMU has in producing the given output, shown in Figure 7-4. The slack represents the remaining portion of inefficiencies after proportional reductions in input and outputs have been calculated (Coelli et al. 2005; Cook & Zhu 2013; Sherman 2006). Slacks exist for inefficient firms, as well as weakly efficient firms. Weakly efficient firms are on the frontier, but may still be able to reduce one or more of the inputs used (Sherman 2006).

Figure 7-4 shows the slack results generated from running Model 1 in Table 7-2. The first row shows the labels for each column, where DMU No is the number of the decision-making unit and DMU name represents the organisation under examination. The heading in grey shows the input slack for each of the customer interface variables: SC1 is the low level supplier complexity level 1, SC2 is the medium level supplier complexity level 2, SC4 is the high level supplier complexity level 4, CI-Self and CI-FF are the customer interactions of self-service and face-to-face, CL-New the number of new customers, CCB2C and CCB2B the customer channels of B2C and B2B. The section in green shows the output slack of each customer interface variable of willingness to pay, shown as willingness to pay (WTP) and customer loyalty, including referred (CL-Ref) and repeat business shown (CL-Rep).

		Input Slacks								Output Slacks		
DMU No.	DMU Name	SC1	SC2	SC4	CI- Self	CI - FF	CL-New	CCB2C	CCB2B	WTP	CL-Ref	CL-Rep
1	AA1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	AA2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	AA3	40.00000	32.94309	115.65041	0.00000	186.59350	0.00000	186.59350	0.00000	62273.00000	0.00000	17.00000
4	PA1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	PA2	831.14291	0.00000	72.65126	7059.08218	0.00000	3123.62735	0.00000	831.14291	0.00000	2128.63918	33.84252
6	PA3	0.00000	0.00000	140.63743	3407.18147	7833.60794	5453.10361	0.00000	0.00000	0.00000	4143.35091	0.00000
7	PA4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
8	PA5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
9	PA6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
10	PA7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
11	PA8	0.00000	0.00000	39.86307	6730.64382	3000.35487	2900.88804	0.00000	0.00000	0.00000	2578.15522	15.45214
12	PA9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
13	PA10	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
14	PA11	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00003	0.00000	0.00000

Figure 7-4 Slack for customer interface data

The first observation made is that all efficient firms (AA1, AA2, PA1, PA 4, PA5, PA7, PA9, PA10 and PA11) are truly efficient, as the two conditions of having an efficiency score of one and zero slack are met.

The red boxes in Figure 7-4 highlight the slack amounts for inefficient firms. For example, it is observed that AA3, PA2, PA3 and PA8 all have slack across various customer interface inputs. This indicates that the customer's configuration of resources required to process transactions across the customer interface variables is inefficient. The output slack indicates that output augmentation is possible, and that firms AA3, PA2, PA3 and PA8 are able to provide greater value to customers, compared to their peers. For example, the slack for AA3 indicated a potential to increase the value provided to customers, and should look to increase their customer (combined) willingness to pay by $62273. This represents value currently unrealised by the firm.

How this would be achieved would be informed by comparing their performance against their comparative peer, as identified in Figure 7-2.

7.2.2.4 Explaining the slack results specifically for DMU PA3

As DEA focuses on individual DMUs rather than the population average, I examine the results for one specific DMU to explain slack; the selected DMU is PA3. A comparison of the slack compared with the original value for PA3 is provided in Table 7-3. This table summarises the customer interface variable, the proportional input slack for each of the variables and the original input value. It is possible to reduce the service complexity level for PA3 by 140.63743, down from the original value of 540. Other inputs that can be reduced are the number of customer interactions (CI-Self and CI-FF), the number of new customers (CL-New), the number of agent bookings (CC-B2B) in different proportions by the amounts shown in the input slack column. The results also indicate that PA3 can provide greater value to their customers, thereby increasing customer loyalty and the number of customers willing to refer the property to friends and relatives (CL-Ref) by 4143. 35091.

Table 7-3 Slack for PA3 compared to original input and output values

Customer interface variable	**Input slack**	**Original input value**
Service complexity (C4)-High	140.63743	540
Customer interface, self	3407.18147	27470
Customer interface, face-to-face, FF	7833.60794	36796
Customer loyalty, new customer	3123.6235	56439
Customer channel: B2B	831.1414291	15108
	Output slack	**Original output value**
Customer loyalty, referred	4143.35091	7526

The data in Table 7-3 shows the following information regarding PA3:

1. A reduction of 140 customers with high levels of service complexity will be better for business efficiency.
2. The values for the customer interface data for self-service and face-to-face indicate that the two interfaces are imbalanced. Other organisations use these two channels more efficiently, although without further investigation it is not possible to say how.
3. PA3 should be able to reduce the number of new customers by 3123, as shown in Figure 7-4 (Input slack column CL-New), as this may lead to greater efficiency. This could be achieved by increasing the number of referred customers. This is implied, as output augmentation is also shown in the output slack.
4. PA3 needs to examine their distribution as business coming through their agencies, as the data indicates they should be able to reduce the number by 831, possibly leading to greater efficiency. This may be achieved by increasing the number of direct bookings. However, further investigation regarding implementation would be required.
5. PA3 should increase the number of customers referred to them by 4143 to achieve greater efficiency.

These are new measures and the dynamics of how these measures relate with each other is not fully known. Other variables not included in this analysis, such as the cost differential between each categorical variable, may also affect these results. However, the data indicates that there is a dynamic between the measures and the perspective of the customer and the firm.

7.2.2.5 Explaining the target results specifically for DMU PA3

These efficiency targets are the result of respective slack values added to outputs. According to Sherman (2006), in order to calculate the target values for inputs, the input value is multiplied with an optimal efficiency score, then slack amounts are subtracted. The content of the *target* result generated by running model 1 is shown in Figure 7-5. The first row shows the labels of each of the columns. The first column is the decision-making unit number; the second column is the name of each of the decision-making units; and the labels in the grey section represent each of the customer interface variables—SC1 is the low level supplier complexity level one, SC2 is the medium level supplier complexity level two, SC4 is the high level supplier complexity level four, CI-Self and CI-FF are the customer interactions of self-service and face-to-face, CL-New the number of new customers, CCB2C and CCB2B are the customer channels of B2C and B2B. The section in green shows the output slack of each customer interface variable of willingness to pay, shown as WTP and customer loyalty referred, and repeat business shown as CL-Ref and CL-Rep, respectively.

		Efficient Input Target								Efficient Output Target		
DMU No.	DMU Name	SC1	SC2	SC4	CI- Self	CI - FF	CL-New	CCB2C	CCB2B	WTP	CL-Ref	CL-Rep
1	AA1	74.00000	10.00000	45.00000	0.00000	131.00000	114.00000	131.00000	0.00000	83000.00000	0.00000	17.00000
2	AA2	55.00000	11.00000	111.00000	0.00000	177.00000	127.00000	127.00000	0.00000	54421.00000	0.00000	50.00000
3	AA3	74.00000	10.00000	45.00000	0.00000	131.00000	114.00000	131.00000	0.00000	83000.00000	0.00000	17.00000
4	PA1	33740.00000	0.00000	203.00000	14690.00000	19050.00000	31951.00000	28546.00000	5194.00000	1026880.00000	1166.00000	623.00000
5	PA2	22735.83814	0.00000	185.77961	7891.62223	8616.27664	17539.35645	17543.62748	5192.21067	774515.00000	5162.63918	33.84252
6	PA3	53511.87112	0.00000	279.02434	19466.05009	22805.03162	41541.52020	40932.01009	12579.86103	1811384.00000	11669.35091	301.00000
7	PA4	11647.00000	0.00000	338.00000	5359.00000	6288.00000	11193.00000	9648.00000	1999.00000	470725.00000	446.00000	8.00000
8	PA5	8891.00000	0.00000	180.00000	5190.00000	3701.00000	6780.00000	6073.00000	2818.00000	320009.00000	2109.00000	2.00000
9	PA6	10167.00000	0.00000	258.00000	4880.00000	5287.00000	5862.00000	7603.00000	2564.00000	213933.00000	4273.00000	32.00000
10	PA7	25132.00000	0.00000	271.00000	13894.00000	11238.00000	19710.00000	22382.00000	2750.00000	638423.00000	5355.00000	67.00000
11	PA8	35772.99091	0.00000	315.31920	11324.14480	14717.84741	28802.38354	28525.22711	7247.76379	1256749.00000	6894.15522	76.45214
12	PA9	94516.00000	0.00000	125.00000	44892.00000	49624.00000	85056.00000	58877.00000	35639.00000	2011709.00000	9192.00000	268.00000
13	PA10	73091.00000	0.00000	356.00000	41047.00000	32044.00000	45479.00000	43604.00000	29487.00000	2616952.00000	27204.00000	408.00000
14	PA11	153866.00000	0.00000	93.00000	10413.00000	49683.00000	130513.00000	141670.00000	12196.00000	4892109.00003	23273.00000	80.00000

Figure 7-5 Target output for customer interface data

The amounts shown are the input and output target amounts required for each DMU to be efficient and therefore reach the frontier. The target value for DMU PA3 is shown in Table 7-6. The table highlights the customer interface variable, the target amount and the original input or output values.

Table 7-4 Target values for PA3

Customer interface variable	Customer variable code	Target input value	Original actual input value	Variance
Service complexity, high	SC4	53511.87112	64266	10755
Service complexity, medium	SC2	0.00000	0.00000	0.0000
Service complexity, medium	SC3	279.02434	504	225
Customer interface–self-service	CI-Self	19466.05009	27470	8004
Customer interface–face-to-face	CI-FF	22805.03162	36796	13991
Customer loyalty–new customers	CL-New	41541.52020	56439	14898
Customer channel Business-to-consumer	CCB2C	40932.01009	49158	8226
Customer channel Business-to-business	CCB2B	12579.86103	15108	2529
		Target output	**Original output value**	
Customer willingness to pay	WTP	1811384.0000	1811384	0
Customer loyalty–referral business	CI-Ref	11669.35091	7526	4143
Customer loyalty–repeat business	CI-Rep	301.00000	301	0

The results indicate that PA3 should decrease service complexity. High and medium levels of service complexity may be causing operational inefficiencies. The target input value for high levels of service complexity (SC4) is 53511.87112, compared to the actual of 64266, and the medium level of service complexity (SC3) is 279.02434, compared to an actual input value of 504. This indicated that focusing on their core competency would result in a more efficient operation.

In addition to reducing service complexity, it appears that PA3 has a quality issue, as indicated by the number of customer referrals and the low number of repeat clients. The increase in customer loyalty of referral business (CI-Ref) should be increased to 11669.35091, compared to the actual figure of 7526, a variance of 4143.

This section examined the results of running an input-oriented VRS for all 14 firms, using all SEPIA customer interface variables. The next test involves eliminating each variable at a time, to determine what affect each variable has on the efficiency of the firm, if any.

7.2.3 Eliminating customer interface input variables one at a time

The variable being eliminated and the variables remaining for each of the models is outlined Table 7-2. The removal of one variable at time shows the effect on the efficiency scores for each organisation, and provides insight into the dynamics each variable has on the efficiency of each firm. The red boxes in Table 7-4 highlight the efficiency score when one variable is reduced. The efficiency scores highlighted in yellow indicate a change in efficiency when the respective variable is removed.

Table 7-5 Efficiency scores eliminating one customer interface variable at a time

DMU No	DMU name	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
1	AA1	1.00000	1.00000	1.00000	1.00000	1.00000	0.83867
2	AA2	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
3	AA3	0.30894	0.30894	0.30894	0.30894	0.30894	0.00000
4	PA1	1.00000	0.91597	1.00000	1.00000	1.00000	1.00000
5	PA2	0.95715	0.95715	0.93518	0.88797	0.89182	0.40754
6	PA3	0.83266	0.81444	0.81606	0.83266	0.83266	0.52674
7	PA4	1.00000	1.00000	1.00000	1.00000	1.00000	0.14265
8	PA5	1.00000	1.00000	1.00000	1.00000	0.80657	0.68319
9	PA6	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
10	PA7	1.00000	1.00000	0.74280	1.00000	1.00000	1.00000
11	PA8	0.92980	0.92980	0.89397	0.92980	0.92980	0.41459
12	PA9	1.00000	1.00000	1.00000	1.00000	0.61693	0.96467
13	PA10	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
14	PA11	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

The removal of each of the variables has differential effects on each firm. For example, the efficiency of PA3 is reduced from 0.83266 to 0.81444 and 0.40754 as the customer channel and willingness to pay is removed, respectively. This implies that there is a higher level of importance on the overall value provided to customers than customer loyalty and customer channel.

7.2.4 Testing one set of variables at a time

The final analysis on customer interface variables was performed by examining individual variables. Table 7-5 shows DMU, organisation, the efficiency score for model 1, where all customer interface variables included in this research are included, and the model number with the name of the variable being tested.

Table 7-6 Efficiency scores for each customer interface variable

DMU no.	DMU name	Model 1	Model 7	Model 8	Model 9	Model 10
			Service complexity	Customer interaction	Customer channel	Customer loyalty
1	AA1	1.00000	1.00000	1.00000	1.00000	1.00000
2	AA2	1.00000	1.00000	1.00000	1.00000	1.00000
3	AA3	0.30894	0.16764	0.12743	0.30894	0.12354
4	PA1	1.00000	1.00000	1.00000	1.00000	1.00000
5	PA2	0.95715	0.86904	0.80607	0.57875	0.83495
6	PA3	0.83266	0.78656	0.59635	0.55648	0.83266
7	PA4	1.00000	1.00000	0.65618	0.63034	1.00000
8	PA5	1.00000	1.00000	0.79621	0.64265	0.79910
9	PA6	1.00000	1.00000	1.00000	1.00000	1.00000
10	PA7	1.00000	0.74280	0.61309	0.51028	1.00000
11	PA8	0.92980	0.88891	0.65789	0.61963	0.92980
12	PA9	1.00000	1.00000	0.47280	0.40730	0.59223
13	PA10	1.00000	1.00000	1.00000	1.00000	1.00000
14	PA11	1.00000	1.00000	1.00000	1.00000	1.00000

The result indicates that service complexity and the decisions of what customers buy and what service organisations offer affects service productivity. Productivity for organisations AA3, PA2, PA7 and PA8 is reduced, with PA7 not on the efficiency frontier when *service complexity* (what services are offered and what customers buy) is considered in isolation to other decision variables. Eight organisations are affected, depending on the type of c*ustomer interaction*. The balance between face-to-face and online transactions shows that AA3, PA2, PA3, PA4, PA5, PA7, PA8 and PA9 are inefficient in interacting with customers. Four of the firms—PA4, PA5, PA7 and PA9—move to the efficiency frontier as other decision variables are added. The *customer channel* decision variable reflects whether transactions occur through B2B or business (intermediary) to consumer (direct). The results show that six organisations—AA1, AA2, PA1, PA6, PA10 and PA11—are efficient in respect to the mix of direct and indirect business, whereas AA3, PA2, PA3, PA4, PA5, PA7, PA8 and PA9 are inefficient.

In this chapter, the SEPIA customer interface variable was analysed, using an input-oriented VRS model. Three approaches were included. The first test included all decision variables and showed ten efficient and four inefficient firms. The slack, target and peer that could be used for benchmarking was also identified. The second test included eliminating one variable, and the third included running DEA for each variable at a time. The results show that all variable impact firms are on the efficiency frontier in differing degrees.

Chapter 8: Social Network Analysis of the NEPIA Model

> The magnitude of the socio-economic change that networked organisations portend may be as great as the industrial revolution (Achrol 1997, pp. 56-7).

This chapter is structured into three sections. In Section 8-1, social network analysis is used to explore the NEPIA model at a whole-of-network level. The use of visualisation techniques enables the structure of the network to be made visible. In Section 8.2, the structure of the network is explored, together with its relationship to service productivity. In Section 8.3, each firm is positioned within the network, and the importance of the firm in the network is explained by the degree of centrality. Measures of centrality include the degree of centrality, betweeness, closeness and eignvector centrality (Borgatti, Everett & Johnson 2013). These measures indicate intangible factors such as importance of the firm in the network and the opportunity and risks associated with the firm's position in the network. An attempt is also made to explain the correlation between a firm's position in the network and the efficiency score obtained by the firm in the SEPIA analysis.

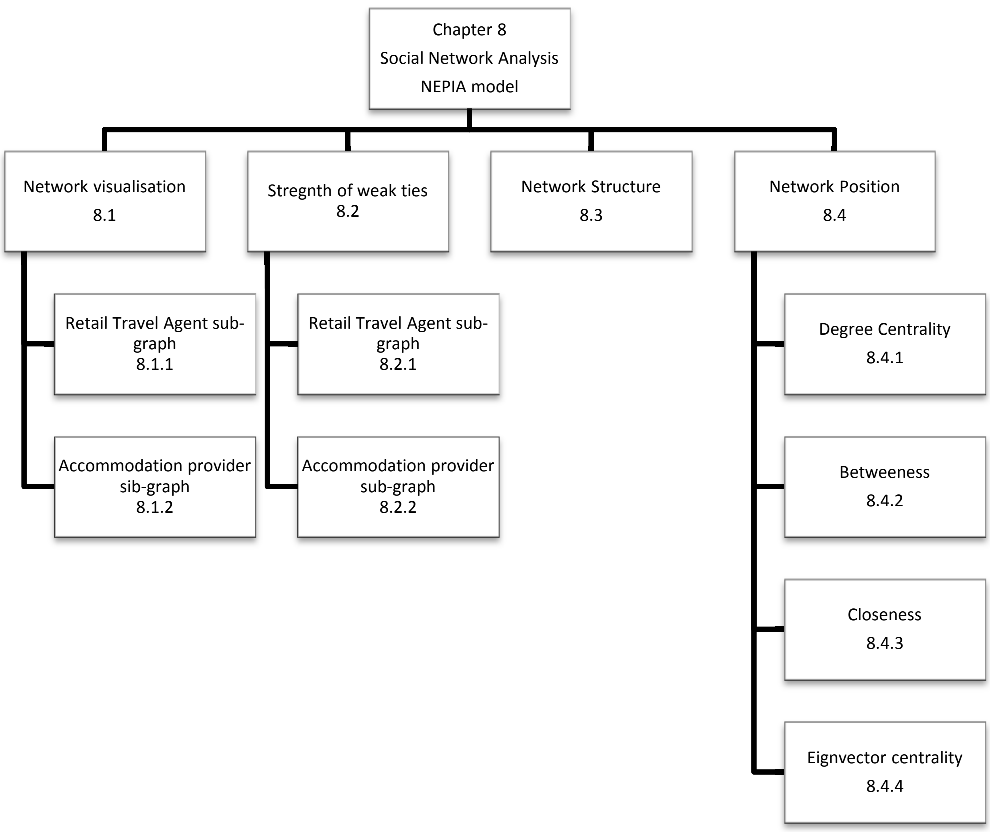


Figure 8-1 Outline of Chapter 8

8.1 Network visualisation

Visualisations are used to represent large data sets or data with complex sets of relations (Withall et al. 2007). According to Tufte (1997, 2001) and Withall, Phillips and Parish (2007) there are three classes of visualisation technique and it is critical to select the most appropriate one. The three techniques identified by them are: graphic visualisation, where the measurements place the nodes or agents in physical location according to where they reside at any given time; abstract typological visualisation, where the focus is on the relationships (ties) between nodes; and finally, plot-based visualisations, where the focus is on a single point in the network. In this research, an abstract typological visualisation method is adopted, given the focus is on the "who buys from who" relationship between customers, employees (representing the firm) and suppliers.

The application used to perform the network analysis is UCINET and NETDraw. Figure 8-2 is the visualisation of the unstructured (random) network.

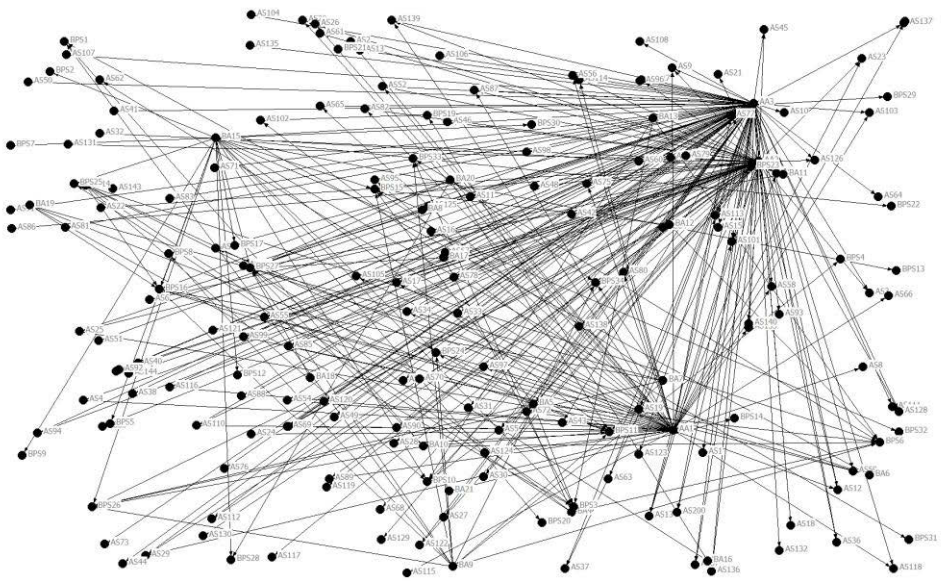


Figure 8-2 Visualisation of the random network structure

This visualisation is based on the data collected for all 14 organisations used in the SEPIA model. The data is reformatted, so that the node data represents each organisation and their suppliers, and the tie is representative of the flow of financial and booking data between each organisation. A common approach to examining network structure is to apply a spring layout algorithm to the network (Chan et al. 2003; Withall et al. 2007). The spring-embedded algorithm locates the nodes in such a way that it places the smallest path lengths next to each other, reducing the number of crossing paths (Hanneman & Riddle 2005). The application of the spring layout algorithm is a feature of NETdraw, and the result of the application of this on the whole network—that is, all nodes within the data set are illustrated in Figure 8-3. This visualisation highlights two distinct networks: that of the retail travel agent, and of the accommodation provider.

The retail travel agent network is organised in a hub and spoke-type structure (Withall, Phillips & Parish 2007), where the agents have a brokerage position connecting customers and suppliers. Conversely, the accommodation provider network is more distributed and less dense, with no apparent centre. In Sections 8.1.1 and 8.1.2, the sub-graphs are examined in more detail, and comparisons made between each.

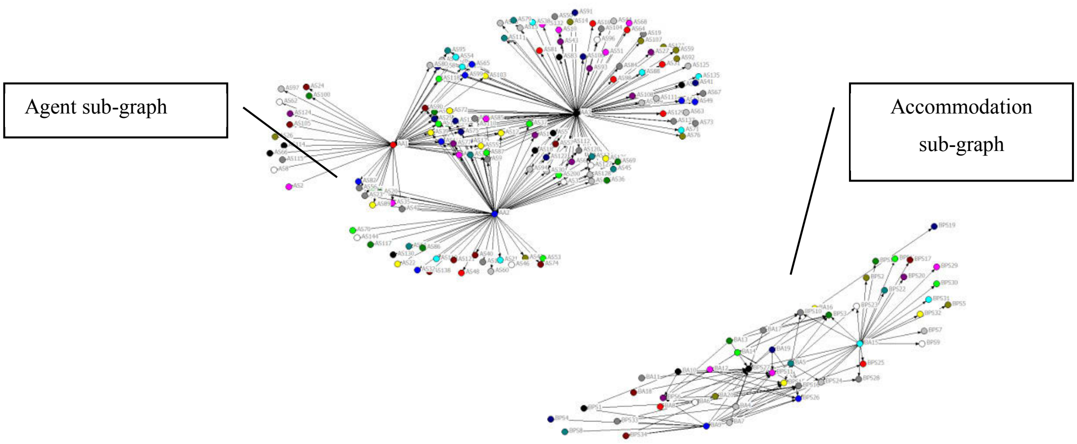


Figure 8-3 Whole-of-network graph (195 nodes, 333 ties)

8.1.1 Retail travel agent sub-graph

The retail travel agent sub-graph is shown in detail in Figure 8-4, with each retail travel agent node circled in blue. Each retail travel agent is located in suburbs of Sydney. All retail travel agents participating in this research focus on face-to-face service delivery. The role of the retail travel agent as an intermediary is similar to that of a broker. According to Long, Cunningham & Braithwaite (2013), brokers facilitate transactions between customers and suppliers, and each supplier is connected to the network via one or more of the agent nodes. The suppliers located within the red circle are highly embedded, with a position of influence. The level of influence is determined by the path length (Hanneman & Riddle 2005; Scott et al. 2008), that is, the number of ties between each of the nodes in the network. Firms located within the red circle are no more than two links away from any other node in the network. All other nodes are three or four links away from other nodes in the network. The greater the number of links, the more influence is diluted. Positions of influence afford firms the ability to extract greater value from other nodes in the network, and will be the focus of deference and attention (Hanneman & Riddle 2005).

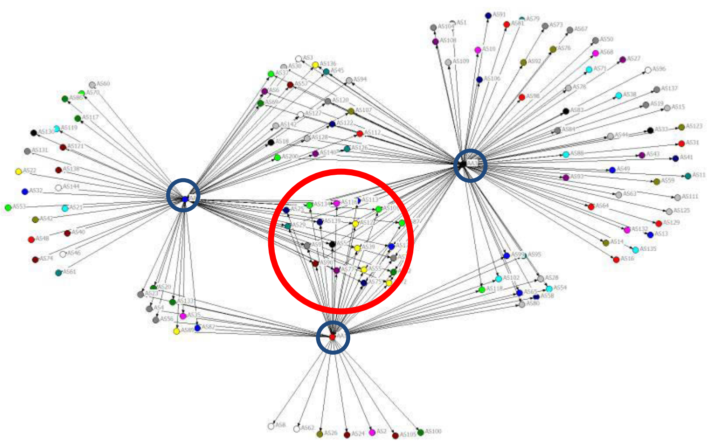


Figure 8-4 Network visualisation—agent sub-graph (146 nodes, 218 ties)

Studies of networks tend to focus on measuring and reducing the distance between firms (nodes) in the network. However, there are only a few studies that examine the cost of exclusion from the network. Exclusion may be the result of restricted entry or removal of a firm from the network, leaving other firms isolated and disconnected from each other (Sasaki & Uchida 2013; Tongia & Wilson 2011). Figure 8-5 is a visualisation of the retail travel agent network as agent (AA1), which was removed from the network. The result is that a number of suppliers are disconnected from the network, appearing as isolates. However, exclusion from one network does not necessarily mean exclusion from all (Tongia & Wilson 2011), and while the level of connectivity of suppliers with other networks is not known, it is apparent that the disconnection from this network would have an effect.

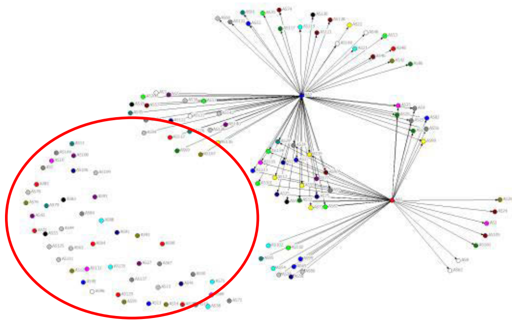


Figure 8-5 Visualisation of the cost of exclusion

8.1.2 Accommodation provider sub-graph

The accommodation sub-graph is shown in Figure 8-6. The accommodation network is more dispersed and less dense than the retail travel agent network. This is consistent with their geographical location in various tourism destinations throughout Australia. The strength of the ties in the accommodation network is weaker than that of the retail travel agents. The one node circled in red stands out as a small hub, and is the accommodation providers' website. The website enables the aggregation of internet bookings from customers and distribution partners. Booking transactions are aggregated in virtual space rather than a physical place, and the impact technology has on altering network connections is evident (Kalakota & Robinson 1998; Mislove 2009). The virtual nature of these transactions makes the geographic locations irrelevant regarding the flow of information, as proposed by Friedman (2005), but not in respect to how the customers travel (flow) between geographical locations (Leiper 1979, 1989). This is in contrast to the retail travel agent networks that participated in this research, for whom the physical location and proximity to customers was a key factor in the creation of value. Remembering that the visualisation technique is a representation of mathematical expressions, we explore the mathematical construction of networks next.

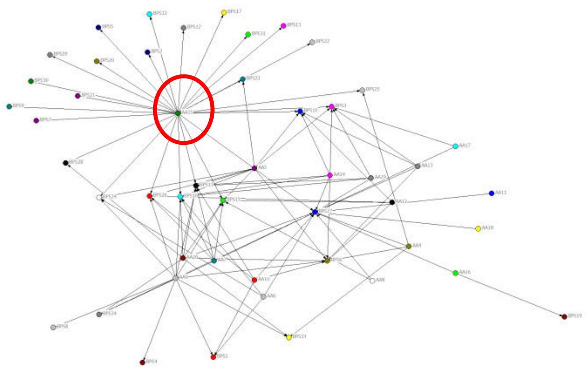


Figure 8-6 Accommodation sub-graph (52 nodes, 1010 ties)

8.2 Strength of weak ties

Granovetter (1973) first identified the strength of weak ties in a personal context and the concept was later discussed in a business context by Powell (1990), Uzzi (1996) and Rowley (2000) environment. The frequency of interactions (transactions) was one measure amoungst others that was used to measure the strighnt of a tie. Here, an attempt is made to explore the strength of weak ties to each of the sub-networks.

8.2.1 Retail travel agent sub-graph

The dyadic relationships (inter-firm) relationships are illustrated by the links between each organisation and the strength of each tie in Figure 8-7 is differentiated by the width of the tie (lines connecting the organisations) which is based on the number of bookings.

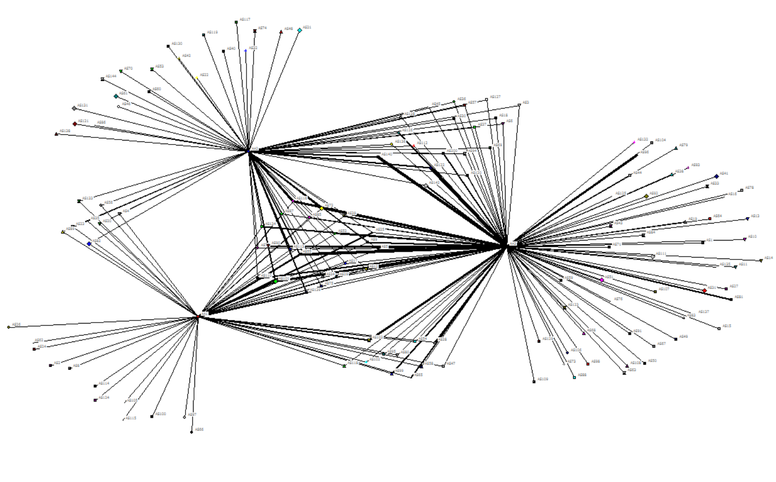


Figure 8-7 Strength of weak ties for the retail travel agent network

In order to illustrate the number of weak ties within the network Figure 8-8 shows network structure where the links representing the weak ties (a weak tie defined here as 5 bookings or less) are removed from the graph.

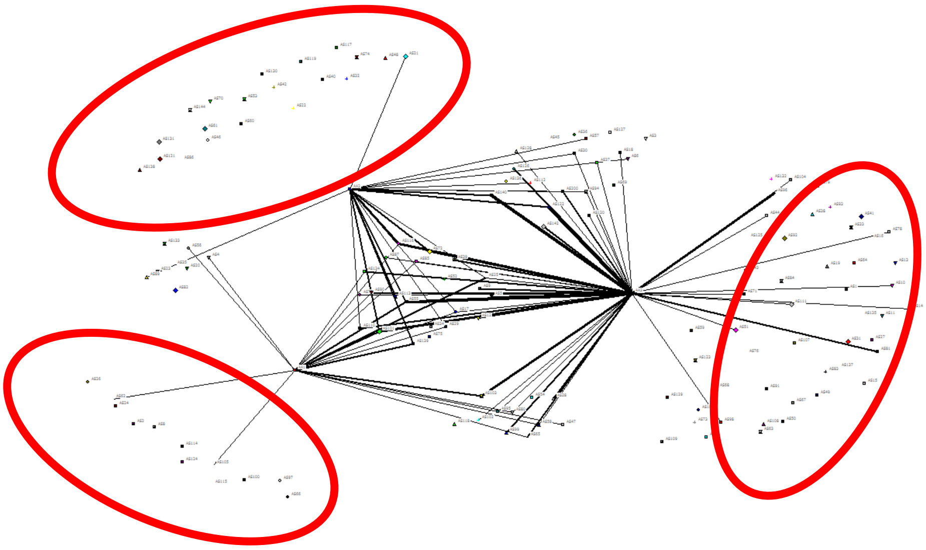


Figure 8-8 Links for weak ties removed from the retail travel agent network graph

The number of disconnected nodes in this graph indicates the positive effect of weak ties, where the weak tie between the agent and the supplier benefit both organisations. Agents are able to offer clients a wider range of services and supplier are able to access new markets or increase their market share through the relationships with agents. The red circles explemlify the organisation benefiting the strength of weak ties.

8.2.2 Accommodation provider sub-graph

The accommodation provider network is more dispersed and the whole accommodation sub-graph is illustrated in Figure 8-9.

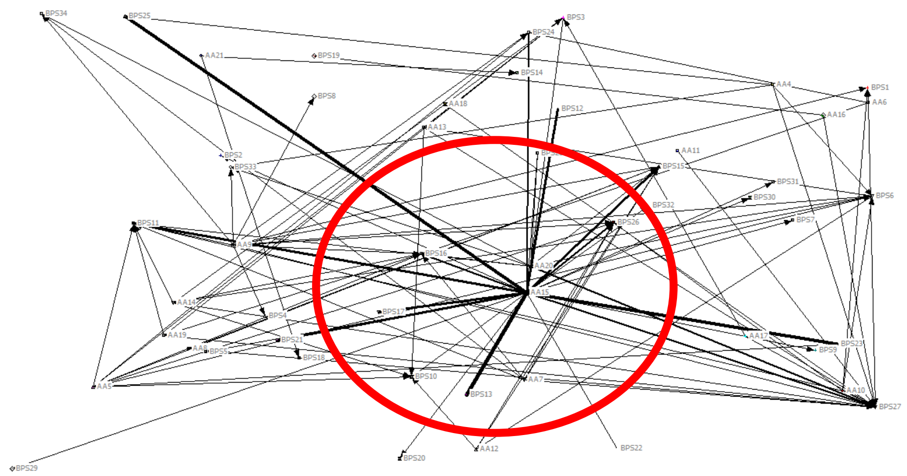


Figure 8-9 Strength of weak ties for the accommodation network

The strength of ties can be seen emanating from AA15, the organisations an online booking website. Figure 8-10 excludes the links of weak ties, where less than 5 bookings are transacted. Closer examination of the nodes with weak ties shows the accommodation agents and other service providers such as sightseeing tours. This suggests the accommodation network is strong and less reliant on weak ties. However, the website providing distribution plays a significant role in attracting customers and channelling bookings across the accommodation network.

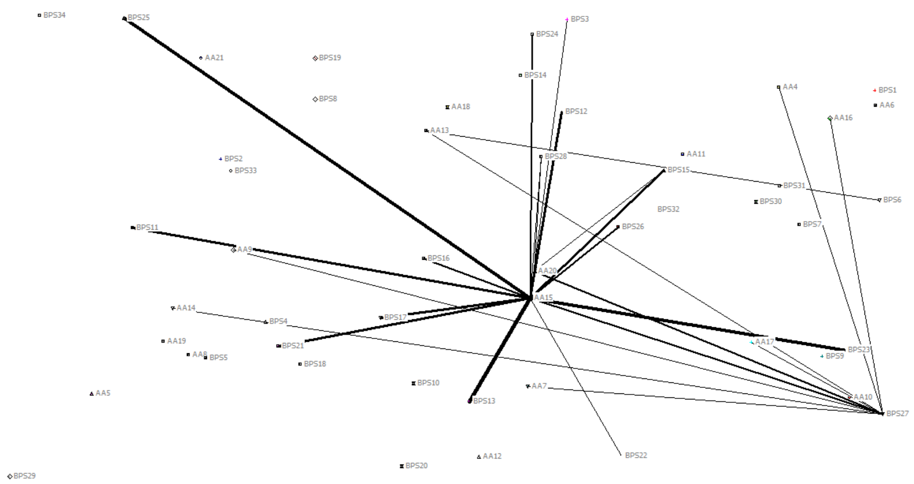


Figure 8-10 Links for weak ties removed from the accommodation network

The exploratory nature of the dyadic (inter-firm) assessment requires further examination including establishing a full set of metrics that can be used to measure the strength of weak ties.

8.3 Network structure

According to Long, Cunningham and Braithwaite (2013) and Borgatti and Halgin (2011), the network structure is formed by the number of ties connecting each firm. This determines the firm's position within the network. The network's structure determines the levels of density and centrality. Centrality is determined by the degree in which the firm occupies a central position, how close the firm is to other firms, the extent to which the firm is connected to other firms within the network (betweeness centrality) and the degree to which the firm's connections are connected (eignvector centrality) (Borgatti et al. 2013; Jackson 2010; Scott et al. 2008) . These measures are discussed next.

8.3.1 Network density

Network density is an expression of the number of ties in the network, expressed as a proportion of the total number of ties possible. In an ordinary undirected non-reflexive graph, the mathematical expression identified by Borgatti, Everett and Johnson (2013) is:

$$\boldsymbol{n(n-1)/2} \qquad \textbf{Equation 6}$$

Where n is the number of nodes.

Density is also interpreted as the probability that a tie exists between any randomly-chosen nodes, and is almost always used is a comparative measure (Borgatti, Everett & Johnson 2013). The density calculation making an adjustment of the total tie strength with the number of nodes enables comparative measurement across networks of different sizes. However, the average degree is an easier metric to interpret, as it is the number of ties of each node (Borgatti, Everett & Johnson 2013). The relationship between the average degree (d) and density for undirected non-reflexive graphs is given by:

$$d = \frac{2T}{n} = \text{density x } (n - 1)$$ **Equation 7**

Where
d = average degree density
T = the number of edges in the network
n = the number of nodes
(Borgatti, Everett & Johnson 2013, p.152)

Table 8-1 shows the number of nodes and ties, average value, standard deviation and average weighted degree. For comparative purposes, the whole network (alldata-Attr) is compared to the agent sub-graph (agentdata-Attr) and the accommodation network (a_accomdata-Net).

Table 8-1 Network data

Network	Nodes	Ties	Average value	Standard deviation	Average weighted degree
alldata-Attr whole network	195	333	51.071	44.113	153.213
agentdata-Attr retail travel agent network	146	218	34.877	35.322	104.630
a_accomdata-Net accommodation provider network	52	101	1.294	18.718	66.019

Network density is expressed as a single number and used for comparative purposes. The density is an index showing the degree of dyadic connections in a population. It is observed through the graph, as well as the density rating of the agent (agentdata-Attr), which with a density score of 104.630 is denser than the accommodation (a_accomdata-Net) network, with a score of 66.019. According to Provan, Fish and Sydow (2007), the standard deviation indicates the level of dispersion of the network, with lower levels of dispersion indicating that the nodes are close to the centre. Here, the retail travel agent network (agentdata_attr) shows a standard deviation (Std Dev) score of 35.322, compared with the accommodation provider (a_accomdata_Net) score of 18.718. This confirms what is known qualitatively: that the retail agent network is less dispersed than the accommodation network.

8.3.2 Network centrality and centralisation

Network centrality is a measure of the number of ties connected to a firm. It is an indication of the level of importance held by the firm as a result of its position within the network (Borgatti, Everett & Johnson 2013; Freeman 1979). The removal of firms holding positions of importance is likely to impede the operation of the whole network (Tongia & Wilson 2011). The notion of centrality also exists at a whole-of-network level, referred to here as centralisation. The measure of centralisation at a whole-of-network level characterises and calculates the distributive effect the organisation has on the network. This captures the level of inequality between nodes. According to Borgatti, Everett and Johnson (2013) and Provan, Fish and Sydow (2007), high degrees of centrality indicate the existence of dominant nodes connected to many other nodes. Low levels of centrality indicate a more evenly distributed network (Provan, Fish & Sydow 2007).

Table 8-2 Network centrality and DEA efficiency scores

DMU	ID	Degree centrality	Betweeness centrality	Closeness centrality	Eigenvector centrality	Efficiency score from DEA analysis
AA1	AA1	52	2316.325	10271.000	0.061	1.00000
AA2	AA2	70	3688.313	10235.000	0.081	1.00000
AA3	AA3	102	6880.362	10171.000	0.112	0.30894
PA1	BPS22	1	0.000	28983.000	0.000	1.00000
PA2	BSP26	6	44.291	28961.000	0.000	0.95715
PA3	BPS3	6	34.585	28971.000	0.000	0.83266
PA4	BPS15	7	60.584	28959.000	0.000	1.00000
PA5	BPS16	8	61.415	28957.000	0.000	1.00000
PA6	BSP10	5	23.74	28961.000	0.000	1.00000
PA7	BPS17	1	0.000	28983.000	0.000	1.00000
PA8	BSP11	8	59.55	28957.000	0.000	0.92980
PA9	BPS23	2	2.466	28979.000	0.000	1.00000
PA10	BPS24	4	26.176	28965.000	0.000	1.00000
PA11	BSP27	15	330.367	28941.000	0.000	1.00000

8.3.2.1 Degree centrality

Degree centrality is the simplest of the centrality measures and it is representative of the number of ties for each firm (Borgatti, Everett & Johnson 2013). The higher the degree centrality score, the more central the organisation . The retail travel agents (AA1, AA2 and AA3) all show higher levels of degree centrality, with scores of 52, 70 and 102, respectively, compared with that of accommodation providers, with scores ranging from one to eight. AA3 has the highest level of centrality, yet is the least efficient firm. Further research into the cause of inefficiency is warranted, and discussed in Chapter 9.

As mentioned, the accommodation providers exhibit very low levels of centrality. However, company structure is such that the accommodation provider owns a third party company operating tour desk and guest services from the property reception. The tour desk sells tickets to attractions, day tours, weekend and longer tours. These transactions were excluded from this analysis. Therefore, the importance and benefits resulting from geographic proximity for accommodation and other service providers is not captured in this study. However, the co-location of operations brings to light the importance of agglomeration and geographic proximity to network operations.

8.3.2.2 Closeness centrality

Closeness centrality is the degree to which firms are near other firms in the network. Closeness is measured in terms of geodetic distance. According to Hanneman and Riddle (2005), the closeness centrality measure can be interpreted as a measure of the mean time it takes for information to flow through the network. Firms with high levels of closeness centrality play an important role in diffusing innovation by transmitting new ideas and methods throughout the network more quickly than other nodes are able to (Garson 2012). Given that this research defines network productivity as the speed at which benefits flow though the network; this makes closeness centrality a key measure for productivity for networked-based firms. The higher the closeness centrality score, the more likely the firm to receive the benefits resulting from the flow of customers, material, information and money. The closeness centrality measure is expressed mathematically as:

$$C_c(v_i) = \frac{1}{\sum_{j=1}^{n} d(v_i, v_j)}$$ **Equation 8**

Where $d(v_i, v_j)$ is the distance between v_i and v_j

In this study, AA1 has the highest closeness centrality score of 10271.000, and PA5 has the lowest centrality score of 28957.000. Therefore, it is predicted that AA1 would have higher levels of innovation than PA5. However, both have an efficiency score of one. Therefore, from this small sample size it is not possible to link or predict whether there is a correlation between closeness centrality and efficiency.

8.3.2.3 Betweeness centrality

Betweeness is the measure of the extent to which a node is connected to other nodes that are unconnected to each other. The measure shows the degree to which a node is in the bridging position (Hanneman & Riddle 2005). The probability is that a path from one firm to another takes a particular route through an intermediary, that Adamic (2013) expresses mathematically as:

$$C_B(v_i) = \sum_{j<k} g_{jk}(v_i) / g_{jk}$$ **Equation 9**

Where g_{jk} is the probability that for each pair of nodes *j* and *k,* vertex *i* belongs to geodetic *jk*.

That is, the betweeness centrality of node of v_i is the number of geodetics between j and k that go through *i*, while g_{jk} is the total number of geodetics between *j* and *k*. Therefore, it is possible to measure the centrality of *i* with respect to its possible role as an intermediary between *j* and *k*. According to Adamic (2013), the betweeness measure depends on the size of the network. To allow for comparisons between networks, the betweeness is divided by *(n-1)(n-2).*

The data in Table 8-2 indicates that retail travel agents have high levels of betweeness. This is consistent with their role in the travel industry acting as an intermediary between customer and wholesaler. The relatively low levels of betweeness for accommodation providers are also consistent with their role as service providers, where the role of intermediary is transferred to their wholly-owned subsidiary. The impact of the intermediary or organisations in a brokerage position on efficiency is identified as an area for future research.

8.3.2.4 Eigenvector centrality

Eigenvector centrality can be described from a number of perspectives (Bonacich 1972). These include a measure of popularity, in that a node with a high eigenvector centrality is connected to other nodes, which are themselves well-connected (Garson 2012). Eigenvector centrality is often used as an indication of importance, popularity and risk (Borgatti, Carley & Krackhardt 2006; Borgatti, Everett & Johnson 2013). Eigenvector centrality is represented mathematically by Borgatti, Everett and Johnson (2013, p. 168) as:

$$e_i = \lambda \sum_j x_{ij} e_j$$ **Equation 10**

Where e is the eigenvector centrality, score (lambda) is a proportionality constant called the eigenvector.

The retail travel agents all have eigenvector centrality values. By including the efficiency score calculated in the SEPIA analysis using DEA, it is possible to align the effects of network position and level of influence or popularity (all intangible factors) with efficiency scores. This may provide insight into the positive and/or negative effects of social constructs such as power, trust; reciprocity and the effect such constructs have on the efficiency for service and network-based firms. In this case, a retail travel agent (AA3) has a high eigenvector score, indicating that they are popular and possess influence in the network. However, it is also the least efficient firm. The link between popularity and efficiency is not generalisable in this research, but is a factor for future research, and discussed in Chapter 9.

8.4 Network effects on firm level productivity

In this section a review of the whole network and the potential network effects on firm level productivity examined. The data is reorganized based on the highest degree centrality score as shown in Table 8-3.

Table 8-3 SNA centrality and DEA efficiency measures ordered by the number of connections

DMU	ID	Degree centrality	Betweeness centrality	Closeness centrality	Eigenvector centrality	Efficiency score from DEA analysis
AA3	AA3	102	6880.362	10171.000	0.112	0.30894
AA2	AA2	70	3688.313	10235.000	0.081	1.00000
AA1	AA1	52	2316.325	10271.000	0.061	1.00000
PA11	BSP27	15	330.367	28941.000	0.000	1.00000
PA5	BPS16	8	61.415	28957.000	0.000	1.00000
PA8	BSP11	8	59.55	28957.000	0.000	0.92980
PA4	BPS15	7	60.584	28959.000	0.000	1.00000
PA2	BSP26	6	44.291	28961.000	0.000	0.95715
PA3	BPS3	6	34.585	28971.000	0.000	0.83266
PA6	BSP10	5	23.74	28961.000	0.000	1.00000
PA10	BPS24	4	26.176	28965.000	0.000	1.00000
PA9	BPS23	2	2.466	28979.000	0.000	1.00000
PA1	BPS22	1	0.000	28983.000	0.000	1.00000
PA7	BPS17	1	0.000	28983.000	0.000	1.00000

From the table the following are not conclusive but can be inferred

- Agents demonstrate greater popularity than accommodation providers as measured by their degree and eigenvector centrality scores. It is possible to speculate that this may be the result of the geographic proximity to their customer base.

- Accommodation providers demonstrate greater capacity to diffuse information and innovation. This is inferred by the higher level of closeness centrality. However, no one accommodation provider is more able to diffuse information or innovate than any of the other accommodation providers.

- The higher the level of network density and popularity assumed by AA3 as a result of the high levels of network connections does not lead to greater efficiency. On the contrary, AA3 is technically inefficient. It is possible to infer that increases in popularity do not automatically translate to greater levels of efficiency or positive organisational outcomes. This analysis may provide another measure which illustrates economies and diseconomies of scale, where bigger is not always better. The preliminary analysis, whilst not conclusive or generalisable leads to speculation that the effects of co-ordination or an inability to leverage resources across network boundaries is what leads to AA3's lower level of efficiency.

- No one network factor stands out as a key driver of efficiency, however, popularity may be a key driver of inefficiency. The may be attributed to the additional co-ordination or an inability to leverage resources across the network.

In this chapter, social network analysis was applied to the 14 tourism, travel and hospitality organisations in this study. The visualisation of the whole network identified the existence of two distinct networks: the retail travel agency network and the network of accommodation providers. A closer examination of the visualisation of the retail agent network further showed three distinct yet connected networks. The three networks were each structured in a hub and spoke configuration, with each retail agent in a central position. Additionally, the visualisation of the network showed that some suppliers enjoyed a level of influence with a geodetic distance of two. Further study aligning the efficiency of firms and their position within the network is recommended.

Chapter 9: Findings, Limitations, Future Research and Conclusion

The study of service productivity is a comparatively new field. It appears in a number of disciplines, including economics (Avkiran 2006; Syverson 2011), marketing (Gummesson 1998; Parasuraman 2002), human resource management (Hu & Cai 2004), operations management (Agarwal & Selen 2005; Schmenner 1986; 2004) and management (Green & Agarwal 2009; Gummesson 1998; Maglio et al. 2006). Researchers developed a number of models attempting to explain and generalise service productivity. However, the models were not able to be operationalised, as the variables incorporated within each model were not defined with sufficient specificity to enable the unambiguous assignment of measures.

Additionally, three incorrect assumptions existed, which also prevented an organisation's operations from being plotted with any degree of accuracy. The first was that firms adopt a single mode of operation; however, this is not the case with service organisations. Service organisations adapt their service offerings to accommodate customer variability, and as such have multiple modes of operation. The second assumption is that service firms have a single entry and exit point into the organisation. This is depicted in a linear, single plane, single direction operation, input-transformation-output model. However, current business practice is that firms interact with both customers and suppliers, resulting in inputs and outputs received and sent through *front office* and *back office* operations (Agarwal & Selen 2005; Kalakota & Robinson 1998). Therefore, it is necessary to include multiple input and output points for service operations.

Finally, the assumption that decisions affecting a firm's productivity are wholly within management control is not the case in service organisations. Service is the result of multiple decisions made by multiple stakeholders, namely customers, employees and suppliers. These decisions are made in real-time during the course of the service delivery process. As a result, service productivity is defined in this research as the result of multiple decisions made by multiple stakeholders during the service delivery process.

The focus of this thesis is:

How can productivity be measured for service and network-based firms?

This chapter is structured into four sections. Section 9.1 outlines nine key findings and discusses the managerial implications of each. As with any research, this study has its limitations, and these are presented in Section 9.2. Ideas for future research are consolidated in Section 9.3. The thesis concludes with a summary of the four key contributions made by this research.

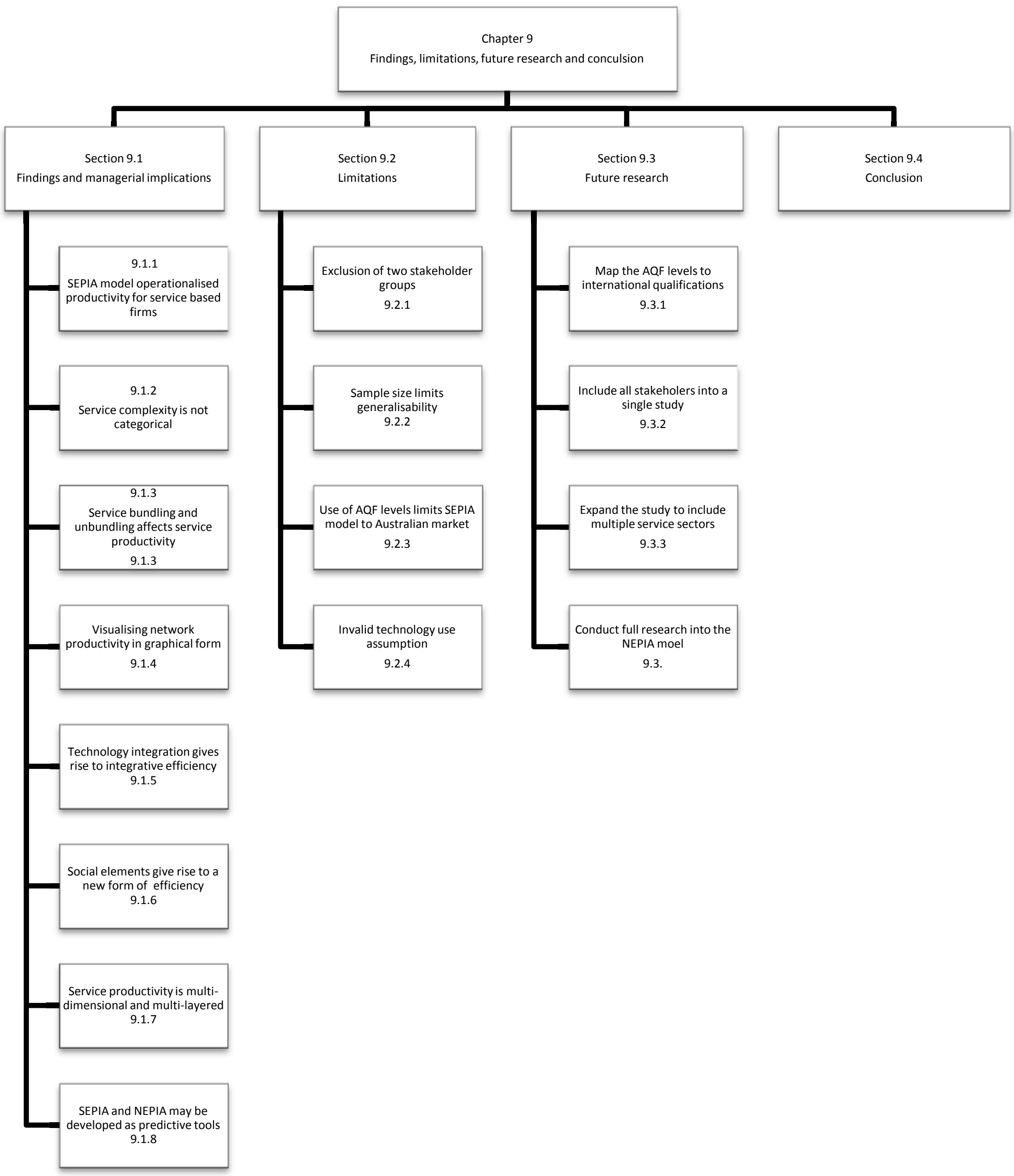


Figure 9-1 Outline of Chapter 9

9.1 Findings and managerial implications

Transactional data recorded from business interactions between customers, employees and suppliers was collected from 14 organisations operating in the Australian tourism, travel and hospitality industry. The heterogeneous nature of the organisations was due to their belonging to one of two ANZSIC codes. Three of the organisations were retail travel agents and 11 were accommodation providers. Variables and variable categories were identified and defined in this research from a multi-disciplinary review of the academic literature. Transactional data was collected and prepared for analysis using two mathematical techniques, one for each of the two models developed. The SEPIA model examined service productivity at a firm level, and DEA was the mathematical technique applied. Conversely, the NEPIA model represents network productivity, and SNA was the analytical technique applied at a whole-of-network level. From this research, a generalised approach to measuring productivity for service firms is presented, which in part answers the research question of how productivity can be measured for service and network-based firms. Additionally, ten key findings emerged, and are listed and discussed below and shown in Table 9-1 with the sections and page numbers within the thesis that contributes to each finding, after which each finding is presented in more detail.

1. Firm level data aligned to KLEMS, ANZSIC and SNA93 accounts.
2. Network productivity is a new area of study.
3. SEPIA is a generalised approach to measuring service productivity.
4. Service complexity is not categorical.
5. Service bundling and re-bundling affects service productivity.
6. Network productivity can be visualised in graphical form.
7. Technology integration produces integrative efficiency.
8. Social interactions produce collaborative efficiency.
9. Network productivity is multi-dimensional and multi-layered
10. The SEPIA and NEPIA models may be developed into predictive productivity management tools.

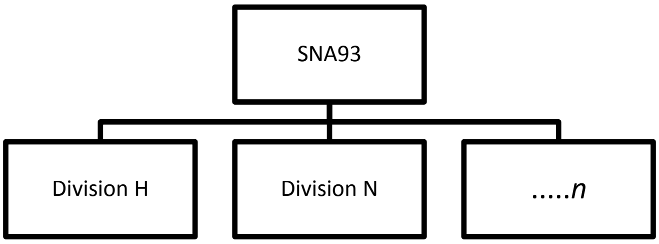
9.1.1 Firm-level data aligned to KLEMS, ANZSIC and SNA93 accounts

Productivity is one of the economic performance measures critical to the assessment of the economic wellbeing of a nation (Jorgenson, Ho & Samuels 2010; O'Mahony & Timmer 2009; Timmer, O'Mahony & van Ark 2007). Productivity at an economy level is calculated from data in the Standard National Accounts (SNA93). The SNA93 accounts are structured by the 32 industry codes and 72 industry sub-categories specified in the ANZSIC codes. The data collected for the SNA93 accounts is collected using the KLEMS database and framework (O'Mahony & Timmer 2009; Timmer, O'Mahony & van Ark 2007).

One of the limitations of the KLEMS framework, identified in Chapter 2, was the absence of firm-level data. The operationalisation of the SEPIA model using variables determined by academic literature and expert opinion (Avkiran 2006) and measures from three of the five stakeholders (namely, customers, employees and suppliers) is highlighted in Table 9-1. It extends the KLEMS database by providing a set of firm-level variables, aligned to the KLEMS framework. Additionally, the red text shows areas where KLEMS may be extended, with the inclusion of customer and information technology categories and the extension of variables used to measure labour productivity to incorporate the heterogeneous nature of employees in future measures of labour productivity.

Table 9-1 also highlights the multi-disciplinary nature of the study and the alignment of the variables and shareholders to the various functions within an organisation. This holistic view of the firm and the incorporation of the different stakeholder perspectives illuminate the firm's complexity and the impact that decisions made by various stakeholder have on overall productivity of service and network-based firms. The study, measure and reporting of service firms is recommended by aggregating service sectors, as represented by the Australian Services Roundtable. It will unite the service sector and provide estimates and a standardised means to benchmark and compare productivity across different firms operating in different service sectors.

Table 9-2 SEPIA and NEPIA models aligned to the KLEMS framework

Economy	As defined by geographic boundary Including service and non-service sectors Linked to the Standard National Accounts (SNA93)					
Generalised approach to service sector measures	Bringing together service sectors identified by the ASR with ANZSIC codes 					
Industry Productivity KLEMS framework	Consumption Addition to KLEMS as input (Customer)	Labour productivity (Extend KLEMS Measure)	Intermediate input	Addition to KLEMS (Information communication technology)	Capital	Labour
NEPIA model (industry and cross-industry network configurations)						
Firm (ANZSIC code)	Marketing	Human resources	Operations management	Information communication technology	Finance	Management
SEPIA model (stakeholder decision-making and resource integration)						
	Information technology enabling data and information sharing between processes, systems and stakeholders					
Individual	Customer	Employee	Supplier	Connection	Shareholder	Manager
Construct	Client interface	Employee attributes	Supplier input	Supplier integration	OUT OF SCOPE (Future research)	
Variables	Service complexity	Physical	Service providers	Data		
	Customer interface	Cognitive	Service types	Access		
	Customer channel	Engagement	Technology	Integration		
	Customer loyalty					
	Willingness to pay					

9.1.2 Network productivity as a new area of study

Economists use KLEMS to measure productivity (O'Mahony & Timmer 2009b; Timmer et al. 2007). A weakness of the KLEMS framework is the absence of firm level measures and this weakness is addressed in this thesis. Academic literature positions productivity at a an economy level as macro view, productivity measures at an individual and firm level a micro view and productivity measures of industries or geographies as a meso- level analysis (Simon 1959). In this thesis and through the exploration of network productivity, productivity for network based firms emerges as a new area of study, one that geographic and industry boundaries.

Networks vary in configuration and have been incorporated in the NEPIA model. Organisations operating in networks share resources and perform work in an orchestrated and co-ordinated way (Gattorna 2010). The formation and configuration of these networks enable the identification of defined units of production. Network configurations such as dyads, triads, hub and spoke, pendent, circles and constellations, form new productive unit rather than a single firm working autonomously (Gattorna 2010). Hence, networks form a valid unit of analysis that transcends geographic boundaries and often include organisations from one or more industry sectors. Figure 8-2 illustrates the network layer that sits between the firm layer and the current industry productivity layer and KLEMS framework, highlighting a number of the potential network configurations open for examination.

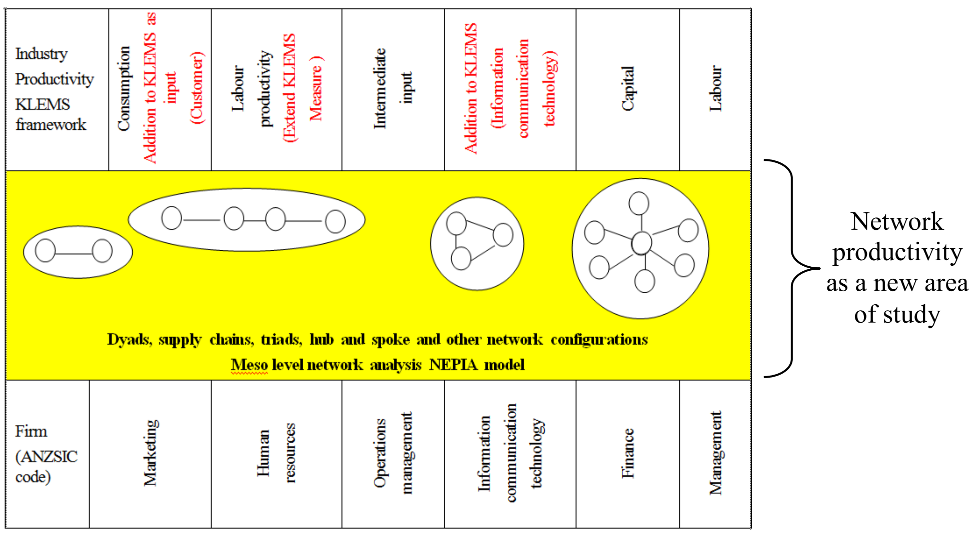


Figure 9-2 Network productivity area

9.1.3 The SEPIA model operationalises service productivity

The SEPIA model operationalises service productivity. Given that customer input into the service delivery process is a key condition of the service delivery to commence (Sampson & Froehle 2006), the customer variables were determined at the point at which the customer and firm interact, that is, the customer interface. Customer interface variables include service complexity (Roth & Menor 2003; Schmenner 2004), customer interaction (Froehle & Roth 2004; Roth & Menor 2003) and customer channel (Boyer, Hallowell & Roth 2002; Kalakota & Robinson 1998) as inputs. Outputs are willingness to pay (Boyer, Hallowell & Roth 2002; Ng 2008), and customer loyalty (Heskett et al. 1994; Lam et al. 2004). The customer's willingness to pay was used as a proxy for customer value (Ng 2008), and customer loyalty is used as a proxy for service quality. Customer loyalty is determined by the number of repeat and referral customers (Lam et al. 2004).

Employee attributes include variables enabling the heterogeneous nature of employees and managers to be included as a factor of service productivity. The categories of employee attribute, physical (Avolio & Waldman 1994; Gomez & de Cos 2006), cognitive (Wolff 2002) and psychosocial (Kahn 1990; Wilson 2009) included in the SEPIA model extend the current KLEMS measure of labour productivity. KLEMS' measure of labour productivity is currently the number of employees multiplied by the number of hours worked. These attributes relate to the physical, cognitive and psychosocial aspects of the person.

Supplier variables originally included measures relating to the mechanistic nature of systems integration, such as data structures (Clifton & Thuraisingham 2001; Swatman & Swatman 1991), data transfer mechanisms (Postel & Reynolds 1985; Swatman & Swatman 1991) and data access. However, during the exploratory stages of the NEPIA model it became apparent that the more appropriate units of measure are the number of suppliers (nodes within the network), the volume of customers and the value of transactions (a representation of the existence and strength of the ties) flowing from and to (between) each of the entities.

Integration of ICT systems was found to be important despite changes to the variables and units of measure applied in the SEPIA model. An analysis of the systems used to transact and connect with customers, employees and suppliers resulted in the introduction of new entities, that is, the technology providers. These technology providers were most often external organisations with contractual relationships with either the decision-making unit firm or the supplier. This presented differences in the network structure, depending on the flow examined, be it customer, information or financial flow, thereby making productivity for service firms both multi-dimensional and multi-layered. This is discussed in more detail in Section 9.1.7.

The operationalisation of the SEPIA model has three important implications. The first is that the contemporary nature of the SEPIA model makes it possible to systematically analyse and compare service productivity across all service sectors. This results in insights into the factors and drivers of productivity for all service and network-based firms. The second implication is the potential to expand the labour characteristics currently used in the KLEMS framework (O'Mahony & Timmer 2009; Timmer, O'Mahony & van Ark 2007). The inclusion of extra employee attributes will help account for the heterogeneity of the firm's workforce in relation to skills and experience. This will provide for the intangible contributions of employees and the effects of their value creation efforts. The third implication is the potential to extend the KLEMS framework to include customer (C) and information technology (I) as new categories, thereby creating a KLEMS CI framework incorporating firm-level data.

9.1.4 Service complexity is not categorical

Service complexity was operationalised using Schmenner's (2004) customer variability levels of high and low, and Roth's (2001) P3 service matrix design, which incorporated the level of knowledge required as a means to measure complexity. In keeping with Schmenner's and Roth's matrix models, a service complexity matrix was defined and operationalised based on the inclusion of single or multiple service providers and single or multiple service types in the one service transaction. Each service transaction was categorised into low, medium (service provider), medium (service type) and high level, with each attaining a score of one to four, respectively.

This scoring method eliminated the limitation found in Schmenner's (2004) Service Complexity Matrix, where an organisation's operations cannot be plotted accurately. It enabled each of the service transactions to be categorised unambiguously into low, medium and high service complexity levels. However, it was not until the data coding phase that it became apparent that the scoring method applied to the high category was inadequate in determining just how complex the service transaction was. For example, the incorporation of eight service providers into the service offering required more coordination than including only three service providers. As a result, the level of complexity depends on the number of service providers and types included in the service transaction. Additionally, during the model validation phase it was determined that the number of customers in a service transaction also contributes to service complexity.

During model validation, two managers and two employees of the travel agents confirmed that service complexity is also the product of the number of customers being serviced within the same service transaction (booking). One consultant expressed it this way:

> group travel is more complex than one person travelling on their own, you have to collect more information and everyone invariably wants to do different things and you have to make sure everyone gets what they want (AA2).

The inclusion of customers as a measure of service complexity also leads to service complexity being derived mathematically rather than categorically:

$$\sum_{i=1}^{n} C_i P_i T_i$$

Equation 11

Where i is the number of transactions, Ci = the number of customers, Pi = the number of service providers, and Ti = the number of service types.

This research found that service complexity is a function of the number of customers, service providers and service types present in any given service interaction. As service offerings are atomised, the bundling and unbundling of services increases the complexity of service transactions. This new mathematical calculation of service complexity enables the effects of service unbundling and bundling and customer variability to be examined with more clarity. When service complexity is seen as a factor of productivity, it can be measured and more clearly understood. This is an area identified for future research.

9.1.5 Service bundling and unbundling affects service productivity

This research observes that the phenomenon of service bundling and unbundling affects service productivity. A service bundle contains at least two service offerings that are offered together for one price, and which present value to potential customers (Kohlborn et al. 2010). The process of service unbundling is prevalent in the airline industry, particularly by low cost carriers (Brueckner et al. 2013; O'Connell & Warnock-Smith 2013). In the past, airlines offered a bundle of services, which included auxiliary services such as the use of their call centre to make and change bookings, a baggage allowance, in-flight meal and in-flight entertainment, in addition to their core offer of transportation (Brueckner et al. 2013). The bundle of services was automatically included for a single price.

Customers purchasing bundled service offerings sometimes pay for services they do not need or want (Dye 2014), and the provision of unwanted services to customers is a waste of resources for the service provider. Removing unwanted services from the service offering enables service providers to reduce costs and simultaneously reduce their price offering to the customer. This also allows customers to inspect each service offering separately, and only pay for services of value to them.

Past studies of the effects of service bundling and unbundling have taken the perspective of the customer and the service provider (Brueckner et al. 2013; Dye 2014); there was no mention of the effects of this on agents or other intermediaries. Employees of the travel agency were asked how the unbundling of services has affected their productivity or work practices. They responded:

> it is a nightmare, now when a group of people make a booking …some people want extra luggage and no food, others want to book exit seats and they don't want to pay you for processing it (Employee AA1).

> you should see what happens when they (airline or tour company) cancel a flight or tour, you have to re-do all of the work you have done and don't talk to me about people wanting to change seats (Employee AA2).

A finding from this research is that the perspective of the agent or intermediary differs significantly from the perspective of the customer or service provider. Further research into the effects of service bundling and unbundling across all sectors in the tourism, travel and hospitality industry and other service sectors is warranted.

9.1.6 Network productivity can be visualised in graphical form

The visualisation of the data for all 14 organisations provided a holistic view of the network and how each organisation was positioned within it. The existence of two sub-networks is apparent. The first sub-network represented the retail travel agent network, and the second, the accommodation provider network. The network configuration became visible when the network structure was represented in graphical form. The retail travel agents network is seen to occur in a hub and spoke configuration, while the accommodation provider network was more disbursed, with centralisation occurring around the online distribution channel. A number of other network aspects become visible, such as the identification of organisations holding key network positions—that is, positions of influence or risk and/or dependency. This visualisation and knowledge of network structure can provide management with strategic insights into potential partners and opportunities that may be exploited, and/or risks that may be averted.

The impact of changes to the configuration of networks can also inform managers and government on the up and downstream impacts at a micro (business), meso (industry) and macro (economy) level (Simon 1959). Further, the inclusion of the efficiency score as a node attribute in social network analysis provides insight into the effect of intangible factors such as network size (network density), different network positions (degree centrality), level of influence (betweeness centrality) and level of popularity (eignvector centrality) on productivity for the individual firm and for the service value network. This alignment of efficiency scores with nodes in the network also provides an avenue for future research into the efficiency based on different network configurations.

Future research would also include the creation of customer, information and financial flow maps using geo-spatial coding and techniques. This will allow the effects of geography, place and location and the flows that occur between them to be examined in more detail. This technique may be of varying interest to industry, but is of interest to the tourism, travel and hospitality industry (*Australian international visitor survey* 2010; Leiper 1989).

9.1.7 Technology integration gives rise to integrative efficiency

The question of the benefits of investments in technology, also referred to as the productivity paradox, has been an area of investigation for over two decades (Brynjolfsson 1993; Sigala 2003, 2008). Technology benefits are not gained solely from technology investments or the *levels* of technology use. Technology integration enables the free flow of information between customers, employees, suppliers, systems and business processes (Kalakota & Robinson 1998; Poon & Swatman 1999; Sigala 2003, 2008; Swatman & Swatman 1991). The importance of technology integration and electronic data interchange is found in the literature and supported by many scholars (Gattorna 2010; Kalakota & Robinson 1998; Swatman & Swatman 1991).

Supplier integration variables examine *how* technology is used, rather than *if* or *what* technology is used. This research found high levels of technology adoption. All 14 organisations use technology extensively in their business operations, and all 14 used more than one system. The systems were used for various functions, but the principal use for retail travel agents was to connect and communicate with their customers and suppliers. The primary function for the accommodation providers is to manage their international operations. A secondary function is to connect to customers and suppliers.

Two key findings resulted from this analysis. First, although the level of technology adoption is high, the overall level of technology integration was low. In the case of retail travel agents, it was found they use over five different systems for different business functions or to connect with customers and suppliers. In some cases, the technology is provided by suppliers at no or minimal cost, in order to support adoption. However, this means that there is limited or no integration between internally operated systems and shared systems provided by or connecting with suppliers. The high levels of technology adoption and low levels of technology integration impacted the firms operations and negatively impacted their productivity as non-value adding activities such as rekeying information between systems become integral to business operations was still required. In addition there was no evidence that the use of "informate" that generated as a result of the use of IT was used, exploited or converted to competitive advantage. These findings support the findings of Sigala's (2008) that show productivity from ICT investments do not accrue solely from the use of ICT rather it is the integration of technology and the ability of firms to exploit the ICT "informate" and networking capabilities by streamlining and innovating business processes (Sigala 2008; Zuboff 1985).

The second finding is that the introduction of information technology systems introduced new entities into the network (technology providers), thereby changing the network structure from one representing the business *who buys from whom,* to a network which represents information flows between the organisations. These two networks differ in their configuration and structure. This is discussed in more detail in Section 9.1.8. The effect the lack of integration between systems has on productivity has implications for government and industry business support programmes. Currently, such programmes are targeted at a business or business group, rather than at technology providers. Quarantining funding to support information technology integration projects and increase uptake of integrated technology and business processes should be a government and industry focus.

9.1.8 Social interactions give rise to collaborative efficiency

Social interactions and informal communication give rise to new forms of efficiency, namely collaborative efficiency (Scerri & Agarwal 2011; Singh 2013). It was observed during field visits that social interactions occurred between customers, customers and employees, employees, and employees and suppliers. These informal interactions include the exchange and sharing of information, which lead to efficiency, referred to in this research as "collaborative efficiency" (Scerri & Agarwal 2011). Collaborative efficiency differs from traditional types of efficiency, these being allocative, technical, scale and price efficiencies (Coelli et al. 2005; Sherman 2006).

Collaborative efficiency differs from allocative efficiency in that it is achieved through the integration of resources rather than the mere allocation of them. Collaborative efficiency differs from scale efficiency, as the exchange observed was not dependent on the size or scale of the organisation; rather it was dependent on the willingness of people to collaborate, share information and knowledge, and often occurs through informal communication, on a one-on-one or group basis. Collaborative efficiency differs from technical efficiency as the efficiency gains are the result of social interactions, teamwork creating a collective action (Singh 2013) rather than a new method or process. The notion of collaborative efficiency is also supported in research conducted by Agarwal and Selen (2011a; 2011b) and Agarwal et al. (2014). While collaborative efficiency was observed in this research, it has not yet been included or measured as a driver or factor of productivity. This is an area identified for future research.

9.1.9 Multiplicity of service productivity

The SEPIA model illustrates the multi-dimensional nature of productivity with the inclusion of each of the stakeholders. The literature identifies geography (Porter 1984; 2000); technology (Armenta et al. 2011; Scerri & Dodangeh 2013; Swatman & Swatman 1991); business networks (Agarwal & Selen 2011b; Gattorna 2010) and social networks (Baker, Onyx & Edwards 2011; Onyx, Edwards & Bullen 2007) as affecting firm productivity and competitive positioning. However, to date productivity has been depicted mainly as a linear chain operating on a single plane.

The SEPIA and NEPIA models challenge the linear input-process-out view of productivity as each model incorporates the bi-directional flow occurring between each of the stakeholder groups of customers, employees and suppliers. However, when applying social network analysis, it became apparent that productivity operates on four separate planes, as depicted in Figure 9-3. The four planes represent each network level: geography, information technology, business and social.

The geographic network highlights access to resources and markets. The information technology network shows the information flows between each of the stakeholder groups (nodes). The business network forms the trading environment and shows *who does business with whom,* and finally the social network shows the formal (business communication) and informal (social interactions) communication that occurs between customers, employees and suppliers.

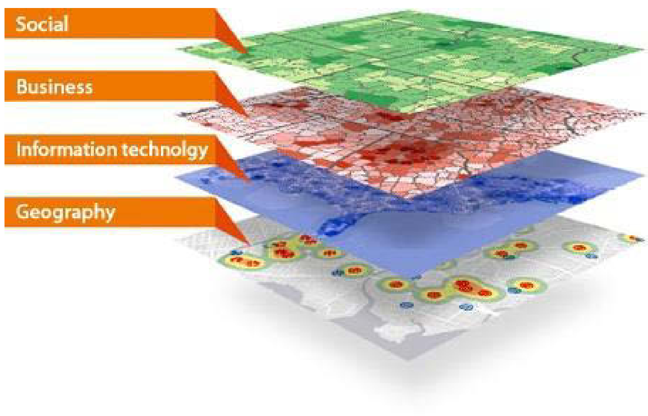


Figure 9-3 Multiplicity of network productivity

As a result, this research conceptualises productivity as multi-dimensional and multi-layered. Examining productivity on each of the layers of geography, information technology, business and social and examining the vertical connection between each layer may provide new insights into the drivers and factors of productivity for service and network-based firms.

9.1.10 SEPIA and NEPIA predictive productivity management tools

The use of models assists with understanding the world and helps predict how things may behave in the future (Boulding 1956a; Simon 1957; Williams 2011). Models underpinned by mathematical algorithms such as DEA and social network analysis have been used to underpin management decision support systems (Gorman & Wynn 2013). The establishment of a common set of variables and units of measure to operationalise the SEPIA model makes it possible to benchmark non-homogenous businesses operating within the same industry. The NEPIA model makes it possible to measure productivity for network-based firms, where networks vary in configuration, as discussed in Section 2.2.5. Adobor (2006), Agarwal and Selen (2009), Tapscott, Ticoll and Lowy (2000) and others highlighted network configurations as dyads, triads, hub and spoke, pendent, circle and constellations, some of which include the integration of cross-industry processes. This is an area for future research.

The exploratory research into whole-of-network productivity found that the efficiency scores based on firm-level transactional data may provide insights into whole-of-network productivity, based on different network configurations as they become visible. This will further our understanding of the impacts of social phenomena and intangibles resulting from varying network structure and a firm's position within a network. The use of "what is and what if" scenarios, suggested by Carroll (2012), will enable predictions to be made when anticipating changes to the network structure, such as estimating the cost of exclusion when nodes are removed from the network, or when firms offshore their business processes or service provision. This provides a practical application for managers and will enable them to assess the impact of decisions made by all stakeholders and network participants, and incorporate decisions made outside the boundaries of the firm into their own decision-making processes.

A summary of the findings are listed in Table 9-2 together with the references and links to the thesis that informed each of the findings.

Table 9-2 Summary of key findings

Section	Finding	Links	Table / Figure	Page number
9.1.1	Firm level data aligned to KLEMS, ANZSIC and SNA93 accounts.	(O'Mahony & Timmer 2009; Timmer, O'Mahony & van Ark 2007)	Table 2-1 illustrates the KLEMS framework aligned to ANZAIC and SNA 93 accounts and the literature identifies no firm level measures Table 9-1 illustrates the SEPIA and NEPIA models aligned to the KLEMS framework and therefore ANZIC and SNA93 accounts.	p. 16 p. 180
9.1.2	Network productivity is a new area of study.	(Borgatti, Carley & Krackhardt 2006; Borgatti, Everett & Johnson 2013; Borgatti & Halgin 2011)	Network configurations identified by no productivity analysis attempt identified other than dyadic relationships or linear supply chains. Different network configurations identified but not from a productivity perspective.	p.30 p.34 p.181 p.181
9.1.3	SEPIA is a generalised approach to measuring service productivity.	(Zhu 2000); (Battese, Rao & O'Donnell 2004; O'Donnell, Fallah-Fini & Truantis 2011; O'Donnell, Rao & Battese 2008; Rao, O'Donnell & Battese 2003)	Section 5.2.2 Decision-making unit considerations Application of DEA in non-homogenous, multi-industry by standardising the unit of measure. Section 5.1.3 Meta-frontier analysis - Enables the comparison of different technology bundles (non-homogenous groups).	p.118-120 p.114
9.1.4	Service complexity is not categorical	Deduction	Section 9.1.4 Service complexity is not categorical - A mathematical derivation to capture a comparable level of complexity	p.183-185
9.1.5	Service bundling and re-bundling affects service productivity.	Observation	Section 9.1.4 Service complexity is not categorical includes a mathematical calculation of service complexity.	p. 183-185
9.1.6	Network productivity can be visualised in graphical form	(Borgatti, Carley & Krackhardt 2006; Borgatti, Everett &	Section 9.1.6 Network productivity can be visualised in graphical form.	p.186

Section	Finding	Links	Table / Figure	Page number
		Johnson 2013; Borgatti & Halgin 2011)	Figure 9-2 Network productivity area.	p.181
9.1.7	Technology integration gives rise to integrative efficiency	(Kalakota & Robinson 1998; Sigala 2008; Swatman & Swatman 1991) Observation	Section 2.6 Enabling technologies. Section 4.3.3 Supplier integration. Section 9.1.7 Technology integration gives rise to integrative efficiency.	p.48-52 p.93-97 p.187-189
9.1.8	|Social interactions give rise to collaborative efficiency	(Baker, Onyx & Edwards 2011; Onyx & Bullen 2000)Observation	Section 2.4.4 Networks emanating from social contacts. Interactions between customers, employees and service fostered co-operation and the creation of social capital.	p.32 - 35
9.1.9	Multiplicity of service productivity	(Jacobs 1969, 1984; Kalakota & Robinson 1998; Porter 1984; Porter 2000; Sigala 2008)	Section 2.4 Network based firms. Section 2.4.1 Networks via geographic proximity. Section 2.4.2 Networks enabled via ICT. Section 2.4. 3 Networks enabled through business partnering. Section 2.4.4 Networks emanating from social contacts.	p.29 p.29-30 p.30 p.31-32 p.32-35
9.1.10	SEPIA and NEPIA models as predictive productivity management tools	(Borgatti, Everett & Johnson 2013; Cook & Zhu 2013)	Section 2.2.1 What is productivity? Section 2.5.1.1 Customer participation and variability. Section 2.6 Enabling technologies.	p.12 p.38 p.48-52

9.2 Limitations

This research has provided new insights into new measures of productivity for service and network-based firms. However, four key limitations have been identified:

1. Exclusion of two stakeholder groups
2. Sample size limits generalisability
3. Use of the AQF levels limits the use of the cognitive construct to Australia.
4. Non-use of available technologies
5. Exclusion of customer attributes and behaviours

9.2.1 Exclusion of two stakeholder groups

The SEPIA model includes five stakeholders, customers, employees, managers, suppliers and shareholders. There is a limitation to the research, as the SEPIA model was operationalised with only three of the five stakeholders. The research is grounded in operations management, so the dynamics of the interactions between customers, employees, suppliers and enabling technologies best represent a firm's operation. Therefore, these three stakeholder groups took precedence, in order to limit the scope and complexity. Managers and shareholders were intentionally excluded for three reasons: first, the impact management capabilities have on productivity has been performed as a full study for the manufacturing industries (Green & Agarwal 2009), and their inclusion would have broadened the scope beyond the time available to complete the study. Shareholders were excluded, as capital as a factor of productivity was not a focus of this research. Rather, non-financial intangible factors of relating to service and service delivery were considered. Hence, future research may address this limitation and include managers and shareholders.

9.2.2 Sample size limits the generalisability of the SEPIA model

The sample size is an issue contested in the literature with no consensus on how to determine the number of decision-making units to include (Boussofiane, Dyson & Thanassoulis 1991; Dyson et al. 2001; Golany & Roll 1989; Haas & Murphy 2003).

The quantitative analysis was undertaken with data collected from 14 organisations operating in the Australian tourism, travel and hospitality industry. Organisational heterogeneity was determined by the fact that they belonged to two ANZSIC codes. The limited number of organisations and the inclusions of only two ANZSIC codes in this research limits the generalisability of the results. However, the aim of the research was achieved: to define new productivity measures for service and network-based firms. Future research should extend the scope of organisations by including a standard number of organisations across multiple ANZSIC codes. In addition to this, it is recommended that the SEPIA and NEPIA models be tested for applicability for public sector and operations operating in the not-for-profit sector.

9.2.3 Use of the AQF levels limits

The literature identified that any incorrect or missing data may have adverse effects on the results and interpretation of meaning from the results (Banker & Nataraja 2011; Bogetoft & Otto 2011). In this research, ten organisations employed high numbers of international students and backpackers. However, in their responses to question seven of the employee engagement survey, “What is the highest level qualification you have received?”, it was unclear whether the qualifications noted were awarded from Australian educational intuitions or were obtained from educational institutions abroad. This issue, along with other data responses known by the researcher to be incorrect, cast doubt about the validity of the employee engagement responses, and as a result they were not included in this research. It is expected that with the inclusion of a larger sample size and larger organisations, more reliable employee data can be collected and incorporated. It is also recommended that AQF levels be mapped to qualification levels in other geographies, so that the SEPIA model can be applicable internationally.

9.2.4 Non-use of available technologies

An assumption made in this research was that the interactions between employees and suppliers were fixed, determined by the technological arrangements in place between the firm and the supplier. However, through observation during site visits and validation it was evident that this was not always the case. Employees often had cause, reason or preference for bypassing automation and fixed processes, and to use non-automated interactions instead. A number of legitimate reasons for this are highlighted in the findings section. This remains an area for future research, as failure to use the systems or processes in place highlights the potential to improve productivity. In addition, the causes or reasons for opting to use non-automated processes is not understood, and therefore a focus for future research.

9.2.5 Exclusion of Customer attributes and behaviour

The marketing literature indicates customer input into the service delivery process is a necessary pre-condition to the service delivery process commencing (Sampson 2010). In this research customer input related to the decisions that customer made in response to the firms offering and captured at the customer interface. However, the marketing literature also presents cases where customer input, in the form of customer behaviour is able to have negative impacts on employee and firm performance (Dallimore 2007; Fisk et al 2010; Gong et al 2014). The customer attributes such as physical, cognitive or behavioural were not included and therefore a limitation of this research and an area recommended for future research.

9.3 Future research

Productivity in Australia is currently measured using the KLEMS framework, and reported at industry and economy level. Limitations in applying productivity measures for service and network-based firms, and limitations preventing current service productivity models from being operationalised, are discussed in the literature. This research is the first attempt at operationalising productivity for service and network-based firms. Future research has been identified and commented on in the findings section. This section makes four key recommendations for future research:

1. Map the AQF levels to international qualifications.
2. Incorporate customer attributes and beahviours
3. Inclusion of all SEPIA stakeholders into a single study.
4. Expand the study of the SEPIA model to include more organisations from multiple service sectors

5. Conduct full a research project into the NEPIA model.

The case for each is presented next.

9.3.1 Map the AQF levels to international qualifications

The use of international employees and the inability to accurately assign the cognitive score is a limitation of this research. This prevents the SEPIA model from having international scope. Consequently, it is recommended that future work aligns the AQF levels to international qualification levels.

9.3.2 Incorporate customer attributes

Customer input and customer variability was limited to the decisions made at the customer interface between customers and the firm. However, marketing literature suggests the personal attributes of the customer such as age, gender, cognitive abilities and behavioural characteristics may impact how they interact with the firm (Fisk et al 2010). Specifically the literature identifies dysfunctional behaviour exhibited by some customers (Bitner et al. 1994; Knutson et al. 2008; Simurda 1994; Stephenson 1995; Zemke & Anderson 1990) have a negative effect on the service experience of other customers, employees and overall firm performance. However, the effect of the customer including the positive and negative behavioural aspects is an area identified for future research.

9.3.3 All SEPIA stakeholders included in a single study

The first area for future research is the inclusion of all stakeholders in the SEPIA model, namely customers, employees, managers, suppliers and stakeholders. This will enable the variables for managers and shareholders to be defined, and a more accurate account of how the dynamics of interactions between all stakeholders affect productivity for service and network-based firms. *The management matters report* (Green & Agarwal 2009) showed that the quality of management practices for manufacturing firms can be measured through three distinct management practices of people, performance and operations. The review of these measures and existing service management literature will inform the variable selection and will enrich the SEPIA model, as well as enabling comparative studies between management practices in manufacturing firms and service-based firms.

Shareholders provide investment and capital for firms to operate. The inclusion of shareholder decisions and the effects they have on management decisions will introduce a new dynamic and set of measures not currently included in the SEPIA model.

9.3.4 SEPIA model expanded

This research is the first attempt to operationalise productivity for service and network-based firms. Consequently, a small sample size was used, to establish a proof of concept. The SEPIA model was operationalised using transactional data collected from 14 organisations operating in the Australian tourism, travel and hospitality industry. It is recommended that future research using the SEPIA model be expanded in three ways. The first is to extend the research to a larger sample size and include all sectors of the tourism, travel and hospitality industry. The second is to expand the scope of the research and include organisations from multiple service sectors, such as banking and finance, education and health services. The third is to attempt to apply the SEPIA model to the public sector and not-for-profit service organisations.

9.3.5 Establish a research project into the NEPIA model

The analysis of the NEPIA model was exploratory in this research. The results generated were of interest and promising. However, due to the small sample size and data limited to the data collected for the SEPIA model, it is recommended that a full study of network productivity be undertaken. The full study should re-examine the variables and data collection processes to incorporate formal and informal social interactions occurring within the firm and between customers and trade partners, as well as business interactions. For example, the mapping of formal (who I report to and take orders from) and informal (who I collaborate with and seek assistance from) interactions occurring within an organisation will provide insights into the importance of social dialogue and how this contributes to productivity for service and network-based firms.

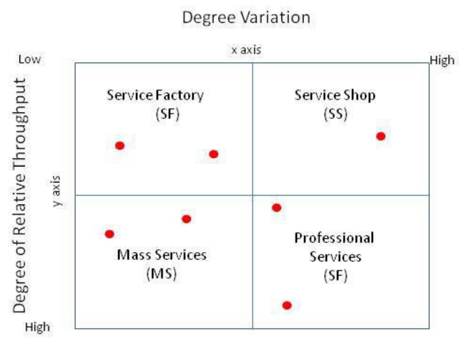
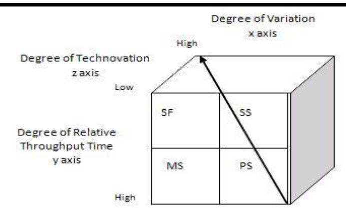
In addition the NEPIA model opens a new area of study. The current meso-level productivity measures are bounded by geography (regions) or industry (ANZIC codes). The NEPIA model on the other hand, transcends these boundaries allowing for groups of organisations working together as co-ordinated and productive units. The use of SNA as a method of analysis enables the structural elements of the network configuration to be visible, clearly identified and validated and therefore opening up the area for future research.

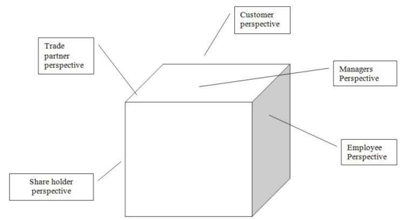
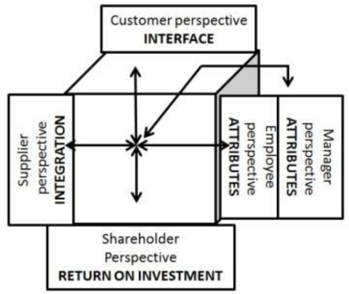
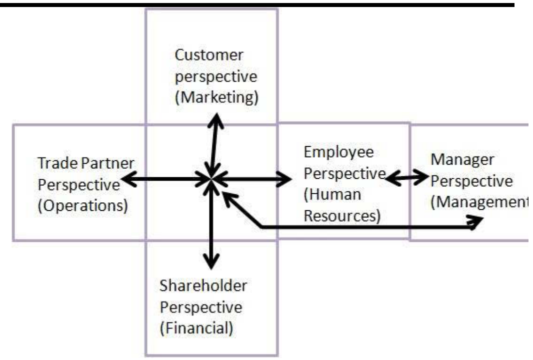
9.4 Conclusion

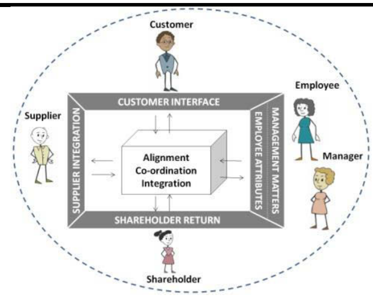
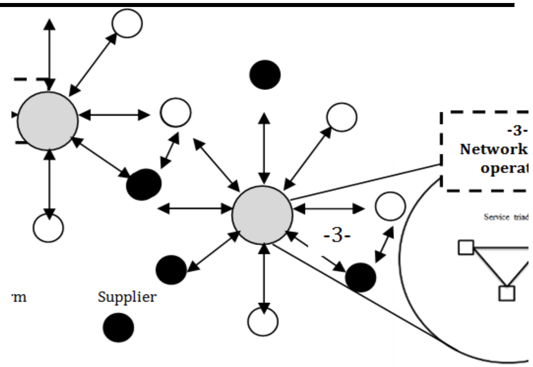
The SEPIA and NEPIA models are the first attempt to operationalise productivity for service and network-based firms. A range of intangible factors were identified and defined through experience, academic literature and the use of expert opinion. This process led to the inclusion of a multi-stakeholder perspective of the firm, with customers, employees, managers, suppliers and shareholders being contributors and recipients of service productivity. Service value networks were defined as the management of the flow of people (customers and employees), material flow, information flow and financial flows. Firm level data was collected from a set of non-homogenous firm operating in the Australian travel and tourism industry. The data was coded using the SEPIA coding schema and analysed using an input-oriented variable return to scale DEA model. The data was then reformatted in accordance to the requirements of the NEPIA model. The NEPIA model was analysed using SNA. Service complexity, technology integration and social dialogue all emerged as determinants of productivity for service and network based firms. In addition service productivity was determined to be multi-layered with geography, information technology, business and social interactions each forming one of the interactive layers. Furthermore the alignment of firm level data to the KLEMS database and current methods of measuring productivity at an industry and economy level make the SEPIA and NEPIA models a platform for collaborative research into productivity for service and network based firms.

Appendices

Appendix 1: SEPIA and NEPIA Model Development

Level	Boulding's 9 levels of systems hierarchy described	Alignment of models of service and network level productivity to Boulding's 9 levels of systems hierarchy	Model name and contributing scholars	Diagrammatic representation of the models in development
First	Level of frameworks. These are static in nature and where theoretical models begin.	Service productivity is a function of the degree of interaction and customisation and the degree of labour intensity.	Service Process Matrix Schmenner (1986)	
Second	This level is described as Clockwork. It is where systematic analysis introduces dynamics and motion which affect the steady state.	Service dimension of axis is changed to degree of variation and interaction and degree of relative throughput. The productivity diagonal is included.	Service Process Matrix Schmenner (2004)	
Third	This is the Thermostat level where feedback begins to occur.	Inclusion of the notion of customer and supplier duality.	Service Cubicle Agarwal & Selen (2005)	
Fourth	This is where interactions with the external environment are introduced.	Inclusion of the z axis and the Degree of Technovation.	Service Cubicle Agarwal & Selen (2005)	

Fifth	This is the Genetic-societal level where different geo-types and division of labour occur.	Identification that each plane of the cube represents the human elements of each of the stakeholders rather than the axes being the focus of interaction/measurement. The organisation and the relationships between the human elements create and give the organisation its form.	Service Cubicle in transition to Value Creation Cube (Scerri & Agarwal 2010)	
Sixth	This level is referred to as the Animal level. It is where specialist information receptors and information are able to be sent and received, reorganised and knowledge created.	Establishing connectivity to human elements occurs through customer interfaces, supplier integration. Realisation that the following are important factors: - Input and outputs for service firms are not linear but multi-dimensional and convergent - Stakeholders have different input-output points.	**Value Creation Cube** (Thesis development – knowledge contribution) Scerri & Agarwal (2012)	
Seventh	This is the called the Human level where human elements are added.	Understanding of the dynamics, interactions, actions and activities of each of the stakeholders. Exploration of the human elements and their role in the service delivery process. Customer, supplier and employee recognised as resource allocators. A decision to limit the scope of the research to customer, employee and supplier and to exclude manager and shareholder.	**Opening the Value Creation Cube** (Thesis development – knowledge contribution)	

Eight	This level is Symbolic of behaviour. The unit of the system is defined by the role in the social organisation rather than the individual. The inter-relations and the content and meaning of messages are important.	The inclusion of the roles of each of the stakeholders and the extended view of the firm develops. At this stage customers and suppliers are recognised as resource allocators and therefore need to be included. Therefore it is necessary to extend the boundaries of the firm to include customer interface and supplier integration where their decisions become visible.	**Service Enterprise Productivity in Action (SEPIA)** (Thesis development – knowledge contribution)	
Ninth	This is the transcendental level of the system. It includes the ultimates and the absolutes which sometimes remain unknown.	With a macro view, the position and purpose of the organisation can be seen as can the network structure. The implications of different network formations and structures and measures for productivity become an exploratory stage of our research. Unknown service constellations and molecular structure which include connections between industry hubs – cross industry services are conceptualised	**Networked Productivity in Action (NEPIA)** (Thesis development – knowledge contribution)	

Appendix 2: ANZSIC Framework for Sample Firms

Division N–Subdivision 72–Group 722[5]

Travel Agency and Tour Arrangement Services
This class consists of units mainly engaged in acting as agents in selling travel, tour and accommodation services, as well as units providing travel arrangement and reservation services for airlines, cars, hotels and restaurants. Also included are units mainly engaged in arranging, assembling, wholesaling and retailing tours.
Primary activities:

- Arranging and assembling tours
- Booking service (accommodation)
- Booking service (travel)
- ~~Inbound tour operator service~~
- Travel agency operation
- Travel ticket agency operation
- ~~Tour arrangement service~~
- ~~Tour operator service (arranging and assembling tours)~~
- ~~Tour retailing service~~
- ~~Tour wholesaling service~~

Exclusions/References
Units mainly engaged in operating transport equipment to provide recreation and entertainment are included in Class 5010 Scenic and Sightseeing Transport; and operating tourist.

Subdivision H–(Accommodation)–Sub-group 44 (Accommodation)–Group 4400

Accommodation
This class consists of units mainly engaged in providing accommodation for visitors, such as hotels, motels and similar units.
Primary activities:

- ~~Camping ground operation~~
- ~~Caravan park operation (visitor)~~
- ~~Holiday house and flat operation~~
- ~~Hotel operation~~
- ~~Motel operation~~
- ~~Resort operation~~
- ~~Serviced apartments~~
- ~~Ski-lodge operation~~
- ~~Student residence operation (except boarding schools)~~
- Youth hostel operation

Exclusions/References
Units mainly engaged in renting or leasing (including sub-leasing) residential properties or dwellings are included in Class 6711 Residential Property Operators; providing residential caravan accommodation is included in Class 6711 Residential Property Operators.

[5] Categories belonging to the ANZIC code activities not included in this research have been indicated by way of strikeout

Appendix 3: Letter of Consent to Participants

CONSENT FORM for participants

*- **PRINTED ON UTS (and/or joint) LETTERHEAD***

UNIVERSITY OF TECHNOLOGY, SYDNEY

Re:

I, ____________________ *(participant's name),* agree to participate in the research project *Defining productivity measures for service and network based firms* (the UTS HREC approval reference 201200042) being conducted by Moira Scerri, as part of her doctoral studies at the University of Technology Sydney, Australia.

I understand that the purpose of this study is to define productivity measures for service and network based firms.

I understand that my participation in this research will involve the collection of firm level data and may require access to premises and the review of confidential or commercially sensitive data.

I am aware that I can contact Dr. Renu Agarwal from the University of Technology Sydney (UTS) if I have any concerns about the research. I also understand that I am free to withdraw my participation from this research project at any time I wish, without any consequences, and without giving a reason.

I agree that Moira Scerri, the researcher and her appointed primary supervisor Dr. Renu Agarwal have adequately answered any questions I have regarding this research.

I understand the research data gathered from this research is confidential and will be the property of UTS and is not to be used for any other purpose. I agree that the research data gathered from this project may be published in a form that does not identify me in any way.

____ ____/____/____

Signature (participant)

____ ____/____/____

Signature (researcher or delegate)

NOTE:

This study is under review and will be approved by the University of Technology, Sydney Human Research Ethics Committee. If you have any complaints or reservations about any aspect of your participation in this research which you cannot resolve with the researcher, you may contact the Ethics Committee through the Research Ethics Officer (ph: +61 2 9514 9772 Research.Ethics@uts.edu.au), and quote the UTS HREC reference number 2012000423. Any complaint you make will be treated in confidence and investigated fully and you will be informed of the outcome.

Appendix 4: SEPIA Coding Schema

Construct	Code	Definition	
Service complexity	SC1	Single service provider	Single service type
Service complexity	SC2	Multiple service providers	Multiple service types
Service complexity	SC3	Single service provider	Multiple service types
Service complexity	SC4	Multiple service providers	Multiple service type
Customer interface	CI-Self	Technology assisted	
Customer interface	CI-FF	Human assisted	
Customer loyalty	CL-New	New customer	
Customer loyalty	CL-Ref	Referred customer	
Customer loyalty	CL-Rep	Repeat customer	
Customer channel	CCB2C	Business to customer	
Customer channel	CCB2B	Business to business customer	
Willingness to pay	WTP	Customers willingness to pay as a proxy for value	

Appendix 5: DEA Input-Output Tables for Sample Firms

DMU	SC1	SC2	SC4	CI- Self	CI - FF	CL-New	CCB2C	CCB2B		WTP	CL-Ref	CL-Rep
AA1	74	10	45	0	131	114	131	0		83000	0	17
AA2	55	11	111	0	177	127	127	0		54421	0	50
AA3	369	139	520	0	1028	369	1028	0		20727	0	0
PA1	33740	0	203	14690	19050	31951	28546	5194		1026880	1166	623
PA2	24622	0	270	15620	9002	21588	18329	6293		774515	3034	0
PA3	64266	0	504	27470	36796	56439	49158	15108		1811384	7526	301
PA4	11647	0	338	5359	6288	11193	9648	1999		470725	446	8
PA5	8891	0	180	5190	3701	6780	6073	2818		320009	2109	2
PA6	10167	0	258	4880	5287	5862	7603	2564		213933	4273	32
PA7	25132	0	271	13894	11238	19710	22382	2750		638423	5355	67
PA8	38474	0	382	19418	19056	34097	30679	7795		1256749	4316	61
PA9	94516	0	125	44892	49624	85056	58877	35639		2011709	9192	268
PA10	73091	0	356	41047	32044	45479	43604	29487		2616952	27204	408
PA11	153866	0	93	10413	49683	130513	141670	12196		4892109	23273	80

Appendix 6: Final Survey Instrument

This aim of this questionnaire is to understand the different dynamics between customers, employees and suppliers in the provision of end-to-end services. The questionnaire is divided into three parts. The first relates to customers, the second to employees and the third to suppliers.

Organisation detail

Segment	Retail	[ ]	Wholesale	[ ]
	Inbound tour operator	[ ]		
	Accommodation	[ ]	Ground operator	[ ]
	Tour operator	[ ]	Attraction	[ ]

Employee details

Age	15 – 24	[ ]	25 – 34	[ ]
	35 – 44	[ ]	45 – 54	[ ]
	55 – 64	[ ]	65 – 74	[ ]
	Over 75	[ ]		
Sex	Male	[ ]	Female	[ ]
Country of birth				
Position	Manager	[ ]	Professional	[ ]
	Technical/trade worker	[ ]	Community worker	[ ]
	Personal services worker	[ ]	Clerical worker	[ ]
	Administration worker	[ ]	Sales worker	[ ]
	Machinery operator	[ ]	Driver	[ ]
	Labourer	[ ]		

Experience	Years of overall work experience in this industry	[ ]
	Different industry	[ ]
	Years of work in this organisation	[ ]
	In current role	[ ]

Highest Qualification	Certificate I	[ ]	Certificate II	[ ]
	Certificate III	[ ]	Certificate IV	[ ]
	Diploma	[ ]	Advanced Diploma	[ ]
	Bachelor's Degree	[ ]	Bachelor's Honours	[ ]
	Masters	[ ]	PhD/Doctorate	[ ]

	Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	I speak highly of this organisation to my friends	[ ]	[ ]	[ ]	[ ]	[ ]
2	I would be happy for my friends and family to use this organisation's products and services	[ ]	[ ]	[ ]	[ ]	[ ]
3	This organisation is known as a good employer	[ ]	[ ]	[ ]	[ ]	[ ]
4	This organisation has a good reputation generally	[ ]	[ ]	[ ]	[ ]	[ ]
5	I am proud to tell others I am part of this organisation	[ ]	[ ]	[ ]	[ ]	[ ]
6	This organisation really inspires the very best in me in the way of job performance	[ ]	[ ]	[ ]	[ ]	[ ]
7	I find that my values and the organisation's are very similar	[ ]	[ ]	[ ]	[ ]	[ ]
8	I always do more than is actually required	[ ]	[ ]	[ ]	[ ]	[ ]
9	I try to help others in this organisation whenever I can	[ ]	[ ]	[ ]	[ ]	[ ]
10	I try to keep abreast of current developments in my area	[ ]	[ ]	[ ]	[ ]	[ ]
11	I volunteer to do things outside my job that contribute to the organisation's objectives	[ ]	[ ]	[ ]	[ ]	[ ]
12	I frequently make suggestions to improve the work of my team/department	[ ]	[ ]	[ ]	[ ]	[ ]
13	I trust my manager	[ ]	[ ]	[ ]	[ ]	[ ]
14	This organisation keeps it promises	[ ]	[ ]	[ ]	[ ]	[ ]

Thank you for participating in this research

Appendix 7: E-mail Consent

INFORMATION SHEET AND CONSENT FORM FOR ONLINE SURVEYS

Defining productivity measures for service and network based firms

(UTS APPROVAL 201200042)

My name is Moira Scerri and I am a PhD student at UTS. My supervisor is Dr Renu Agarwal.

The purpose of this research is to define new productivity measures for service and network based firms. This online questionnaire is anonymous; you will not be required to provide your name.

I will ask you to complete an online questionnaire which should not take any more than 15 minutes of your time. The questionnaire is designed for us to better understand the attributes of the workforce in your organisation.

You can change your mind at any time and stop completing the survey without any consequences.

If you agree to be part of the research and to research data gathered from this survey to be published in a form that does not identify you, please continue with answering the survey questions.

If you have concerns about the research that you think I or my supervisor can help you with, please feel free to contact me email moira.scerri@student.uts.edu.au or Dr Renu Agarwal on e-mail renu.agarwal@uts.edu.au.

If you would like to talk to someone who is not connected with the research, you may contact the Research Ethics Officer on 02 9514 9772 or Research.ethics@uts.edu.au and quote this number 201200042.

Appendix 8: List of Semi-structured Interviews

Questions used for semi-structured interviews in the model validation process. Questions were approved by UTS Ethics application number 201200042 and UTS Human Resource Ethics amended application number 2013000527.

Questions:

1. In your opinion, is the (factor) related to, or does it contribute to service productivity?
2. In your opinion, does (factor) convey pertinent information that is not included in the current measures of service productivity?
3. In your opinion, does the (factor) contain elements that interfere with the notion of technical efficiency?
4. In your opinion, is data on (factor) readily available and generally reliable?

Additional questions:

5. Are there any other factors or changes in the business environment that you consider to have a negative effect on productivity for service and network-based firms?
6. Are there any other factors or changes in the business environment that you consider to have a positive effect on productivity for service and network-based firms?

Appendix 9: Node Attribute and Tie Data

Node	Role in network
CU*n*	Customer
AA*n*	Agent
AS*n*	Supplier
BA*n*	Agent for accommodation provider
BPS*n*	Service provider

Appendix 10: Sample.VNA file

UCINET.VNA file format

```
*node data
ID              Name            Industry Sector
AA1             XXXX            Agent
AS1             XXXX            Supplier
BA1             XXXX            Agent
BSP1            XXXX            Provider
*tie data
AA1     AS5     4
AA1     AS8     3
AA8     AS1     1
AA1     AS12    2
```

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