UNIVERSITY OF SOUTHERN QUEENSLAND AUSTRALIA

MAPPING THE SUPPLY NETWORK AND RESOURCE CONSTRAINTS OF PUBLICLY FUNDED UNIVERSITY RESEARCH COMMERCIAL TRANSFER WITHIN AUSTRALIA

A Thesis submitted by

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ABSTRACT

Government and academic literature support a common axiom that publicly funded research undertaken in Australian universities leads directly to an outcome available for industry to commercially develop. The revenue from commercial transfer of research only represents 7% of an Australian university's operating budget and supports Australia's low global innovation transfer ranking. To lift this low ranking, the Australian Government seeks an increase in the rate of university research that is converted to Intellectual Property for commercial transfer, triggering change in the university system to improve commercial output. Despite vast research on industry university collaboration and commercialisation, this research has found there is little work undertaken on the alignment of the university system to support the changed expectations.

This research employed a methodology of multiple case study analysis using the Theory of Constraints Thinking Process to establish constraints in the system that hinder the commercial transfer of university research to industry. An investigation into published governing documents including Government directives (i.e. requirements of reporting), Acts of Incorporation, Strategic Plans and Policies of the University and interviews with system stakeholders revealed a mismatch in the synergy of both the governing documents and the stakeholder intent resulting in the identification of conflicting stakeholder

goals and a primary constraint of governance misalignment. This research identified a system that is atypical, with a plural of customer and constraining factors of multiple independent goals within the system causing instances of practice dominance; siloed activities, passive attitudes; no singular customer focus; and stakeholders with little knowledge or interest in the whole system.

This research established that the system of university research commercialisation is doing exactly what it is designed by its Acts and Policies, specifically, teach, research and occasionally commercially transfer the results when the opportunity arises. However, a governmental push for greater commercial transfer seeks a new outcome from this system. This research supports a radical change in the atypical system of Australian university research to ensure process support for commercial transfer of research outcomes into industry, and in turn, address Australia's low research transfer rate. The change requires legislative reform enabling a change in intent of the university research process itself, by legislating industry to take the lead in the research funding partnership with a university supporting an industry pull environment for outcome of research and, in turn, satisfy growth in Australia's research transfer as a nation.

CERTIFICATION OF THESIS

This Thesis is entirely the work of Pauline Joanne Ross except where otherwise acknowledged. The work is original and has not previously been submitted for any other award, except where acknowledged.

Principal Supervisor: Dr Steven Goh

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Student and supervisors signatures of endorsement are held at the University.

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There are so many opportunities waiting for you.

Go and be what you want to be.

You will be amazing!

love Nan

PUBLISHED WORKS

Edwards, M, Ross, PJ and Styger, LEJ 2018, 'A pilot study into mapping atypical supply networks', *Universal Journal of Educational Research*, Vol. 6, No. 10, pp. 2217-2226.

Working Paper Title: Testing the Theory of Constraints as a Customer Focus Tool in Non Government Organisations.   Target Journal - Industry and Innovation 2022 submission.

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LIST OF ABBREVIATIONS

Abbreviation	Definition
ARC	Australian Research Council
CP	Core Problem (Theory of Constraints)
CRD	Conflict Resolution Diagram (also called Evaporating Cloud) (Theory of Constraints)
CRT	Current Reality Tree (Theory of Constraints)
DE	Desired Effects (Theory of Constraints)
DESE	Department of Education, Skills and Employment
DET	Department of Education and Training
DIISRTE	Department of Industry, Innovation, Science, Research and Tertiary Education
DISER	Department of Industry, Science, Energy and Resources
DoE	Department of Education
EC	Evaporating Cloud (called Conflict Resolution Diagram within this study) (Theory of Constraints)
EE	Expected Effects
FRT	Future Reality Tree (Theory of Constraints)
Go8	Group of Eight
HE	Higher Education
IndR	Industry Representative
IP	Intellectual Property
IRU	Innovative Research Universities
ISA	Innovation and Science Australia
LOA	Licences, Options and Assignments
NCGP	National Competitive Grants Program
NHMRC	National Health and Medical Research Council
OECD	Organization for Economic Cooperation and Development
PCP	Private Commercialisation Practitioner

Abbreviation	Definition
PRT	Prerequisite Reality Tree (Theory of Constraints)
QMS	Quality Management System
RBG	Research Block Grants
Res	Researcher
RC	Root Cause
TOC	Theory of Constraints
TT	Transition Tree (Theory of Constraints)
UCP	University Commercialisation Personnel
UDE	Undesirable Effects (Theory of Constraints)

KEY TERMS

Term	Definition
Commercial Transfer	A commercial transaction between industry and a university for a piece of Intellectual Property that is a net asset.
Commercialisation	The conversion of an idea or knowhow into a replicable product or service that delivers value to a market (AIC 2020).
"Common" stakeholder	"Common" stakeholders are the university research personnel, university commercialisation personnel, external commercial personnel and industry.
Constraint	All systems have constraints that are limiting their systems from growing and achieving the desired goals (Goldratt 1990).
Core Problem	A Core Problem contributes to the Root Cause and is outside of the boundary of the system under investigation, change is typically unable to be influenced by the current system (Reid & Cormier 2003, Dettmer 1997).
Discovery Grants	Sourced through ARC, *Discovery* Grants support fundamental research, essential for Australia's innovations system, new idea and job creation, economic growth and quality of life and do not require a secured customer (industry partner) for the application process (ARC 2018d)
Linkage Grants	Sourced through ARC, *Linkage* Grants have promoted national and international collaboration through funding industry and key stakeholder partnerships since 2000 (ARC 2018d)
Outcome	The result of a study or research (general overview)
Principle	The entity that is putting the money (funding) into the system, but not the recipient of the value.
Publicly Funded University Research	Public funding is funds derived from the Australian Government and excludes donations, philanthropic or industry funding (DoE 2015a)

Term	Definition
Research	Creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications (ARC 2012, DIISRTE 2012).
Recipient	The entity that receives the value of the process, but does not provide the initial funds.
Root Cause	A Root Cause is the final result in the cause and effect mapping process that is able to be augmented within the system (Umble & Umble 2015, Reid & Cormier 2003, Dettmer 1997).
Stakeholder	See "common" stakeholder
Theory of Constraints	Theory of Constraints (TOC) is a holistic management philosophy developed by Dr Eliyahu M. Goldratt in the early 1980s founded on the idea that all systems have constraints that are limiting their systems from growing and achieving the desired goals, the act of ordering the constraints hierarchically and reengineering the system after each constraint is eliminated, enables continuous improvement of the system (Goldratt & Cox 2016).
Transaction	Exchange of something for added value

CHAPTER 1 - INTRODUCTION

1.0 Introduction

Publicly funded research denotes research funded by the Australian Government through either annually awarded Research Block Grants (RBG) or the National Competitive Grants Program (NCGP) administered through the Australian Research Council (ARC), National Health and Medical Research Council (NHMRC), and other government research funding schemes. The funding does not cover research that is addressed by internal procedures and agency contracts, research conducted by government department or agency contracts, or, research conducted for the governments own purpose (ARC 2018a). This work investigates the existence of constraints within the system of publicly funded research commercialisation that hinder the commercial transfer of research output (i.e. the intellectual property) to industry. A multiple case study analysis using the Theory of Constraints Thinking Process (Dettmer 1997) was applied to the publicly funded Australian university research commercialisation system of three case studies. The case study analysis, using published documents and stakeholder interviews, resulted in the identification of 50 findings. These findings were thematically grouped into 6 Undesirable Effects (UDE) to enable a Theory of Constraints Reality Tree cause and effect mapping, identifying constraints in the system and their root cause. This study showed over 70% of the constraints identified were linked to the absence of alignment between the system of the university, legislation governing Australian universities and the requirements of the funder (Australian Government).   As such, identifying a misalignment between the requirement of the funder and the ability of the university's legislative system to deliver to the funders requirement.

Supported through government and academic literature globally, a commonly held public axiom is that publicly funded research undertaken in Australian universities should lead directly to an outcome available for industry to commercially develop (ARC 2000; Cole 2016; DISER 2015; Giones 2019; Go8 2014c).   This axiom

appears in the objectives of the *National Innovation and Science Agenda 2015;* a directive in the *Intellectual Property Australia Guidelines;* and referred to as 'The Technology Transfer Paradigm' by Giones (2019) suggesting that the greater the ability a university has to develop patents, the greater the possibility to generate income and community support (DISER 2015; Giones 2019 p. 3260; IPA 2014). While this is certainly the case, the ability to develop a piece of commercial Intellectual Property does not automatically result in the appearance of a customer wanting to buy, i.e. the difference between the current research "push" system by Australian universities and a potential new "pull" system by industry (Weckowska et al. 2018).

Australian universities rely on government funding for a portion of their operating costs, this portion has declined from 43% in 2010 to 35% in 2018 resulting in a squeeze on university operational finances. At the same time, the makeup of this funding has changed with the allocation directed at research rising slightly from 48% to 51%. The little real dollar change in the actual funding for university research coupled with less funding available for operations demonstrates that the change in the requirement by the funder (Australian Government) was not supported by additional resources, resulting in an illogical expectation that the university would change its practices, which are constrained through legislation (DESE 2015a; 2015b; 2015c; 2015d; 2015e; 2017; 2018; 2019b; 2020a).

Research Block Grants (RBG) and ARC Category 1, respectively represent 32% and 9% of the Australian government university research funding (Section 2.2.1). The balance of Australian government research funding comprises of National Medical Health and Research Council (NHMRC) funding, other community, industry and philanthropic funding, all deemed outside of the scope of this work (Figure 1.1) (DESE 2015a; 2015b; 2015c; 2015d; 2015e; 2017; 2018; 2019b; 2020a; NHMRC 2020a; 2020b). The changing landscape of the funding environment is further discussed in Section 2.2.1 and Appendix A provides the data on the funding allocations for 2010 - 2018. The focus of this study is the identification of

constraints within the system of publicly funded university research that may be hindering commercial transfer of the research outcomes (Intellectual Property). The funding discussed within this study does not have a mandatory industry financial partner, however, it represents a consistent portion of the funding that is typically associated with the concept of the research output being commercially transferred to industry.
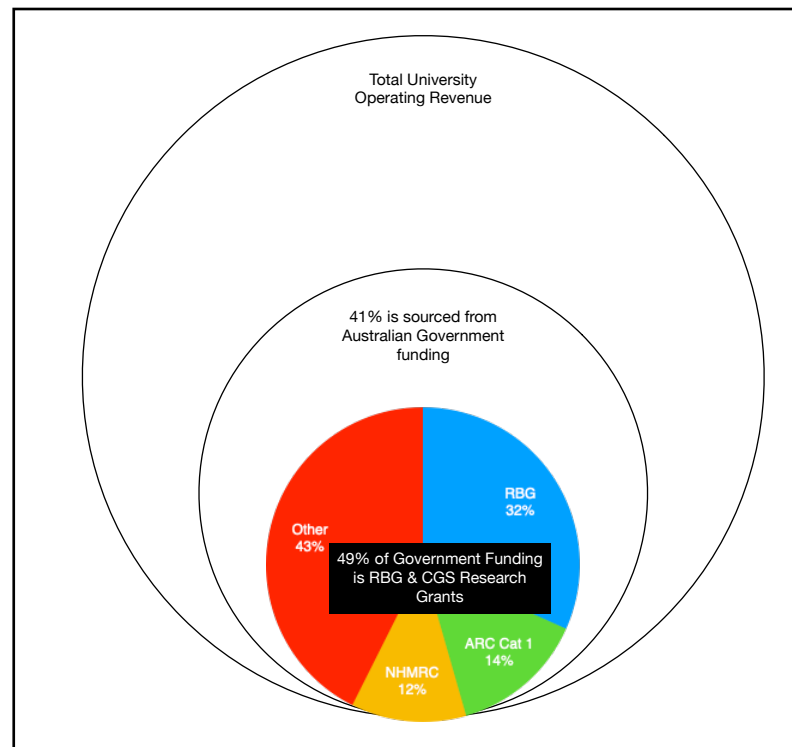
Figure 1.1. Overview of Government Sourced University Research Funding depicting a percentage average over 2010 - 2018 of Government funding   (Sourced - DESE 2015a; 2015b; 2015c; 2015d; 2015e; 2017; 2018; 2019b; 2020a; NHMRC 2020a; 2020b)

A Theory of Constraints analysis found that the availability of funding for the process of research, albeit offered competitively, does not appear to be a constraint in itself, although, a constraint identified was the time taken out of research activities by research personnel to develop and submit applications for this funding. The low transfer to industry of research outcomes cannot be simply excused as a lack of funding at some point in the system, if this was the case, then an elementary realignment of Federal budget policies could mandate a change in the algorithm for the funding and see more funds invested into the commercialisation process to bolster the sporadic or project based offerings. A dilemma within this process is who

(i.e. government, university or industry) should shoulder the cost of this process (DoE 2014; Mazzarol 2015), this is further discussed in Section 2.3.2.

There is much debate regarding an inadequate funding gap for the commercial development of university research into Intellectual Property (Etzkowitz 2013; Munari et al. 2018; Sánchez-Barrioluengo & Benneworth 2019). The requirement to develop industry relevant research outcomes is often referred to as a university's *third mission*, and of itself, demonstrates the hierarchal preference this activity takes over the others (Harman 2010; Harman & Harman 2004; Narayan et al. 2017; Sengupta & Ray 2017). The funding gap is considered as a constraint and is included within the research commercialisation discussion in Section 2.3.1.

The revenue gained from the sale or development of research outcomes with industry[1] between 2010 and 2017[2] represents between 6 and 7% of the total operating income of Australian universities. This income includes revenue earning activities from existing licences, start-up companies and partnerships. Of note, the income that is related solely to royalties, licences and trademarks, these typically represent the sales functions that directly transfer scientific knowledge to industry, is much lower at an average of 0.4% of Australian university operating income (Wu et al. 2015). The case studies within this research provided figures of 0.2% for the Mature University, 0.03% for the Young University and the Establishing University not providing any data for the reporting process[3] (DESE 2015a; 2015b; 2015c; 2015d; 2015e; 2017; 2018; 2019b; 2020a) (Appendix B and C). The definition of Mature, Young and Establishing universities is discussed in Section 4.1.1. Further, the National Survey of Research Commercialisation (NSRC) shows a higher rate of potential Intellectual Property reporting within Australian universities than is eventually commercially transferred to industry fundamentally identifying an

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[1] This figure does not include research contracts and consultancies, but does include royalties, trademarks and licenses and the share of net result of associates and joint ventures accounted for using the equity method (DESE 2015a 2015b, 2015c, 2015d, 2015e, 2017, 2018, 2019b, 2020a).

[2] The Financial Report from 2018 onwards depict the revenue differently, and as such, are unable to be correlated with confidence

[3] An analysis of the government reports identified a number of universities that did not completely report their activities, or, continually repeated the same output figures for their activities.

existing opportunity for "better" commercial transfer (Burston 2020; DIISRTE 2019). Yet, an investigation of the system recognised a lack of Intellectual Property identification capability, in both the skill levels of the personnel and opportunity in the system guiding the process (Section 5.3.3.3), as the system design is not optimal, constraining the output. There is no shortage of interest from external stakeholders, and indeed, as stated, an expectation exists that publicly funded university research benefits industry. Therefore, it is logical to suggest that there is a discrepancy in the system somewhere, and, what has not been recorded before, is the major discrepancy (aka constraint) actually lies in the university Acts of Incorporation and that of the stated aims of the customer (i.e. Government) as the funding body (ALRC 2010; ARC 2000; 2018a; 2018c; DISER 2015; Go8 2014c).

This research demonstrates that the commercial transfer instances of research outcome to industry is low (Section 2.2.1), naturally correlating to low revenue earned from this activity (Section 2.3.2), low global innovation ranking and it is not a focus of Universities to gain return on research activities because of their Acts of Incorporation. The Australian government has instigated a requirement for better commercial transfer (DISER 2015), however, this research demonstrates there is not a corresponding change to the monetary value of the input to the system (funding), nor the process, leaving a system that has a required change in output, but not a change in its functional foundation. The measurement of the system is discussed in Section 2.3.3.

1.1 Supply Principles and the University Research Commercialisation System

This work demonstrates that the process of commercialisation can be described as a system. In so doing, the pattern and nature of value creation mimics that of industrial and commercial supply chain systems. The principles of supply are self evident in the policies managing research commercialisation of Australian universities, where the flow of both value creation and resource are recognised through the description of nodes and linkages, supporting the use of supply theory as a theoretical base for

this study (Christopher 2011; Deming 1986; Hines 2006). Mapping supply systems traditionally commences with an audit of the system (Habib 2000; Knouse et al. 2009) to provide a view of how individual elements interact (Fahmy Salama et al. 2009) by tracking raw materials entering the system, through a process of value creation, to be passed to distribution on the customer side of the supply system (Plenert 2014), demonstrating a forward movement. More recently, and supported in this research, supply chain systems have been identified that demonstrate irregular patterns or dynamics and are reactive to the environment (Cilliers 2005; Snowdon & Boone 2007). Edwards et al. (2018) described these supply chain systems as Atypical Supply Chains and depict a duality of customer. Whereas, Edwards et al. (2018) identified a duality of customer, this research provides contribution to knowledge in the identification that the publicly funded university research Atypical system has a plural of customer in both the Federal and State governments' symbiotic relationship to fund and authorise the university as the Principals, and, the university industry and community as the Recipients (Section 3.2.3). In addition, establishing that although publicly funded Australian university research commercialisation supply systems are Atypical in nature, the occurrence is not untypical in the publicly funded environment. Figure 1.2 illustrates the Atypical Australian university system with plural of customer.
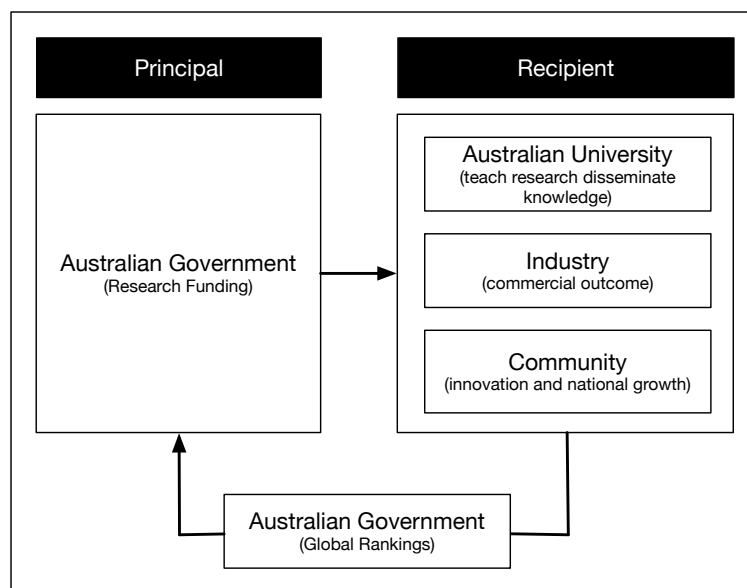
Figure 1.2. The Atypical Australian University system with plural of customer

As a supply system, the Atypical publicly funded University research commercialisation supply system should be able to be audited for flow and efficiency (Atilgan & McCullen 2011; Childerhouse et al. 2011), however a methodology is needed. The Theory of Constraints (TOC) was considered a robust methodology, not only for its focus on identifying and augmenting constraints through cause and effect modelling, but its particular ability to recognise policy constraints and identify the root cause of constrained flow in the system (Chou et al. 2012; Dettmer 1995; Goldratt & Cox 2016; Mohammadi et al. 2015; Umble & Umble 2015). This work is the first time TOC has been used on a university research commercialisation supply system and demonstrates a causal mapping of the system and identification of constraints.

1.2 End-to-End System of University Research

An overriding principle of commercial supply chain configuration and total system improvement is the design and operation of the system. In common with the Quality Management Principles of ISO 9001:2015 (International Organisation for Standardisation 2015a) the optimum results in terms of cost, and customer value are achieved when the focal node (i.e. the university providing the research output) is focused on the end customer (i.e. recipient) at the point of configuring the supply system. What is evident in the case of Australian university research commercialisation is the emergence of plural supply systems and polarisation of system configuration between universities and industry where:

- *University Research* - is based on a peer review and approval process, centred around, novel research and output. It is typically long-term research, reinforcing the players within a closed loop system and rewards participants with more research funding, accolades and personal promotion (Patrinos et al. 2015).

- *Commercial Research* - is based on customer defined need, approved on a short-term payback basis and is therefore near market in terms of its technological maturity. It relies on rapid product development, incremental progression and defined life cycle principles to ensure reward to the organisation in terms of return on investment (Mäntyneva 2020).

On face value, it is difficult to see how both parties can collaborate within a single research and commercialisation supply system. However, the principle of a common end-to-end supply chain system, if adopted in Australian universities, would drive the research focus from a push system, that is peer reviewed within the university ecosystem, into a customer pull system, where output is specified by the industrial recipient from the inception of the research. As radical as this would first appear, this model is not without precedence, for example, Fraunhofer-Gesellschaft zur Forderung der angewandten Forschung e.V. (Germany), Warwick Manufacturing Group (University of Warwick, UK) and Industrial Centre (Hong Kong Polytechnic University, Hong Kong) (Fraunhofer-Gesellschaft 2019; HKPU 2019; WMG 2017), this change is further discussed in Section 7.2.

1.3 Commercial Transfer

Research is commonly defined as a process that creates new knowledge, adding value through a series of activities starting with an initial input of enquiry into the system, to the process of the investigation and resulting in an output of discovery (ARC 2012; DIISRTE 2012). Typically, university research output is recognised through publication and peer citation, of academic papers promoting the discoveries and the governmental monitoring of national innovation and commercial transfer of university research into industry (ARC 2019; DIISRTE 2019; OECD 2013). The development and implementation of *impact* measurement of university research on the community (ARC 2017) has resulted in a softening of university research commercialisation definition from 'the derivation of economic returns from a R&D effort' (AIC 2004) requiring an economic return, or a point of action or *launch*

(Crawford & Di Benedetto 2003), to measuring a return of value in 'the conversion of an idea or knowhow into a replicable product or service that delivers value to a market' (AIC 2020). One of the measurements of commercial transfer, 'research commercialisation income', is derived from developing the Intellectual Property into a saleable form, such as the license of a patent. However, it is argued that the shift in focus from an event based measurement, to an impact based measurement, broadens the scope and blurs output measurement by placing qualitative measurement over a traditional quantitative metric, creating ambiguity in the system (Gunn & Mintrom 2018; IRU 2015). This change redefines system report output to favour a more ambiguous definition of transfer than a quantitative measurement of instances of commercial transfer directly into industry.

In the context of this research, the term *commercialisation* did not enable a clear understanding of 'what' was to be mapped and measured. A measurement term was needed that defined the point of reference within the system and also signalled that there was value exchanged. The term *commercial transfer* has emerged mirroring emerging global ranking terminology (Gaus & Raith 2016; OECD 2016) to describe the transfer of university research for use in industry. This term defines a point that the research is transferred to industry and the use of the word commercial indicates that there was a financial exchange of some sort (Gaus & Raith 2016). The exchange point, and what is to be exchanged, can be determined from this research and a measurement placed on whether this is more or less than the previous measurement, however, the target of "better" commercial transfer required by the government of the Australian universities is not quantitatively defined. For the purposes of this research the term commercial transfer will be used as a measurement point, in place of commercialisation and defined as *"a commercial transaction between industry and a university for a piece of Intellectual Property that is a net asset"*, leaving the quantitative definition of "better" defined only as more than the previous measurement.

1.4 Challenges of Mapping the System

This research established the point of measurement for mapping the system of commercially transferring university research. To do this, publicly funded university research was recognised as a supply system, and, as a supply system, would uphold supply chain management principles, including throughput and customer focus (Section 3.2.2) (Deming 1986; Hines 2006; Li & Morgan 2010). An initial challenge was the absence of a recognised mapping system able to map more than a flow chart of agreed process, as to find the constraints, the actual practice of the system was to be mapped, i.e. what was the system doing?

The next challenge was understanding the implied versus the actual value of the commercial transfer of university research to industry (IRU 2015). The value of commercial transfer is not clear in the literature and, therefore, difficult to measure (Section 3.2.3). Although measurement data is collected by the Australian government on commercialisation instances and revenue, little evidence is provided on the value placed on this research by either the university or industry, identifying a gap in system knowledge.

The low system value knowledge lead to determining if publicly funded Australian university research commercialisation mattered strategically from a revenue point of view to a university, the community, or the Government (who typically focus on innovation rankings, not return on investment of publicly funded research) (OECD 2013). The return to an Australian university from commercial transfer of research Intellectual Property to industry represents under 10% (9.9%) of the total Australian Government Research Funding allocated to universities for the 2010-2018 period (ARC 2018d), or 6-7% of the average operating budget of an Australian University[4], demonstrating a low commercial conversion rate of university research outcomes into industry. Although the low rate of transfer is identified, it is not possible, from the existing commercial transfer metrics to identify the cause. This research has

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[4] (DESE 2015a 2015b, 2015c, 2015d, 2015e, 2017, 2018, 2019b, 2020a) (Appendix B and C)

shown that there are elements of budgetary constraint (Section 5.3.2.3), low commercial skill base (Section 5.3.3.2 & 5.3.3.3), level of reward causing inertia in the system (Section 5.3.3.2), the transfer of commercial IP is not the main driver for university (Section 5.4), with relationship building impacting on this mere trickle to industry (Section 5.3.3.1) (ARC 2018d).   There is an absence of a stated level for 'enough' commercial transfer, the low instance of commercial transfer in comparison to the funding supplied signals that it could be increased, however, there is an absence of system change to implement the increase, hence the purpose of this study.

The absence of common systems of mapping and value definition naturally lead to a challenge in defining best practice, and in turn, the existence of a Standard to base this best practice.   International Standards exist to guide the system of research, namely, Standards in the Research and Development ISO 03.100.40 family, specifically Project Management ISO 21500-2012; Innovation Management ISO 56000:2020 (International Organisation of Standardisation 2012; 2015b; 2020); Quality Function Deployment (QFD) ISO 16355-1:2015 (International Organisation of Standardisation 2015c); and Quality Management ISO 9001:2015 (International Organisation of Standardisation 2015a).   Although these Standards are used widely in industry to provide a framework for measurable research or quality management processes, they do not appear to be implemented well in the academic system. Instead the quality management system of a university, typically represents a series of policies, processes and reporting requirements specific to the projects, faculties and the institution as a whole.   In the context of this work it was not possible to define best practice for publicly funded research within an Australian university.

A final challenge was finding a research project at each case university that could be followed from funding application through to the commercial transfer of the research outcome within Australian universities.   The difficulty stemmed from the lack of recognised mapping of the process as it was not a common practice to firstly, map the research project, and secondly, and most importantly, to take a publicly funded research project through to commercial transfer.   This issue was also found by

Innovative Research Universities when measuring the extent research meets industry needs (IRU 2015).   Therefore, in the absence of the mapping, this research investigated common practices for publicly funded research that was sourced from Block Research Grants or the Australian Research Council and the associated process of this research to enable the development of a common map of the system.   This challenge supported an identified gap of this research where Australian universities have little understanding the system of commercial transfer of research.   In short, as one interviewee stated, 'it just happens' (INT2) Section (5.3.3.2).

1.5 Defining the Gap

The commonly held axiom is that publicly funded research undertaken in Australian universities leads directly to an outcome that is transferred to industry for the betterment of the community. Whereas, there is evidence of this happening, although at a low rate, there is growing national pressure on Australian universities for "better" commercial transfer through Australian Government expectations (DoE 2014, DISER 2015).   There have been few instances of constraints analysis applied to the university research commercialisation system, and none have mapped the system to understand constraints in the flow of commercial output.

Through constraints mapping this work has demonstrated that the system has multiple stakeholders with independent goals that compete for dominance, causing inward facing ecosystems focussed on ensuring individual and departmental goal satisfaction, not growth in the system as a whole (Cilliers 2005; Kelly & Allison 1999; Snowdon & Boone 2007).   Overall, this work has discovered the system of university research commercialisation is doing exactly what it is designed to do, research and commercialise when the opportunity arises, and doing it well, despite a low understanding of the system by the internal stakeholders.   However new conditions by the funding body (principle) for "better" commercial transfer requires a different product from the system, in short, to get a different product, a redesign of the system is needed.

1.6 The Terms of Reference and Scope of this Work

This research uses a combined methodology of multiple case study analysis using Goldratt's Theory of Constraints Thinking Process to investigate the planned and practical system of publicly funded Australian university research commercialisation to identify constraints that may hinder the commercial transfer of research outcomes to industry.

1.7 Research Question

The research question is developed in line with Goldratt's (1990) philosophy that all systems have constraints. The research question is:

What are the internal or external system or resource constraints in publicly funded university research within Australian Universities that restrict output from that research being commercially transferred to industry?

To answer the question this research undertakes a multiple case study analysis using using Goldratt's Theory of Constraints Thinking Process to map and identify the system or resources causing constraints that are hindering commercial transfer.

1.8 Propositions to Address the Research Question

The propositions developed to address the research question (Section 1.7) are:

Proposition 1 - The process of university research commercialisation is a supply system and therefore can be mapped and measured within supply parameters and audit methods (Section 6.1.1).

Proposition 2 - A disconnect exists within the expectations of the number and value of the outcomes of research between the initial funder, the researchers and the university (Section 5.4).

Proposition 3 - There are internal and external constraints in the system of university scientific research that hinder the research outcome being commercially transferred to industry (Section 6.1.2).

1.9 Methodology

This work adopted a methodology of multiple case study analysis (Yin 2014) using Goldratt's Theory of Constraints Thinking Process (Goldratt 1990) on three Australian universities planned and practically applied system of publicly funded research commercialisation to identify constraints hindering the commercial transfer of research outcomes to industry. The case study universities were selected to provide variance in the data and perspective, and were selected on size, location and stage of development (Brodaty et al. 2014; Hedt & Pagano 2010) and referred to as the *The Mature Uni (Mature), The Young Uni (Young) and The Establishing Uni (Establishing)* (Section 4.1.1). Approval for the design of the research was gained through Human Ethics (Approval Number H17REA234).

A number of stakeholders (referred to as "common" stakeholders) were identified in the system - Government, University (as a corporate), university personnel (researchers, commercialisation personnel) and industry. The Theory of Constraints Thinking Process analysis commences with an understanding of the Goal of the system (Bevilacqua et al. 2009; Dettmer 1997; Gupta and Boyd 2008; Moroz et al. 2016; Watson et al. 2007). An audit was undertaken of Government directives and governing documents (i.e. requirements of reporting) and the Act of Incorporation, Strategic Plans and Policies of the University to understand their individual intents (aka Goals) (Section 4.3.3.1). Interviews were then undertaken with university and industry personnel to establish the practical application of the research

commercialisation system (Section 4.3.3.1). The data was then analysed for gaps and constraints against the published university processes and government expectations. The constraints were thematically grouped to form a list of Undesirable Effects (UDE) to be used as the base for the construction of a TOC Current Reality Tree (CRT) to identify the Root Cause of the constraint (Section 4.3.3.2) (Banerjee & Mukhopadhyay 2016; Dettmer 1997; Librelato et al. 2014; Reid & Cormier 2003; Umble & Umble 2015). The identified Root Causes were then analysed for constraint mitigation (Conflict Resolution Diagram (CRD)) (Section 4.3.3.3) (Gupta et al. 2011; Kim et al. 2008) and the resultant Injection into the system (change) tested for robustness through a Future Reality Tree (Section 4.3.3.4) (Dettmer 1997; Reid & Cormier 2003). The schematic of the methodology is illustrated in Section 4.1 and the design is described in Table 4.5. Chapter 4 discusses the research methodology selection, rationalisation and tactics in greater detail and data analysis undertaken in Chapters 5, 6 and 7.

1.10 Limitations

This work does not set out to provide the silver bullet to this problem but rather aims to provide a framework for a better understanding of the system of university research commercialisation and the constraints that hinder the commercial transfer of the research outcome to industry. As such, the limitations of this study include:

- No unit of Standard was found to base the measurement work on, therefore this research provides legitimacy to the system, contribution to knowledge and the development of a unit of standard for the future.

- The study is seeking data from 3 of the 42 universities within Australia and there is a risk that it may not represent the research activities in all Australian and international universities.

- The limited available information on how some Australian universities undertake the publicly funded research commercialisation process.

- Due to lack of publicly available information, or restrictions on access to confidential information, it may be difficult in establishing the following:

  - What is considered as an act of commercialisation by an Australian University. This definition may not be the same for all Australian Universities.

  - What is considered as a publicly funded research outcome that can be commercialised by an Australian university. This definition may alter depending on the stakeholder in the University, for example, researcher, commercialisation department or industry. This is investigated as an element of Proposition 2.

  - How individual Australian universities are measuring commercialisation, for example, income, product/service produced, the published data may provide conflicting information for the study and a balanced view may not be possible.

1.11 Motivation, Justification and Contribution of the Work

The motivation for this work stemmed from the desire to understand why more academic research was not being taken up by industry as an accelerator into new product development. As the initial research progressed, it became obvious that there was a paradox in the actual process and measure of publicly funded university scientific research and the rhetoric surrounding it. It was discovered that this was, indeed, a supply chain system (albeit atypical) that could be mapped, measured and improved and yet, little work had been done in this area (i.e. there has been no transfer of supply chain management principles into the sector).

There is national and international pressure for increased engagement between universities and students (OECD 2016), however, there seems to be a conspicuous lack of commercial transfer, with reasons stated, such as, a long tail in the process or IP confidentiality and ownership. Even with these issues, one would still assume that after all this time, and considering the discussions have been around for in excess of 20 years, as a nation we would be seeing some flow in the system to increase this. Instead it is a gradual increase and a mere trickle of commercial transfer.

On a sustainability level, this research is important as funding rules for Australian universities are changing, with future research funding linked to impact of research as well as physical instances of Intellectual Property generation (Bexely 2019; DESE 2020d; Ross 2020). This in turn will represent a significant disruptor in the hierarchy and status of established universities within Australia post COVID-19 (Benson 2021, Tudge 2021). We must expect more emphasis on funding in a need to off-set deficits now and into the future, coupled with the need to mitigate institutional risk from an over reliance on International students (Benson 2021; Doughney 2020).

The contribution to knowledge from this research is:

1. Identification of the system of publicly funded research commercialisation as an atypical system with a plural of customer.

2. Mapping of the system of publicly funded Australian university research commercialisation process.

3. Identification of constraints within the publicly funded research commercialisation process that are hindering commercial transfer of research outcome to industry.

4.   Development of an alternate funding system for publicly funded research commercialisation in Australian universities to enable greater commercial transfer of research output to industry.

1.12 Structure of the Thesis

In order to satisfy the research question by mapping the supply system to identify constraints within the system that hinder commercial transfer of research outcomes to industry, the remainder of thesis is organised in the following manner:

Chapter 2 - Provides a background to Australian university commercialisation, discusses the published models of commercialisation and the changes in the research funding streams within Australian universities to increase research commercialisation (Section 2.2.1).   This Chapter also focusses on the 'permission' and 'ability' of Australian universities to commercially transfer their research outcomes, the expectation of funding bodies and the requirement of increased university and industry collaboration (Section 2.3.1).

Chapter 3 - Discusses system theory, supply theory and system mapping with a focus on the system of publicly funded university research commercialisation.   This Chapter also identifies the system as atypical and the challenges in measuring for quality and continual improvement. A plural of customer within the atypical system is discussed, along with the difficulty of customer focus.

Chapter 4 - Outlines the research methodology of a multiple case study analysis using the Theory of Constraints Thinking Process to identify constraints within the atypical system of publicly funded university research that are hindering commercial transfer of the outcome. The chapter outlines the value of constraints mapping as an alternative to more traditional process mapping of a system and the required data sources. A research plan is discussed that includes the processes for data collection and analysis using the Thinking Process tools of Current Reality Tree (CRT) to

identify the constraints and their root cause, Conflict Resolution Diagram (CRD) to develop injections to augment the constraints, and a Future Reality Tree (FRT) analysis of the injections to establish suitability.

Chapter 5 - Identifies the stakeholders of the system and categorises them as the Australian Government, Australian Universities and "common" stakeholders.   The findings from the analysis of the Acts, Policies and Procedures to determine the planned practices and the stakeholder interviews to determine the practical application of the system is thematically collated into 6 Undesirable Effects (UDE), to be used for constraints mapping in Section 6.1.1.

Chapter 6 - Develops an analysis of the impact and relationships of the UDE through cause and effect mapping using the Theory of Constraints (TOC) Current Reality Tree (Section 6.1.1). The analysis identifies the constraints in the system, and then, the Root Cause of these constraints (Section 6.1.2) enabling the research question *What are the internal or external system or resource constraints in publicly funded university research within Australian Universities that restrict output from that research being commercially transferred to industry?* to be addressed. Analysis of the Root Cause is undertaken through the TOC Conflict Resolution Diagram (CRD) to 'break' the constraints through a change in the process of research funding resulting in a focus of the university research commercialisation system customer identity.

Chapter 7 - Discusses the suitability of the suggested change in the system through the development of a Future Reality Tree to test the logic in the system change.

Chapter 8 - Concludes the work and provides some recommendations for further work arising from this research.

CHAPTER 2 - BACKGROUND

2.0 Introduction

The previous chapter provided an introduction to this work and the research question:

What are the internal or external system or resource constraints in publicly funded university research within Australian Universities that restrict output from that research being commercially transferred to industry?

The research question was presented within the contextual framework of publicly funded university research where the funding body, *government*, is seen as the customer (principal) due to "demand and ability to pay" for research practices within Australian Universities (Section 1.0).   There is a global expectation that universities will increase the commercial transfer of research outcome into industry to strengthen international economic competitiveness (Acworth 2008; OECD 2016; O'Brien 2010; Rasmussen et al. 2006), however, this research found that there has been little change in the governing process for the publicly funded research in Australian universities that may lead to commercial transfer of the output (Section 1.3).   In Chapter 1 the challenges of mapping this system were outlined in the absence of a commonly recognised measurement metric (Section 1.4), the identification of the gap in the literature was discussed (Section 1.5) and the use of a combined methodology of multiple case study analysis and Goldratt's (1990) Theory of Constraints Thinking Process to determine the constraints in the system that are hindering the commercial transfer of publicly funded university research (Section 1.9).

This Chapter will investigate the research question through a critical analysis of the publicly funded university research environment in Australian universities and address the Propositions outlined in Section 1.8 through a focus on:

1. The Purpose of Universities
2. Motivation of University Research
3. Commercial Transfer of Australian University Research Outcomes

2.1 The Purpose of Universities

Australian Universities are defined by the *Higher Education Support Act 2003 (HE Act)* as a Higher Education Provider (HEP) and specifically listed within the HE in Table A or B (Higher Education Support Act 2003). The HE Act describes the purpose of an Australian university is to educate and, in turn, enabling people to take a leadership role in 'the intellectual, cultural, economic and social development of their communities; the creation and advancement of knowledge; and, the application of knowledge for the betterment of their communities in Australia and internationally' (Higher Education Support Act 2003 section 2-1(b)). It is through university research that new knowledge is developed, and in conjunction with industry, economic growth for the nation (Kumar 2017; Roessner et al. 2013). A full list of the Australian Universities registered in Table A and B[5] of the HE Act 2003 and their recognised acronyms appear in Appendix E.

Australian universities are created under the laws of the Commonwealth[6] through the HE Act 2003 to educate, create, advance and apply knowledge for the betterment of communities (Higher Education Support Act 2003 Section 2-1 (b) p. 4). Each university is incorporated under State or Territory Acts of Incorporation that focus on the individual University purpose and the benefit they represent to their community (Figure 2.1). Specific research commercialisation functions listed in these State and Territory based Acts of Incorporation include the provision to exploit research intellectual property and research based consultancy services to generate revenue for the university including teaching and research activities, however, the intent focusses

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[5] Table A providers are Public Universities, Table B providers are Private entities that have gained full University licence (DESE 2019c)

[6] Commonwealth, Federal and Australian are all terms used for the first level of government in Australia, for the purpose of his research, the term Commonwealth is used.

on enabling only, and not a specific measured requirement. An analysis of the Incorporated Acts led to the identification of five (5) common objectives of an Australian university, namely, *research; disseminate knowledge and promote scholarship; provide facilities for education; confer degrees; and, commercially exploit (for the benefit of the university) facilities, knowledge, research and study,* these will be discussed Section 5.3.2.

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│  │   Australian Government   │  │
│  │        HE Act 2003        │  │
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│  │     State Governments     │  │
│  │    Act of Incorporation   │  │
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│  ┌───────────────────────────┐  │
│  │   Australian Universities │  │
│  │  Strategic Plan, Policies &│ │
│  │         Processes         │  │
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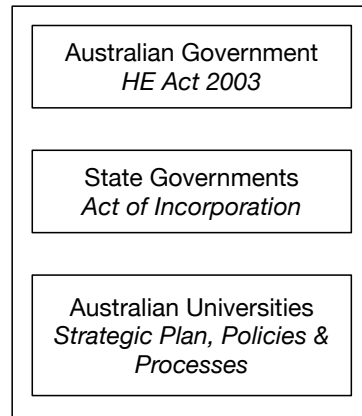
Figure 2.1 - Creation of an Australian University (Higher Education Act 2003)

Universities were set up as public institutions providing the service of education and research (Ekem 2019) and have always played a key role in a nation's innovation system (Acworth 2008; O'Brien 2010; Rasmussen et al. 2006). Progressively, governments are focusing on universities as a growing source of innovation, problem solving, policy development and source of skilled personnel (Boulton 2009; Cheah & Yu 2016; Roessner et al. 2013) and their contribution to global business development and innovation rankings (Acworth 2008; OECD 2016). The increase of specialised education institutions and changing university funding models has altered attitudes towards financing university activities, enabling an emergence of profit making models within universities (Remenyi 2019), resembling project based or siloed departmental activities, not a change to the holistic university system. University product value was identified through a focus on the 'market value' of university output starting in the 1980's (Donleavy 2019) along with addressing community needs through institutional relevance (Blair & Lee 2019). Interestingly, this historical focus has not developed into a significant rise in developing financial or continual industry collaboration (Banasicwicz 2019; Moon 2019). Market value of

research is investigated to determine its contribution to consistently low commercial transfer of commercial output to industry (i.e. constraint in the system).

2.2 University Research

Universities educate, research and disseminate knowledge. The research undertaken at a university enables the development of new knowledge, technical know-how, development of equipment and instrumentation, and, enables an engine of economic growth and relevance in industry and the community (Kumar 2017; Roessner et al. 2013). Within the context of this study commercial research output can take the form of patents, licences or spinoff companies, it is also published in books, journal articles, works of art, or discussed in a public forum such as a lecture (Carrington et al. 2018).

2.2.1 Funding University Research

A global focus on developing university and industry research collaboration (Section 2.3.1) has seen the Australian government regularly develop funding opportunities to assist with this collaboration and, in turn, enhance Australia's global economic competitiveness (Harman 2010). Public funding assists Australian Universities to research and collaborate, enabling the development of knowledge, contributing towards industry growth with Australian and international markets (Adams 2018; Kumar 2017). Australian University research activities are primarily funded through *Research Block Grants* and the *National Competitive Grants Program (NCGP)* (Categories 1 - 4) with additional university research funding requirements sourced from international undergraduate and postgraduate student fees; industry research and consulting contracts and partnerships; and philanthropic funds, donations and bequests (DET 2018b).

Funding through *Research Block Grants* (RBG) is allocated to universities annually under a reward system for attracting external research income and successful

completion of higher degree by research students. RBG's are made up of a combination of *Research Support Funding* providing a flexible funding stream to support systematic costs of university research; and, *Research Training Funding* that provide scholarship support for domestic and international students who are undertaking higher degrees (DESE 2020b; DET 2018a).

The *National Competitive Grants Program* (NCGP) - Category 1, 2, 3 and 4 is managed by the Australian Research Council (ARC) on behalf of the Australian Government. Category 1 consists of Australian Competitive Grants that are listed in the Australian Competitive Grants Register (ACGR) and has two focusses, *Discovery* and *Linkage* Grants. *Discovery* Grants support fundamental research, essential for Australia's innovations system, new idea and job creation, economic growth and quality of life and do not require a secured customer (industry partner) for the application process and represent 70% of ARC Funding issue. *Linkage* Grants have promoted national and international collaboration through funding industry and key stakeholder partnerships since 2000 and represents 30% of total ARC funding available for research (ARC 2018d). *Linkage* funding access was expanded in 2016 to facilitate a program of rolling application submissions, instead of annual submission, with no more than 6 months from application to decision, as recommended in the *Review of Research Policy and Funding Arrangements 2015*[7] to enable more timely access to collaborative funding (ARC 2020; DoE 2015b; DESE 2016).   However, during the process of this research it was found that it has not yet yielded an increased in the provision of funding to a university, and therefore a marked increase in research commercialisation within the university or industry, it has simply enabled easier access to the funding (Figure 2.2) (ARC 2018a; 2018d; DESE 2015a-e; 2017; 2018; 2019a; 2019b).   The combination of funding through RBG and NCGP represent the largest input of research funding to an Australian university and an opportunity for an outcome that can be commercially transferred. This research shows that there are constraints, other than funding hindering this transfer, primarily, a misalignment of the intent of the whole system (Section 5.4).

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[7] *The Review of Research Policy and Funding Arrangements - November 2015* is commonly known as the Watt Review in reference to the author Dr Ian Watt AO (DoE 2015b)

Other constraints include, a focus on securing the research funding (Section 5.3.3.3), passive environment and low skill level for identifying opportunity (Section 5.3.3.2 & 5.3.3.3) and a misalignment of business systems (Section 5.3.3.4 & 5.3.3.5). Figure 2.2 illustrates the level of research funding through *Research Block Grants* and the *National Competitive Grant Program* for the 2010 - 2018 period against the total operating cost, and total government funding, of Australian Universities.
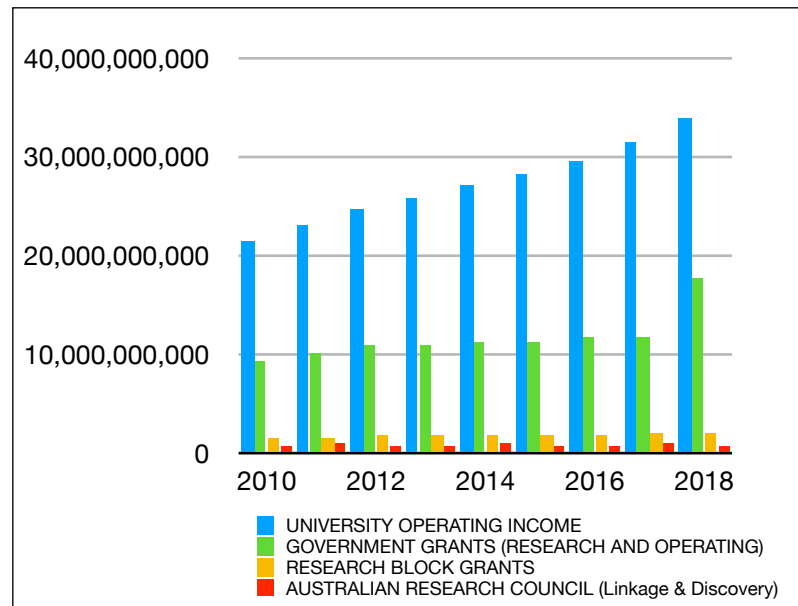
Figure 2.2. University Research Funding (Sourced: DESE 2015a-e; 2017; 2018; 2019a; 2019b; 2020a)

This research focusses on the commercial transfer of research output from *Discovery* funding through, NCGP Category 1 and the potential for their output to be commercially transferred.   University research that is funded through other Government (i.e. NCGP category 2, 3, 4[8]), University, industry and private funds (philanthropic and donation) are outside of the scope of this work and do not address the requirements of the research question as outlined in Section 1.5 (ARC 2018d; UA 2020).

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[8] Category 2 funds consist of Australian Government funding schemes and government business enterprises not listed on the ACGR, and can contain State and Local government funding, and, partly government owned or funded bodies. Category 3 is funding sourced from Industry and other research income, and lastly, Category 4 is research income that is made available for research from Cooperative Research Centre (CRC).

Interestingly, when mapped the regularity of ARC *Linkage*[9] and *Discovery*[10] funding allocation demonstrates an alignment with the first year of a new Australian Federal Government, aligning the intent of the research funding with specific political outcomes, not innovative outcomes for Australia (UWA 2020) (Figure 2.3). It is further noteworthy that, although the Australian Government has called for "better commercial transfer", a noticeable rise in the provision of funding is not demonstrated to address this specific requirement.
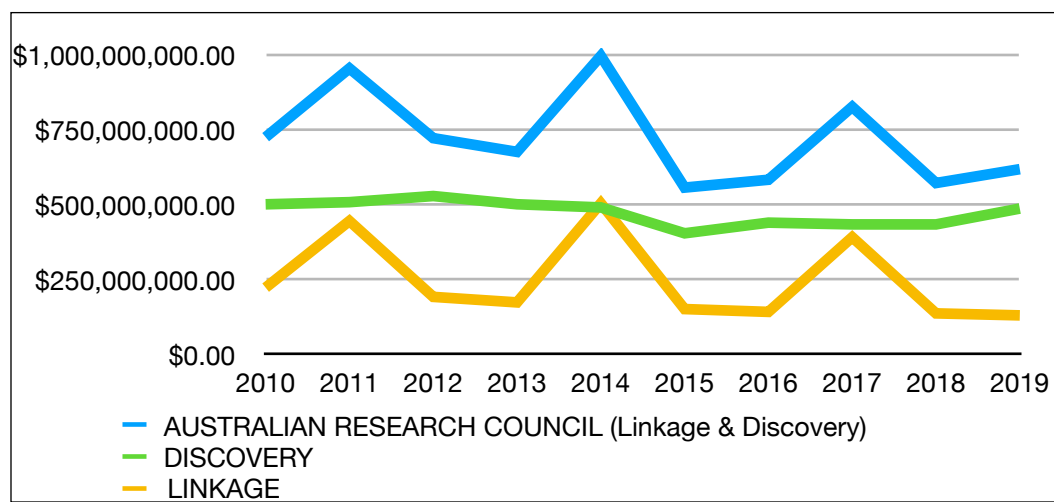
Figure 2.3. ARC funding 2010 - 2019 (ARC 2018a; 2018d; DESE 2015a-e; 2017; 2018; 2019b)

Initial funding through the RBG and NCGP system supports the process of research. Further funding is required through internal or external (industry) sources for the production of Intellectual Property and sourcing potential customers (Section 3.2.4), with even further investment required, usually in the form of seed funding, to move the process to 'proof of principle'[11] and market ready stage (Figure 2.4) (DoE 2014;

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[9]Linkage promotes national, and international, collaboration and research partnerships between key stakeholders, in research and innovation, including higher education providers, government, business, industry and end-users. Research and development is undertaken to apply advanced knowledge to problems, acquire new knowledge and as a basis for securing commercial and other benefits of research. The Linkage schemes are: ARC Centres of Excellence; Industrial Transformation Research Program; Learned Academies Special Projects; Linkage Infrastructure, Equipment and Facilities; Linkage Projects; and Special Research Initiatives.

[10] Discovery supports fundamental research, essential to Australia's innovation system, for the development of new ideas, job creation, economic growth, and an enhanced quality of life in Australia. The Discovery schemes are: Australian Laureate Fellowships; Discovery Early Career Researcher Award; Discovery Indigenous; Discovery Projects; and Future Fellowships (ARC 2018d)

[11] 'Proof of Principle' provides a version of the potential product that can be used to show customers the potential product, this could be a spreadsheet model or outline (Ulrich & Eppinger 2000)

DoE 2015a; Etzkowitz 2016; Heinonen 2015; Munari et al. 2018).   Whereas, there have been a number of short term focussed Government programs to fund this process, a continuing solution is not evident (DoE 2015b; Redfire Consulting 2016).
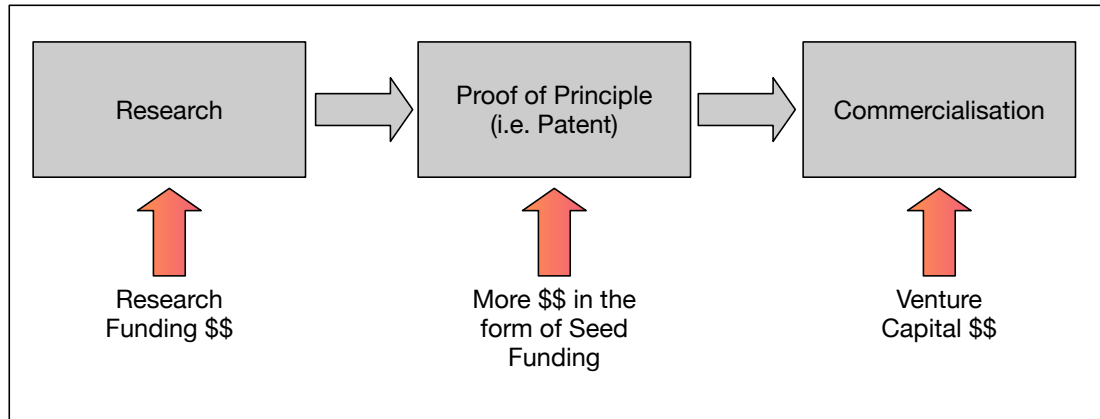
Figure 2.4. Allocations of Funding Required in the Commercialisation Process (adapted ARC 2000 p.11)

The cost of the university research commercialisation process is not clearly defined in the literature, either by industry, where it is perceived that the process has too much bureaucratic cost embedded in the system (Tartari et al. 2012), or the academic environment, notably, discussion on the perception of a high cost without outlining a true understanding (Baldini et al. 2007; Owen-Smith & Powell 2001; Tartari et al. 2012); or management processes of the cost (but not the cost) (Wu et al. 2015). Thus, this leaves a gap in the comprehension of the actual cost to a university of the commercialisation process, and importantly, the financial value of the outcome to a university.   This gap is mirrored in the low enthusiasm of the system of commercialisation identified through this research.   A comparison of the university process against commercial product development literature can be undertaken using an industry benchmark that for every \$1 that leads to a promising research outcome, the requirement to convert that outcome to successfully commercialised Intellectual Property is \$100 (Harman & Harman 2004; Smith & Reinertsen 1991).   To put this cost into perspective, Table 2.1 demonstrates the theoretical cost of research against government expenditure for Defence and a Tax Credit Scheme, highlighting that sole government funding of research commercialisation is financially untenable. Demonstrating the importance of industry collaboration, not only for the

identification of a customer for the research output, but also, for cost sharing to enable the further commercial development of these outcomes. Although, the Australian government invests considerably, through funding, for core research, however, there is a much lower practice of investing in the conversion of publicly funded research output. This gap has provided a platform for discussion on the *third mission* of a university (ARC 2000)[12] to formally identify and manage the requirements of this process.

Potential Research Commercialisation Cost to Australia			
Source	Funding Amount	Development and Commercialisation Cost	Comparison
2008 - Total Government Funding To Universities	$649,000,000	$64,900,000,000 ($64.9b)	Twice the spending in 2008 on Defence in Australia
2014 ARC Centre of Excellence Engineering, Mathematics and Informatics	$65,000,000	$6,500,000,000 ($6.5b)	Approximate spend on the Fuel Tax Credit Scheme ($6.27b) 2014-2015 Australian Government Budget

Table 2.1 - Potential Research Commercialisation Cost to Australia (Adapted - ARC 2000; 2013; Budget 2014-2015; Duke & McKean 2008)

The *third mission* of a university moves the focus of a university from basic research to an entrepreneurial university with broader interest in regional economic development and industry formation practices through collaboration, resulting in a move towards university sustainability (Etzkowitz 2013; Sánchez-Barrioluengo & Benneworth 2019). This requires a shift in the focus of academic research, and indeed revenue seeking, to a more collaborative approach moving towards breaking the culture of inward facing internal ecosystems with research practices organically designed to perpetuate grant sourcing (Narayan et al. 2017). These ecosystems are described as a triple helix of university research collaboration where university is positioned as the guiding force in research, subsequently taking control of the collaboration with industry (Etzkowitz & Leydesdorff 2000) (Figure 2.5). This development also enables national and university development of a changed

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[12] This may prove to be the biggest constraint within the system. This constraint is highlighted and discussed in Chapters 5, 6 and 7.

contribution to society definition of a university (Sengupta & Ray 2017). Specifically, once considered only a contributor to local economies through functions such as, employment and education, universities are directly contributing to regional economic development through relevant technology transfers (Etkzkowitz 2016; Narayan et al. 2017).
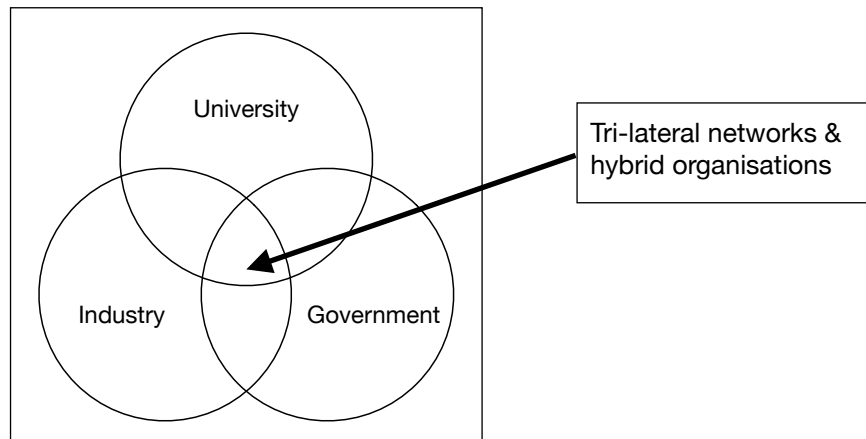
Figure 2.5. Triple Helix of University Industry Government Collaboration (adapted Etzkowitz & Leydesdorff 2000)

Helixes have been used to describe models of government university collaboration from different perspectives with the aim to identify the lead organisation. Etzkowitz & Leydesdorff (2000) described a timeline of helix development starting with Triple Helix 1 where the government encompasses both university and industry, with strong versions of this found in socialistic states (Figure 2.6). This model was also found in Europe, however it contained highly circumscribed relationships (Figure 2.7).
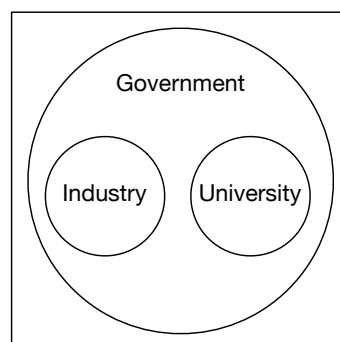
Figure 2.6. Triple Helix 1 of University Industry Government Collaboration (adapted Etzkowitz & Leydesdorff 2000)
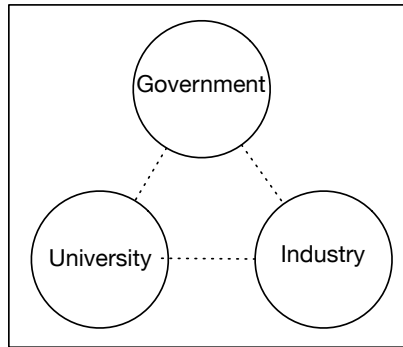
Figure 2.7. Triple Helix 2 of University Industry Government Collaboration (adapted Etzkowitz & Leydesdorff 2000)

The concept was further developed to identify, and develop, a university's ties to the business community, resembling a quadruple helix (Figure 2.8) (McAdam et al. 2016; Miller et al. 2018), to acknowledge the environment of the whole system (Figure 2.9) (Carayannis et al. 2018).
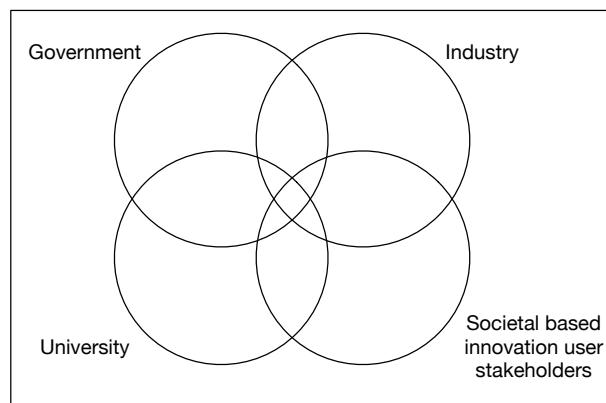
Figure 2.8. Quadruple Helix of University Industry Government Community Collaboration (adapted McAdam et al. 2016; Miller et al. 2016)
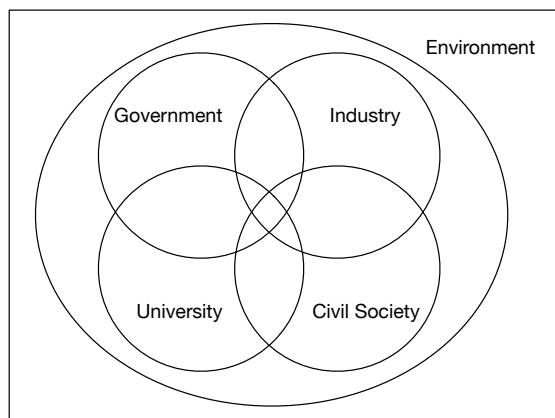
Figure 2.9. Quadruple Helix of University Industry Government Community Collaboration and the Environment (adapted Carayannis et al. 2018)

This research identified that an overall funding shortfall is acknowledged for the cost of the commercial transfer process, resulting in universities attempting to meet current industry collaboration requirements with no additional resources. At the same time, the collaboration model (Helix) of a university has developed to include all stakeholders, unfortunately there is no evidence of the internal system of commercialisation changing at the same rate.

2.2.2 Stakeholders of University Research

Australian universities provide value to its stakeholders, i.e community, industry and government, through education, research and development of new knowledge for dissemination (Ferrero-Ferrero 2016). University research, often funded through grants and collaboration with the Australian Government or industry, supports Australia's global innovative standing (ARC 2018c; OECD 2016). Stakeholders of an organisation are any individual or group, either internal or external, that is affected by, or can influence, the organisations objectives (Brits 2015; Ferrero-Ferrero et al. 2018; Freeman 2010). Frameworks that support the relationships, perspectives and expectations of the stakeholders (Stakeholder Theory), and an organisation is influenced by the these relationships bring the influence they wield on the organisational system (Ferrero-Ferrero et al. 2018; Freeman 2010; Tantalo & Priem 2016).

Stakeholders of Higher Education Institutions can be classified as internal (students, staff, academics, volunteers) or external (Government, graduates, investors, industry, competitors, suppliers, community) (Ferrero-Ferrero et al. 2018; Sahney et al. 2004). Stakeholder relationship for university research commercialisation is based on the transfer of knowledge and the influence each stakeholder has on the outcome of this system (McAdam 2012; Miller 2018). The selection of system stakeholders for this study was initially identified through the analysis of the Acts of Incorporation, Strategic Plans and Policies. The triple helix model provided guidance for the choice

of Government, University and "Common Stakeholders" (Section 2.2.1) (Carayannis 2018; Leydesadorff 2011; McAdam 2012; 2016; Miller 2018).

2.3 Commercial Transfer of Australian University Research Outcomes

Commercially developing university Intellectual Property (IP) includes a number of time heavy processes, such as, identification of potential IP, registration, product development, testing, customer sourcing and market placement.   Whereas, the Intellectual Property Management Policies of Australian universities provide a guide to this process for the development of IP into a commercially transferrable product (Section 5.3.2), an environment that supports research, commercial development and industry transfer is also required (Farsi & Talebi 2009).   Operationally, this environment should include a quality research base with science and technology skill maintenance; the availability of industry receptors to take up the research results; availability of venture capital to provide funding for the development stage; good management and regulatory environment; and competitive business environment to drive excellence (Auranen & Nieminen 2010; Carrington et al. 2018; Kemp 1999; Thompson et al. 2011).   In addition to regulatory and operational environments, a system of ideation is needed to lead the idea through to commercial transfer.   Often time for ideation or IP identification skills are not evident within the researchers with issues cited as high teaching load, poor systems of technology transfer; lack of resources to build industry links or funding to commercialise the research (Alibekova et al. 2019; Bansi 2018).   In addition, the ideation stage, within a university is often facilitated by 'startup' or 'design thinking' programs, and where the promise of success is often due to the selection of the participants of the scheme that will pitch to selected investors, not the outcome of research that is looking for a partner. Although this system can have some successes (Dang et al. 2019) and can lead to informal partnerships, the system is problematic and can suffer from a lack of expertise or insufficient capital to invest (Jamil et al. 2015).   Opportunities can often be limited to seeking investment through known networks, namely, alumni or current business contacts rather than seeking new partners or pitch events organised more to

"get the idea out there" rather than to find inventors (Minguillo & Thelwall 2015). There is little evidence of a dedicated and controlled systems approach akin to, Total Design (Pugh 1991) or the Quality Function Deployment (QFD) Standard ISO 16355-1:2015 (International Organisation for Standardisation 2015c). Although, it is important to note that successful paths of funded research commercialisation identified in the literature, it has been predominantly on a direct industry needs basis, where a need was identified commercially and addressed within a successful research to commercialisation system, demonstrating an industry pull environment. (Bonutti et al. 2008; Christoudios 1998; Gingles et al. 2008; Vecht et al. 2010).

Having the right environment does not ensure success, and, the ability to develop the Intellectual Property (put something on the shelf) does not ensure customers will find it or buy it. Developing the Intellectual Property without customer pull (i.e. a need) has been demonstrated through the open access marketing of 'ready to go' Intellectual Property. Open access is available for publications data and research results from university research allowing researchers to source the latest data and publications (Boyle & Cullen 2016) and has developed to encompass Intellectual Property resulting from university research. One such platform is EasyAccessIP promoting ready developed IP for industry take-up (EasyaccessIP 2019). Enabling a university to allow industry to the use developed IP for a short period, at no cost to industry, bypassing lengthy cost and contractual negotiations, with the aim to enable industry to develop new product. It is planned that the IP will eventually return collaboration or income to the university (Fishburn 2014). Although, the early development of Intellectual Property in the research to commercialisation system provide more opportunity to seek a customer, Weckowska et al. (2018) found that although early development of Intellectual Property leads to a higher potential patent output, it was not found that there was any connection between developing Intellectual Property and a higher rate of industry transfer. Having Intellectual Property waiting for industry, was not the same as industry doing research to solve a problem, and, although this platform was encouraged at Australian universities to assist with dissemination, it was not well utilised (Boyle & Cullen 2016). This

research found that it was possibly due to perception of Intellectual Property value (Section 1.2), creating a perception that university IP was valueless (Section 5.4).

There is no singular path to commercialisation, one size does not fit all, in addition consideration should be given to a culture within researchers who may want to keep autonomy. For some researchers, output is, by their own choice, conducive to their perception of future industry needs, not resultant of industry demands, demonstrating a push system embedded within the process of university research commercialisation (Bruneel et al. 2010).

2.3.1 University Industry Collaboration

At a basic level universities educate and research to develop knowledge, whilst industry undertakes research to develop product, capitalising on valuable knowledge that can be leveraged for commercial gain (Bruneel et al. 2010; Estrada et al. 2016). This statement identifies the divergent intent of university and industry towards research, causing a mismatch when the system calls for collaboration (Estrada et al. 2016). Research collaboration between university and industry fosters the growth of the nations' economic standing (OECD 2016) and at regional level, these partnerships are responsible for economic development (Sánchez-Barrioluengo & Benneworth 2019) that can include the establishment of research and science parks to further support collaboration (Hobbs et al. 2020). It is commonly understood that collaborative research provides benefit to society as a whole, however, motivation is triggered when benefits are understood by the organisations themselves (Ankrah et al. 2013). Industry/university collaborative relationships are personal and based on trust, communication and an understanding that people are the universal drivers of the system, and management of how each player views the drivers and opportunities is beneficial (Casper 2013; Ho et al. 2016; Plewa et al. 2013; Tartari et al. 2012). Rarely is the basis for the relationship business-to-business (Boehm & Hogan 2014). On the other hand, this research found that the relationships, albeit reliant on continuing personal interaction, were often sourced from companies that would

provide benefit or leverage to the research and the university itself. Often, the management of these different views require the existence of an intermediary, person or organisation, that takes control of the scientific and market relevance of the project (Ankrah et al. 2013; Cunningham et al. 2015) managing the value creation resulting from an alliance with different resources and capabilities are managed towards the common goal (Sarkar et al. 2001).

The literature on collaboration is typically authored by academia and the perspective is a view primarily from the stance of the academic (Ankrah et al. 2013). Such as, training to enable collaborative commercialisation of research outcomes provided by the university for industry (Giones 2018), and the absorptive capacity of industry for the commercial transfer of university IP and knowledge (Maphumulo & Nel 2019). A deeper look at the barriers that lead to the overarching mismatch of intent in collaboration identified two types of barriers, translational and orientational. Translational barriers related to Intellectual Property on ownership, timing of the projects, disclosure and negotiation of contracts (Tartari 2012). Orientational barriers identified differences in industry and university purpose for research (Bruneel et al. 2010), such as, university personnel misunderstanding industry due to a practice of accessing industry only to gain project support, future research opportunities or funding under the guise of collaboration (Berman 2008; Perkmann et al. 2013); or, seeking collaboration as a reaction to reduced government funding (Berman 2008). Tension was also caused between the dual needs of high academic output (publications) and a push for high commercial transfer or collaboration (Ho et al. 2016), typically resulting from researchers having little interest in collaborating with industry (Perkmann et al. 2013). The mapping undertaken of the system of publicly funded research commercialisation supports these findings (Section 6.1.1).

2.3.2 Rate of Intellectual Property Identification and Commercial Transfer

During the 2010 - 2018 period Australian universities, as a whole, disclosed, an average of 1100 inventions annually that possibly exhibited potential to be developed

into Intellectual Property (IP) and could be transferred to industry, this equates to an average of 29 inventions identified per university per year (DIISRTE 2019). A much lower portion of inventions progress to be developed into Intellectual Property, resulting in a yearly average of 464[13] Licences, Options and Assignments (LOAs) developed, or, an average of 12 commercial pieces of saleable Intellectual Property per university per year (Appendix G). Licences, Options and Assignments (LOAs), are the measurable and saleable Intellectual Property from a Patent (DIISRTE 2019) and the tangible element identified in this research for commercial transfer. Consequently, financial return for a university from these LOAs indicates that only 30% of all active LOAs yielded income. This revenue represents an annual average of 7% of the operating income of a university and in some individual universities it is much lower (Appendix B). In the context of this research, the low occurrence, and commercial transfer of, Intellectual Property products, of itself, suggests a constraint in the system, this mapped in Section 6.1.1 (DIISRTE 2019).

2.3.3 Measurement of University Research Commercial Transfer

Prior to 2016 the Australian Government undertook a biennial quantitative audit of research commercialisation by Australian Universities through the National Survey of Research Commercialisation (DISER 2019). The audit measured the invention disclosures (those discoveries that may lead to Intellectual Property (IP) registration); Patents; Licences, Options and Assignments (LOAs), Material Transfer Rights (MTAs) and Start-up Company activities. These commercialisation elements have differing intents and purposes, a patent is the registration of IP ownership; a LOA, MTA or Plant Breeders Rights are commercially transferrable and a research consultation or contract is a service the university has 'commercialised' and is selling to government and industry as a tool for investigation (DIISRTE 2012). These elements are often combined for reporting purposes and blur the line within a university of a research output and a fee for service commercial activity. To further blur the line, the Australian government introduced a disruptor into the Higher

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[13] A piece of Intellectual Property can have multiple LOA's issued

Education sector in 2015 with the development of a measurement for *impact*, which will become critical when understanding, managing and improving the supply channel of research to industry (i.e. commercial transfer) for the continuation of university research funding (Bexely 2019; DESE 2020d; Ross 2020). This addition has effectively changed the reporting intent of the measurement, from the impact of the research to the impact of the research on the community (Bornmann 2017) reminisce of pubic value mapping (Bozeman & Sarewitz 2011) and changing the measurement from strictly quantitative to a combination of quantitative and qualitative (Gunn & Mintrom 2017; Moed 2018). In turn, developing a new metric for measurement of this impact and adding ambiguity and stress to an already divergent system (Section 2.3) (Deeming et al. 2017; DISER 2015; IRU 2016).

The intent of "better commercial transfer" (DISER 2015) has been commonly used within government publications, this research found there is no measurement for "better" nor its value. If the value and format is known, then the system can be measured, and if measured, then it can be managed and improved (Deming 1986; Kocaoğlu et al. 2013). Without this metric, ambiguity or inertia takes hold of the system, as identified within this research though a Theory of Constraints Current Reality Tree (CRT) cause and effect mapping exercise (Section 6.1.1), specifically the system leading to the development of the constraint theme (Section 6.1.1.3 *UDE 3 - A Passive Environment)*.

In addition, an acceptable level of value growth for university commercialisation outputs is not addressed in reviews of research funding and commercialisation undertaken in the 2013 - 2016 period in preparation for the development and release of the National Science and Innovation Agenda (DIISRTE 2019; DISER 2015). The high reliance on publication for career progression and standing, not impact on the community, may stifle the flow of commercial IP identification due to publication embargoes placed on promoting the discovery. These perception are addressed in the Australian Government Innovation and Science Australia Strategic Vision - *Australia 2030 Prosperity through Innovation* (ISA 2017b), however, although acknowledged,

only minor changes have been made to the recognition. This research has identified that a more radical system change is needed (Section 7.2).

2.3.4 Intellectual Property Ownership

All Intellectual Property that is developed through activities undertaken whilst employed by an Australian university is, primarily the property of the University, with internal policies enabling researcher rights to the Intellectual Property (IP) (ARC 2018a; IPA 2020). Similar practices are evident in universities globally, for example, in the UK and Canada rights are automatically assigned to the university, along with responsibility to commercialise or gain value from the research outcome (CIPO 2020; UK 2020). Additional, guidelines have been developed within the UK to enable IP ownership agreements to be reached when the research is collaboratively undertaken with industry to bolster the attractiveness of collaboration (UK 2019). The USA have made provisions Federally under the Bayh-Dole Act, 1980, enabling a university to have first option (within a reasonable time) of retaining the intellectual property rights of Federally funded research, or the rights are reverted back to the government source of the funding (USGAO 1998). Although the adoption of legislation that address the ownership of publicly funded research, in turn, enables a smoother path to commercialisation, such as the Bayh-Dole Act that has been proved to raise the level of commercial development of the research output, it does not ensure transfer to industry (Ito et al. 2015; Weckowska et al. 2018). Alternatively, Sweden exercise Professor privilege and have moved the commercial development and industry transfer decision of the Intellectual Property from a university committee to the specific faculty of research origin. This ensures the faculty controls the commercial development in addition to gaining the benefits. Färnstrand Damsgaard & Thursby (2013) argue that this approach results in a higher rate of successful commercialisation due to the direct line of benefit to the researchers.

Within Australia, the *National Principles of Intellectual Property Management* guide the development and ownership of the Intellectual Property, and guide individual Australian university Intellectual Property management policies to manage the

development of IP and distribute revenue appropriately. The policies outline a shared allocation of revenue between the university (as the enabling body), the faculty (as the enabling department) and the researcher or research team. An analysis if the 42 Australian universities showed no Standard for the allocation of this commercialised research revenue, however there are similar patterns in distribution, with all universities distributing a portion of the research revenue to the researcher(s), their faculty and the university, while keeping a teaching and research option on any Intellectual Property developed within their university (Appendix F) (ARC 2018a; DISER 2015; IPA 2020). Although the split is usually equal, it is mostly after all costs by the university of the commercial development have been recouped, and more often the revenue is obtained many years into the future due to the long commercial development and industry transfer time on research output. In addition, the IP many be allocated to many researchers, or be combined with other university discoveries for the commercial development, further reducing the return for the researcher and supporting the low enthusiasm for the researchers have expressed for following the path of commercial development.

This research did not identify IP ownership, or potential revenue, as a driver for developing commercialisation within most of the stakeholders, interestingly, the ethics of ownership was questioned by stakeholders interviewed. Not only were the rights of the university IP ownership questioned, but more strongly, the ethics of gaining revenue from publicly funded IP questioned (Section 5.3.3.3). Mostly, the process of developing the Intellectual Property (time and effort) was identified as a significant constraining factor, with time and career progression cited as the main stakeholder concern (Section 5.3.3.2 & 5.3.3.3).

2.4 Summary

There is a global push to develop university research into Intellectual Property that can be taken up by industry. The purpose of a university is defined by legislation and reflected in university practice. However, more commercial transfer of research is

being globally sought of universities. This requires a change in the output of a university from teaching and disseminating knowledge to add measurable commercial transfer and industry relevance. Possibly changing the definition or purpose of a university. Funding for Australian universities research does not stretch to increasing commercial output (Section 2.2.1 and 2.3). University/Industry collaboration is encouraged (Section 2.3.1), however this has not resulted in a substantial increase in Intellectual Property identification, however it has identified a gap in the skills needed for potential IP identification activities (Section 2.3.2) and the metric for measurement of success (Section 2.3.3). If the changes in the requirement of the system ("better" commercial transfer) have not increased the commercial transfer of research, then the system itself needs change to enable more output. To change the system, there would need to be changes in the policies and procedures within the university. The system of university research commercialisation is discussed in the context of systems and systems theory in the next Chapter 3. The university system is identified as an atypical supply network with a plural of customer (Section 3.2.3) and the gaps that are hindering the development of more commercial transfer.

CHAPTER 3 - LITERATURE REVIEW

3.0 Introduction to the Literature Review of this Study

This chapter hinges around identifying publicly funded university research commercialisation as a system, and thereby, enabling the identification of constraints within the system that hinder the commercial transfer of its outcomes. The Incorporating Acts of Australian universities make provision to commercially exploit university assets, including research outputs, but do not require research outputs to be commercially transferred as a condition of operation (Section 2.1). Chapter 2 discussed the 'permission' and 'ability' to commercialise; the expectation of increased university and industry collaboration (Section 2.3.1); and, that access to more collaborative based research funding since 2010 (i.e. ARC Linkage Grants) (Section 2.2.1) has not resulted in an increase in income from commercial transfer of research, instead, holds a consistent low at 7% of the operating budget of an Australian university. Universities have the resources to support a system that can provide commercial transfer in their management of personnel, research funding, projects and facilities, however, this research identifies constraint in the system caused by a misalignment between the funder (Government) and the university in the legislation that governs the funded research commercialisation process (Section 2.1 & 6.1.2). This Chapter reviews literature on systems and commercial transfer of publicly funded University research with particular focus on:

1. Systems
2. Systems and University Research Commercialisation
3. Managing the System
4. Measuring the System

3.1 Systems

A system is a set of interrelated elements that work together to achieve a common objective or purpose (Adams et al. 2014; Drack & Schwarz 2010; Kerzner 2009) demonstrating functional relations between independently existing parts (Caws 2015). Definitions of a system in the literature incorporate tangible and intangible explanations, including, "collections of people, products, technology and tools organised in a particular way" (MacCuspie et al. 2014 p.17); group of human or inhuman elements organised to act as a whole (Kerzner 2009); systems, processes or phenomena (Barber 2008); and, a mix of equipment, skills, techniques and information (Fawcett et al. 2004) demonstrating broad schools of thought. A system node is a single instance of the input of resources (input), creation of value (process) and output of the enhanced value (output) (Figure 3.1), each of these singular nodes feed into other nodes to create a larger system (Bohme et al. 2008; Christopher 2016; Dettmer 1997; MacCuspie et al. 2014; Tricker 2003).
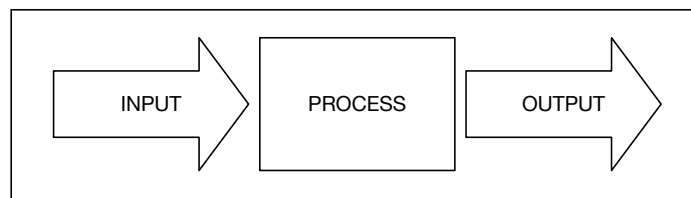
Figure 3.1. System (Bohme et al. 2008a; Christopher 2016; Dettmer 1997; MacCuspie et al. 2014)

A system node is an independent unit separated from the environment by a boundary, this boundary enables it to interact and create relationships with other systems to form larger systems, in turn, becoming the sub-systems of even larger systems (Caddy & Helou 2007) (Section 3.2.1) (Figure 3.2). The nesting of these systems creates a hierarchy and interdependency enabling alignment with a quality standard, such as, Quality Management Systems ISO 9001:2015 (Figure 3.2) (Section 3.3.1) (Tricker 2016a; International Organisation for Standardisation 2015a; Styger 2014).
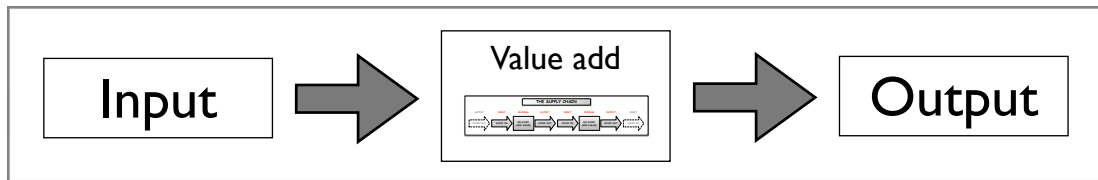
Figure 3.2. Value Adding Process (nested) (Bohme et al. 2008a; Christopher 2011, 2016; Dettmer 1997; Tricker 2003)

3.1.1 Systems Theory

Systems Theory is the study of systems, it originated in the field of natural sciences with the concept developing further to include the development of models, principles and laws by early systems theorists, such as, Bertalanffy, Boulding, Klir and van Gigch (Adams 2014; Caws 2015; Drack & Schwarz 2010). Systems Theory grew in prominence around the 1950's with the early system theorists, in an attempt to build on the concept, developed theories centred on specific aspects of systematic behaviour, although this has had the effect of fragmenting the understanding of systems into diverse specialisations (Rousseau 2015). In turn, the process of breaking down the general understanding of a system has not, over time, progressed the development of a holistic trans-disciplinary system, resulting in a single powerful definition of Systems Theory remaining elusive (Adams et al. 2014). Systems Thinking is the application of Systems Theory to frame our understanding of the world in its past, present and future form, forging the base for what ought to, or, could be (Dettmer 2011; Holmberg 2000; Midgley & Wilby 2015).

The development of Systems Theory, and in turn, Systems Thinking has enable the discovery of patterns and principles that provide an understanding of systems across all disciplines and at all nesting levels (Adams 2014; Drack & Schwarz 2010; Holmberg 2000; Midgely & Wilby 2015), enabling a framework to investigate the system of university research commercial transfer (Section 3.2.2). Systems Theory, as a management approach, integrates information from all fields of knowledge to solve problems by observing the big picture instead of analysing individual components (Cabeza-Pullés et al. 2016; Crowder 2013; Moturi & Mbithi 2015).

Systems Theory is identified within management systems through the organised nesting of Objectives, Policies and Processes and further discussed in Section 3.3.2.

Systems are considered as either open loop and take on influences from external sources, or closed loop and unresponsive to external influences (Bertalanffy 1950; Dettmer 1997; Moeller & Valentinov 2012). Schools of thought differ on the definition of an open system. Kerzner (2009) believed that most systems are open, react with the environment and are reliant on the environment for survival. Others describe hybrid systems that are partially open, defining them as exhibiting characteristics that focus on the immediate needs of the system; can tend to be volatile; selective and inward focussed with tentative links to other systems (Caws 2015; Kelly & Allison 1999). This hybrid school of thought supports an understanding of complex, complicated and chaotic systems.

The characteristics that define systems, such as, chaotic, complicated, complex or simple, are dependent on the eco-system they occupy (Dettmer 1997; Snowdon & Boone 2007). The functionality of these systems differ, and as complex systems are adaptive to influences and their nodes react and learn; chaotic systems react to the slightest influence and can dramatically change; where a simple system is predictable and has little capacity for change. However, it is a complicated system, consisting of identifiable silos that are inward focussed and resistant to external change that best describes the system of university research commercialisation (Section 3.2.1) (Cilliers 2005; Snowdon & Boone 2007). In the context of this research, the system of publicly funded university research commercialisation is considered as a complicated hybrid system with both tangible and intangible elements (Section 3.2.1). A systems theory approach to this study investigates the system holistically, analysing processes that include a composite of inputs, such as, equipment, skills, techniques and the information that supports the operations and outcomes (Fawcett et al. 2004). As such, the deployment of the Theory of Constraints analysis enables a systematic approach to determine the interrelationship between the systems nodes,

enable process visibility and, in turn, identify constraints (Puche et al. 2016) (Section 4.2.3).

3.2 Systems and University Research Commercialisation

The published academic literature on the university research system has doubled over the last decade (2011 - 2020) with an average of 132 publications a year compared to the previous decade of 57 publications a year. Although some of this rise in publication could be attributed to the "publish or perish" culture fuelling academic career progression (Berman 2008; Gunn & Mintrom 2018), the doubling of output signals the topic of university commercialisation system is a focus of discussion. The university research commercialisation system was discussed in 884 papers between 2011 and 2020 with 169 of these including government funding for the university research commercialisation system with 37 of the papers focussing on collaboration for economic benefit and a further 55 focussing on the factors needed for the commercialisation process and entrepreneurial universities. Fewer papers concentrated on the global effects of university policies (Gong & Peng 2018; Jung & Lee 2014; Kochenkova et al. 2016; Strong et al. 2018), academic freedom and the level of academic entrepreneurial activity (Bourelos et al. 2012; Färnstrand Damsgaard 2013; Hancock 2020; Holden 2015; Oliver & Sapir 2017), and, academic incentives and intellectual property ownership (Ayres & Ouellette 2017; Brantnell & Baraldi 2020; Kim et al. 2017; Muizniece 2020; Ouellette & Tutt 2020; William Cowell & Reed 2017). Discussion specific to the Australian university commercialisation environment focussed on academic productivity (Burston 2020; Grobler & van Niekerk 2011), corporatising knowledge development (Hancock 2020; John & Page 2019; Martin-Sardesai et al. 2020), knowledge transfer channels (Dang et al. 2019; Hine et al. 2018; Subramanian 2014), understanding the funding source of the research (Critchley & Nicol 2011) and commercialising specific medical technology (VerMilyea et al. 2020). Although the literature discussed processes and throughput, the link to systems theory to support these processes is vague. In addition, it is common for the literature to look at university research

output commercial transfer from the perspective of the university or university personnel, treating commercial transfer to industry as a logical step.

3.2.1 University Research Commercialisation as a System

This research established the system of university research commercialisation is a complicated hybrid system, being only partially open and typically inward focussed (Cilliers 2005; Dettmer 1997; Kelly & Allison 1999; Snowdon & Boone 2007) (Section 3.1.1). Although only partially open, the system of university research commercialisation should be adaptive to external influences and reacts to change. Instead, this research, supporting the work of Cilliers (2005) and Snowdon & Boone (2007), identified self-fulfilling ecosystems with individual knowledge needed for some aspects to function and these siloed elements only linked when necessary. These self-fulfilling eco-systems place primary priority on the satisfaction of their individual needs, over the needs of the holistic system, and demonstrate a minor, needs based, connection to the overall system (i.e. funding to function) leaving gaps in the ability to map the flow of the system for measurement and supply (Agyemang & Broadbent 2015; Jayaratne 2015) (Figure 3.3). Four primary eco-systems were identified within university research commercialisation - funding application; research; commercialisation of Intellectual Property; and, the transfer into industry, and these are further discussed in Section 5.4.
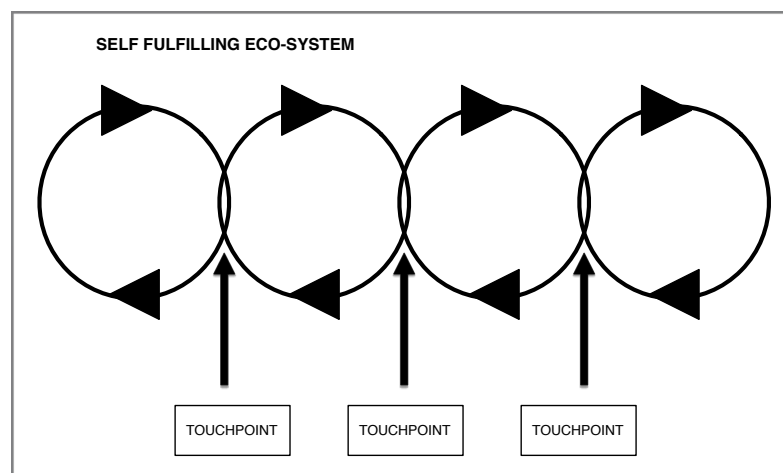
Figure 3.3. Siloed Departments with Minimal Touch-Points (Cilliers 2005, Snowdon & Boone 2007, Jayaratne 2015)

3.2.2 University Research Commercialisation as a Supply Chain

A supply chain exists if there is a tangible flow of transactions, or exchange, between system nodes to add value (Deming 1986; Hines 2006; Li & Morgan 2010) and should be managed as a whole, adapt to environmental influences, demonstrate visibility from beginning to end to enable mapping for risk and measurement, customer focus and, in turn, continual improvement (Bevilacqua et al. 2009; Mason-Jones & Towill 1997; Puche et al. 2016; Styger 2011). The process of continual improvement, identified by Deming's (1986) production view is continually testing the supply chain for quality and process control by driving out waste, reducing costs and adding value. The identification, understanding and management of the flow of material, labour and service has been an historically important element of both commercial and social networks through the trade of product (Christopher 2011). Trading products and services to add value to society has led to the development of an effective methodology for the movement of products, services and knowledge downstream and upstream within the supply chain with the objective to deliver benefit (or value) to the customer, the supplier and community stakeholders (Christopher 2011; Deming 1986; Hines 2006; Knouse et al. 2009; Zokaei 2007).

The principles of supply and systems are evident in the research commercialisation management policies of Australian universities, where the flow of both value creation and money is described along with the description of nodes and linkages (Section 5.3.2.3). Mapping traditional supply generally is understood as linear and forward looking in its approach and follows a line of investigation centred around establishing the next activity or node that the transforming product or service takes, triggering the next activity or ecosystem (Porlezza & Colapinto 2012) (Section 3.4.1) (Figure 3.4). The management of the total flow of materials and knowledge from suppliers to end users is defined as Supply Chain Management (Gardner & Cooper 2003).
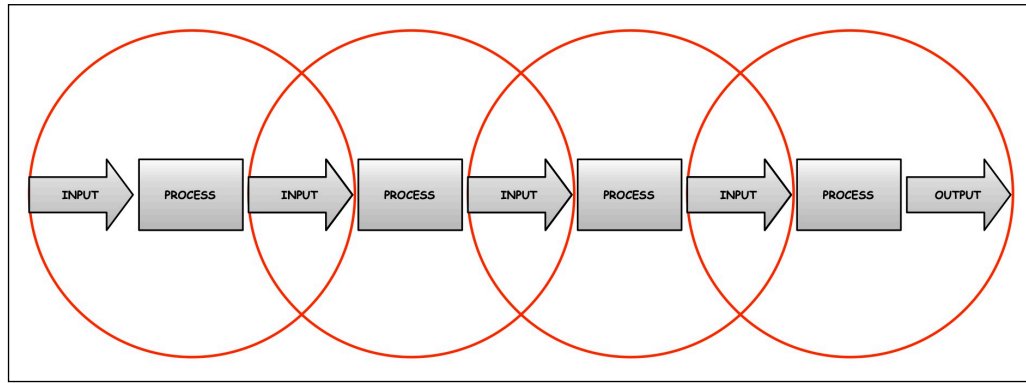
Figure 3.4. Forward process of the supply system moving through the siloed systems (Porlezza & Colapinto 2012)

In the context of this research, publicly funded university research commercialisation identifies, fundamentally, as a supply system because holistically it demonstrates tangible transactions to add value (i.e. research funding received for research activity and output). Difficulty lies in formal identification and mapping of the research commercialisation system due to gaps and breaks along the path causing ambiguity in the value of outcome of the system and low customer focus (Habib et al. 2010). In addition, the absence of frameworks for formal management systems within the research commercialisation supply chain has allowed the development of individualistic interpretations of the output and customer identity of this supply system, and therefore, the development of siloed ecosystems (Agyemang & Broadbent 2015).

3.2.3 Atypical Supply Network

Supply networks that do not demonstrate 'raw' material and 'end' customer nodes are less understood within the literature, as is a supply network that does not clearly identify the customer. An atypical supply chain is identified when the "payment for the product or service is not undertaken by the end customer" (Edwards et al. 2018 p. 217). The existence of dual customers can cause a loss of clarity and shield the identification of the customer or the 'raw' material and intent. This shielding enables the players within the system to develop the system to suit their own immediate needs, rather than that of the whole system (Finding 15, Section 5.5). This system of

public funding is not a unique funding model within Australia. This model also exists in the not-for-profit (NFP) sector and the non-government-organisations (NGO) where government provides funding for service provision (principal), and a second customer in the system is the "recipient" of the service (ARC 2020; AUSAID 2012; Edwards 2018; Edwards et al. 2018; Hurford 2012). These atypical supply networks are, typically, high spend activities with uncertain outcomes. The program delivery often undertaken remotely from the funder (principal), i.e. the new money into the system (Edwards et al. 2018; Hurford 2012), developing an environment where the two customers (principal and recipient) of the system do not overlap, leaving funders with no first hand knowledge of the benefit of the system and the recipient little ability to communicate with the source of the funds, both relying on the non-profit intermediary to broker the need and benefit (Edwards 2018; Hurford 2012) (Figure 3.5). The result is a system difficult to measure as there is no direct evidence of exchange of value in the system, but instead enabling a siloed perception of value for funding (Hurford 2012), resulting in an opportunity for the systems to be accused of inefficiency, as well as, providing an opportunity for corruption (Burnley 2010; Easterly 2007; OECD 2005; OECD-DAC 2008; White 2007). Both 'customers' within this system have a symbiotic relationship, even though different deliverables exist for both, and without either participant, funding and undertaking the project do not exist. These systems exist in public funding where the recipient is unable to pay, or the cost is prohibitive, for the service or product, such as humanitarian aid and community development programs. Interestingly, within the limited publications on the identification of atypical supply chains, primarily the research focuses on human hour investment, measure of tangible output or the outcome of research projects, not the mapping of the system. For example, Ramani & De Giovanni (2017) defined atypical supply systems as product cannibalising through a duality of supplier, namely, IT manufacturer and refurbisher selling into the same market and Chirumalla et al. (2013) investigated if customer knowledge sharing networks constituted an atypical network.

Edwards et al. (2018) found a reluctance in the literature to recognise or consider the complexities of an atypical supply chain, due to more traditional studies of linear or dyadic commercial or industrial, supply chains such as automotive (Madenas et al. 2015), aerospace (Koblen & Nizníková 2013), retail, or service supply such as medical (Bohme et al. 2013). Commonly these traditional studies centre around an entity tracked from the time the tangible item, e.g. a part or a drug, enters to the system to the time it exits the system and focus on tracking the 'product' of the system, not the trigger of the system (Christopher 2016). Edwards (2018) mapping of the atypical system of humanitarian aid to audit the path of the funding in retrospect from the recipient back to the funder, discovering an atypical system with a duality of customer, comprising of disconnected siloed events that, and although a result at completion was achieved, it typically could not be measured as value for money. Interestingly, this retrospect mapping of the university atypical system funding was considered for this study, and although it would highlight the siloed events and gaps in the process, it would not enable the identification of constraints (Section 4.2.4). The analysis of this system is discussed in Section 6.3.
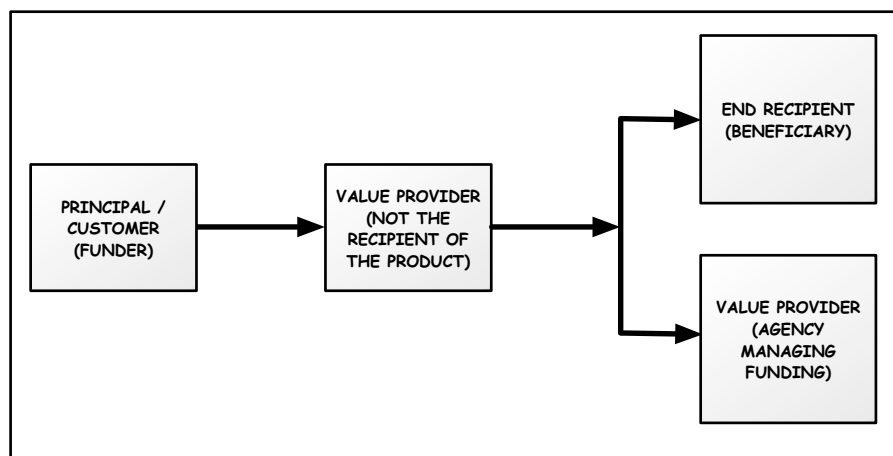
Figure 3.5. Schematic of an Atypical Supply Chain with Dual Customer and Funder (Edwards 2018; Edwards et al. 2018; Hurford 2012)

3.2.4 Identifying the Customer

The plural of customer for the atypical system of publicly funded university commercialisation and its impact on customer focus conflicts with the basic premise

of focused customer output for a quality system (Mauch 2010). Identification of the customer provides support for the motivation of any organisation or business process (Deming 1986). In the context of an organisational management system, a customer is defined as a '*person or organisation that could, or does, receive a product or service that is intended for, or required by, this person or organisation*' (International Organisation for Standardisation 2015a), or defined as having the '*demand and ability to pay*' (Pugh 1991).

However, within the system of publicly funded university research commercialisation, the internal identification of the "customer" is often unclear. Khelifa et al. (2013) identifies the student as the customer of the system, with, Owlia (1996) identifying the student as also the "raw materials", or "work in progress", and, Kayani (2012) identified a duality of a customer for the product of a university, as the student and society. From a different view, Bayraktar et al (2013) found that the attitude of the university, as a customer, differed depending on where research funding was sourced, private or public. In addition to these observations, by default the customer is considered as the need of the department/ecosystem in which the action is taking place (Martin-Sardesai et al. 2020; Möllers 2017).

3.3 Managing the Atypical University System

A Quality Management System (QMS) provides a framework for customer centric value adding, clear communication, guidelines for mapping and measurement of all stages of the process. The QMS framework must be driven by clearly defined goals, strategic plans and be recognised in an organisation's objectives, policies and procedures (Deming 1986; Manatos et al. 2017; Mauch 2010). A QMS exists in all types of organisations, such as, commercial, not-for-profit, non-government organisation or educational organisations. The QMS structure allows the information and knowledge to be controlled, clear, consistent, current, traceable and measurable, enhancing the competitiveness and strategic advantage of the organisation (Anderson et al. 1994; Deming 1986; Karapetrovic et al. 1997; Mauch 2010). Australian

Universities, and in the context of this work, the atypical systems of university research commercialisation, need to be able to respond to changing needs, whether that be student, environmental, industry or government. Therefore, a well developed and implemented Quality Management System should enable a university to respond to this dynamic environment (Moturi & Mbithi 2015).

3.3.1 Quality within the University System

Australian universities are required, through their Acts of Incorporation, to provide education, undertake research and disseminate knowledge for the benefit of the community (Carrington et al. 2005; HEAct 2003). The understanding of a quality management in the university system has been challenged by Kargyte (2015) and Sursock & Smidt (2010) who outline that universities, instead, develop a 'compliance culture' where the 'intent', or 'output', of the QMS, is not to continuously improve the holistic system of a University, instead it is to enable a regime of self-supporting reporting to be developed (Section 3.3.2). In the context of this work, a "compliance culture", although is not in itself a novel discovery, is identified for the constraint it represents within the system (Section 5.3.2.4).

Cruickshank (2003) highlighted the move from considering quality through continual improvement activities to a system that responds to external monitoring through audit procedures in Australian universities, moves the responsibility model to one of delegated accountability. This has further developed a compliance culture of reporting, mirroring trends in European and American Higher Education Institutions, as a means to access funding streams and accreditation (Anderson 2006; Basir et al. 2017; Sitnikov 2011; Tutko 2016). Differences in output focus motivation between privately funded and publicly funded university research commercialisation processes was identified. When the funding was sourced from private industry, the output from the university was higher, compared to publicly funded university systems that demonstrated a compliance culture resulting in low commercial output motivation (Bayraktar et al. 2013).

The implementation of a Quality Management System, such as ISO 9001:2015, into any organisational system is typically the result of an environmental challenge, such as, a need for more skilled workers; government reporting requirements; compliance with external audits (Cheng 2011; Shah 2013; Shah & Nair 2011); internal audits for capability development (Meade 1995); or, the result of a directive from senior management (Balagué Mola 2007). Multiple positive effects are gained by a quality system implementation that include the delivery of a holistic system that fills in the gaps experienced by changing reporting requirements and multiple accreditation systems (Karapetrovic et al. 1997; Kasperavičiūtė-Černiauskienė & Serafinas 2018; Moturi & Mbithi 2015; Thonhauser and Passmore 2006), providing clearer understanding of roles and responsibilities, skilled and informed workers (Thonhauser and Passmore 2006), leading to increased efficiency, cost saving and higher customer satisfaction (Dumond & Johnson 2013; Moturi & Mbithi 2015).

The key use of the term quality, in the context of this work, is total quality (Chiarini 2011; Kayani 2012; Khelifa et al. 2013) and aimed at providing a uniform customer centric system that can be objectively measured and continually improved in line with changing customer needs and demands, and should, therefore, be able to provide the bridge between industry needs and the focussed output of universities measured against these needs. However, as it is demonstrated through this study, when the system does not have focus on quality or the customer, the outcome (quality) of the system suffers (Mulay et al. 2017).

3.3.2 Using a Quality Standard within the University System

Shutler & Crawford (1998) and Stojanovic (2015) discussed that, typically, the education system did not readily accept the commercial language that is used within the standard and raised concerns that it could lead to a change in focus of a university, if the students were defined as clients, and that this may affect the focus of a university (i.e. teaching, disseminating knowledge or commercialisation). A

change in the focus to the customer being the student, and continually servicing the customer need, may potentially impact output standards of the university, as processes are developed for the customer (student), not the required knowledge development (Incorporated Acts). There is significant contradiction here and it might be argued that this position is made to maintain the status quo of a university and not improve the output for the student, industry or community in terms of engagement, commercialisation or indeed customer focus.

An understanding of the process of Quality Management development is important to this study as, it is assumed, historically, universities have followed a quality management process to ensure auditable and consistent educational output, however, it seems to have been undertaken using terminology and processes that are better suited to manufacturing than knowledge development, possibly in the absence of a bespoke knowledge development based Quality Management System, leading to resistance within the system (Section 3.3.3). The education industry sector is changing and moving from a supply driven teaching environment to a demand lead learning environment (Stojanovic 2015), at the same time, more organisations, generally, are following a QMS, prompting the Quality Standard need to encompass broader terminology than the strictly manufacturing process of past Standards (Tricker 2016a). Prompting the Quality Standard, ISO 9001:2015, to not only encompass a broader terminology and include education, but also move from a process approach to quality management (manufacturing), to a risk based management and leadership style (Thonhauser & Passmore 2006). In the process causing management to have full control of the Quality Management System, not delegate the responsibility to a management representative (International Organisation for Standardisation 2015a, Tricker 2016).

The implementation of ISO 9001:2015 benefits an education system in a number of ways, such as, delivering a holistic system that fills in the gaps experienced by multiple accreditation systems (Karapetrovic et al. 1997), providing clearer understanding of role, responsibilities and competence, increased efficiency and cost

saving, higher customer satisfaction, ongoing feedback for continual improvement and improved staff moral and ownership of the processes (Dumond & Johnson 2013; Moturi & Mbithi 2015). However, implementation in the university system can tend to be siloed and inward looking (Section 3.2.1) (Balague 2007), and not, as is usual in the commercial world, focussed on customer satisfaction (Agyemang & Broadbent 2015; Mauch 2010). Supporting the advantages, Moturi & Mbithi (2105) reported on the application of ISO 9001:2015 university wide in a Nairobi University that saw an increase in student admissions and graduations; a doubling in university revenue, and relevant to this work, a rise in the funds attracted for research. Further, Thonhauser and Passmore (2006) compared the reason for implementation of ISO 9000 Quality Management Standards in education providers in the UK and US. One trigger was pressure from industry to provide more skills, workers and additional government reporting requirements. Other triggers were compliance with external audits (Cheng 2011; Scott 2003; Shah 2013; Shah & Nair 2011); internal audits for capability development (Meade 1995), and, the result of a directive from senior management (Balague Mola 2007), supporting the finding of a compliance culture.

Conversely, Dumond and Johnson (2013) discussed that the implementation of an ISO 9000 QMS creates a bureaucratic system that clashes with the open academic system, adding that staff do not understand it, again, possibly signalling an error in communication of the value of a QMS, which would appear to be the case. This causes frustration around managing the system, and that, even though the standards are developing they are still too general to be relevant and the perception is they create too much work. This is not a weakness of the Standard and the case against implementation appears to be somewhat misguided as the standard only says, what is needed, it does not prescribe how it should be achieved (further discussed in Section 3.3.3). Other negative aspects were discussed including the cost and time needed to implement the system (Kasperavičiūtė-Černiauskienė & Serafinas 2018) and, where cross industry disciplines are involved, such as, industry and education, the terminology to be used (Stojanovic 2015).

This research has found, through an analysis of the policies, that the Quality Management System of a university is developed to reflect the intent of a university, (i.e. educate, research and disseminate knowledge), and does not provide a customer focussed system to support the university research commercialisation process (Section 5.3.2.3). Therefore, enabling siloed and inward facing systems to develop, further hindering the commercial transfer of research. This impacts on the system's ability to measure the current system, and without a measurement, a judgment on how to grow cannot be made. Ultimately, impacting on the ability to address the requirement of Australian Universities for "better" commercial transfers by the Australian Government.

3.3.3 Academic Culture and a QMS

Academic freedom and autonomy are elements most valued by the academic community to provide a less restricted operational environment, thereby encouraging the development of new research and knowledge (Akerlind 2005; Cardoso et al. 2013; Koch 2003; Mårtensson et al. 2011; Michael 2004). The literature offers a positive consensus on the value of the implementation of a QMS into higher education, that it requires a shared vision and all stakeholders need to be part of the design, implementation and delivery (Brits 2015; Srikanthan & Dalrymple 2003; Sunder & Anthony 2018). And yet, resistance to the implementation exists. On the surface academics are committed to quality in research and teaching, however, prescribed systems incite issues of power definition and efficacy, skepticism of the choice of model and mode of delivery, extra workload for unknown gain, or considered it another management fad and the functions of accountability and performance indicators, developed by bureaucrats, were games to be played (Anderson 2006; Basir et al. 2017; Cruickshank 2003; Owlia 1996). While Basir et al. (2017) perceived this as arrogance within the academic community, Sutton & Brown (2016) listed that autonomous motivation is a fundamental factor in influencing research success, it could be undermined when academics feel pressured, managed or controlled. The measuring of academic skill level was generally not well received. Conversely, academics involved in the audit of skills through a quality

based system listed this fun action as a benefit to their career development (Moturi & Mbithi 2015). Although reluctance to implement a QMS is discussed, it should be noted that there is no directive from the respective governments in the US, UK and Australia that require Higher Education Institutes to implement an ISO9000 based Quality Management System. Having said that, the licensing body Tertiary Education and Quality Standards Agency (TEQSA[14]) within Australia suggests Australian universities implement a quality system to enable a university to be a registered organisation (TEQSA 2018).

3.4 Summary

This chapter discussed the identification of an atypical system and the challenges in measuring for continual improvement. In the course of the research the system of publicly funded research commercialisation is identified as an atypical system with a plural of customer. It is this plural of customer that allows siloed networks to be developed with inward facing intent causing instances of minimal connection to the holistic system. Further tension is evident when an attempt is made to map the holistic system to identify constraints that are hindering the commercial transfer of the output and, in turn, customer identification. This chapter discussed the tension that is caused when the intent and intended outcome of the stakeholders differ. Chapter 4 provides support for the methodology of a multiple case study analysis using the Theory of Constraints to determine the constraints that are hindering the system of commercial transfer of university research to industry (Section 4.2). A research plan is then demonstrated using the Theory of Constraints Thinking Process tools of Current Reality Tree to identify and categorise the constraints, a Conflict Resolution Diagram to identify injections that could augment constraints, and, testing the findings through the development of a Future Reality Tree.

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[14] TEQSA is the Australian Government's registration body for Australian Higher Education providers. TEQSA uses a "standards-based quality framework and principles relating to regulatory necessity, risk and proportionality" as listed in the Higher Education Standards Framework (Thresh-hold standards) 2015 (the HES Framework). These standards are determined by the Minister for Education on advice from an expert Higher Education Standards Panel, which consults widely with the higher education sector before providing the advice (TEQSA 2018)

CHAPTER 4 - METHODOLOGY

4.0 Introduction

Chapter 3 discussed the system of publicly funded university research commercialisation (Section 3.1) in the context of an atypical system (Section 3.2), the relevance of a Quality Management System to this research (Section 3.3) and the identification of the customer of the system (Section 3.2.4). This chapter outlines the choice of the research methodology of a multiple case study analysis (Section 4.2.2) using the Theory of Constraints Thinking Process (Section 4.2.3) to determine constraints that are hindering the commercial transfer of Intellectual Property (IP) to industry in the the system of publicly funded research commercialisation within Australian Universities. The research design provides the steps taken to perform a document analysis, undertake stakeholder interviews, a cause and effect mapping, analyse the constraints to determine the root cause and test the logic of the solution (Section 4.3.1). To this end, this Chapter is discussed in the following order:

1. Research Design, Parameters and Limitations
2. Research Methodology
3. Research Plan for Data Collection and Analysis

4.1 Research Design, Parameters and Limitations

This work adopted a combined methodology of multiple case study analysis (Yin 2014) and Goldratt's (1990) Theory of Constraints on the planned and practically applied systems of publicly funded research commercialisation of three Australian universities to identify constraints hindering the commercial transfer of research outcomes to industry. The case study universities were selected to provide variance in the data through their size, location and stage of development (Section 4.1.1).

An investigation of the Australian University Acts of Incorporation, Policies and Strategic Plans was undertaken to establish the Australian Government and University goal for the system of publicly funded university research commercialisation. Once the goals were identified, interviews were performed to determine how this system was practically applied within the three case studies. The results were mapped, using the Theory of Constraints Thinking Process (Section 4.3.3) resulting in the identification of the Root Cause of the system constraints and the development of a framework for an alternate system (Dettmer 1997; Goldratt 1990; Rahman 2002). Approval for the design of the research was gained through Human Ethics (Approval Number H17REA234). Figure 4.1 illustrates a overview of the research design which is discussed in more detail in Section 4.3.1.
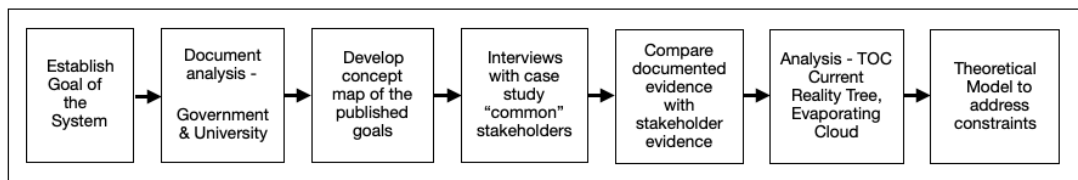
Figure 4.1. Schematic Overview of the Audit Approach

4.1.1 Universities as a Case Study

Initially it was planned that the research would include all Australian universities as listed on Table A and B of the Higher Education Support Act (HEAct 2003 Section 16.15-16.20). Considering that Australia has 42 Universities, undertaking this research on all universities with Australia made the scope of the research project too large and impractical (Etikan et al. 2015), as the collection of data is not able to be sought within the timeframe of this study. Therefore, to enable the project to be undertaken within a viable time limit, research on a fewer number of universities was decided and this research undertaken as a pilot project. The benefits of a pilot project would enable the development of the process of mapping the publicly funded university research commercialisation process on a smaller number of universities (Kline 2018) to allow for questions to be tested and analysis methodology refined (Ossenberg 2016), and perhaps, identify the scope of a much larger project (Arfken

et al. 2013; Kumazaki et al. 2017). The development of a larger project from this research is further discussed Section 8.1.

The three Australian universities chosen for the case study analysis were selected on size, location and stage of development to enable variance in their data and avoid the possibility of bias through convenience sampling (Brodaty et al. 2014; Hedt & Pagano 2010). The selection helps to offer a snapshot of the sector covering small, medium and large size, mature and young as well as city and regional city of universities, their expenditure and output.   The National Survey of Research Commercialisation Report (NSRC) collects quantitative research and commercialisation data on Australian Research Organisations and was a source of data for this selection (DISER 2019). Additionally, the universities were selected for maturity and geographic diversity using a selective criteria of a *mature established city-based (The Mature Uni)*, *fast growing young university (The Young Uni)* and a *regionally located university (The Establishing Uni)* see Table 4.1. The G08 network of universities data was used to source the *mature established university*, as the membership of this group are mature, located in capital cities, well established histories of undertaking research, have research expenditure of over $500m per annum (DISER 2019; Go8 n.d.). A medium sized university was sought and a young rapidly growing city based medium sized university was secured (research expenditure between $100m and $500m per annum).   A regional university was approached, and permission received, satisfying the smaller university criteria (under $100m research expenditure annually). Four universities in total were approached, with one university refusing participation in the study. Permission was sought and granted from all participating universities, to speak to staff and researchers. Table 4.1. illustrates the demographics of the case study universities used in this research.

Demographics of the Australian Universities chosen for the case study analysis				
University	**Research Expenditure**	**Location**	**Age**	**Size**
UNI1 (The Mature Uni) (Mature)	> $500 million annually	City	Mature - established more than 65 years	Large
UNI2 (The Young Uni) (Young)	Between $100 million and $500 million annually	City	Young - established less than 40 years	Medium
UNI3 (The Establishing Uni) (Establishing)	Less than $100 million annually	Regional	Establishing - established between 40 and 65 years	Small
UNI4 (permission denied)	Between $100 million and $500 million annually	Regional	Establishing - established between 40 and 65 years	Medium

Table 4.1. Demographics of the Australian Universities Chosen for the Case Study Analysis (DISER 2019; Go8 n.d.)

4.1.2 Validity of the Data

To ensure transparent and unbiased collection and analysis of data, the research design incorporates a data triangulation from varied sources within the system and involves the use of government and university report analysis combined with face to face interviews to develop a comprehensive understanding of the system of publicly funded university research commercialisation (Section 4.3) (Baxter & Jack 2008; Creswell 2014; Saunders et al. 2016). Interviews were transcribed through an independent external professional transcription service that held no personal relationship with the researcher. Finally, saturation was considered when there was no more unique data providing the necessity for additional codes to be added to the codebook (Dworkin 2012; Morse 2000).

4.1.3 Parameters of the Research

Where to start, where to finish and what to consider measurable within the system of publicly funded university research commercialisation posed a challenge to the design of the data collection. In the context of this work the mapping will begin at the input of public funding to a university for a research project and complete at the

commercial transfer of the research outcome, in the form of IP, to industry, or where the system stops (Figure 4.2).

It is not enough to just determine the parameters of this research, and as this research undertakes a measurement, it is necessary to identify the triggers that progress the system. This research discovered a number of triggers to the system of research commercialisation, and, where the funding of this research is triggered by a Research Grant application, the process tangibly starts when the funding is applied. Another important trigger was the identification of research output that has the potential to be commercially transferred by the researcher, and the decisions made on the initial path of this discovery (Section 5.3.3.2), other triggers included decisions made by commercialisation personnel on budget availability, fit with the university strategy and availability of an industry customer for the IP.
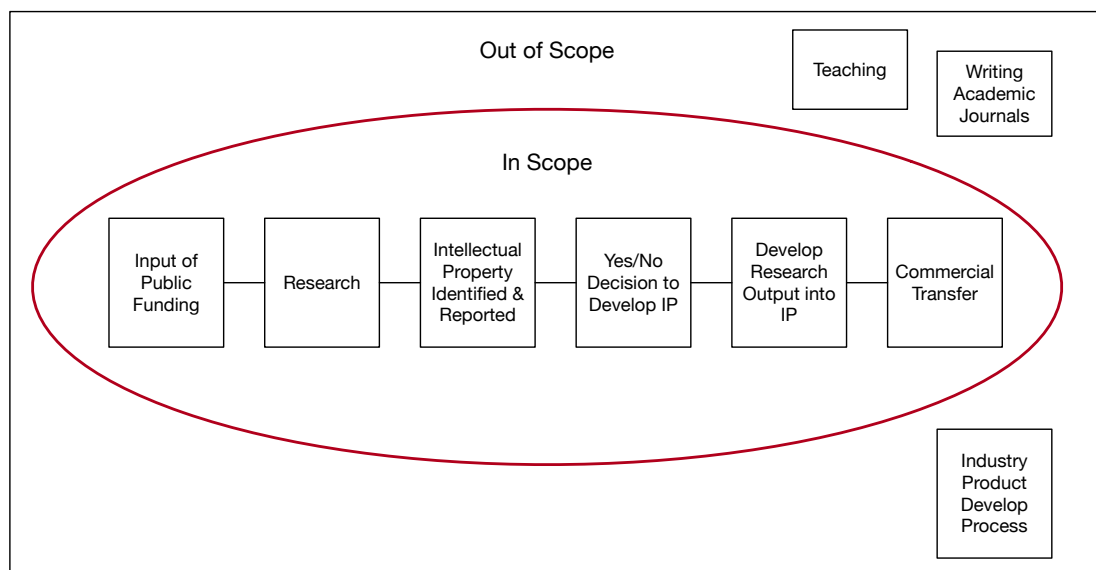
Figure 4.2. Parameters of the Research

The funding identified within this work is managed by the Australian Research Council (ARC) and allocated through the *Research Block Grants Scheme* and the *National Competitive Grants Program (NCGP)*. This funding does not, traditionally, require an industry partner to be engaged by the university to obtain the funding (ARC 2018d; DET 2018b). Funding from the National Health and Medical Research Council (NHMRC) was considered, however the funding purpose (i.e. medical

research), generally required a practitioner based interaction with industry and relied on a different government funding stream, therefore, deemed outside the scope of this work (NHMRC 2018).

The research set out to map the common processes of publicly funded university research system by following the flow of funding to identify constraints that hindered the commercial transfer of intellectual property outcomes to industry. System stakeholders were identified and classified into three categories, namely, the Australian Government, Australian University and "Common Stakeholders" that consisted of University commercialisation personnel, researchers employed by the university, industry representatives associated with a university and private commercialisation practitioners (Section 5.1). Publicly available documents of the Australian Government and Australian Universities (Acts of Incorporation, Strategic Plans and University Policies) were sourced and analysed to establish the governing framework for the system (Section 5.2). Interviews were undertaken with the "common" stakeholders to establish the practical application of the system (Section 5.3.3).

4.2 Research Methodology

This methodology uses an interpretive approach to the qualitative data sourced from the multiple case study analysis (Yin 2014) using Goldratt's (1990) Theory of Constraints (Cooksey & McDonald 2011). Put simply, this research is gathering data on the systems to analyse the relationships for constraints that are hindering the commercial transfer of publicly funded research output to industry (Cooksey & McDonald 2011; Dettmer 1997; Yin 2014). The methodology leads to a research design that incorporates the operational framework of the Theory of Constraints Thinking Process, using the Focussing Steps to guide the system; Goal analysis to understand the system and identify constraints; Current Reality Tree mapping to identify the root cause of the constraints; Conflict Resolution analysis to find an

injection that could mitigate the constraint; and the Future Reality Tree to test the logic of the solution (Section 4.2.3) (Figure 4.3).
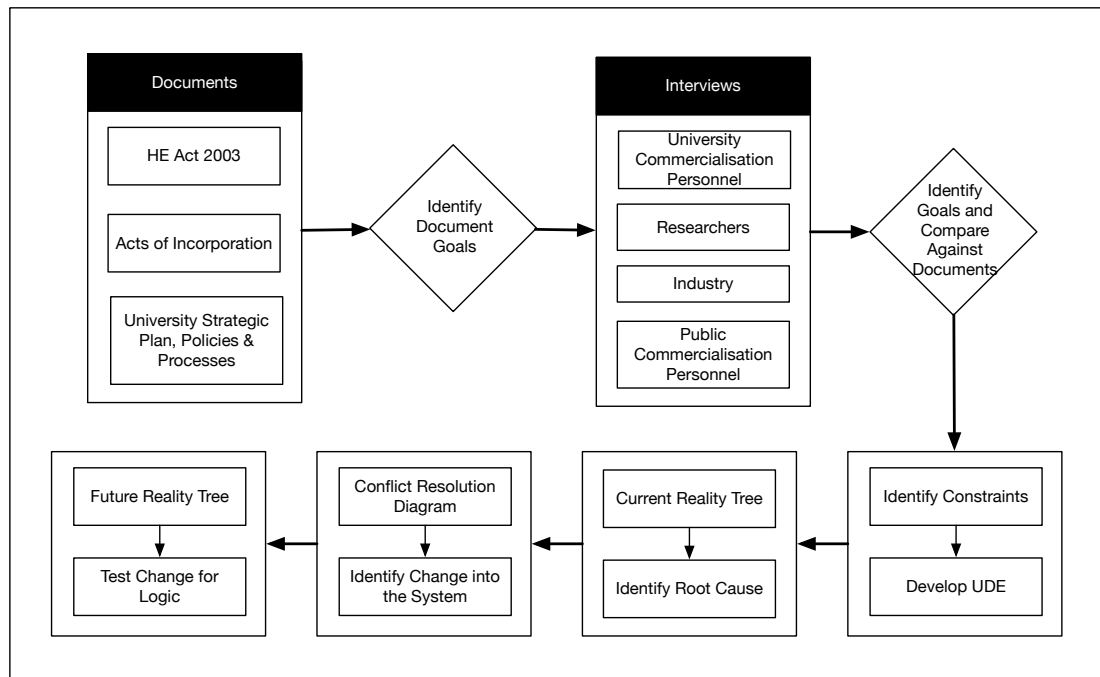
Figure 4.3 - Methodology

The practice of mapping provides an internal or external perspective to enable the identification of stakeholders, decision streams and key influencers (Gardner & Cooper 2003; Greasley 2006; Windisch et al. 2013). A well designed map is interpretable, recognisable and focussed on demonstrating a process/system in an easy to disseminate format (Bevilacqua et al. 2009; Theodore Farris 2010). The choice of a mapping mechanism and development of its visual representation is reliant on the purpose of the mapping, data type and scope of the process communication requirement (Jun et al. 2010; Knoll et al. 2016; Simsekler et al. 2018). A mapping of university strategies and policies represent a forward looking intent, typically demonstrating "what should happen" (i.e. planned), through process and public value mapping (Bozeman & Sarewitz 2011) identifying any gap between policy intent and implementation (Patrinos et al. 2015). The data collected from the interviews is from the aspect of practical application, or, what happens (actual) (Gardner & Cooper 2003). Mapping of the two different perspectives of the system

(i.e. the planned and actual) will support the identification of gaps in the internal and external communication and practice of university research commercialisation (Barbrow & Hartline 2015; Knoll et al. 2016).

4.2.1 Rationale for the Methodology

Initially, it was reasoned that mapping the system (funding in, research undertaken, and research outcome commercialised) would demonstrate where there may be constraints or opportunities. Although logical, this was naive, as it was assumed that, along with the common axiom that publicly funded university research is transferred to industry (ARC 2000; Cole 2016; DISER 2015; Go8 2014c; Goines 2019), the process of university research commercialisation was a common stand-alone system within the university environment. This research has revealed that this is not the case and no clearly defined system existed, this finding is further discussed in Section 5.3.2.

With a basic mapping methodology unsuitable, an investigation of other methods was necessary. Statistical analysis was considered to supplement a mapping, however, collecting quantitative data to enable a statistical probability, or a return on investment (ROI) may identify funding or resource constraints, but leave the more complex subject of process or policy constraint untouched. The intent of the research was not a statistical analysis of the funding or resource availability, rather understanding the hinderances (at times these are intangible) to commercial transfer of Intellectual Property to industry using the basis of a constant of public funding (money). Benchmarking university research commercialisation systems against each other to compare publicly funded research commercialisation systems was considered, however, benchmarking identifies similarities and differences, but not the constraints, nor does benchmarking provide a tool to develop solutions for continual improvement of the system (Kuzmicz, 2015; Nazarko et al. 2009). Mixed Methods Methodology was considered, by using multiple methods on the same dataset to understand it from different perspectives (Saunders et al. 2016). Although

this method may form a richer theoretical understanding of the results, the intent of this study was to source data from a number of mediums (literature, governing documents and interviews), enabling triangulation for rigour and gap identification (Baxter & Jack 2008) leading to an identification of constraints.

The methodology considered most appropriate to identify constraints in the system is a comparative case study analysis on three universities (Section 4.1.1) using the Theory of Constraints Thinking Process (Section 4.2.3) (Dettmer 1997; Goldratt 1990).

4.2.2 Comparative Case Study

A comparative case study approach is the investigation and exploration of an identified phenomenon through a number of angles or themes to provide a factual view of a process (Rosenberg & Yates 2007; Yin 2014). This approach enables the development of concrete, context dependent, knowledge (Freeman et al. 2012), in turn, enabling an understanding of the organisational operation, practice and policy implementations for the cases in this research (Gale 2015). Case study analysis is mostly considered as a qualitative research that is suitable for complex data collection, however, it makes use of both qualitative and quantitative research within the context of the phenomenon (Gibbert et al. 2008; Tsang 2012).

Different approaches to case study analysis are demonstrated by Stake (2006) and Yin (2014). Stake's (2006) view that case studies should be used as scenarios to understand future alternative views, by using different lenses to alter the view of the phenomenon (Barth & Thomas 2012). Stake defines case studies as *intrinsic* - a case is studied when the need is to better understand the case; *instrumental* - a single case is used to understand a phenomenon; and *collective* - more than one case is studied (Baxter & Jack 2008). Yin's (2014) view provides a focus on "how" and "why" of the real life phenomenon and the behaviour of those involved, (i.e. what is, is!) (Baxter & Jack 2008; Gale 2015).   Hence, Yin categorises the case studies as

explanatory - explain the causal links; *descriptive* - describes the intervention or phenomenon and its context; and, *exploratory* - explore a situation where the intervention is being evaluated as in a pilot study (Baxter & Jack 2008; Freeman 2012; Yin 2014).

In the context of this work, a multiple case study approach has been undertaken to enable the identification of patterns, it is possible the use of only three universities may be insufficient to allow a thorough analysis of the entire environment (Mabin & Balderstone 2003), supporting a pilot study, with a view for further future research. The undertaking of a factual mapping and analysis of the current phenomenon, albeit through three cases, including an identification of the constraints of the processes, makes Yin's philosophy the relevant choice to discover the "how" and "why" of the system (Yin 2014).

4.2.3 Theory of Constraints (TOC)

Theory of Constraints (TOC) is a holistic management philosophy developed by Dr Eliyahu M. Goldratt in the early 1980s (Goldratt 1990) founded on the idea that all systems have constraints that are limiting their systems from growing and achieving the desired goals, the act of ordering the constraints hierarchically and reengineering the system after each constraint is eliminated, enables continuous improvement of the system (Dalton 2009; Dettmer 1995; Goldratt & Cox 2016; Inman et al. 2009; Moroz et al. 2016). Anything that is considered to hinder a system operating at its highest potential is considered a constraint (Trojanowska & Dostatni 2017; Watson et al. 2007).

The Theory of Constraints was initially developed for measuring systems, production planning and control within manufacturing (Goldratt & Cox 2016; Golmohammadi 2015; Tsai & Jhong 2019) with scheduling analysis tools developed to address the flow of tangible materials. The Theory of Constraints Thinking Process were developed by Goldratt to address solutions to common throughput problems, and

later further developed into a suite of Thinking Process Tools to enable the discovery of the source of these problems (Mabin & Davis 2010). This philosophy and the tools have been readily applied to business and project management systems (Johnson et al. 2015), smart technology (Liu 2019), new product development and innovation (Dalton 2009), healthcare (Strear et al. 2010), and the Internet of Things, knowledge development and management (Moroz et al. 2016). Further, the literature demonstrates interest from academia in comparing TOC with other management philosophies and theories.

Dettmer (1995) published research on the comparison between Total Quality Management (TQM) and TOC concluding the main difference is TQM focusses on process control and process improvement concurrently improving all components or process in the TQM system and "glueing the results together", where TOC recognises that there are always constraints and addresses them in a hierarchical order, and improving the system. Bevilacqua, Ciarapica and Giacchetta (2009) compared TOC with traditional Risk Management Analysis Tools to develop a prioritisation process for work packages, resulting in a greater result in turnaround.

The prominence of theories used to analyse Project Management in prominent project management journals over a 15 year period resulted in the Theory of Constraints ranking second out of five in popularity (Johnson et al. 2015). Other management tools attempt to identify the constraints in the system, such as, Nave's (2002) comparison of the management tools of Six Sigma, LEAN and TOC to develop a framework to use when choosing the right management tool for the outcome required. Librelato et al. (2013) compared the features of Value Stream Mapping (VSM) and the TOC Thinking Processes to establish beneficial complementary aspects and Puche et al. (2016) looked at TOC from a systems perspective comparing Beer's Viable Systems Model and TOC through the lens of achieving a customer service level at a reasonable operating expense. Later, Puche et al. (2019) again looked at the financial impact of TOC by comparing the Kanban system from LEAN and the drum-barrel-rope (DBR) system from TOC for financial

viability on a supply chain, the finding was that although Kanban can be implemented at a lower cost, and DBR requires a higher transparency of information, and as it has solid connections with the whole system, provides a more beneficial outcome.

Along with the many positive discussions of TOC in the literature, there is also criticism. Trietsch (2005) did not think TOC had enough original content, citing TOC likeness to the process of Managing by Constraint (MBC) for constraint identification, and the TOC Critical Chain tool's use of buffers to PERT/CPM. However, Trietsch (2005) concedes that Goldratt's true contribution was TOC's holistic view of the system (end-to-end), not evident in the other tools. In addition, Trietsch (2005) challenged that TOC was in fact a theory, this was later addressed and disproved by Gupta and Boyd (2008). Earlier, Plenert (1993) discussed the inability of TOC to be effective in a multi-constraint laden system, supporting an alternative use of Linear-integer programming, however, this research showed no support for this school of thought as the basic action of TOC is 'treat the weakest link first' (Dettmer 1997). More recently, Banergee and Mukhopadhay (2016) combined TOC with design thinking, people's opinions and mathematics to address "leagality" (a combination of LEAN and agility) in the supply chain. Their criticism is that TOC does not contain high enough mathematical processes to undertake the analysis, perhaps the reality is that Bangeree and Mukhopadhay (2016) are making the simple too complex.

The Theory of Constraints is considered a quality management system through its continuous improvement processes (Kumar et al. 2018) concentrating on understanding the cause and effect relationship within a system to identify the why, not how, in a system (Librelato et al. 2005). The Theory of Constraints philosophy guides the user to achieve whole system optimisation, over individual process maximisation, through identifying the need for change in the system (Dettmer 1997) focusing on change in the context of transformation (i.e. continual improvement) (Deming 1986). TOC's practice of addressing only constraints that have been

identified enables the system to move forward. Unfortunately, it is often tempting to address elements in a system that "seem" to need a change, resulting in no impact on the system, and often the result of the absence of constraint identification and hierarchy, causing inertia in the system (Dalton 2009; Goldratt 1990). The Theory of Constraints identifies three main types of system constraints in resource, policy and dummy.

- **Resource constraints** are commonly understood and easy to identify, consisting of materials or products as part of a process, personnel, or knowledge and ability (Dalton 2009).

- **Policy constraints** are not as visible within the system and are business or management decisions that limit a system's output. These constraints can be more insidious than physical constraints as they are rules based and the rigidity around adhering to the rules will negate other innovative avenues of problem solving as demonstrated in this research (Section 5.4) (Dettmer 1995; Mazzarol 2014; Sadat et al. 2013). Organisations can unknowingly, or voluntarily, enable this constraint through following a policy, without question, although, the policy may have been developed to address earlier situations. Policy constraint may seem quite obvious once identified, although, previously the policy had not been questioned, and constraint only identified by a change in the system or 'fresh eyes' (Dalton 2008; Sadat et al. 2013).

- **Dummy constraints** are problematic, comprising of resources that are easily broken, or need resetting, and require time to be repaired or reset within the system. These constraints have the ability to confuse or blur the focus on the primary constraint and, if not identified correctly, can cause more constraint through loss of focus on the root cause (Dalton 2009; Goldratt & Cox 2016).

Within the context of this research, the Theory of Constraints, will be used as a holistic measurement tool incorporating the overarching framework of the Thinking

Process to guide whole system analysis. The Focussing Steps are used to ensure the measurement and change is undertaken within an established and traceable framework and data collection and management through the Mapping Tools of Goal Analysis, Current Reality Tree, Conflict Resolution Diagram and Future Reality Tree (Dettmer 1997; Goldratt & Cox 2016; Inman et al. 2009; Lacerda et al. 2010; Librelato et al. 2013; Moroz et al. 2016; Taylor et al. 2006).

4.2.3.1 Thinking Process

The constraints in a system are not always obvious or, if they are, a mitigation strategy is not clear. To this end, analysis tools have been developed to rigorously investigate the system (Figure 4.4). Goldratt (1990) developed a number frameworks to identify and elevate the constraint. The first is the *Thinking Process* (Dettmer 1997; Goldratt & Cox 2016; Inman et al. 2009; Moroz et al. 2016; Taylor et al. 2006) is an overarching framework to guide the analysis of constraint identification and the process of enacting change. This framework asks three simple questions:

1. What to change? - *Where does constraint exist in the system?*
2. What to change to? - *What should we do with the constraint?*
3. How to cause the change? - *How is the change implemented in the system?*

4.2.3.2 Focussing Steps

The *Thinking Process* supported the framework of five *Focussing Steps* (Goldratt 1990; Gupta & Boyd 2008), further developed to include two prerequisite steps for completeness of implementation (Dalton 2009; Watson et al. 2007) to keep focus on at the system level, not the component level (Dettmer 1995). The *Focussing Steps* provide a feedback loop to ensure the system is undergoing continuous improvement. Once a constraint is identified and addressed, the system characteristics are likely to change forcing the system to be reengineered and the next constraint identified

(Dettmer 1995; Gupta and Boyd 2008; Watson et al. 2007). The *Focussing Steps* are listed and explained in Table 4.2.

Focussing Steps of the Theory of Constraints		
Step	**Action**	**Description**
Prerequisite 1	Decide on the goal of the system	Deciding on the goal of the system will allow a focussing point for analysis of constraints.
Prerequisite 2	Determine the systems performance measures	What metric is being followed through the system to enable consistency and clarity.
Step 1	Identify the system's constraints	Identify the systems weakest link, there may be many weak links, however the weakest link should be targeted for the first improvement.
Step 2	Decide how to exploit the constraint	Decide how to make the constraint as effective as possible.
Step 3	Subordinate everything else to the above decision	The rest of the system must be aligned and adjusted to support the maximum effectiveness of the constraint.
Step 4	Elevate the system's constraint	If step 2 and 3 do not relieve the constraint of being the weakest link, undertake more rigorous action.
Step 5	Reengineer	If, in the previous steps, a constraint has been broken, go back to step 1, but do not allow inertia to cause a new constraint (feedback loop).

Table 4.2. Focussing Steps of the Theory of Constraints Analysis Tools (Blackstone 2010; Dalton 2009; Goldratt 1990; Dettmer 1997; Gupta & Boyd 2008; Watson et al. 2007,)

The application of these steps are discussed in Section 4.3.3, the findings of the research in Section 5.5 and the resultant mapping is discussed in Section 6.1.1.

4.2.3.3 Thinking Process Tools

The *Thinking Process Tools* is a philosophy developed by Goldratt (1992) to analyse cause and effect relationships to identify the root cause of the constraints in a system (Gupta & Boyd 2008; Librelato et al. 2013). The Thinking Process tools are used to assist the analysis when the problem is complex, a solution is not intuitive and there is no clear cause and effect relationship (Dettmer 1997; Goldratt 1990; Rahman 2002) and can be used individually or in a logical order, depending on the outcome requirements of the system analysis, such as constraint identification (CRT), the elevation of a complex problem (EC), or the development and testing of a solution

(FRT, PRT and TT) (Librelato et al. 2013). The analysis requirement of the system under investigation will govern which tools to use, for example, simply identifying constraints or a deeper analysis of the logic of a proposed solution (Dettmer 1997; Mohammadi et al. 2015). In the context of this research, the aim was the identification of the constraints in the system, not the development of a replacement system, and although a suggestion is made in Chapter 7, it is theoretical and does not complete a full analysis. Therefore, the tools used for this research are the Current Reality Tree and the Conflict Resolution Diagram (also known as Evaporating Cloud). An explanation of all five tools is:

- **The Current Reality Tree (CRT)** - The primary goal of the CRT is to define the central problems found within a specific system through cause and effect mapping based on asking the simple question *if …. then..* The mapping starts with, through system analysis, the development of Undesirable Effects (UDE) impacting on the system and maps the actions of the system back to the Root Cause, and then, further back to an overall Core Problem (Banerjee & Mukhopadhyay 2016; Librelato et al. 2013; Umble & Umble 2015) (Section 6.1.2). UDE are symptoms within a system that hinder the throughput, and these UDE help identify the deeper underlying Root Causes, and in turn, the discerning of the Core Problem (Umble & Umble 2015). A Root Cause is the final result in the cause and effect mapping process that is able to be augmented within the system. A primary Root Cause is the result of approximately 70% of the UDE, and identifies as the first Root Cause to address when mitigating the system, it is usual to identify only one or two within a CRT mapping (Umble & Umble 2015). In addition, a Core Problem may be identified, typically these contribute to the Root Cause and are outside of the boundary of the system under investigation and change is unable to be influenced by the current system (Dettmer 1997; Reid & Cormier 2003). The term Core Problem and Root Cause are often used interchangeably within the literature (Dettmer 1997; Reid & Cormier 2003; Umble & Umble 2015). For the purposes of this research, a Root Cause is considered as within the system

of university research commercialisation, and a Core Problem is considered as external to the system and not able to be influenced by the system. The steps taken within this process are illustrated in Section 4.3.3.2.

- **The Conflict Resolution Diagram (CRD)** - the conflict resolution diagram verbalises assumptions to create solutions through innovative solutions (injections) to complex problems to develop a win-win situation (Cox et al. 2005; Gupta et al. 2011; Librelato et al. 2013) (Section 6.2). The conflict resolution process requires the root cause to be flipped on its head as, the logic is that if the current situation is causing constraint, then the opposite 'should' not cause constraint (Gupta et al. 2011; Kim et al. 2008). The Conflict Resolution Diagram (CRD) is also referred to as the Evaporating Cloud, or just simply Cloud within the literature (Cox et al. 2005; Dettmer 1998; Gupta et al. 2011; Kim et al. 2008; Rahman 2002; Sommer & Mabin 2016), however the term Conflict Resolution Diagram is preferred for this research as the title is easier to understand than Cloud. The CRD is developed right to left, starting with the prerequisite (or conflict) and moving towards the object that would satisfy both sides of the conflict and read left to right using 'necessity logic'[15] When developing the CRD, statements are made about the relationships and injections developed that can change the outcome to a win win solution. Assumptions are developed for each relationship to further investigate the cause of the conflict. These assumptions are constructed in a format to articulate and validate the conflict correctness, with clear statements enabling the development of possible injections (Andersen et al. 2013). For this research, injections (i.e. what could be done) were developed for each Assumption (Table 6.3) to find a win-win solution for the conflict within the system caused by the requirement of "better" commercial transfer. These injections were aimed at removing the concerns in the system of university

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[15] Necessity or Necessary Condition Logic is "The validity of a relationship where in order for A to occur B must exist or happen. Both the Evaporating Cloud and the Prerequisite Tree use necessary condition logic" (Cox, James, Victoria Mabin, and John Davies. "A Case of Personal Productivity: Illustrating Methodological Developments in TOC." Human Systems Management 24.1 (2005): 39-65. Web.)

identity as a traditional source of knowledge development and compliance with the governing legislation (Acts of Incorporation) and resolve the conflict created by the requirement of "better" transfer (Goldratt 1990; Sommer & Mabin 2016). The outcome of the CRD forms the input into the Future Reality Tree. The steps taken within this process are illustrated in Section 4.3.3.3.

- **The Future Reality Tree (FRT)** - The purpose is to ensure the suggested changes work and are logical before more time, resources and planning are invested (Chou et al. 2012; Dettmer 1997, Librelato et al. 2013; Reid & Cormier 2003). The FRT serves 7 basic purposes:

  1. Enables effectiveness testing;
  2. Determines whether the proposed changes will result in the desired effect;
  3. Identifies (through negative branches) if the changes will cause the situation to stay the same, get better or worse;
  4. Enables the identification of self sustaining practices;
  5. Determines the impact of local decision on the whole system;
  6. Enables evidence to source support for the decision; and,
  7. Initial strategic planning tool.

The steps taken within this process are illustrated in Section 4.3.3.4.

- **The Prerequisite Tree (PRT)** - Assists with implementing the decision by identifying immediate goals that must be in place to enable change to happen, identifying obstacles to the implementation and possible solutions (Dettmer 1997; Librelato et al. 2013).

- **The Transition Tree (TT)** - Sets the action plan by enabling the development of a step by step instructions for implementing the new course of action and, in turn, eliminating the identified root cause (Dettmer 1997; Librelato et al. 2013).

The Prerequisite Tree and Transition Tree develop the strategies for a change in the whole system. This is considered outside of the scope of this research and their development forms part of the recommendations for future work required (Section 8.1).

4.2.4 Limitations of the Methodology

All care was taken to ensure the robustness of the methodology for the study. This research is a pilot study and only three universities are included in the comparative case study. It is possible that the results may not represent the wider cohort of 42 universities (Mabin & Balderstone 2003). Additionally interviewees might not provide truthful data as a result of job security concerns. Data triangulation of the document analysis and interview responses was undertaken to identify any anomalies due to errors (Creswell 2014; Saunders et al. 2016).

4.3 Research Plan for Data Collection and Analysis

The research design enables a mapping of the system of university research commercialisation to identify the process, the plural nature of the customer (Section 3.2.4) and constraints that are hindering the commercial transfer of research outcomes to industry.

4.3.1 Research Plan

In order to undertake the data collection to address the research question *What are the internal or external systems or resource constraints in publicly funded university research within Australian Universities that restrict output from that research being commercially transferred to industry?,* consideration was given to the structure of the research design, type of data to be collected, data analysis methods and how sources of evidence would be treated within this work (Bazeley 2013). The data to be collected for this research is predominantly qualitative, or information based, with

interviews conducted through open and probing questions using terms such as "how", "why" and "demonstrate" to obtain responses that described the systems, process and stakeholder attitudes (Holliday 2016 p.33, Saunders et al. 2016 p.408). Adapted from qualitative research models by Baxter & Jack (2008), Creswell (2013) and Moons (2016) a research plan was developed from the planned methodology (Figure 4.2) to communicate a logical step by step approach to the collection and analysis of the research data for this study. The plan is outlined in Table 4.3.

Research Plan		
Step	**Data Collection**	**Analysis**
1	Australian Government Funding	What is the Goal? (Section 5.2.1)
2	Acts of Incorporation for Australian Universities	What are Australian Universities mandated to do? What is the Goal? (Section 5.2.2.1)
3	Australian University Strategic Plans	Undertake a comparison of how each university's strategic plan aligns with their Act. Are universities planning in line with their mandate in the Act? What is the Goal? (Section 5.2.2.2)
4	Australian University Policies on the commercialisation of publicly funded university research output	Undertake a comparison of each university's Policies and Procedures. Do they align with their strategic plan, Act of Incorporation and each other? What is the Goal? (Section 5.2.2.3)
5		Compare Goals. Is there evidence of a single Goal, and therefore customer focus? Are their constraints identified?
6		Is there evidence of a holistic Quality Management System?
7		How do Australian University governance documents address research commercialisation?
8		Develop a master map of the university research commercialisation system from the documents.
9	Semi-structured interviews with publicly funded Australian university research commercialisation process stakeholders. Stakeholders within this process include university commercialisation personnel, researchers, industry representatives and industry commercialisation personnel	Using the data collected at the interviews, map the process of publicly funded university research commercialisation from the practitioners perspective. (Section 5.2.3) • Does the practically applied process align with the published university policies and procedures, or intent • What do the stakeholders believe the customer wants? • Who do they think the customer is? • How are they satisfying the customer? • Is there evidence of sub-systems within the system?
10		Undertake a comparison of the maps to identify similarities, differences and gaps. Are the three case studies representative of the universities? (Section 5.3 & 6.2.1).
11		List the findings from the document analysis and the interviews
12		Thematically group findings Undesirable Events (UDE).
13		Use the TOC Thinking Process tool of Current Reality Tree to map the system. Start with the UDE and work backwards using a cause and effect analysis until a root cause is reached.
14		Identify the Root Cause of constraint. The common rule is the primary root cause has approximately 70% of the feeds leading to it is the primary root cause.
15		Analyse the primary Root Cause to 'break' the conflict using the TOC Thinking Process tool of Conflict Resolution Diagram (Section 6.2.5).
16		Develop a Future Reality Tree to establish the soundness of the finding in 15 and identify a framework for implementation.
17		Discuss a potential model for the change.
18	Write up and present findings	Thesis is written

Table 4.3. Schematic of the Research Design with Explanation (adapted Baxter & Jack 2008; Cooksey & McDonald 2011; Creswell 2013; Moons 2016)

4.3.2 Stakeholder Interviews

Primary data for this research was collected through face-to-face interviews with internal and external stakeholders of the university research commercialisation process. Stakeholders include research and commercialisation personnel and industry representatives. Permission to access University staff was sought through the DVCR at each case university (Section 4.1.1). Findings from the interview process are discussed in Section 5.2.3. Interview questions and ethics documentation is in Appendices H, I, J, and K respectively.

4.3.2.1 Interview Process and Participant Consent

Interviews were gained through DVCR or stakeholder recommendation and participants approached by phone or email. Consent was sought for audio recording and professional transcription, and manual notes taken if this was refused. Consideration was given to the management of the integrity of the interview process, with participants interviewed individually and at a convenient location to ensure confidentially and confidence. Interviews were in a conversational tone and took one hour. Participants were provided with research documentation for completion prior to the interview (Appendices H, I and J) as outlined in Ethics Approval H17REA234 (Appendix K).

During the interview, the participants were given the opportunity to draw or verbally illustrate their view of the research commercialisation process within their university, identifying the process, participants and the part they play. Drawing materials were supplied. The participants were offered of a copy of the interview transcript, with more than half commenting on its value for their own personal development. The findings from the interviews are discussed in Section 5.3.3.

4.3.2.2 Interview Questions

The interviews were based on 17 open ended questions (Appendix H) sorted into four categories to gather *Identifying Information, Perceptual Information, Actual Information,* and *Expert Insights on the Process.* These categories collected data on the stakeholders' position within the process, their perception of the planned events, how this perception fits with practical application and why the stakeholders think the processes are in place. The interviews were conducted in an open format with themes and ideas followed to complete a story.

4.3.2.3 Identifying Information

The questions in this section gathered identifying information to confirm stakeholder experience with publicly funded university research commercialisation within an Australian University (Table 4.4). Additionally, the questions gathered stakeholder understanding of the concept of research commercialisation within a university, how it was measured and sources of funding. The outcome was to identify an alignment with organisational intent or constraints that are hindering the process.

Identifying Information	
Number	**Question**
1	Are you involved with some element of Publicly Funded University Research Commercialisation (PFURC) Process at a university?
2	What is your definition of commercialisation?
3	Why does the university you are involved in do commercialisation?
4	How are you and your university measured on it?
5	Who measures you and your university?
6	Where do you source the research funding from? Does it usually include a allocation for commercialisation?

Table 4.4. Interview Questions - Identifying Information

4.3.2.4 Perceptual Information

These questions gained the stakeholders perception of the requirements of their role in the process. The stakeholders were asked if they would, or could illustrate, the process of publicly funded research commercialisation and identify their interaction with this system (Table 4.5).

Perceptual Information	
Number	**Question**
7	Draw the whole process of publicly funded university research commercialisation in the university you are involved in.
8	Identify the portion that you (the participant) are responsible for.

Table 4.5. Interview Questions - Perceptual Information

4.3.2.5 Actual Information

The purpose of these questions was to gain the stakeholders' understanding of the practical application of the process. This was achieved through the stakeholder retelling their involvement post the illustration of the system. A gap in the system between perception of role and practicality of role was identified at this point. This finding identified a gap in the actual process and provided a challenge when it was to be mapped (Table 4.6)

Actual Information	
Number	**Question**
The following questions are in relation to the section of the process the participant is responsible for.	
9	What do you do?
10	Who pays you?
11	What do they pay you for?
12	Who do you pay?
13	What do you pay them for?

Table 4.6. Interview Questions - Actual Information

4.3.2.6 Expert Insights on the Process

The purpose of these questions was to encourage the stakeholder to provide information on the outcomes of the system including any further information that the stakeholder felt they needed to provide. This section of the interview was designed to enable the participant to provide any further information not previously covered and always resulted in a story about their experiences (Table 4.7).

Expert Insights on the Process	
Number	**Question**
14	What happens to the research outcomes that do not go to the commercialisation unit (i.e. where do they go?). Prompt for % that does not move onto the commercialisation department.
15	What happens to the research outcomes that are rejected by the commercialisation unit (i.e. where do they go). Prompt for % that are rejected. Does this correlate with the commercialisation department answer?
16	How are you rewarded for transferring an outcome to industry? Promotion, IP Ownership (who owns the IP), Other?
17	Is there anything else you would like to add?

Table 4.7. Interview Questions - Expert Insights on the Process

4.3.3 Applying the Theory of Constraints Thinking Process

The Theory of Constraints Thinking Process can, at times, be complex to communicate due to the multiple levels of tools within the framework. The following information provides a step by step outline of using TOC for this research in Sections 6.1.1, 6.2 and 7.1). In addition, a schematic was developed to be used throughout this research to enable clear communication of the TOC tools in play at any one time (Figure 4.4).

The analysis for this research begins with identifying the Stakeholders of the system (Section 5.1) and then establishing the Stakeholder Goal of the system through document analysis and stakeholder interviews (Section 5.3) (Bevilacqua et al.. 2009; Dettmer 1995; Gupta and Boyd 2008; Moroz 2016; Watson et al. 2007). The

findings were grouped into 6 major themes (UDE) (Dettmer 1997; Rahman 2002) and applied to Current Reality Tree (CRT) cause and effect mapping (Section 6.1.1) to identify Root Causes of the constraints (Section 6.1.2) (Banerjee & Mukhopadhyay 2016; Librelato et al. 2013; Umble & Umble 2015). A Conflict Resolution Diagram (CRD) was developed to augment (break) the primary Root Cause (Section 6.2) (Cox et al. 2005; Dettmer 1998; Gupta et al. 2011; Kim et al. 2008; Rahman 2002; Sommer & Mabin 2016). Finally, the solution developed through the CRD was tested for effectiveness through the development of a Future Reality Tree (Section 7.1) (Chou et al. 2012; Dettmer 1997; Reid & Cormier 2003).
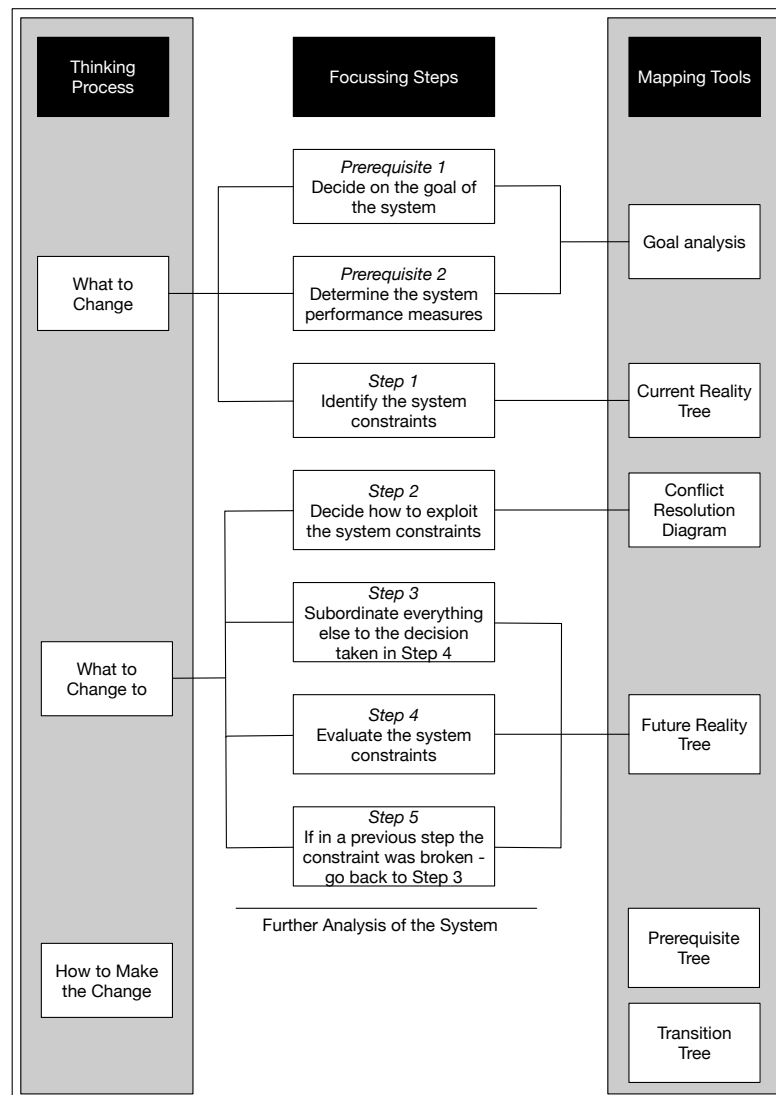
Figure 4.4. Theory of Constraints Analysis Tools Roadmap (Dettmer 1997; Goldratt & Cox 2016; Inman et al. 2009; Librelato et al. 2013; Moroz et al. 2016; Simsit et al. 2014; Taylor et al. 2006)

4.3.3.1 Identifying the Goal

The initial step in the Theory of Constraints analysis is to identify *What to change* by identifying the "Goal" (i.e. the objective) of the system (Bevilacqua et al. 2009; Dettmer 1995; Gupta and Boyd 2008; Moroz 2016; Watson et al. 2007). Anything that is considered to get in the way of the system operating at its highest potential (achieving its 'Goal') is considered a constraint (Trojanowska & Dostatni 2017; Watson et al. 2007). The Goal of the government and the university was identified through an audit of the documentation. Clarification of the goals was sought through interviews with internal and external stakeholders ("common" stakeholders). The published and practical goals of the system are compared for similarities, gaps and constraints and the finding from the analysis used as the data for the Current Reality Tree mapping.

4.3.3.2 Current Reality Tree (CRT)

The steps to mapping the Current Reality Tree (CRT) were undertaken using procedures outlined by Dettmer (1997):

Step 1	*Identify the influencing boundaries of the system.* Span of Control (can be influenced by system outcomes) and Sphere of Influence (cannot be influence by the system outcomes).
Step 2	*Create a list of UDE.* The findings from the document analysis and interview research were thematically grouped into Undesirable Effects (UDE) and the worst 5-6 are selected for the next step (Section 4.3.3.2) (Dettmer 1997; Rahman 2002).
Step 3	*Build the CRT.* Place the UDE at the top of the page, find two that are related and subordinate one. Continue this until the *lead* and *following* UDE are established.
Step 4	*Build the cause and effect map downwards.* Using the findings from the study and any additional connecting reasoning, construct the cause and effect map using the question *if… then….* Stop when all the original UDE have been connected.
Step 5	*Redesignate and trim.* Read the tree and trim for any duplicates or out of scope branches.

Step 6   *Identify Root Causes.* Entities in the map at the end of the analysis with outbound connectors only. Determine how many UDE feed into each Root Cause to establish hierarchy.

Step 7   *Define the influencing boundaries in Step 1.*

Step 8   *Decide which Root Cause to address first.*

The primary root cause is identified as the root cause that had the most UDE feeding into it (Umble & Umble 2015).   The conflict caused by the root cause is then analysed through a Conflict Resolution Diagram to 'break' the conflict and eliminate the constraint.

4.3.3.3 Conflict Resolution Diagram (CRD)

The Conflict Resolution Diagram (CRD) was undertaken to identify a solution using procedures outlined by Dettmer (1997):

Step 1   *Construct a blank CRD diagram for use as a base to the analysis* (Dettmer 1997) (Section 6.2).

Step 2   *Articulate the conflicting prerequisites.*   Write the opposing positions (on one hand… and on the other).

Step 3   *Determine the requirements.* Analyse what must happen to change the current situation (we must… in order to….).

Step 4   *Formulate the objective.* Determine the purpose of the requirements and write an objective statement.

Step 5   *Evaluate the CRD relationships.* Read the CRD and ensure it is logical.

Step 6   *Develop assumptions.* (..in order to… we must…).

Step 7   *Evaluate assumptions.*

Step 8   *Create injections* (ideas that will break or satisfy the assumptions).

Step 9   *Select the best injection* (criteria could include easiest to do; breaks the most critical assumption; breaks the most frequent assumption; least expensive).

The selected injection is then analysed thought a Future Reality Tree for logic and effectiveness.

4.3.3.4 Future Reality Tree (FRT)

The solution was tested for logic using the Future Reality Tree (FRT) as outlined by Dettmer (1997):

Step 1	*Develop the desired effects (DE).* Use the UDE developed for the CRT and convert them to a positive effect.
Step 2	*Add the injection from the CRD.* All or some or one of the injections can be used.
Step 3	Fill in the gaps. Put the chosen injection and the current reality at the base of the mapping and build upwards through expected effects until a Desired Effect is reached. This mapping is built from the bottom up, unlike the CRT.
Step 4	*Put in positive reinforcing loops.*
Step 5	*Look for negative branches.* What else could impact.
Step 6	*Develop the negative branch.* Entities in the map at the end of the analysis with outbound connectors only. Determine how many UDE feed into each Root Cause to establish hierarchy.
Step 7	*Find the turning point.* This is the point that the negative branch (issue) started.
Step 8	*Develop injections to 'turn' the negative branch.* Eliminating the problem.
Step 9	*Redesignate and trim*. Read the tree and trim for any duplicates, further negative or illogical entries.
Step 10	*Is there validation for the injection and the new normal?*

The confirmation of the soundness and effectiveness of the Injection decision provides a solution to the problem and can be used as a base for the Prerequisite Tree (PRT) to develop a more detailed plan leading to the Transition Tree (TT) and system change. Both the PRT and the TT are outside of the scope of this work as this

research was to identify constraints that are hindering the system, not develop a new system (Section 8.1).

4.4 Summary

Chapter 4 outlined the methodology design and plan to be undertaken in this research project to investigate and analyse the constraints within the atypical system of publicly funded research that are hindering commercial transfer of the outcome. The methods used will be a multiple case study analysis using the Theory of Constraints Thinking Tools to undertake an investigation of the system. Chapter 5 discusses the identification of the system stakeholders (Section 5.1) and the case universities (5.2). The Chapter then discusses the analysis of the goals of the system, resulting in the identification of constraints in the commercial transfer of research outcomes to industry (Section 5.3). Lastly, an identification of the mis-alignment of the goals (Section 5.4) and a compilation of a list of primary Undesirable Effects (UDE) (Section 5.5) to enable a cause and effect mapping to identify the root cause of the system constraints (Section 6.1).

CHAPTER 5 - RESULTS AND FINDINGS

5.0 Introduction

Chapter 4 established the methodology that will be used to identify constraints in the system of publicly funded university research that are hindering the commercial transfer of research outcome to industry. The methodology design is a multiple case study analysis using the Theory of Constraints Thinking Process and Focussing tools, to firstly, identify what should be changed in the system (*What to change*), what the system should be changed to (*What to change to*) and how to enact the change (*How to cause the change*) (Dettmer 1997; Goldratt & Cox 2016; Inman et al. 2009; Moroz et al. 2016; Taylor et al. 2006) (Section 4.2.3.1). The Theory of Constraints Thinking Process uses cause and effect mapping techniques that identifyies both policy and physical constraints and is considered suitable to investigate the planned (policy) and practically applied (physical) system (Section 4.2.1) (Inman et al. 2009; Johnson et al. 2015).

This Chapter presents the data collected for the study to define the stakeholder Goals (Section 5.1) and the alignment of these goals with the case universities (Section 5.2) by using document analysis of Government reports (5.3.1), University Acts of Incorporation, Strategic Plans and Policies (Section 5.3.2) and interviews with "common" system stakeholders associated with the case universities (Section 5.3.3). The findings are developed and thematically collated into Undesirable Effects (UDE) (Section 5.5) to enable the cause and effect mapping using a Current Reality Tree (CRT) in Section 6.1.1. This Chapter will discuss the stakeholders and findings of the research in the following order:

1. System Stakeholder Identification
2. Case Study Alignment
3. System Stakeholder Goal Analysis
4. Alignment of the Goals

5.1 System Stakeholder Identification

An investigation into the identification of the stakeholders of a university (Section 2.2.2) was required to enable this research to establish the Goal of the system, and in turn, enable a constraints analysis using the Theory of Constraints (Section 4.2.3). Three key stakeholders were identified, the Australian Government (Section 5.1.1), the Australian University (Section 5.1.2) and "common" system stakeholders (Section 5.1.3). Whereas, the Australian government and the university were simple to identify, the development of the "common" stakeholders resulted from an investigation into the university policies to understand the stakeholders that are at the practical level of the system (i.e. "doing it"). These "common" stakeholders were identified as the university research personnel, university commercialisation personnel, external commercial personnel and industry (Figure 5.1).

Figure 5.1. Stakeholders of the Publicly Funded Research Commercialisation System

5.1.1 Australian Government

The Australian Government is a key stakeholder in the process of publicly funded research commercialisation (Section 2.1). The Australian Government provides support to the universities to ensure governance through legislation (HEAct 2003), the licensing for relevance and an applied quality standard through Tertiary Education Quality and Standards Agency (TEQSA) (TEQSA 2018). In addition, the Government provides funding for university research projects to enable the continued development of new knowledge. Research funding is managed through the governmental organisations of the Australian Research Council (ARC), National Health and Medical Research Council (NHMRC), and other smaller government

research funding schemes (Section 2.2.1). The Australian Government also relies on the universities to provide data on new knowledge development (research outcomes), the development of this knowledge into Intellectual Property, and any transfer of this Intellectual Property to industry through annual reporting (Section 2.3.2) (ARC 2019; DIISRTE 2019; DISER 2019).

5.1.2 Australian University

Australia has 42 registered 'Universities' that have satisfied the requirements of TEQSA and are listed on the Federal Higher Education Support Act (HE Act 2003; TEQSA 2018) (Section 2.1). This research initially investigates the systems of these 42 universities to establish the common elements of their governance and approach to the research commercialisation of publicly funded research. A deeper analysis is then undertaken through interviews with stakeholders of three case university systems, identified within this research as, *The Mature Uni* (Mature), *The Young Uni* (Young) and *The Establishing Uni* (Establishing) (Section 5.2).

5.1.3 "Common" System Stakeholders

The investigation into the practical application of the publicly funded university research commercialisation system through an analysis of the Policies (Section 5.3.2.3 and Table 5.8) governing research commercialisation exposed four unique sets of "common" stakeholders, with different responsibilities to the decision making process within the system:

1. University Commercialisation Personnel
2. Researchers employed by the university
3. Industry Representatives associated with university research projects
4. Private Commercialisation Practitioners with links to the university

An analysis of the individual connection to the case universities of each stakeholder is outlined in Section 5.3.3)

5.1.3.1 University Commercialisation Personnel (UCP)

Interviews were conducted with commercialisation personnel employed by the case universities to better understand the 'Goal' of the system from their perspective. The responses to the interviews were typically guarded and protective of the intent behind the "Goal" and processes of their employer, (i.e. the university (Section 5.3.3.1)). These responses provided an insight into the tension between the published and practical systems, providing a significant finding (Finding 1) for this study and further discussed in Section 5.3.3.2.

5.1.3.2 Researchers Employed by the University (Res)

Interviews were conducted with researchers employed through the university that undertook publicly funded research. These researchers were sourced from *The Establishing Uni* and *The Mature Uni.* However, *The Young Uni* was unable to source researchers that were willing to undertake interviews. The reason provided was a low prior achievement rate of obtaining ARC Discovery Funding for research (Section 2.2.1), and of the completed projects that were funded, the academics no longer were employed by the university. They had moved on to other career opportunities mostly due to the completion of their doctoral degrees. There was no explanation put forward for the balance of the academics (Section 5.3.3.1) (Finding 2) (INT2 & INT5). The inability to attract ARC Discovery Funding was also explained by the University Research Personnel approached as being due to the young age of the university and the primary focus on growth and establishment as a university. It should be noted that although *The Young Uni* did not have a legacy of researchers with publicly funded research experience, it was discussed that there is an emerging push within the university itself to raise the level of ARC funding, showing some recent funding acquisition success, however, no researchers willing to be interviewed at this early stage. This resulted in a finding that the system of publicly funded research commercialisation, particularly with a focus on the practical application of the process, was not comfortably discussed. This was a common

theme with researchers when the discussion moved from research to tangible outcomes (Finding 3). An additional interview was obtained from one of the industry representatives due to previous experience employed by another university.

5.1.3.3 Industry Representatives (IndR)

Industry representatives with experience in university research commercialisation processes were interviewed next, these representatives were sourced from known associates of the universities. All representatives were enthusiastic firstly, about the opportunity that could be sourced from university/industry collaboration, and secondly, about the results of their collaboration and the benefit it bought in an expanded understanding of their industry's research. The potential was tempered with discussions on the often misaligned expectations of the project outcome between industry and the university, causing tension in the relationship. The interviews additionally highlighted the differing business environments through a mismatch of the 'business' systems used by industry and university leading to confusion or miscommunication (Finding 4). Finding 4 provides support to Finding 5 - differing expectations from different stakeholders.

5.1.3.4 Private Commercialisation Practitioners (PCP)

Interviews were undertaken with Private Commercialisation Practitioners recommended by the university personnel through their personal network or known business associates of the university. As with the industry representatives, these practitioners were keen to work with a university, however, found interacting with the university system challenging due to differing expectations of the system (Finding 5), as well as, time consuming, with universities demonstrating many governance layers to negotiate.

Once the stakeholders of the system of publicly funded research commercialisation were identified, interviews were undertaken to determine the Goal of the system

(Pre-requisite 1, Table 4.3). For a system to achieve its desired output, all stakeholders must be working towards the same Goal (Dettmer 1997; Goldratt & Cox 2016) (Section 5.4). Identifying a single unified Goal of this system proved elusive due to the tension caused by multiple key stakeholders working to address the needs of a plural of customer (Section 3.4) and siloed individual needs (Figure 5.2) (Finding 6). The tension caused by the multiple requirements on the system has been identified as a constraint within the system of publicly funded research commercialisation.
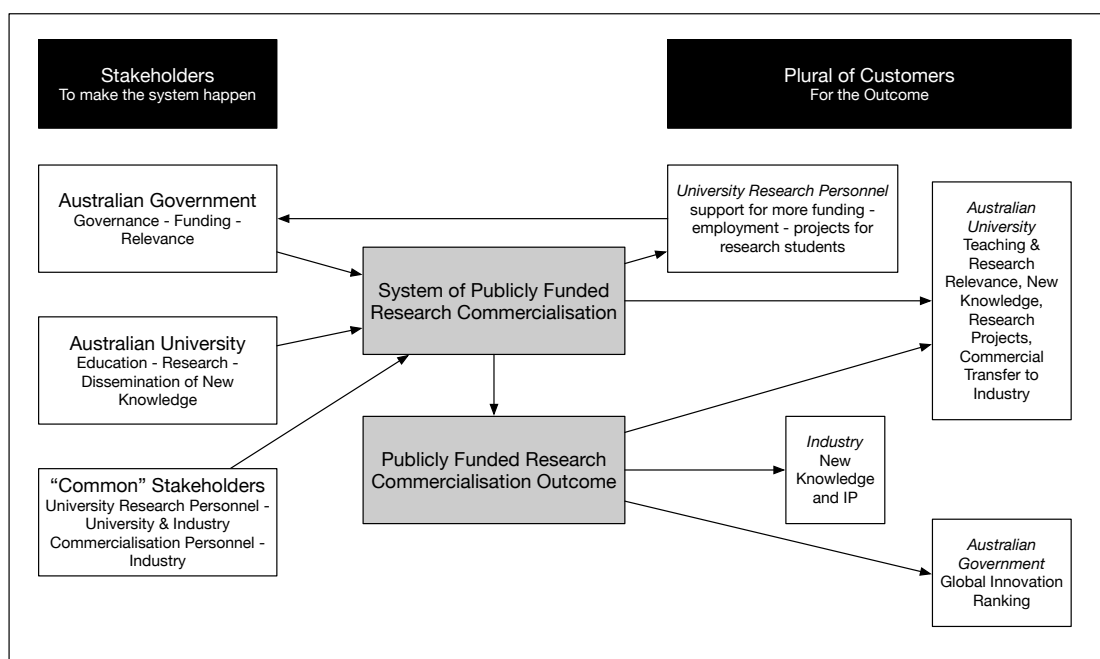
Figure 5.2. Tension in the System Goal between the Stakeholders and the Plural of Customers

5.2 Case Study Identification

An analysis of the three case universities demonstrated that confidence in developing long term strategic plans correlated with length of university establishment (Table 5.1). The longer the university had been established the university correlated with the length of the timeframe of the Strategic Plan, demonstrating confidence in their forward direction, but perhaps less able to pivot to meet unforeseen circumstances, such as the COVID-19 global pandemic and remain competitive (Doughney 2020; Porter 1985).

The *Mature University* set a 10 year strategy to become a globally recognised leader in education, research and new knowledge development. Whereas, long term plans enable the university to enter complex markets by devising longer running objectives and resource planning (Blair & Lee 2019), it may also make the university difficult to manoeuvre should there be rapid global change, such as the COVID-19 pandemic that caused a catastrophic reduction in international student income and need for rapid system changes (Doughney 2020).

The *Establishing University* has a 5 year strategic plan equally seeking global standing and a reputation for high standards, leadership, and the promotion of their brand of a positive student experience. However, being a smaller university with a mid-range establishment period, cautious planning, nimbleness and creativity are required due to low staff numbers, smaller student base and fewer resources. This is demonstrated by their low research expenditure. Although budget conscious, the absence of commitment to large research projects and long term visions could enable this university to adapt to a rapid environmental change with more success than the Mature university.

The *Young University*, has a medium range research budget and a 3 year plan with mid-term analysis to analyse currency and awareness of market changes, and, within this study would be placed at most ready to address a rapid environmental change. The *Young University* frames their Strategic Plan to demonstrate why they are planning the changes, demonstrating an outward focus to their plans and and intent on communicating with the community. Whereas, the *Establishing* and *Mature Universities* chose to use more traditional language that discusses *what they want to do,* demonstrating an inward focussed intent, focusing their own needs and little industry collaboration.

Strategic Plan Analysis of the Australian Universities chosen for the case study			
University	**UNI1 (The Mature Uni)**	**UNI2 (The Young Uni)**	**UNI3 (The Establishing Uni)**
Age	Mature - established more than 65 years	Young - established less than 40 years	Establishing - established between 40 and 65 years
Size	Large	Medium	Small
Length of Strategic Planning	10 years	3 years with mid-term analysis	5 years
Strategies	Will be a global university and a leading research-intensive and teaching-intensive university	Securing Success	Lead in economic and social development through higher education and research excellence.
Objectives for Research and its outcomes	• World Leading research. • Research Impact through generation of new knowledge	• A research-informed learning experience that is innovative, flexible and responsive. • Research-led university with regional, national and global impact	• Enhance our national and international standing for high quality, focused and engaged research that makes a difference to communities. • Build our reputation for research training that produces innovators and entrepreneurs.
Observations	• Demonstrating confidence in knowledge of future needs • May not be able to manoeuvre quickly	• Acknowledging the potentially fast changing environment	• Smaller budget and student load • Creativity with fewer resources

Table 5.1 Strategic Plan Analysis of the Australian Universities chosen for the case study (Sourced: individual case university Strategic Plans; DIISRTE 2019)

The case university Strategic Plans contain a research focus, however, not specifically to commercially develop for transfer to industry, rather, the betterment and improvement of the community and solving societal needs. The strategy of any organisation sets the intent of the organisations actions and supports the operational framework (Hamel & Prahalad 2010; Hines 2006; O'Shannassy 2015). Therefore, if there is no strategic intent to commercially transfer research outcomes, there will also be a lack of framework or embedded intent with the stakeholders to support the process, and at best, the results will be opportunistic only (Hamel & Prahalad 2010; Owens & Khazanchi 2018). A mapping of the strategic plans of the 42 Australian universities shows that all universities planned for research[16], seeking a research partner from industry, government, another educational institution or the community was an intent by 38 of the universities, and 31 were planning for 'impact' of their

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[16] This is in line with their Act of Incorporation (HE Act 2003)

research. However, only 11 planned to commercialise their research (Table 5.2) demonstrating the absence of focus within the system. Full breakdown of the intent in the Act of Incorporation, Strategic Plans and Intellectual Property Management Policies in Appendix N.

Mapping of the Intent to Commercialise in the University Strategic Plan					
Undertake Research	Seek Research Partnerships - business, government, research institutions, community	Want impact	Want to commercialise	Increase research revenue from other sources of funding e.g industry or philanthropic	Increasing citation ranking
42	38	31	11	12	6

Table 5.2 Mapping of the Intent to Commercialise in the University Strategic Plan (Sourced: Australian University Strategic Plans Appendix N)

5.2.1 Mapping the Case University System

An investigation into the 42 Australian University Intellectual Property Management Policies (Section 5.3.2.3) developed a conceptual map of the research commercialisation process for comparison to the case universities. This map developed a "should do", or planned, view of the system (Greasley 2006) (Figure 5.3) (Appendix L), providing an overview of how the system should look, sourced from the University Policies (Cañas & Novak 2006; Estrada et al. 2016). The map demonstrates a flow of decision making, however, it can be seen that there is little discussion on the outcome of research that the university does not want to commercialise. Additionally, there is scarce data in the policies that discuss sourcing a customer for the outcome (Section 5.3.2.3), process mapping does not identify the Goal of the system (Goldratt 1990), expected throughput value (Gardner & Cooper 2003), time (Knoll et al. 2016) or constraints in the system (Dettmer 1997). This research is an investigation of the constraints in the system, and whereas, a process map can provide an overview of how the system is intended to function (Cañas & Novak 2006, Estrada et al. 2016; Greasley 2006; Moeller & Christensen 2009), a more in-depth mapping of the system using a Theory of Constraints cause and effect mapping, the Current Reality Tree, is required to identify constraints hindering the system (Section 6.1.2)
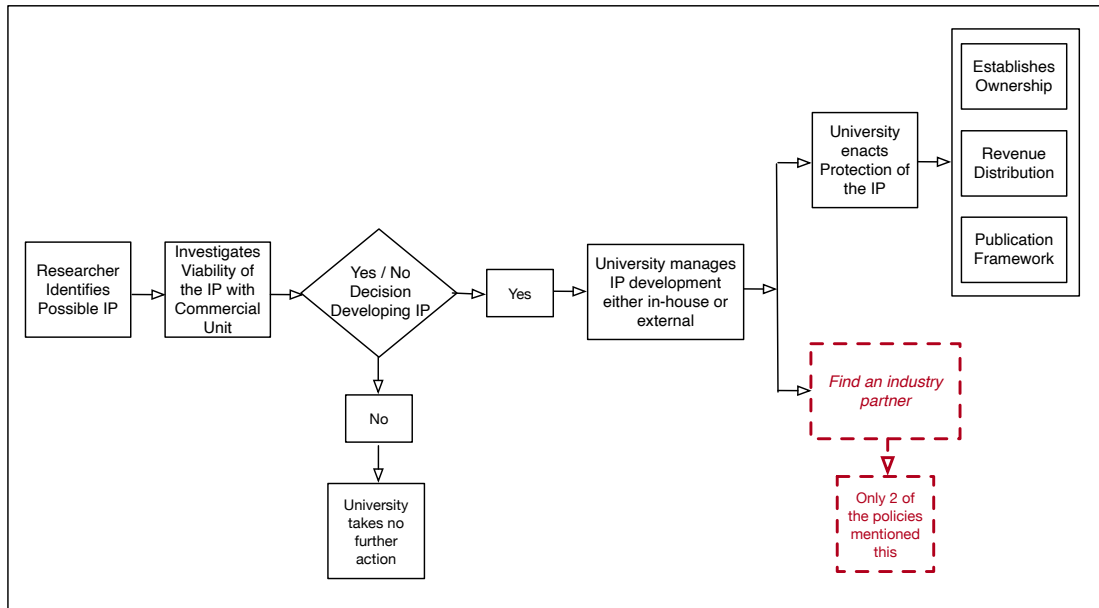
Figure 5.3: Conceptual Map of the Research Commercialisation Process (Sourced: Appendix L)

The process of research commercialisation of the case universities was mapped using data sourced from their Intellectual Management Policies (Section 5.3.2.3) to establish alignment with the conceptual map and their individual similarities and differences. The case universities are represented by Figure 5.4 *The Mature University*, Figure 5.5 *The Young University* and Figure 5.6 *The Establishing University*. The mapping commences at the point the researcher identifies Intellectual Property of possible commercial value.
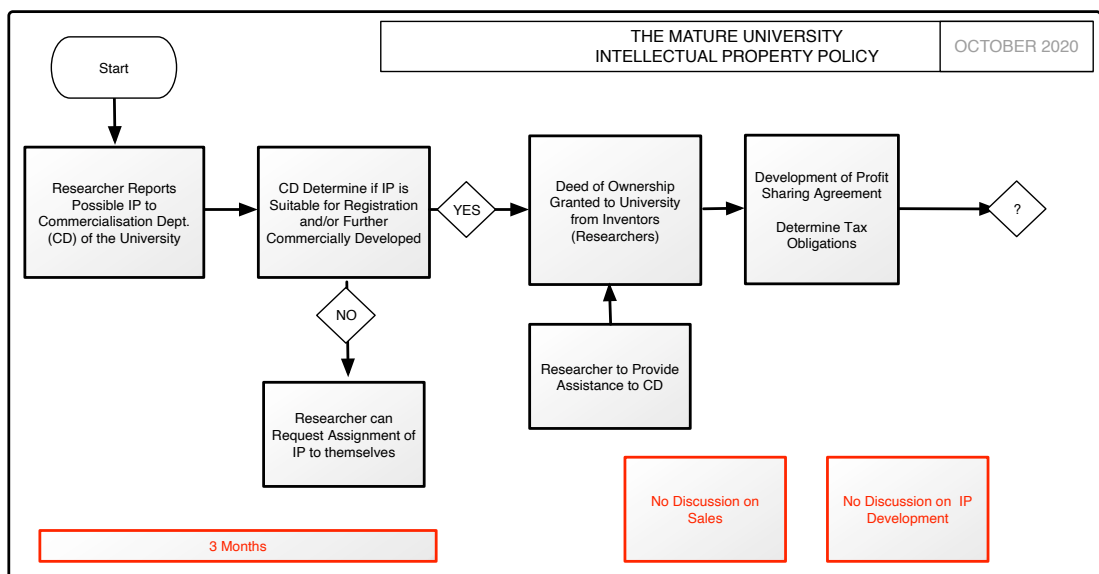
Figure 5.4 The Mature Uni (Sourced: Appendix L)
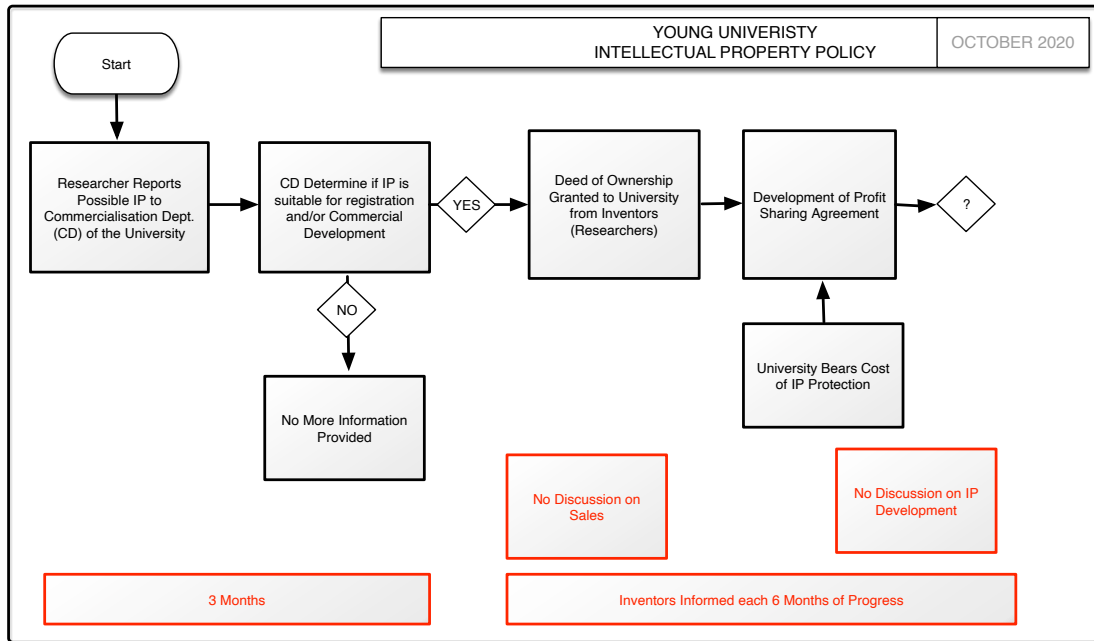
Figure 5.5 The Young Uni (Sourced: Appendix L)
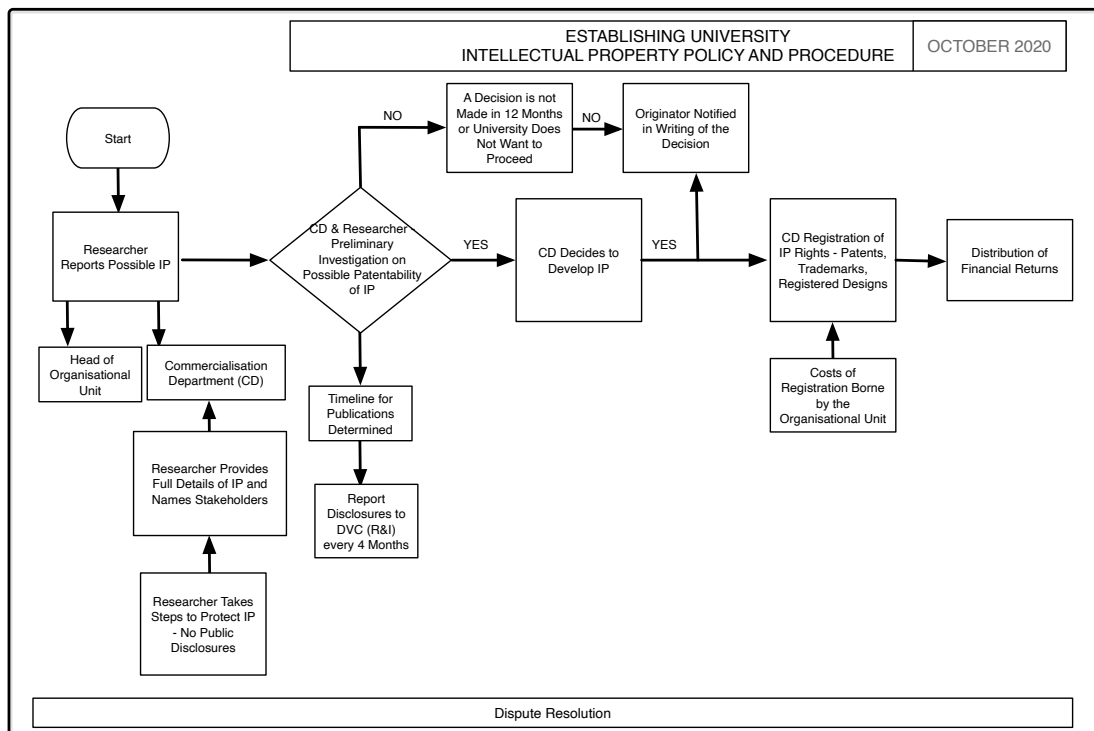
Figure 5.6 The Establishing Uni[17] (Sourced: Appendix L)

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[17] This drawing is more complex due to additional information included in the policy document.

Table 5.3 provides a schematic of the alignment, illustrating that the three systems are similar to the conceptual model, supporting the existence of a common system within the universities.

Comparison of Research Commercialisation Systems of the Case Universities				
	Conceptual Model	Mature University	Young University	Establishing University
Research identifies/reports possible IP	x	x	x	x
Investigate viability of the IP with commercialisation unit	x	x	x	x
Decision to develop	x	x	x	x
Decision not to develop	x	x	x	x
University take no further action	x			
Researcher can request assignment of IP to themselves		x		
Researcher notified in writing of outcome				x
No further information provided			x	x
University manages IP either in-house or externally	x	x		x
Researcher to provide support to the university development process		x		
University enacts IP protection	x			
Establishes ownership	x	x	x	
Establishes revenue disbursement	x	x	x	x
Establishes publication framework	x			x
Find an industry partner for IP transfer	x			
Dispute resolution				x

Table 5.3 Comparison of Research Commercialisation Systems of the Case Universities (Sourced: Case Australian University Policies Appendix L)

5.2.2 Mapping the Case University Source of Research Funding

The yearly income (not the specific ARC grant awarded for that year) allocated from the Australian Government Research Grant Scheme (ARC Linkage and Discovery)

for each of the case universities is illustrated in Table 5.4. To demonstrate the value of this income to each university, the ARC research income is represented as a percentage of each University's operating budget. Universities source approximately 50% of their operating costs through educational grants, that also support research, from the Australian Government, however, the returns from commercially transferrable Intellectual Property through the issue of Licences, Options and Assignments, is nothing more than a rounding error in a large organisations budget (Table 5.4) (ARC 2018e).   The annual ARC funding allocation granted annually through ARC Discovery and Linkage projects is collated in Table 5.5. The funding amount post 2016 does not show any significant rise in the allocation to assist with the requirement to produce "better" commercial transfer.   This demonstrates that, although, the requirement of the university system is for "better" commercial transfer, it has not been supported by increased Australian Government funding.

Research Funding and Income as a % of University Operating Income from LOA'S 2012 - 2018		ARC Funding	Australian Government Grants for Education	Royalties, Trademarks and Licenses (LOA)
2012	Mature University	4.9	47.2	0.0038
2013		4.7	45.2	0.0026
2014		4.5	43.3	0.0037
2015		4.0	41.8	0.0028
2016		3.4	38.6	0.0019
2017		3.4	36.4	0.0010
2018		2.9	35.7	0.0007
2012	Young University	1.1	51.1	0.0003
2013		1.2	49.0	0.0003
2014		1.3	45.8	0.0001
2015		1.1	46.8	0.0003
2016		1.0	45.2	0.0003
2017		1.1	41.8	0.0003
2018		0.9	36.5	0.0002
2012	Establishing University	0.0006	53.0	No figures published
2013		0.0006	51.5	
2014		0.0003	51.9	
2015		0.0003	41.1	
2016		0.0007	50.7	
2017		0.0015	49.0	0.0002
2018		0.0012	47.4	0.00005

Table 5.4. ARC Funding and Income from LOA's as a % of Operating Costs (Sourced: ARC2018e)

ARC Funding Allocations			
	Mature University	**Young University**	**Establishing University**
2012	$63,036,230	$5,625,561	$0
2013	$60,279,504	$9,749,391	$216,000
2014	$60,469,108	$10,180,313	$0
2015	$64,880,733	$3,677,928	$219,959
2016	$53,583,863	$7,113,896	$340,000
2017	$156,454,430	$5,642,312	$345,124
2018	$54,250,483	$3,597,128	$282,491

Table 5.5 ARC Funding Allocations (Sourced: ARC 2018e)

Although, a quantitative measurement of Intellectual Property development activities is undertaken by the National Survey of Research Commercialisation (DIISRTE 2019); a measurement of research is undertaken by ARC in their Excellence in Research report (ARC 2019); and, an additional measurement for research outcome impact on the community is in its early stages (ARC 2018b), none of these measurement systems, even if combined, undertake an analysis of the constraints that are hindering the commercial transfer of research outcome. To identify the constraints within this system, both within policy and practical application, the Theory of Constraints *Thinking Process* (Section 4.2.3) is used to identify *What to Change, What to Change To* and *How to Cause the Change.* The first step focusses on identification of the Goal of the system, this research identified multiple goals causing a mismatch in the system (Section 5.4). Following the establishment of the Goal(s) cause and effect analysis is undertaken through the *Focussing Steps* to augment the identified constraints (Dettmer 1998; Rahman 2002) (Section 6.2.4).
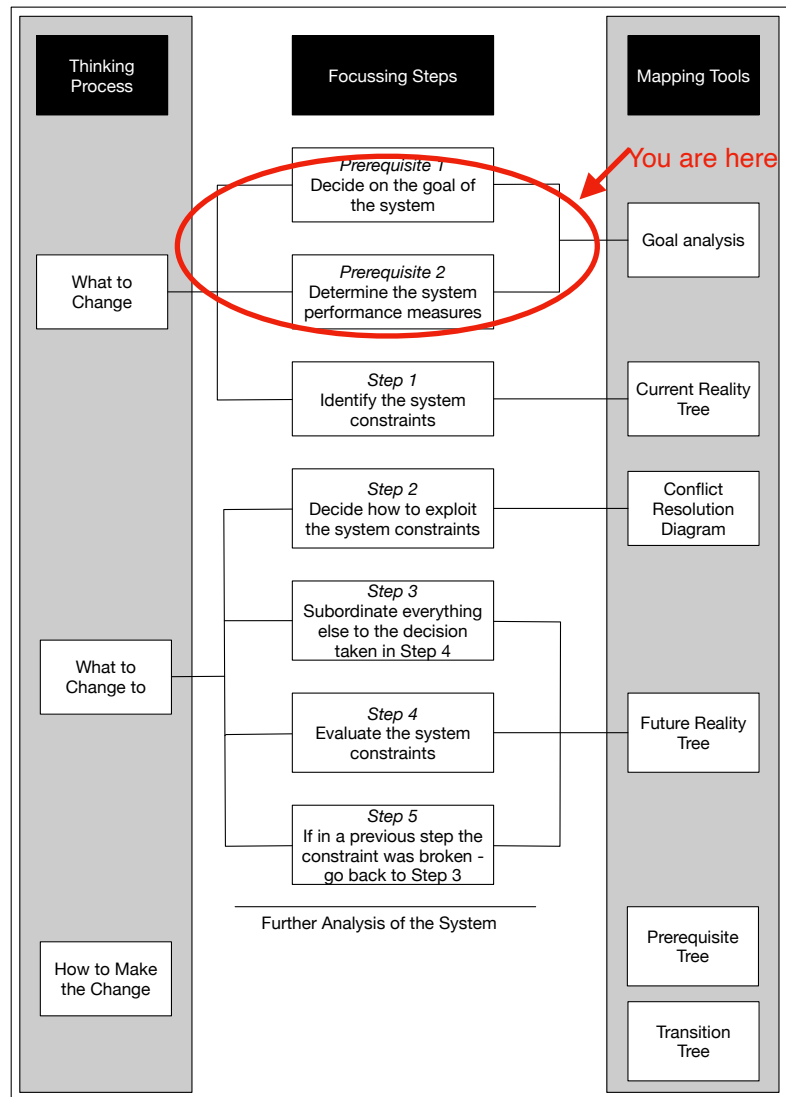
Figure 5.7 Theory of Constraints Methodology Map - Place Locator - Goal of the System

5.3 System Stakeholder Goal Analysis

This research identified multiple Goals within the system of publicly funded research commercialisation intrinsically linked to the stakeholders position, situational function and perceived impact.   The premise that a university responds to the requirements of the government stipulation for permission to operate under licence, and this response is historically reflected in the University's Acts of Incorporation. University Strategic Plans support the Incorporated Acts and University Policies provide guidance for the practitioners, all stages of this governance process clearly reinforcing the organisational goal (Dooris 2003) (Figure 5.8).   An investigation of

the correlation of the intent of the Act, Strategic Plans, Policies and practical application of the publicly funded research commercialisation system within Australian universities did not result in a unified goal, instead, multiple siloed stakeholder Goals were identified (Section 5.4). The existence of multiple goals represent a constraint in the system (Finding 7) and are discussed in more detail in the following sections.

Figure 5.8 Hierarchy of Governance

5.3.1 Analysis of the Government Goal

Institutional relevance and responsible use of public money for the benefit of the Australian economy is a fundamental requirement of Australian Universities (HE Act 2003). The paradigm of benefit for the Australian economy has led to the Australian Government's quest for universities for *"better transfer[18] of research into commercial outcomes"* in the attempt to boost Australia's Global Ranking in Innovation (ranked 30 out of 30 countries) and Transferring Research to Industry (ranked 28 out of 30) (DISER 2015; OECD 2016; DoE 2014). Boosting these global rankings enable Australia to demonstrate an economy that excels in the transfer of investments in innovative research to successful industry output (WIPO 2019). This research found that this intent of the Australian Government to measure *"better transfer"*, has resulted in the narrowing of the focus of innovative output qualitative measurement of 'more', and in turn, the addition of more measurement functions in the reporting process, such as, the development of protocol for measuring 'impact', all this with no change in the overall basic system of providing public funding to universities for research (Bornmann 2017; DISER 2015; Gunn & Mintrom 2018; IRU 2016). In addition, the increased focus on the reporting of commercial transfer and the need to prove the action of industry collaboration, has resulted in a

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[18] OECD uses the term 'better translation' the Australian Government uses the term 'better transfer' (OECD 2016, DoE 2014)

manipulation of data reporting within these systems to be only respondent to "current government requirements" (INT5) rather than a holistic policy change to underpin the measurement requirement of "better", as demonstrated in responses to the "common" stakeholder interviews (Section 5.3.3). This manipulation of the measurement of the system, without holistic system change, demonstrates constraint in the system.

5.3.1.1 A Change in the Intent

Traditionally a university was considered as a source of content for knowledge development, however, in the Australian Government's quest for *"better transfer"*, university research has become a target for exploitation as the source of opportunity for commercial transfer to industry, unfortunately, without providing the support of new laws (i.e. legislation) or the system of public funding of research (Boulton 2009; Cheah & Yu 2016; DISER 2015; Ekem 2019; Roessner et al. 2013). Instead there is evidence of function creep within the technology around data collection, enabling historically embedded data gathering methodologies to be manipulated, not redesigned, to provide the new governmental reporting requirements (Dahl & Sætnan 2009; DISER 2015; OECD 2016). Interestingly, this research found, through interviews with the "common" stakeholders (I8, I5, I2, I9) (Section 5.3.3), that ARC *Linkage* Grants were more readily sought to address these reporting requirements. However, as Figure 5.9 demonstrates, the amount of funding is not increasing to meet the newfound interest, identifying a lack of focus by the Government (Principal), apart from periodic funding spikes corresponding to the first term of a new government cycle (Section 2.2.1). Although, *Linkage* grants are able to address the requirement of *"better transfer"* through the collaborative university/industry funding process, there is no demonstrable change in the funding strategy by the Government to increase the availability of the funding, rather placing the requirement for reporting change with the university system. In addition, the measurement metric the government is seeking is *"better"*, not *"all"* or a *"specific"*

numeric target in relation to "*transfers*", adding further ambiguity to the measurement and reporting process.
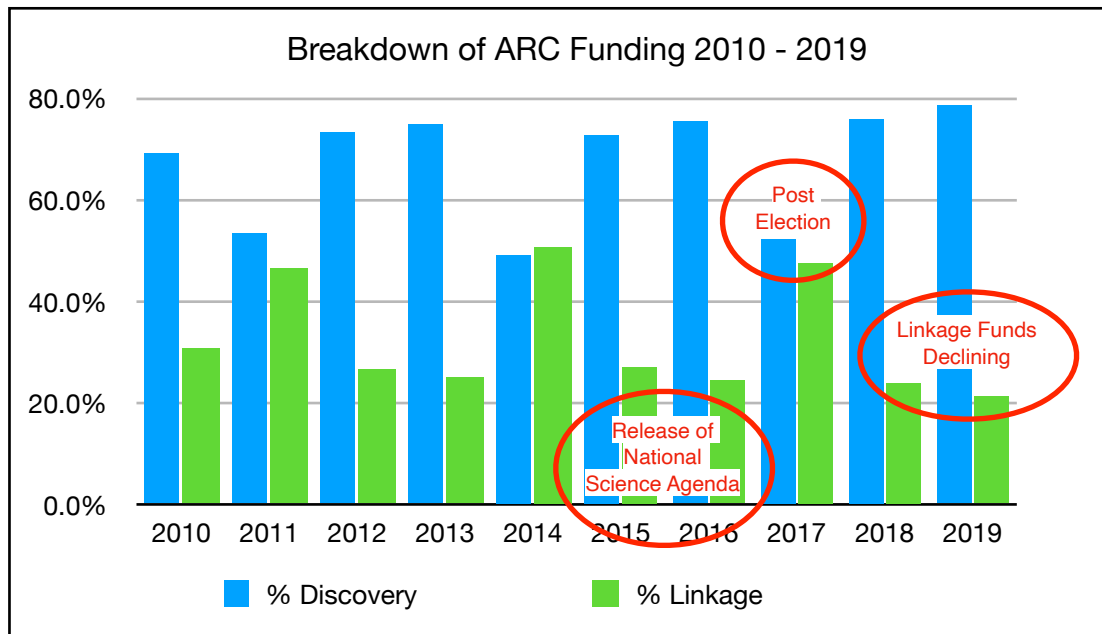
Figure 5.9 Breakdown of ARC Funding Disbursement 2010 - 2019 (ARC 2018d)

This research has identified that the Australian Government is sourcing "better" commercial transfer from Australian Universities to raise the innovation ranking of Australia as a nation, through focussing on university research output by the implementation of an enhanced research and innovation mandate (DISER 2015). This has resulted in a change in the output required by the funding body, Government, without a change in the system that is being measured through funding levels or change to the legislative framework of universities to address this required outcome, leaving a system that is under stress to produce a different result from the same process.

5.3.2 Analysis of the University Goal

Section 5.3.1 established that the Goal of the Government as *better transfer of research into commercial outcomes*. This section will establish the Goal of Australian Universities and how this Goal translates between the Acts of

Incorporation (Section 5.3.2.1), Strategic Plans (Section 5.3.2.2) and the Policies that provide guidance to the process (Section 5.3.2.3).

5.3.2.1 Analysis of the Acts of Incorporation

The Acts of Incorporation are State Government legislation under the guidance of the Federal Higher Education Act (HE Act 2003) and set the intent and framework for each university. This research investigated the objectives (or functions[19]) listed within these Acts of Incorporation (Act) for each Australian University to establish the overarching Goal of the university. In total, twenty (20) objectives were identified (Figure 5.10) with a common objective within universities of promoting research practices to address the Threshold Standards[20] and maintain relevance as a University (Tertiary Education Quality and Standards Agency Act 2011 No. 7).
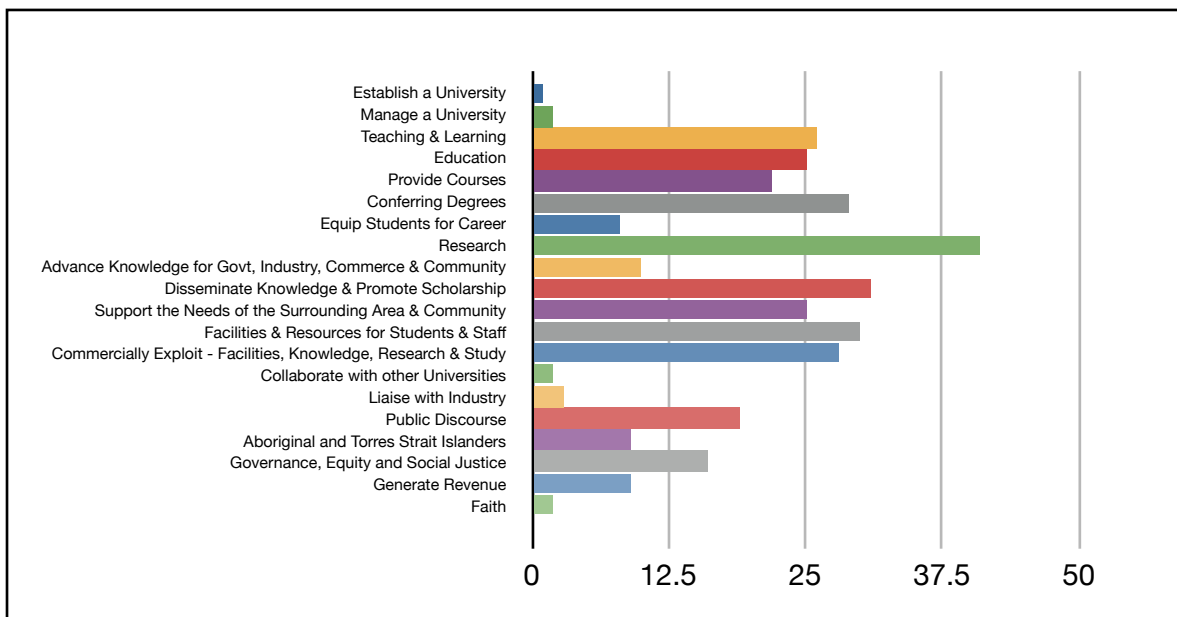
Figure 5.10. Objectives for Australian Universities (Sourced: Individual Australian University Acts (Appendix D))

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[19] The term 'function' or 'objective' is used interchangeably within the Acts of Incorporation, with the term selection often aligned to the State in which the Act of Parliament was written.

[20] Threshold Standards means the following: (a) the Provider Standards, which are: (i) the Provider Registration Standards; and (ii) the Provider Category Standards; and (iii) the Provider Course Accreditation Standards; (b) the Qualification Standards (Act 2011 https://www.legislation.gov.au/Details/C2015C00025) (Higher Education Standards Framework (Threshold Standards) 2015 https://www.legislation.gov.au/Details/F2015L01639)

The four university objectives listed most frequently within the Incorporated Acts are aligned with the provision of education. Exploitation of resources for the benefit of the university was only included in 29 of the 42 Acts (Table 5.6) and is defined in the Acts as the commercial use of facilities, knowledge, research and study for the functional operation of the university. Within the Acts, there is no specific directive that the university *must* commercially transfer to industry use of its resources, or indeed, source a customer. It simply represents that the University is *able* to exploit the resource for commercial use. As there is no consistent requirement to commercialise, there is an absence of a communicated measure, and therefore, identifying a constraint (Finding 8). Although, one Australian university, University of Tasmania, included commercialisation of Intellectual Property within their Act, the sourcing of a customer (i.e. industry) was not mentioned (University of Tasmania Act 1992). These figures illustrated that all universities were legislated to undertake research, however, 32 said they were disseminating knowledge and more (29) universities said they were able to commercially exploit university assets (including research) than the 27 universities that listed teaching and learning. These figures show high intent by the university to undertake research (42), but low dissemination of this research. This further discussed in Section 5.3.3.

Objectives for Australian Universities							
Number of universities	Research	Disseminate knowledge & promote scholarship	Provide facilities for education	Confer degrees	Commercially exploit (for benefit of university) facilities, knowledge, research & study	Teaching & learning	Support the needs of community and the region
42	42	32	30	30	29	27	26

Table 5.6 Objectives for Australian Universities (Sourced: Individual Australian University Acts).
(Appendix D)

This research has found that the objectives of the Acts do not directly support the Australian Government's current requirement for "*better*" commercial transfer of Australian Universities research output.

5.3.2.2 Analysis of the Strategic Plans

Strategic Plans were analysed from 41 universities[21] to identify whether they included a plan to commercially transfer university research outcomes. As with the Acts, all Australian Universities incorporated the need to undertake Research within their Strategic Plans (Figure 5.11) alongside Planning of Teaching, Learning and Student Experience.   Strategic Plans secure an organisations identity through the planning and implementation of objectives (Hamel & Prahalad 2010, O'Shannassy 2015, Hines 2006).   This research found that the intent to establish 'identity' was listed as an objective in only half of the universities, leaving opportunity for a loss of focus on ensuring relevance and connection to the community at large.
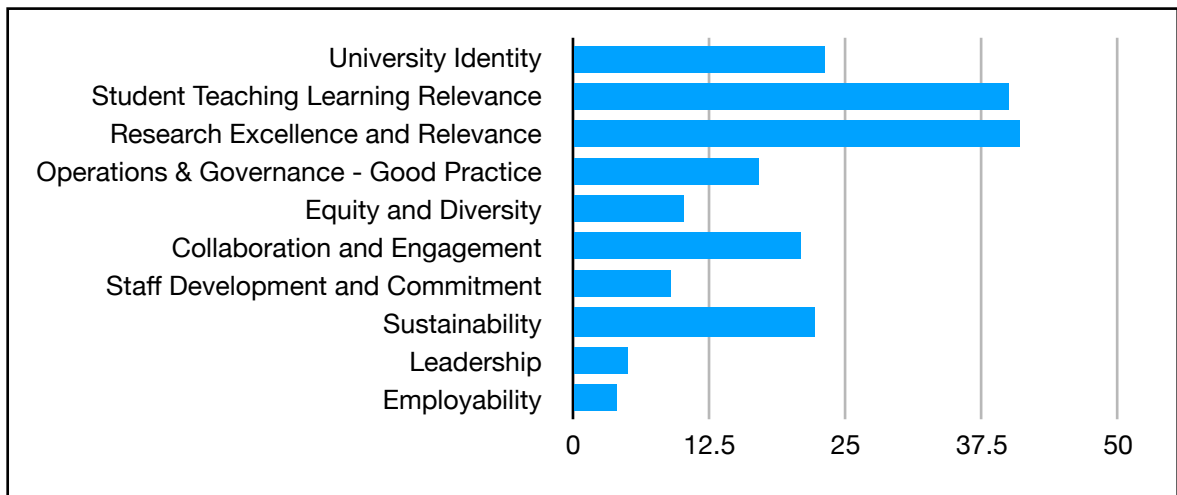
Figure 5.11. Objectives of the Strategic Plans (Sourced: Individual Australian University Strategic Plans)

Developing research partnerships with business, government, research institutes and the community were listed in 38 University Strategic Plans with 30 universities planning research impact on the community through objectives, such as, attaining global recognition, expanding research capacity (more ability, students or money) or building community capacity through university research. Figure 5.12 illustrates the planned research impact paths, 5 of the universities considered research commercialisation as impact, but no plans for a rise in this development.

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[21] Only 41 of the universities publicly published a Strategic Plan, with one university 'Torrens' not providing public access to their Plan. Data was gained for Torrens on Research Plans directly from their website.
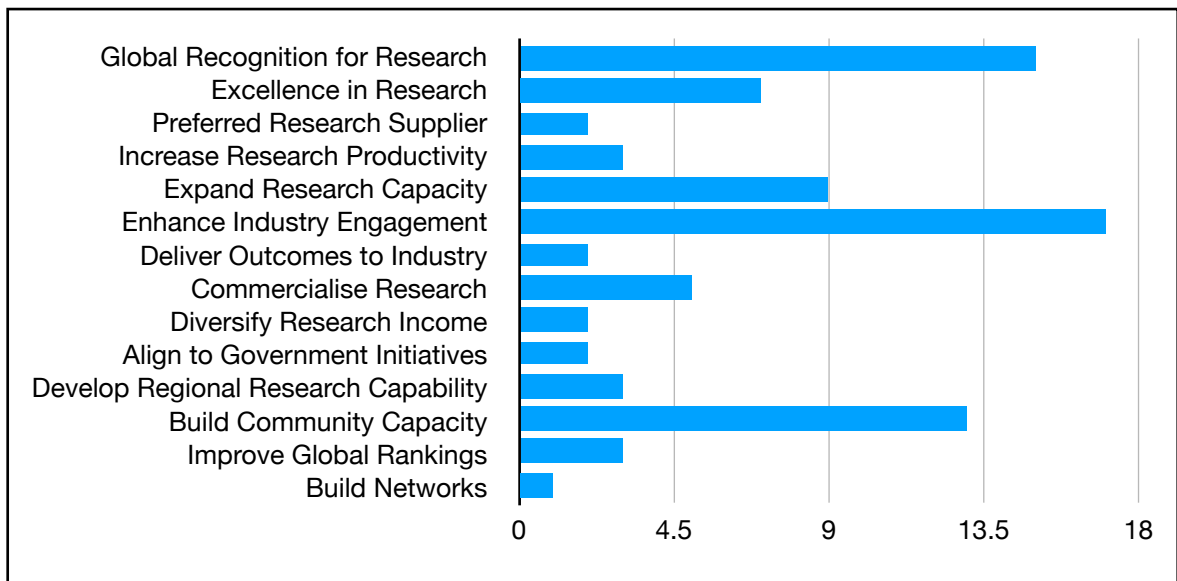
Figure 5.12 Planned Research Impact of Australian University Strategic Plans (Sourced: Individual Australian University Strategic Plans)

Commercialising university research was an objective in 11 of the University's Strategic Plans and 12 universities were planning to increase research revenue by sourcing funding through industry support or philanthropic donations, i.e. not sourcing more revenue through commercial transfer. However, only 2 of the universities planning to increase their research revenue (i.e. 12 of 40) were also planning to commercialise university research, demonstrating no common link between raising research revenue and the opportunity to commercialise research outcomes (Finding 9).

System disconnect was further demonstrated between the Acts of Incorporation and the intent in the Strategic Plans. Twenty-eight (28) universities provided for commercial exploitation of research within their Acts (Section 5.3.2.1), however, only 9 universities transferred this intent to their Strategic Plans, with a further two universities providing for commercial outcome in their Strategic Plans with no corresponding link back to their Act of Incorporation(Table 5.7). This demonstrates a disconnect between the Act of Incorporation and the Strategic Plan that is to carry out the intent, therefore, therefore, not representative of the purpose of the organisation. (Finding 10).

Intent of the University Strategic Plan for Research Commercialisation in Australian Universities					
Number of universities	Research partnership with business, government, research institutes & the community	Planning Impact of research results on community	Planning to commercialise university research	Increase research revenue	Planning to commercialise and increase research revenue
41	37	30	11	12	2

Table 5.7. Intent of the University Strategic Plan for Research Commercialisation in Australian Universities (Sourced: Individual Australian University Acts)

The Strategic Plans had little intent to commercially develop research outcomes, and, with no firm directive in the Acts of Incorporation (Section 5.3.2.1), commercial development of research outcomes is not mandated or required to generate income. Therefore commercialisation, or "commercial transfer" cannot be considered as the Goal of the Strategic Plans. Instead there is a focus on seeking institutional or organisational partnerships for the purposes of funding, not growth of new product development and community relevance through commercial output. This analysis demonstrates the Goal of the Strategic Plans does match the university's intent to educate and research. Section 5.3.2.3 undertakes an analysis of the university policies that guide the commercial treatment of research outcomes.

5.3.2.3 Analysis of the Policies

Even though, given somewhat sparse, coverage in the Acts of Incorporation and Strategic Plans, it is still reasonable to expect that an Australian university would have a stand-alone focussed commercialisation policy that provides a quality framework for the process of commercially transferring research outcomes (Dooris 2003). This did not prove to be the case, instead the potential development of research outcomes into commercially transferrable Intellectual Property lies within the Intellectual Property Management Suite of Policies forming part of the Intellectual Property Management Tools alongside the management of research activities, personnel and student research activities.

An investigation into the Policies demonstrated common nodes of Identification of IP; Revenue Distribution; Disputes; IP Ownership Establishment; however, no node specifically allocated to Finding an Industry Partner or "recipient". In addition, the Objective, Introduction or Intent[22] of the Intellectual Property Management Policies of Australian Universities are written from different perspectives. These differing perspectives include the possible development of Intellectual Property and return of revenue; the risk surrounding the Intellectual Property moving through the system (i.e. publish, secrets etc); and allocating responsibility for decisions and actions. Along with the common nodes, the Intellectual Property Policies are constructed mostly in a linear format, followed a similar design containing common nodes[23] (Appendix L) (Figure 5.3) and held little evidence of feedback loops, and focussed on moving responsibility through the system. Initially this research assumed that these nodes would identify the departments or units that were to undertake defined activities within the system and these decisions guide the system stakeholders. Rather, execution responsibility lay with key figures (usually individuals) within the process, specifically, *Researcher* or *Commercialisation Personnel* that include the Commercialisation Manager, DVC Research or similar, or legal and accounts. Further supporting a low level of implied importance to practice by subordinating roles to individuals, not departments, and indeed, was a potential conflict, such as, the accounts department needing to pay for legal or Intellectual Property investigation, halting the process for budgetary reasons. The decision making responsibilities of the system stakeholders are outlined in Table 5.8.

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[22] Objective, Introduction or Intent are used interchangeably when the Universities are discussing policies and generally have a similar meaning within their communication process.

[23] Of the 41 Australian Universities identified for this study, the policies were unable to be sourced from 2 universities as they were under review and one is classed as a 'special' university and does not develop the outcomes of research. Leaving a 38 universities (n = 38).

Responsible Decision Maker Listed in Australian University Intellectual Property Management Policies - Node Occurrence								
	Policy n=38	Research Staff	Uni Comm Unit	DVC	Legal & Finance	Industry	Faculty	Uni	External IP Profession
Identify									
Identify IP & Notify	35	32							
Uni Protect IP									
IP Ownership Establishment	25	29	23	8			4	8	
IP Restrictions during decision process	2								
Educate on IP protection	3								
Investigate IP Viability									
IP dev. Discussion with researcher & Uni	16	18	22	6	5		1	8	1
Manage publication & commercial	4								
Decision to develop IP									
IP Development									
Revenue Distribution	34	1	12	13				11	
Moral Rights	13								
Disputes	26								
Uni choose not to commercialise	13								
Finding an Industry Partner									
Finding an industry partner	0	2	9	2				2	
Spinoff Company	2								

Table 5.8 Responsibility Centres and Common Nodes in the Spreadsheet (Appendix O). Note: where there is no responsibility cited in this table, it was not allocated in the policy.

Located in 32 of the Intellectual Property Management Policies was the singular responsibility to trigger (launch) the commercialisation process was the Researcher, though the action of reporting potential commercially relevant Intellectual Property. This singular responsibility represents a conflict of interest within the process, as the researcher is additionally responsible for seeking funding for new research, and may

face a choice between these two time intensive processes and perhaps restricting career progression, through lack of publication activity, as research is quarantined during the IP development process (Section 5.3.3.2). After the initial trigger to enact the system, further decision processes are needed to move the system forward, such as, budget availability; fit with university strategy; and availability of an industry customer, the risk at each stage is the system will halt due to a negative decision and the Intellectual Property will not be developed any further.

Although a stand-alone Commercialisation policy was not discovered, it was found that funding applications require compliance to the *National Principles of Intellectual Property Management of Publicly Funded Research* (ARC 2018a) and the *Australian Code for the Responsible Conduct of Research* (NHMRC 2018) to demonstrate the existence of governance structures for the ethical management of funding. This discovery is significant as the varied internal focusses in the policies, along with the absence of customer focus demonstrates a lack of continual improvement practices and identified measurements to support a quality management system, further provide opportunity in the system for self-serving inward facing eco-systems to be nurtured at the expense of developing research outcomes for commercial transfer (Finding 12).

5.3.2.4 Research Commercialisation Goal of an Australian University

To identify the Goal of Australian universities published in their Acts, Strategic Plans and Policies, the relationship was mapped between the processes of university research commercialisation (Sections 5.3.1 through to 5.3.2.4) (Dettmer 1997; Goldratt & Cox 2016; Inman et al. 2009; Moroz et al. 2016; Taylor et al. 2006). This mapping shows that the Acts typically provide for the opportunity to commercially exploit research, however do not specifically state that the commercial exploitation is to be a transfer to industry, or that customer identification is required. The Strategic Plans, somewhat, align with the Acts, although the focus is the promotion of the university image, its unique projects and the resulting reporting responsibilities (i.e.

looking for an opportunity to promote the university to governing bodies). Constraints and conflict were identified through the typical focus on short term projects, facilitated through student, Government or Industry funding, to satisfy the measurement and reporting requirements, rather than longer term development of industry relationships to enable research outcomes to be developed into market ready offerings. University policies acknowledge the value of research, usually as a process that needs to be managed for governance and compliance, often omitting the more difficult activities of Intellectual Property development (IP) (i.e. readying for commercial transfer), or at best IP is vaguely addressed, such as, consult industry, or outsourced to external bodies, therefore, not addressing the policy focus (i.e the development of Intellectual Property from a research outcome). Put simply, university governance of the commercialisation of research output demonstrates poor policy development and an arms-length approach to the activity of industry collaboration. As a result of this research, the university governing documents identify the Goal of the university as the provision of education, research and the dissemination of knowledge and do not promote the tangible outcome of commercial transfer of research outcomes to address the evidence required by the Government. This results in a misalignment of the expectations of the system of university research commercialisation between the Australian Government and Australian Universities (Finding 13).

5.3.3 Analysis of the "Common" System Stakeholder Goal

The "common" stakeholders identified in Section 5.1.3 were typically only undertaking one function for the university, such as researching or commercial development. However, two stakeholders demonstrated combined experiences as university researchers, private commercialisation practitioner, and, developing personal Intellectual Property for commercial transfer (Table 5.9).

Breakdown of stakeholder interview categories				
University	Researcher	University Commercialisation Personnel	Industry	Industry Commercialisation Practitioner
UNI1 *The Mature Uni*	2	1		1
UNI2 *The Young Uni*		3	2	1
UNI3 *The Establishing Uni*	3	1		
INDUSTRY	1	1	1	3

Table 5.9. Breakdown of stakeholder interview categories

The Goal of the University differed between "common" stakeholders, and this research found it to be dependent on the functional responsibilities held by the stakeholder within the system. Although, all stakeholders, including industry, were in agreement that universities were designed to educate, research and disseminate knowledge for the benefit of the wider community, there were varying opinions between the stakeholders on how this should be done. In line, this study found the university based stakeholders concentrated on addressing the more immediate goals of their employment or vocations, such as, developing networks and sourcing funding to enable projects (educate and research), not customers for their research outcomes to enable commercial transfer.

All stakeholders demonstrate multiple external network memberships for collaborative purposes and stressed that networks were successful when personal connections (relationships) were formed, becoming part of their own personal network. These personal connections were severed if one or more of the players move on to a different organisation or project, identifying a constraint if the contact is lost, and possibly losing the champion for the research (INT2, INT3, INT4, INT5, INT8, INT9, INT13, INT14) (Finding 14). Interestingly, when university/industry collaboration is promoted by either party, it is the organisational business to business (B2B) collaboration that is generally promoted to the public, not the personal bond that was required to initially develop and then cement the collaboration (INT4, INT13, INT8, INT2). Table 5.10 outlines the stakeholder networking patterns

reported in the interview conversations, again demonstrating that the purpose of the network differed depending on the stakeholders' position within the system.

Stakeholder Networking of the "Common" Stakeholders							
Stakeholder	University	Research Institution	Industry	Peer Researcher	Peer Uni Comm Profession	Peer Industry Commer	Peak Body
INT1	1						1
INT2	2				1		
INT3	2					2	
INT4	1	1	1				1
INT5	1			2			
INT6	2		1			1	
INT7	4					1	
INT8	1	1		1	1		
INT9	1	3		1	1		
INT10	1				1		
INT11	1						
INT12	1		1				
INT13	1				1		
INT14	1	1			1		
INT15	1						

Table 5.10. Stakeholder Networking Intensity (Source: Interviews)

When the allocation of funds and resources was questioned in the context of *'who pays you?'* and *'who do you pay?'* (Section 4.3.2.2) it was found that even though the stakeholder understood the position they held in the system, they had little understanding or interest in the processes surrounding their specific niche, including the flow of the funding. This lack of understanding demonstrates the siloed nature of the elements of the system, putting the system at risk due to low vision (cannot see the system before, or after) causing a constraint when there is a flow problem (Finding 15). This difficulty was highlighted when the stakeholders were asked to verify their knowledge by illustrating the system from their perspective and identify the part they play within this system. Interestingly, half of the interviewees did not agree to undertake this task, providing reasons such as *'it is too broad'; 'depends on the way you look at it'*; or suggesting that the researcher independently source the

organisation's published version instead as it outlined the process (INT1, INT2, INT10, INT11). Demonstrating conflict in the system if there is ambiguity on how the system works, and constraint, as they are unable to identify the people and processes in the system (INT4, INT10) (Finding 17). The stakeholders that did provide an illustration showed a mixed level of detail that ranged from comprehensive - Figure 5.13 (INT5), to an overview of the system - Figure 5.14 (INT8) & Figure 5.11 (INT9). The outcome of this activity demonstrating a surprisingly low level of knowledge for some stakeholders of the system and supported the finding of the absence of a known system.
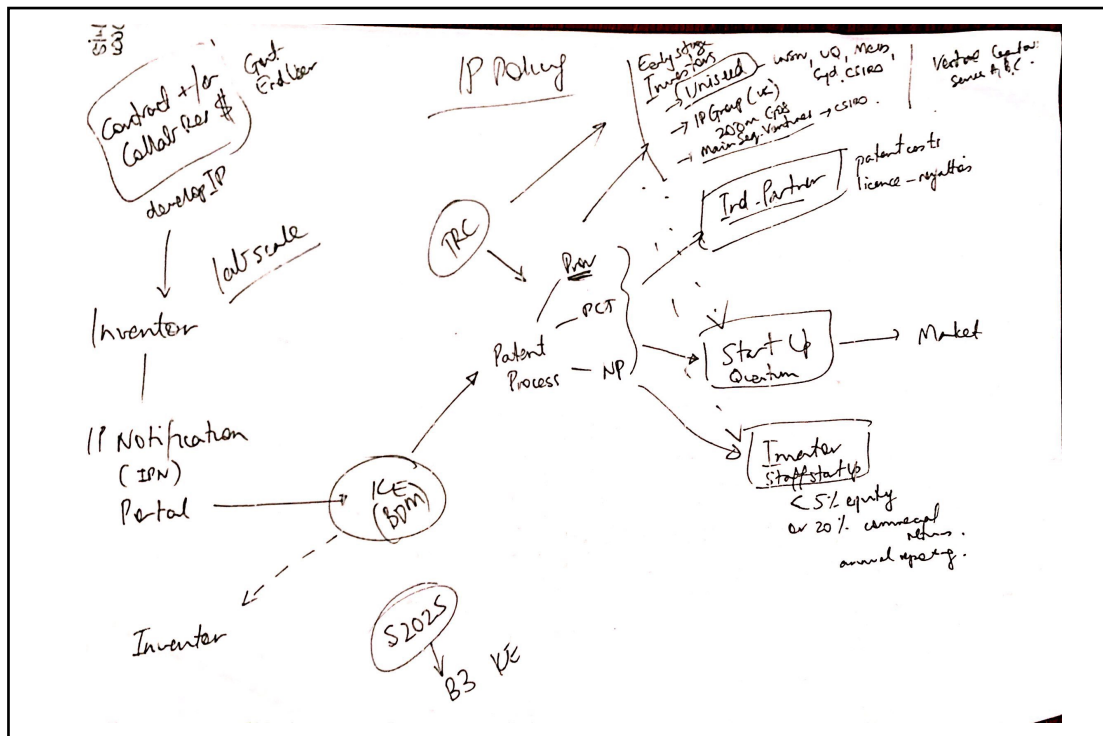
Figure 5.13. INT5 Discussion of the Process (commercialisation personnel)
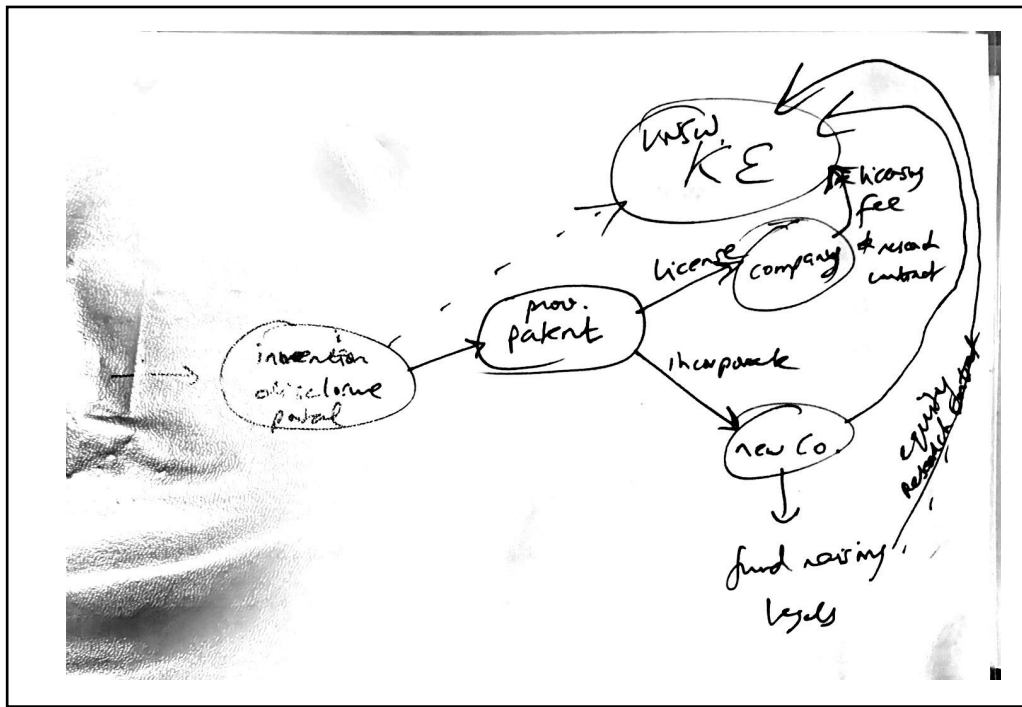
Figure 5.14. INT8 Discussion of the Process (researcher)
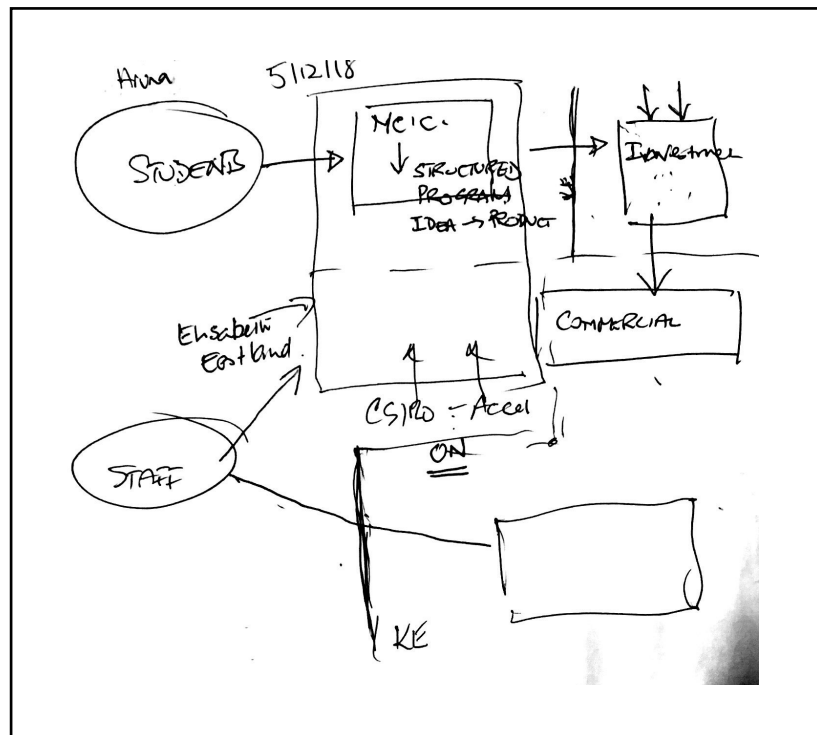
Figure 5.15 INT9 Discussion of the Process (researcher)

Sourcing industry stakeholders for interviews provided further challenge. These stakeholders were sourced through recommendations from the university itself or commercialisation personnel, with interviewed university researchers typically

unable to provide referrals for industry representatives that commercialised the outcome of university research, supporting the Finding 15, siloed view of the system.

5.3.3.1 Findings Typical to all "Common" Stakeholders

Interviews were undertaken with the internal and external stakeholders ("common" stakeholders) of the system of publicly funded university research commercialisation (Section 5.1.3) associated with the three selected university cases (Section 4.1.1). The focus was to identify the Goal of each "common" stakeholder. Five common themes were identified - *Networking, Communication, the University System, Competence, and Passive Environments.* Collaboration between university and industry was commonly discussed, however, in the context of developing relationships to source funding, support for student projects or practical support for research, not, product development or commercial transfer. Findings typical to all "common" stakeholders:

Findings typical to all "Common" Stakeholders	
Number	**Finding**
16	Different expectations from a single system. Document analysis and interviews found at the university purpose level, an Australian University is to research, teach, create and disseminate knowledge, not focus on undertaking commercial transfer of research outcomes (INT2, INT5). However, at an individual stakeholder level the focus was inward facing and servicing their own systems.
18	Interviewees struggle to describe a customer focussed system. The system is reactionary to current needs that focused on reporting to the governing body and often designed around workload commitments (i.e. inward focussed system) (INT2, INT10, INT5, INT16).
19	Publish or perish pressure on junior researchers who were caught between the pressure to publish for career advancement and the internal push to create industry networks, demonstrating a constraint caused by duality of requirements with this section of the system (INT1, INT2, INT5, INT8, INT9, INT13, INT14)
20	Moral-v-practical. As university research stakeholders the ethics of publicly funded research outcomes being 'sold' to industry, and making money (profit) from public funding (INT13), produced reluctance to commercialise as common agreement was that it should be made available for the community's benefit (INT1, INT2, INT10, INT13). However, as private tax payers, there was an expectation of a better Return on Investment (ROI) for publicly funded research (INT2, INT5, INT9, INT13, INT15)
21	Stakeholders found networking difficult and all were reluctant to participate. It was perceived as mutually difficult, "*some are nervous about dealing with industry as it is a different activity to university research*" (INT4); not part of their job remit. This reluctance often constrained project progress as industry representatives typically wanted to speak to the researcher/inventor, not a broker (INT3, INT6). Industry were unsure how to approach an academic or university about a research project.
22	Timing of collaborative projects, in particular the 3 year cycle of the university teaching system of HDR research did not provide enough time to undertake both the task of research and commercialisation with the same team. Further, industry saw university research processes governed by the practice of university addressing the needs of industry around the teaching timeframes of a semester, such as, a 3 year Phd (INT3, INT4, INT6, INT7).
23	Difference in opinion of project importance between industry and university; difficulty with agreeing on the expectations for of the product offering, i.e. education for students versus commercial problem solving (INT7, INT13, INT3).

Table 5.11. Findings Typical to All "Common" Stakeholders (Source: interviews)

Further individual perspectives on the system is discussed by each of the identified "common" stakeholders in Sections 5.3.3.2, 5.3.3.3, 5.3.3.4 and 5.3.3.5. Table 5.17 lists all 50 findings.

5.3.3.2 University Commercialisation Personnel Goal (UCP)

The main themes emerging from the interviews with the University Commercialisation Personnel (UCP) were internal and external networking; the University system; communication; competence; ethics and the passive mode of the activities. The findings relating specifically to UCP's are:

Findings - University Commercialisation Personnel Goal (UCP)	
Number	**Finding**
24	Developing network relationships is part of the UCPs remit, and is outlined in the University policies (Section 5.2.2.3), however, UCP's typically delegate this task to the researcher (INT10, INT2, INT5), with the UCP accessing industry networks for potential Intellectual Property development much later in the process, demonstrating an absence of quality management of these important relationships and loss of focus on a customer.
25	An assumption by the UCP that researchers hold the skills, passion and time, to develop and attend the networking events, and, although training schemes for researchers were acknowledged (INT5, INT2), there is little career projection impact for the researcher and low time capacity causing constraint (INT5, INT2).
26	Instances of limited subject matter knowledge of the UCP may cause IP to remain undeveloped (INT1, INT11) (Simon 1990; KCA 2016).
27	The UCP's described the system of publicly funded university research commercialisation system as research PUSH, where research is undertaken first and a customer for any outcomes is sought much later (Miller et al. 2016).
28	Universities were not good at selling research outcome opportunity (INT2, INT4).
29	The UCP's see the system as a passive environment, with potential Intellectual Property thrust upon them through disclosure by a researcher to find an industry customer. This push often leads to an initial consideration by the team of "can we take this one on?" not "is this good for industry". A result of this activity is more IP is reported to a commercialisation unit than is progressed (INT1, INT2, INT5).
30	UCP's reported too many researchers to effectively manage by the UCP team. One UCP citing 900 researchers and only 4 commercialisation staff, and UCP's feeling they are unable to address all potential Intellectual Property for the benefit of the university and industry (INT2).
31	Lengthy time to commercially develop Intellectual Property, and the difficulty for UCPs to keep researchers interested in the process while researchers were under pressure to move to new research and seek more funding (INT1, INT2, INT5). UCP's suggested research Champion/ Intermediary that could gain and maintain traction with industry was considered valuable to keep focus on commercialisation.
32	There is little incentive to do more, the revenue split was contentious with no revenue benefit for the UCP as the UCP's job is to manage the system from identification to commercial transfer within budget and capability.

Table 5.12. Findings - University Commercialisation Personnel Goal (UCP) (Source: Interviews)

5.3.3.3 Researcher Goal (Res)

The differentiating theme within the researchers was the tension between the requirement to source research funding and publish for personal career progression. Researcher specific findings are listed below:

Findings - Researcher Goal (Res)	
Number	**Finding**
33	The researchers discussed pressure to establish industry networks and to measure the impact of these networks as an additional task (INT8, INT9, INT15, INT14).
34	Researchers were not confident on the process for sourcing a customer for the commercial transfer of research outcome, researchers often referred this task to the commercialisation personnel, the commercialisation personnel either referred this task to either their own supervisor or looped it back to the researcher. This identifies that there is no developed system for sourcing industry partners and the ambiguity causes constraint in the system (INT8, INT9, INT15, INT14).
35	Researchers were reluctant to network with industry, it was considered tedious, an extra task and taking focus away from research and teaching. Researchers found it difficult to maintain a continuous network connection as networking usually took place outside of work time and not their regular activity. Whereas, half the researchers agreed that industry networking was important (I8, I9, I14), others only undertook the task to satisfy job requirements (I13) or choose not to have any direct contact with the networking process, "avoided the topic of commercialisation as he was a researcher' (I14, I15), 'not his job, he was a researcher' (I13). This demonstrates constraint in the system due to no established requirement, and therefore, no system of measurement.
36	The researchers spoke of a mismatch in the language used by industry and the university requiring a language adjustment i.e. "having to dumb down the process to help them understand" (I8), or, "had to explain it within their own framework" (I9).
37	Research activities and commercial development were not commonly linked within the conversations with the researchers. Commercialisation was treated as an extra additional requirement.
38	Researcher held the power to not report the Intellectual Property, or to use the discovery for publication, or possibly report the Intellectual Property, but refuse to champion it through to industry transfer. This may result in the Intellectual Property falling into a state of inertia and simply deposited in the registry and left there, "perhaps someone comes along" (I5, I13, 114), potentially resulting in 'cupboards' of IP that are not being developed for commercial transfer. This results in waste in the system and a constraint on commercial transfer. However, a solution was discussed by two of the commercialisation personnel as an opportunity to connect the university with industry, and instead of finding a customer for a project, investigate if any of the IP identified was useful for industry, unfortunately this may further burden the networking activities (I5, I12).
39	Discussions with researchers supported the policy analysis outcome that researchers bore the highest responsibility for identifying possible Intellectual Property in research outcomes and industry networking (Table 5.7, Section 5.3.2.3), however it is research ability, not the ability to identify Intellectual Property and industry networking, that is the key skill required for researcher employment (Prospects 2020). Identifying constraint through misaligned capability of the stakeholders in the system.
40	The researchers definition of commercialisation responsibility, such as, considering commercialisation to be something that is adopted by somebody, either for money or even not for money (INT13, INT9) (i.e. somebody else's job).
41	When pressed on how market ready were university research outcomes, the answer was a strong "not industry ready and require further development", "not very", "not at all" (I2, I6, I13, I14) (i.e. not part of the researchers job). This need for funding for the commercialisation process, which is not included in the original funding application, was often outside of the time scope of the project, therefore, requiring extra support (I8, I9).

Table 5.13. Findings - Researcher Goal (Res) (Source: Interviews)

This research has identified that the researchers understanding of their Goal, through their actions and interaction within the system, is to undertake research and seek

more funding for research, whilst continually publishing for career progression. Again, there is no mention of "better" or scaling the result.

5.3.3.4 Industry Representative Goal (Ind)

Industry are external stakeholders to the university commercialisation system through collaborative partnerships enabling the sharing of ideas, partnered research projects, practical testing facilities, funding and the recipient of the research outcome for their commercial use. Industry are generally not concerned with the academic requirement of the system, they are concerned with solving industry problems quickly, and, to this end, industry often need persuading that academic/scientific work is necessary (i.e. time) (Berman 2008; Plewa et al. 2013), resulting in industry not undertaking collaboration for near market research and product development. It is, therefore, understandable that industry may struggle to fully understand, and trust, the university system (INT4, INT6, INT7). This research did find that industry believe that a university is to provide education and interacts with industry through research (INT3, INT7) and in a bid to bridge the gap, an Industry representative suggested longer term planning for collaborative projects, suggesting the development of large complex research projects that enabled multiple industry representatives and university researchers to undertake research in their own pockets of expertise for as long or short as needed, enabling stakeholders able to plan their research participation (INT7). How this would be managed is a topic for future investigation. Further issues listed by the industry interviewees include:

Findings - Industry Representative Goal (IndR)	
Number	**Finding**
42	Industry's perception of the cost of a university was negative, with the opinion that a university would be too expensive and take too much time to provide the more immediate results required by industry (INT7). Funding of research, typically dollar for dollar for ARC Linkage grants, or 100% for specific research, was considered too much cash for an industry to risk on a new style of research partnership and an unknown result. Industry felt that university had a perception that there is lots of available cash within industry with instances reported of one of the case studies asking for $100,000 to undertake research and university researchers not understanding business turnover and cash flow (INT4, INT7). Identifying a constraint in the system where either industry is reluctant to engage with university under their current system, or, university is unable to change their system of funding for research.
43	Industry struggled with the absence of an externally identifiable university system showing a clear path to the right academic or research department, resulting in a lack of confidence in industry accessing the university system, causing some industry members to delay attempting to collaborate with university research until evidence of success is gained from a trusted industry peer network (INT4, INT6, INT7).
44	Industry representatives highlighted the issue of trust in the system as a constraint. Although, industry viewed working with a university as gaining a competitive advantage with fresh and new perspectives to problem solving (INT3, INT6, INT7). Similarly the issue of trust is apparent within the ability of the system to deliver research results citing cross university collaboration posing problems with system and student access, stifling multiple industry and university collaboration and commercial confidentiality (INT6, INT7).
45	A further constraint was identified in the allocation of Intellectual Property ownership, where, unless otherwise negotiated, the university owns part, or all, of the IP rights with industry (Section 2.3.4) (INT6, INT7). Discussion was held on industry feeling uneasy about the ownership, and felt if the research is for their commercial benefit, they should own the IP. This finding does not correlate with the Researcher's perception of Intellectual Property development, where they had little interest in who owns the Intellectual Property, identifying a mismatch of intent and understanding, causing constraint (Finding 48).

Table 5.14. Findings - Industry Goal (IndR) (Source: Interviews)

This research has identified that the Industry had a low understanding of the University system however they understood the value; were frustrated with the cost and time requirements, disputed the current practice of Intellectual Property ownership; and, more work is needed to develop a better standard of communication, and in turn, greater trust. Again, it should be noted that there is no "better" or scaling the result in this statement.

5.3.3.5 Private Commercialisation Practitioners Goal (PCP)

The Private Commercialisation Practitioners (PCP) provided similar outcomes to the other groups of stakeholders, citing difficulties in networking, negotiating the university system, communication and competency as problems with the system,

however adding professional credibility to their list of difficulties (INT3, INT4, INT6, INT12).

Findings - Private Commercialisation Practitioners Goal (PCP)	
Number	**Finding**
46	The PCPs discussed the concerns about the view of their personal credibility, having experienced common accusations from universities of drumming up work for their own company (INT3, INT4, INT6). Credibility was a strong topic and they were frustrated that they found the market hard to crack, even though they have the skills, with success only being when either university or industry were looking for support.
47	A further finding was that they were frustrated with KPI's attached to any service provided, with the requirement to "find commercialisable IP" resulting in a judgment on the quantity found, not quality (ie. nature of the commercial outcome) stating "commercialisation cannot be ordered by the bucketful" (INT4, INT12).
48	The lack of a standard to enable the development of a value for university research outcome Intellectual Property caused a communication problem on an agreed value between university and industry. In addition, it provided a point of complexity when the university chose to promote their research outcomes through Open Access, enabling a perception within the market that university Intellectual Property was valueless, inadvertently supporting the common axion that university research outcome should be made available to the public (INT3, INT4, INT5, INT12) (Links to Finding 45).
49	Conversely, questionable Intellectual Property valuation practices by universities emerged as a possible contributor to low commercial transfer, with PCP's providing examples, such as, valuing the Intellectual Property on the expenditure of the research to date (regardless of who provided the funding); or, a high expectation that business have lots of cash for IP investment, either of these could cause the IP to be priced out of the market (INT3, INT4), and in turn, contributing to the constraint.
50	Networking - PCP's added 'networking for reputation' as a motivator. Outlining that obtaining a prominent organisation for research support, such as Google, even if it is a very small portion of the funding, was very good for University reputation through association (INT4, KCA 2019), however, chasing prominent names for reputation might stifle the new and emerging outcomes from seeking smaller or more diverse partners

Table 5.15. Findings - Private Commercialisation Practitioners Goal (PCP) (Source: Interviews)

Whereas, it is acknowledged that many of the constraints identified are discussed in the literature, the use of these constraints, through constraint mapping, to undertake a constraints analysis is not.

5.3.3.6 Alignment of the "Common" Stakeholder Goals

The analysis of the system has demonstrated that all "Common" stakeholders believe the goal of the University is to "teach, research and disseminate knowledge", this is in line with the Goal of the University, however not a current intent for the University by the Government which is "better" commercial transfer of university

research outcomes (DISER 2015). Having said that, each of the "Common" stakeholder groups held different views on how this Goal was being achieved, demonstrating conflict in the system, and in turn, these conflicting intents will enable the inward facing systems to develop, causing constraint. The emerging themes of the differing views are:

- **The UCP treated the commercialisation system as a passive system,** choosing to wait for the researchers to identify potential IP and then relying on the researcher to source the industry opportunity through their own networks.

- **Researchers saw the commercialisation system as an ill-defined extra requirement of their job** and only participated in the system when ultimately necessary. These researchers preferred to research and teach, however, had a clear understanding that their ability to teach and research was reliant on seeking funding for research, either through the government or industry, and to undertake this, they were required to build networks with industry. Although seeking funding enabled the teaching and research, it is the ranking and production of publications that enable career progression, causing friction within the expectation of the researcher.

- **Industry representatives primarily required a transparent system** and easier communication on the system and process of university research.

- **A transparent system was also required by PCP'**s, with the addition of credibility with the universities.

Therefore, within the context of this research, the common identified Goal of the "Common Stakeholders" for a University is to teach, research and disseminate knowledge. Although this aligns with the university's Goal, the "common" stakeholders had differing perspectives that relate to their functional position causing conflict within the system (Finding 7).

5.4 Mis-alignment of the Whole System Goals

This research shows that the University Goal is identified as *Teach, Research and Disseminate Knowledge*, and although supported by the "Common" stakeholders (Section 5.3.3), it differs from the Government's current intent for the system, which is seeking "better" commercial transfer of research output from the system (Section 5.3.1). Table 5.16 illustrates the misalignment of the goals of the system from the perception of each university stakeholder groups. Although, the university stakeholders demonstrate a divergence of goals, they are still somewhat related to the general function of research and dissemination of knowledge. A major constraint identified is the requirement mismatch of the publicly funded research commercialisation system and the requirement (expectation) of the Australian Government.

Goals of the University Research Commercialisation System			
System Stakeholder		**Identified Goal**	**Personal Goal of the "Common" Stakeholder**
Government		*"better commercial transfer of research"*	
University		Teaching, research and dissemination of knowledge	
"Common" Stakeholder	University Commercialisation Professional	Teach and Research	Manage outcome from research within university budget and reporting requirements
	Researcher		Undertake research and seek funding for more research projects
	Industry		Seek partnerships with university for research
	Private Commercialisation Professional		Engage with university and industry for more commercial outcomes

Table 5.16. Goals of the University Research Commercialisation System (Sourced from the research)

Traditional mapping of the system demonstrates a linear process (Figure 5.1), however, using a process map methodology of the system of university research commercialisation from the perspective of determining the Goal of each stakeholder, identified the mismatch. This mapping represents the first Step in the *Thinking*

Process of the Theory of Constraints (Dettmer 1997; Goldratt & Cox 2016; Inman et al. 2009; Moroz et al. 2016; Taylor et al. 2006) '*What is the Goal of the System?*' (Section Table 4.4). Through this mapping misalignment in the system is identified that is not evident when simply mapping the flow of the system (Figure 5.16).

The tangible outcome of "better commercial transfer" of research outcomes, as required by the Australian Government, seeks to force Australian universities to change the 'intent' of their system from teaching and research to a more commercial outlook of gaining a return on investment (ROI), and as such, enable conflict and loss of focus as the 'roadmap' on how to do publicly funded research commercialisation is changed to source more output. This misalignment represents the primary constraint within the system and mitigation of this constraint is further discussed in Section 6.2.
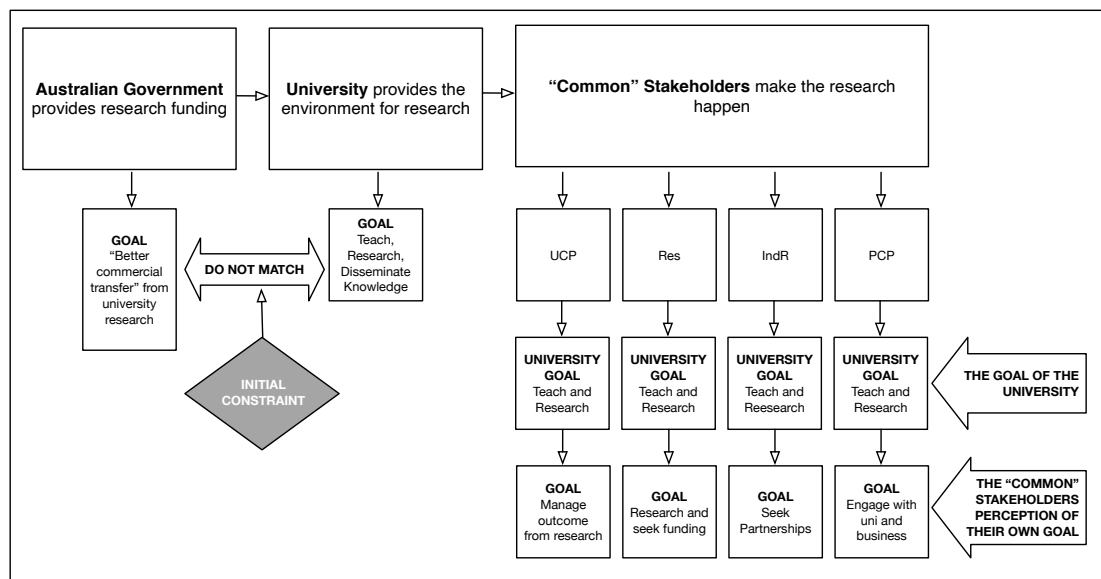
Figure 5.16. Demonstration of the Goals in the system (source: Table 5.12)

Figure 5.16 illustrates that the system of publicly funded research commercialisation has a disconnect between the output requirements of the Government, the governance system of the university and the siloed goals of the "common" stakeholders therefore proving *Proposition 2 - A disconnect exists within the*

expectations of the number and value of the outcomes of research between the initial

funder, the researchers and the university (Section 1.8).

5.5 Findings from this Research

The analysis of documents and the interviews with the "common" stakeholders identified 50 findings that lead to 7 themes of constraints. In the context of TOC Current Reality Tree mapping, identified constraint themes are labelled as Undesirable Effects (UDE) (Section 4.2.3). These UDE will enable the cause and effect mapping of a Current Reality Tree (CRT) (Section 6.1.1) to identify the root cause and then augment these root causes through the use of Conflict Resolution Diagram analysis (Section 6.2) (Table 5.17).

#	Finding	Source of finding	Undesirable Effect (UDE)
2	Staff only employed for the research project, not any further development of outcomes, resulting in loss of development opportunity, further continuity and networks	"Common" stakeholder	
8	Acts of Incorporation contain no consistent requirement to commercialise, therefore, no communicated measure	Document	
9	Strategic Plans contained no common link between raising research revenue and an opportunity to commercialise research outcomes	Document	
22	University cycle of the HDR teaching cycle did not allow enough time to research and commercialise	"Common" stakeholder	
23	Difference in opinion of project importance and outcome between industry and university	"Common" stakeholder	
26	Subject matter limitations	UCP	
27	University system is a research PUSH system	UCP	
28	Universities were not good at selling research outcome opportunity	UCP	
29	Capacity of university commercialisation system to take on all IP identified, resulting in a passive system	UCP	UDE 1 Low commercial transfer of publicly funded research to
30	Capacity of the UCP's to service all researchers	UCP	

#	Finding	Source of finding	Undesirable Effect (UDE)
31	Time to commercialise makes it difficult to keep researchers interested	UCP	industry
32	Little reward incentive within the system to commercialise more (no personal financial reward for the UCP)	UCP	
37	Commercialisation is not included in the regular practice of research	Researcher	
38	Researcher holds the power to trigger the research commercialisation system	Researcher	
39	Capacity for researchers to competently identify IP	Researcher	
40	Researchers defined commercialisation as someone else's responsibility	Researcher	
41	Funding for commercialisation not included within research funding	Researcher& UCP	
42	Industry considers university research funding too expensive	Industry	
47	KPI's associated with the amount of commercialisation	PCP	
48	No standard for the value of IP	PCP	
49	Questionable commercialisation valuation practices	PCP	
11	No policy outlined the intent to commercially transfer research outcomes developed from university research for a previously identified industry customer (Push system) to an industry customer	Document	UDE 2 No Practice of Customer Focus by Stakeholders
18	System is reactionary to departmental need, not customer focussed	"Common" stakeholder	
24	Delegation of the importance of sourcing a customer causing a loss of focus on the customer	UCP	
12	Vague quality management system	Document, "Common" stakeholder	
10	A disconnect between the Act of Incorporation and the Strategic Plan that is to carry out the intent	Document	UDE 3 Practices enable a siloed and passive environment
15	Stakeholders only understood their part of the process, enabling siloes and conflict	"Common" stakeholder	
19	Focus own academic advancement (Publish or Perish)	Researcher, UCP	
46	PCP struggle with personal credibility in the system	PCP	
3	Standard practical application of the system of publicly funded research commercialisation was not well known	University	UDE 4 "Common" stakeholders have no knowledge of the whole research commercial-isation system
17	Interviewees unable to describe a holistic system	"Common" stakeholder	
20	Tension between the moral and practical ethics of commercialising research	"Common" stakeholder	
43	Industry did not understand the university research system	Industry	
44	Industry had a low level of trust in the system	Industry	

#	Finding	Source of finding	Undesirable Effect (UDE)
1	Conflict in the university system of publicly funded research commercialisation between published intent and practical application	Document UCP	
4	Mismatch of the 'business' systems used by industry and university leading to confusion or miscommunication	Industry	
5	Different expectations from different Stakeholders	PCP	
6	Tension caused by multiple key stakeholders working to address the needs of a plural of customer and siloed individual needs	PCP	UDE5 Plural of Stakeholder Goals within the system
7	Multiple Goals of the stakeholders - Government, university and "common" stakeholder	Documents Interviews	
13	Misalignment of the expectations of the system between the Australian Government and Australian Universities	Document	
16	Different expectations from a single system between the Australian Government and the University	All stakeholder	
45	Legalities around IP ownership	Industry	
14	Networks are developed through personal relationships, not business to business	"Common" stakeholder	
21	University - industry networking activities are perceived as difficult causing constraint in the system	"Common" stakeholder	
25	Capacity of researchers to collaborate with industry	UCP	UDE 6 "Common" stakeholders find it difficult to form collaborative university-industry relationships for research projects
33	Pressure on researchers to establish networks considered outside their remit	Researcher	
34	Capacity in researcher to source customers for research outcome	Researcher	
35	Researchers lack the capacity to undertake networking activities with industry	Researcher	
36	Difference between academic and industry terminology	Researcher, PCP, Industry	
50	Networking for reputation, not commercial transfer opportunity	Industry	

Table 5.17 Thematic analysis of the Findings of the University Research Commercialisation System (Sourced from the research)

5.6 Summary

Chapter 5 discussed the data collated from an analysis of the governing documents to determine the planned practices and the goal of the system. Interviews were undertaken with the stakeholders of the system of publicly funded research commercialisation in the three case Australian universities to determine the practical application of the system and alignment of the system goals within this practice. The stakeholders were identified in three primary categories, the Australian Government,

the Australian Universities and "common" stakeholders, including, university commercialisation and research personnel, industry and private practice commercialisation representatives. The collation of the system goals demonstrated a mismatch in the overarching goal of the system between the Australian government requiring "better" commercial transfer and the Australian university system that is mandated to teach, research and disseminate knowledge. Holistically, the "common" stakeholders agreed that teaching and research was a primary intent of the university, however, each stakeholder demonstrated self-serving ecosystems to satisfy the stakeholder needs (Table 5.12). Section 5.5 developed the findings into themes for use as UDE within Section 6.1.1. Chapter 6 will analyse the impact and relationships of these identified constraints (UDE) through cause and effect mapping using the Theory of Constraints Current Reality Tree mapping (Section 6.1.1) and analyse a path of augmentation of the identified root cause of the constant through the TOC Conflict Resolution Diagram analysis (Section 6.2).

CHAPTER 6 - DISCUSSION

6.0 Introduction

Chapter 5 discussed the findings of this research and an analysis of the Goal of the three key stakeholder sets, Government, University and "Common" Stakeholders (Section 5.1). The findings from document analysis and Stakeholder interviews were sorted thematically into *Low Commercial Transfer of Publicly Funded Research; No Practice of Customer Focus by Stakeholders, System Practices enable a Siloed and Passive Environment, Low Knowledge of the Whole System, Plural of Stakeholder Goals within the System,* and, *Difficulty in Forming Collaborative Relationships.* These themes formed the Undesirable Effects (UDE) (Section 5.5) for Current Reality Tree cause and effect mapping in the (Section 6.1.1) (Dettmer 1997).

This Chapter continues to analyse the first key question of the process, *What to Change,* using Step 1 of the TOC Focussing Steps (Goldratt 1990; Gupta & Boyd 2008) and cause and effect mapping through the development of a Current Reality Tree (CRT) (4.3.3.2). The CRT uses the UDE identified in Section 5.5 to start the mapping and eventually determine the constraint hierarchy and the Root Cause (Section 6.1.1). Once the order of hierarchy is determined, the next phase - *What to Change To* is developed using a Conflict Resolution Diagram analysis (Cox et al. 2005; Gupta et al. 2011) (Section 6.2). In the next phase, *How to Cause the Change,* the logic of the solution is then tested through a Future Reality Tree analysis (Chou et al. 2012; Reid & Cormier 2003) (Section 7.1).

6.1 Constraint Identification

This section will use the collated Undesirable Effects (UDE) to develop a Current Reality Tree (CRT) of the system to identify the Root Causes that are causing constraint in the system (*What to Change*). A Conflict Resolution Diagram will then be developed to identify *What to Change to*. The results of this analysis will enable

the development of the last stage (*How to Cause the Change*) through the development of a Future Reality Tree to test the logic of the solution in Section 7.1.

6.1.1 Mapping the Current Reality Tree (CRT) - *What to Change*

It is tempting to declare the existence of multiple Goals as the cause for constraints in the system, however, this would not address why constraints exist, and, would be simply jumping ahead to 'band-aid', 'quick-fix' or develop a compromise to address the constraint, none of these actions would provide a long term solution (Taylor et al. 2006; Umble & Umble 2015). Constraint in the system should be eliminated, not masked, and further investigation is needed to identify the Root Cause (RC) of the system constraints, and then put in place actions to ease (or eliminate) the constraint (Dettmer 1998; Rahman 2002; Umble & Umble 2015). The identification of constraints (something stopping continuous flow) in the system has demonstrated that the system can be measured through the use of the Theory of Constraints Thinking Process. Therefore satisfying *Proposition 1 - The process of university research commercialisation is a supply system and therefore can be mapped and measured within supply parameters and audit methods* to be true (Section 1.8).

Through interviews with the "common" stakeholders and an analysis of the published system from University and Government documents, a list of Undesirable Effects (UDE) (Section 5.5) were developed to enable the Current Reality Tree mapping of the system (Section 4.3.3) (Figure 6.1). It is common practice to identify around 10 UDE in the analysis process and literature recommends to only map the top five or six ranking UDE to avoid the analysis process becoming too complex. The UDE is typically ranked for importance by further discussion within the analysis team, however, in the case of this research, six UDE were identified, and all six will be used in the analysis (Dettmer 1998; Rahman 2002; Umble & Umble 2015). This research identified 6 UDE (i.e. thematic groupings of findings from the research) and will include them all within the mapping. An initial listing of the UDE is in Table 6.1 and discussed in more detail in this section.
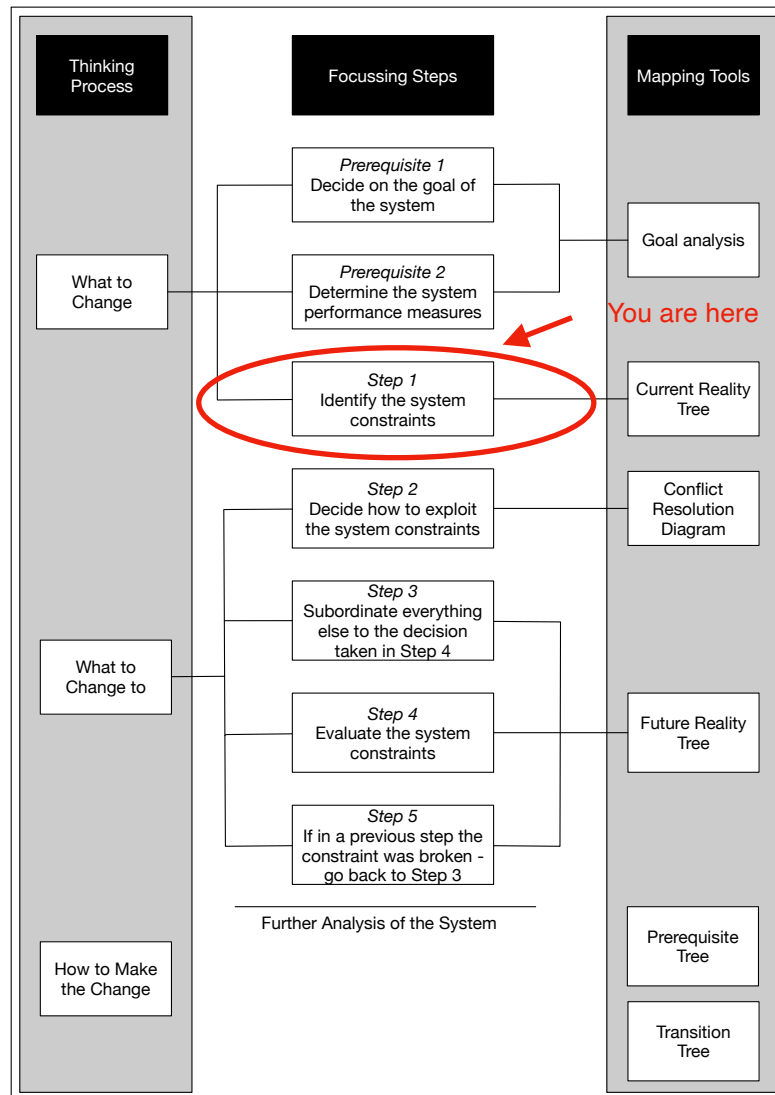
Figure 6.1. Theory of Constraints Methodology Map - Place Locator - Current Reality Tree

Undesirable Effect (UDE)	
UDE	**Description**
UDE 1	There is a low commercial transfer of publicly funded research to industry
UDE 2	No practice of customer focus by stakeholders
UDE 3	Practices enable a siloed and passive environment
UDE 4	"Common" stakeholders have no knowledge of the whole research commercialisation system
UDE 5	Multiple Goals within the system
UDE 6	"Common" stakeholders find it difficult to form collaborative university-industry relationships for research projects

Table 6.1. Undesirable Effects (UDE) (Chovancova & Stopka 2017; Rahman 2002; Umble & Umble 2015)

6.1.1.1 UDE 1 - Low Commercial Transfer of Research to Industry

Low commercial transfer (UDE 1) shows cause and effect feeds, such as, not able to map the system (R22); low customer focus (UDE 2); multiple goals (UDE 5); and, ambiguity in the system (R46) blocking the ability of the system to work effectively towards accessing industry, developing relationships and transferring research outcomes. In addition, researcher skill absence and the "common" stakeholder view that the push for "better" commercial transfer of research outcome is considered an additional task in an already overburdened system.

6.1.1.2 UDE 2 - No Practice of Customer Focus by Stakeholders

Research funding can be sourced without an industry partner, therefore, a partner was not often sought until after the research was complete and Intellectual Property identified. This practice results in an environment where the research, or outcome, was unable to be developed to customer specifications. Additionally, the Multiple Goals (UDE 5) identified for stakeholders within the system was due to stakeholder specific priorities taking precedence over the commercial transfer Goal, such as, publishing in journals, further research projects, teaching or enabling evidence for the further application of funding, all demonstrating that the researcher held control over the system choices (Section 5.3.3.1), thereby, demonstrating ambiguity in the identification of the customer.

6.1.1.3 UDE 3 - Practices Enable a Siloed and Passive Environment

The university knowledge management team discussed a passive environment, in which they wait for the researcher to report potential Intellectual Property (R85). This was contributed to a high number of researchers and very low numbers of commercialisation personnel, leading to a situation where the UCP did not need to seek participation from the researchers.   This demonstrates a constraint in the

throughput of the system, no focus on the customer, and an absence of a clear system to enable a path between research outcome and commercial transfer to industry.

6.1.1.4 UDE 4 - Low knowledge of the Whole System

The system was not well understood, with individual stakeholders only understanding their own section of the system and its associated output requirements, (i.e. sourcing funding). This was evidential as none of the interviewees could verbalise clear steps on how university/industry collaboration works, or even, does not work. Further evidence of low knowledge of the system was the absence of the early identification of a target company for the research output (Zhou 2015).

6.1.1.5 UDE 5 - Multiple Stakeholder Goals within the System

A multiple of Goals were identified internally within the system enabling the existence of siloed inward looking sub-systems (Table 5.12). These include:

- Teaching, research and dissemination of knowledge.
- Manage outcome from research within university budget and reporting requirements.
- Undertake research and seek funding for more research projects and teaching
- Seek partnerships with industry for research.
- Engage with university and industry for commercial outcomes to satisfy industry's need.

The multiple goals enabled a blurring of the system, and supported individual perception of the stakeholder purpose, not a singular customer focus.

6.1.1.6 UDE 6 - Difficulty in Forming Collaborative Relationships

"Common" stakeholders reported that the key tool used to build collaborative university/industry relationships was personal connection (i.e. person to person) and that this relationship could be broken easily when one party moved on. Researchers

and industry reported that the time needed to initiate and build these relationships was too costly on their own resources. Another difficulty supporting the time resource comment was the differing time management requirements of a university semester system and the urgency of new product development within industry. It was also discussed that process was hindered by issues in communication of concepts between research outcomes and near market products, and importantly, differences of opinion on the reason for the collaboration, i.e. facilitating student activities or product development.

The Current Reality Tree mapping was undertaken using the process outlined in Section 4.3.3.3 to identify the Root Causes (Figure 6.2). The mapping identified two Root Causes *RC1 Absence of legislation requiring commercialisation,* and*, RC2 No identifiable path or process for collaboration.* These will be addressed in Section 6.1.2.

6.1.2 Identification of the Root Cause of the System

Within the context of this research, the major constraint in the system is identified as the one with the most nodal paths (83%). This was identified as *"Absence of legislation requiring commercialisation - RC1"* (Table 6.2). The other root cause identified within this system is *"No identifiable path or process for collaboration - RC2",* this Root Cause will be addressed after mitigating RC1, if, after mitigating RC1, it is deemed that RC2 is still a viable constraint (Dettmer 1998; Rahman 2002).

Identification of the Root Cause (primary constraint)		
Undesirable Effect (UDE)	**Description**	**Root Cause (RC)**
UDE 1	There is a low commercial transfer of publicly funded research to industry	**RC1** Absence of legislation requiring commercialisation
UDE 2	No practice of focussing on the customer by Stakeholders	
UDE 3	System practices enable a siloed and passive environment	
UDE 4	"Common" stakeholders have no knowledge of the whole research commercialisation system	
UDE 5	Multiple Goals within the system	
UDE 6	"Common" stakeholders find it difficult to form collaborative university-industry relationships for research projects	**RC2** No identifiable path or process for collaboration

Table 6.2. Identification of the Root Cause (primary constraint) (Chovancova and Stop 2017; Dettmer 1998; Rahman 2002; Umble & Umble 2015)

The mapping of the Current Reality Tree (CRT) (Figure 6.2) was developed using the guiding steps in Section 4.3.3.2. The 6 UDE were identified through thematic analysis and discussed in Section 5.5. Cause and effect questioning is used to construct the CRT, with each node treated with the question *if... then.....* The nodes are numbered for easy identification and the mapping symbols and format follow a developed path by Dettmer (1997) and Umble & Umble (2015) for the design of the mapping and Taylor et al. (2006) and Rahman (2002) for the idea to number the nodes for identification and map communication. Figure 6.3 outlines the Legend of the Current Reality Tree mapping system used.
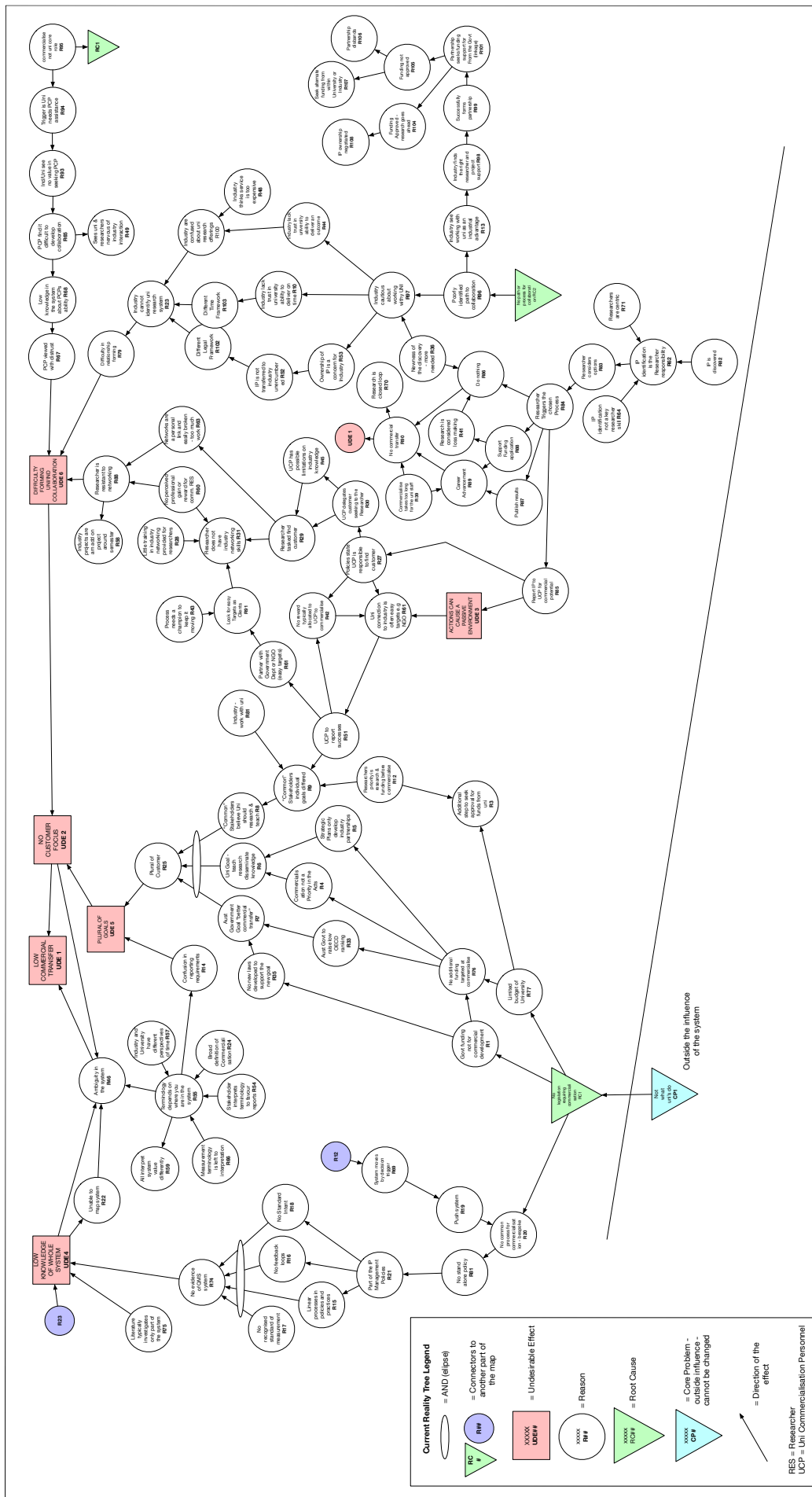
Figure 6.2. Current Reality Tree (sourced: document analysis and interviews with participants)

Current Reality Tree Legend

⬭ = AND (elipse)

RC # (triangle) **R##** (circle) = Connectors to another part of the map

XXXXX **UDE##** = Undesirable Effect

xxxxx **R##** = Reason

xxxxx **RC##** = Root Cause

xxxxx **CP#** = Core Problem - outside influence - cannot be changed

↗ = Direction of the effect

RES = Researcher
UCP = Uni Commercialisation Personnel
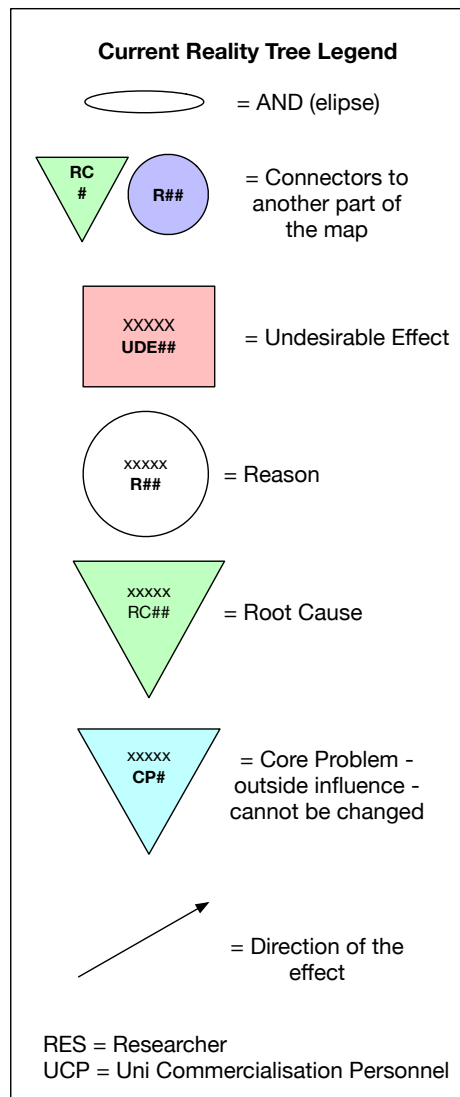
Figure 6.3. Current Reality Tree Legend (Dettmer (1997); Umble & Umble (2015); Taylor et al. (2006); Rahman (2002))

The Current Reality Tree mapping enabled the identification of *What to Change* through the identification of a primary Root Cause (RC1) - *Absence of legislation requiring commercialisation* (Table 6.2).(Kim et al. 2008).   Universities are mandated through the Higher Education Support Act 2003 to undertake teaching, research and disseminate knowledge (HE Act 2003), this is repeated in the university's individual Act of Incorporation.   Focus is lost through reporting responsibilities to the research funder (Australian Government) where there is an expectation that there is to be "better" commercial transfer (DISER 2015), a requirement that is not supported by legislation (Figure 6.3). All activities within a university, including research actives, must adhere to the legal framework of the

university to ensure compliance with the licensing of an Australian Higher Education Institution and eligibility for funding (TEQSA 2018) (See Section 5.2.2).
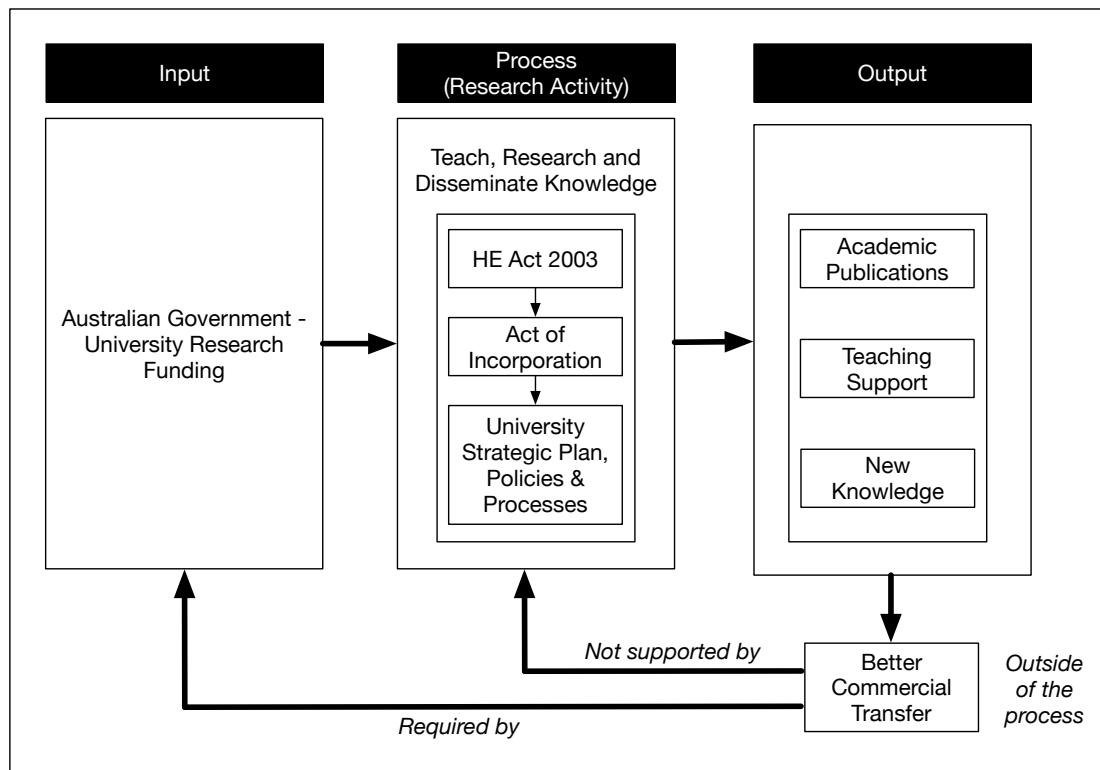
Figure 6.4. "Better" commercial transfer is outside of the legislation (RC1)

The process of Current Reality Tree mapping identified the primary Root Cause to be an a*bsence of legislation requiring commercialisation*, satisfying the first phase of the TOC Thinking Process. The next phase of the Thinking Process is undertaken through analysis using the TOC Conflict Resolution Diagram to determine *What to change to?* (Gupta et al. 2011; Sommer & Mabin 2016).

6.2 Conflict Resolution Diagram (CRD) - *What to change to*
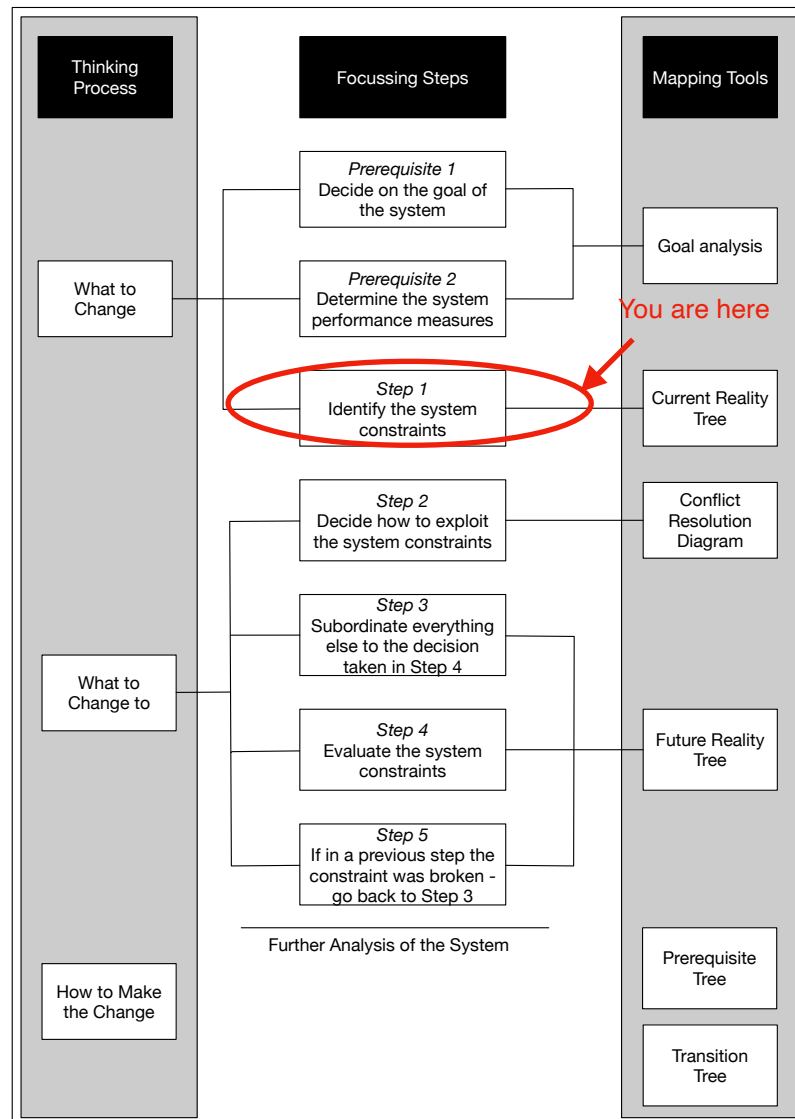
Figure 6.5. Theory of Constraints Methodology Map - Place Locator - Conflict Resolution Diagram

The Conflict Resolution Diagram tool addresses complex trade-off situations where a plausible solution was being sought for a complex root cause problem (Goldratt 1990; Kim et al. 2008) (Section 4.3.3.4). The conflict resolution logic is, if the current situation is causing constraint, then the opposite "should" not cause constraint (flip the problem on its head) (Gupta et al. 2011; Kim et al. 2008). Within the context of this research, the complex situation identified is the requirement by the funder of university research (Australian Government) to gather data on "better" commercial transfer, however, the legislative framework that the university and the funder operate within does not mandate commercial transfer of research, identifying

an absence of supportive legislation at the Australian Government level. The flip required is the impetus to commercially transfer university research to industry by creating a change in the collaboration and legal relationship between university and industry.

The tool enables analysis to resolve the conflict, using a step by step system logic of *we must… in order to…*, where the objective is recognised and the alternative processes worked through to achieve it, details are in Table 6.3 and Figure 6.6. The current practices of the university are identified in Prerequisite 1 "*Undertake research for knowledge development and dissemination*", to do this the requirement of the university is "*Research activities are compliant with University Acts, Strategies and Policies*" (R1). However, this does not address the Objective of the system that has been identified through this research "*University develops research outcomes that are relevant for knowledge development and commercial transfer to industry*" (O). To address the Objective, a change is needed in the system. To enact change, the TOC Conflict Resolution Diagram analysis uses a concept from the Theory of Inventive Problem Solving (TRIZ) to view the system from the other way around to source an alternate solution (Dalton 2009; Kim et al. 2008; Sousa-Zomer & Cauchick Miguel 2017). Looking at the university research system from the perspective of the required outcome of the university, enables the establishment of an opposite pre-requisite, as developed in P2 "*Undertake research for "better" commercial transfer*". This would require the Acts, Strategies and Policies to be changed to reflect the requirement to commercially transfer, in turn, enabling the objective.
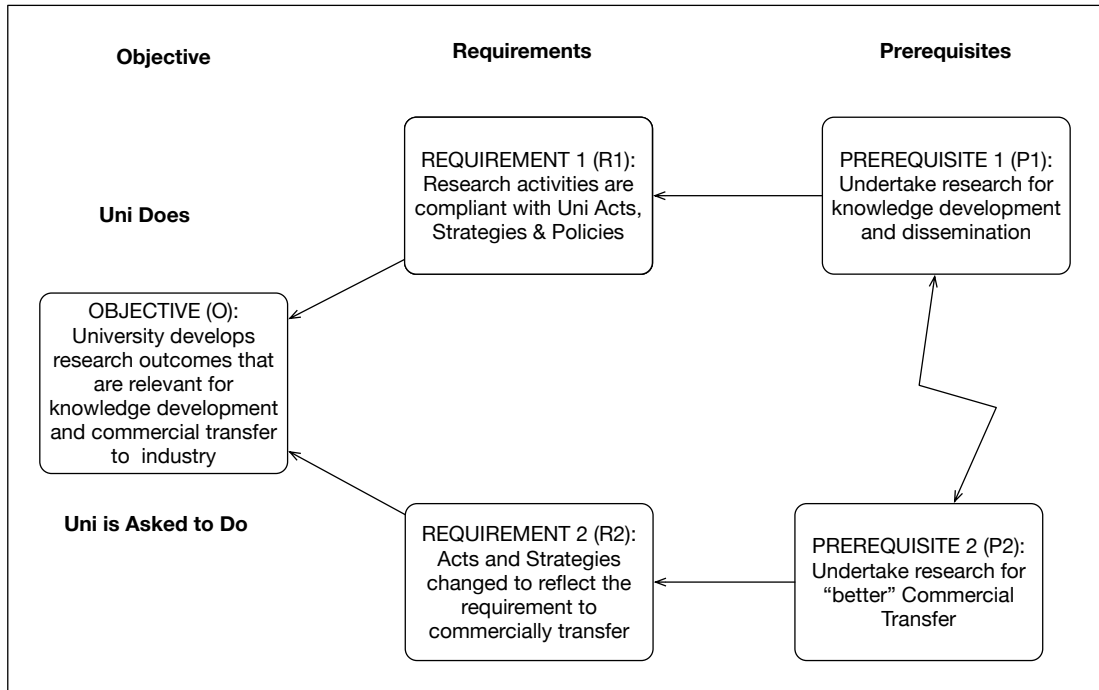
Figure 6.6: Conflict Resolution Diagram (Gupta et al. 2011; Kim et al. 2008)

Assumptions of the System, and Injections to eliminate the constraint	
Assumptions	**Injections**
Objective-Requirement 1: In order to **O** *University develops research outcomes that are relevant for knowledge development and industry*, then **R1** *Research activities are compliant with University Acts and Strategies*, because…. • University Acts and Strategies are developed to support the university to undertake research for the knowledge development and dissemination • University can only act within legislative requirements	Injection 1 - University continues to undertake research in compliance with current Acts and Strategies.
Requirement 1-Prerequisite 2: In order to **R1** *Research activities are compliant with University Acts and Strategies*, then **P1** *Undertake research for knowledge development and dissemination*, because…. • Requirement of the governing legislation	Injection 2 - University continues to undertake research to enable knowledge development and dissemination and does not choose to commercially transfer.
Objective-Requirement 2: In order to **O** *University develops research outcomes that are relevant for knowledge development and industry*, then **R2** *Acts and Strategies changed to reflect the requirement to commercially transfer*, because…. • There is no current governing legislation that requires a university to commercially transfer research outcome	Injection 3 - Acts and strategies can be changed to be compliant with the requirement of "better" commercial transfer, however they would not be compliant with Legislation. Injection 4 - University develops independent functions for research and development and seeks an independent source of income to commercially transfer IP, therefore addressing Govt requirement for "better" and not compromising governance requirements.
Requirement 2-Prerequisite 2: In order to **R2** *Acts and Strategies changed to reflect the requirement to commercially transfer*, then **P2** *Undertake research for "better" Commercial Transfer*, because…. • If the governing legislation is changed then the university can comply with "better" commercial transfer	Injection 5 - Governing legislation is changed to require universities to commercially transfer research outcomes, however this changes a university from a knowledge development institution to an industry collaboration reliant institution, therefore, changing the compliance to their own Act. Injection 6 - Governing university legislation is circumvented by changing the process of funding for the university for research. The suggestion is that Government funds industry for research to be undertaken by university, therefore, the legislation for the funding process is changed, not the legislation that identifies a university.
Prerequisite 1-Prerequisite 2: University cannot **P1** *Undertake research for knowledge development and dissemination*, and **P2** *Undertake research for "better" Commercial Transfer*, because…. • Knowledge development and dissemination is not the same as specifically commercially transferring the outcomes of research	Injection 7 - University could develop more industry relationships, however that may not result in "better" commercial transfer.

Table 6.3. Assumptions of the System, and Injections to eliminate the constraint (sourced: Sommer & Mavin 2016)

Table 6.3 was developed to demonstrate the Injections developed to attempt to 'break' the assumptions of the system. Injection 1, 2 and 7 saw no changes made to

the current status quo, Injections 3 and 4 require the university to internally make changes to their own governance, however this does not address the constraint of the university being asked to undertake a different path for their research outcome than supported by their Legislation. In the context of this work the universities are asked for "better" commercial transfer, the measure of "better" has not been clarified in the literature, and for this work's purpose, better is considered as 'more' (Bornmann 2017; DISER 2015). Injection 5 requires the governing legislation to be changed, however the implications of this process would be a change in the definition of the whole university intent, and take the focus away from teaching, researching and disseminating knowledge to seeking commercial return for their research, in turn, changing the identity of a university. This leaves Injection 6 representing a solution to the arduous task of changing the process of research commercialisation and involves the suggestion is that Government funds industry for research to be undertaken by university, therefore, the legislation for the funding process is changed, not the legislation that identifies a university. Although there is a move towards this model of funding with Linkage Grants requiring a partnership between the university and industry, the funding is still reliant on the University to seek the funding, and in turn, the Industry Partner. Injection 6 suggests that industry finds a university partner.

This research has demonstrated that the system of publicly funded research commercialisation has multiple constraints in the system, originating from a mismatch in the outcome requirement of the publicly funded research system, that lead to interpretations of the guiding strategic plans and policies enabling a best fit for individual stakeholders and a loss of focus on the client. A TOC Current Reality Tree cause and effect mapping resulted in the identification of a primary Root Cause, *RC1 - Absence of legislation requiring commercialisation,* and the development of a mitigating strategy (further discussed in Chapter 7). This finding provides confirmation that *Proposition 3 - There are internal and external constraints in the system of university scientific research that hinder the research outcome being*

commercially transferred to industry (Section 1.8) can be proved and identified constraints can be eliminated to improve the system.

6.3 Atypical System of University Research Commercialisation

The university research commercialisation system has been identified as an atypical network where funding is sought for research from the Australian Government, however they are not the recipients of the system outcome. This research has identified a plural of customer in the Principal (i.e. funder) and Recipients of the goods or services (Intellectual Property) including industry for Intellectual Property; the university for knowledge development and the support needed for further funding applications; and national and local community for economic development, with all entities requiring a different measurable outcome. The plural of customer has enabled the establishment of a disconnect of goals within the system, causing constraint (Section 5.4) and further conflict into the system. As a result of the Australian Government is "better" commercial transfer (DISER 2015) from research funding (money) is "pushed" into the system of university research without clearly defining the "customer" for the eventual commercial transfer. (Figure 6.7).

The development of this agenda and change in focus signalled a change in the requirement from the supplier of the funds (i.e. Australian Government), however, in this case the customer did not provide all of the necessary support tools to get what they want, such as a change in law and measurement system. Mapping the atypical supply network of Publicly Funded University Research Commercialisation (PFURC) using the atypical mapping developed by Edwards et al. (2018) demonstrates the single source of funding through the Australian Government and that they are not the recipient of the output. This atypical mapping demonstrates the inward focus of the system as all value in the system passes through the Homologation[24] node, enabling the University, as the recipient of the funding and the

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[24] Figure 6.6 first mentions a node, "Homolagation", "Homologation means to approve or confirm which indicates that it meets regulatory standards and specifications and is used as a term for bringing together all subsets of the supply chain value creation and then "approving" for finish forwarding to the end customer or recipient" (Edwards 2017 p.57).

beneficiary of the new knowledge to control the path of this new knowledge into the community.

This research has shown that, although the government were the providers of the funding, it is logical to expect the system to be focussed on satisfying their needs ("better" commercial transfer), however, this research found that this is not the case. The government could easily change the system (legislation) to enable them to get what they want, but don't, therefore, the universities are forced to follow the correctly legislated system (and doing it very well), with the outcome of not satisfying the customer (paradox).
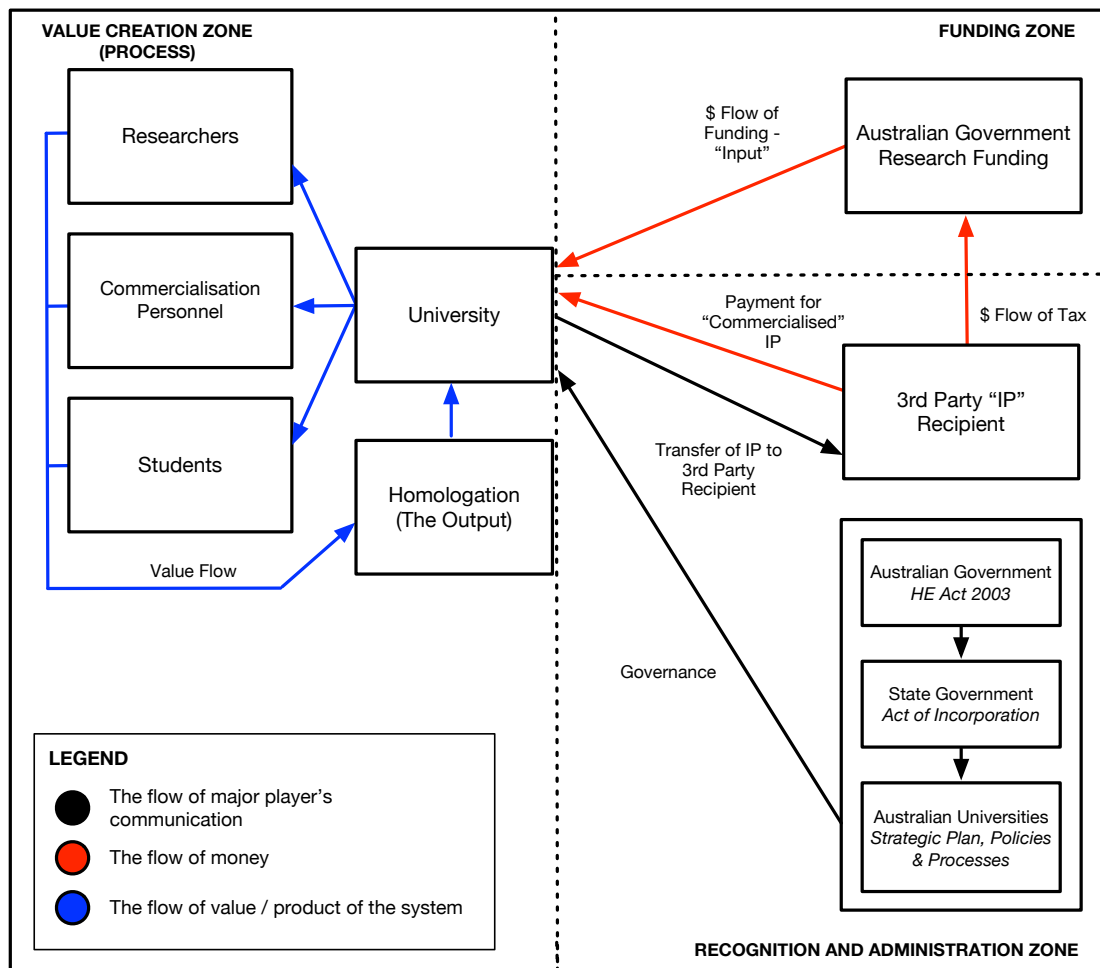
Figure 6.7. Atypical System of Publicly Funded University Research Commercialisation (sourced: research)

The Conflict Resolution Diagram analysis identified that an injection (change) into the system, to enable a win-win situation for the university (following established

Legislation) and the Australian Government ("better" commercial transfer), would be the governing university legislation is circumvented by changing the process of funding for the university for research. The suggestion is that Government funds industry for research to be undertaken by university, therefore, the legislation for the funding process is changed, not the legislation that identifies a university. The logic of this suggestion is further discussed in the next Chapter.

6.4 Summary

This Chapter discussed the system of university research commercialisation from the perspective of the stakeholders. The TOC Thinking Process of Current Reality Tree was applied to the findings of the research, resulting in an identification of the Primary Root Cause of the constraint in the system RC1 - *Absence of legislation requiring commercialisation* (Section 6.1.2). The Conflict Resolution tool was then applied to 'break' the constraint through a change in the identity of the customer of the university research commercialisation system. Resulting in the identification of *Injection 6* suggesting that Government fund industry for research to be undertaken by university, therefore, the legislation for the funding process is changed, not the legislation that identifies a university. Chapter 7 will discuss this proposed elimination of the Root Cause through the Development of a Future Reality Tree to develop a possible plan forward.

CHAPTER 7 - AN ALTERNATE MODEL

7.0 Introduction

The previous chapter discussed the constraints within the system and identified Root Causes of these constraints as RC1 - *Absence of legislation requiring commercialisation*", and, RC2 - *No identifiable path or process for collaboration*". The primary constraint in the system was identified as RC1 with 5 of the 6 UDE being a result of this root cause (Dettmer 1998; Rahman 2002; Umble & Umble 2015) (Section 6.1.2). The TOC tool of a Conflict Resolution Diagram (CRD) was used to "break" the constraint through a hypothetical investigation of possible alternate solutions using a series of 'Injections' (Section 6.2). The identified injection to cause the greatest "break" was *Injection 6 - Governing university legislation is circumvented by changing the process of funding for the university for research.* This "break" suggested that Government funds industry for research to be undertaken by university, therefore, the legislation for the funding process is changed, not the legislation that identifies a university (Section 6.3). This injection would result in a change in the pathway for funding university research, and in turn, trigger a change in the product of a university (more commercial transfer of research outcomes) and how the university is viewed internally and externally without changing the legislated identity of an Australian University.

This chapter uses the TOC analysis tool of Future Reality Tree (FRT) to build on the constraint analysis (Section 6.1) and elevation (6.2) to investigate the reliability of this finding and to test the logic of the idea before further resources are allocated (Dettmer 1997; Eidelwein et al. 2018; Rahman 2002) (Figure 7.1). The outcome of the FRT is the confirmation of the logic of the idea and the development of a framework for an alternate path of university research funding to address the "better" commercial transfer requirement of the government (Section 7.1).
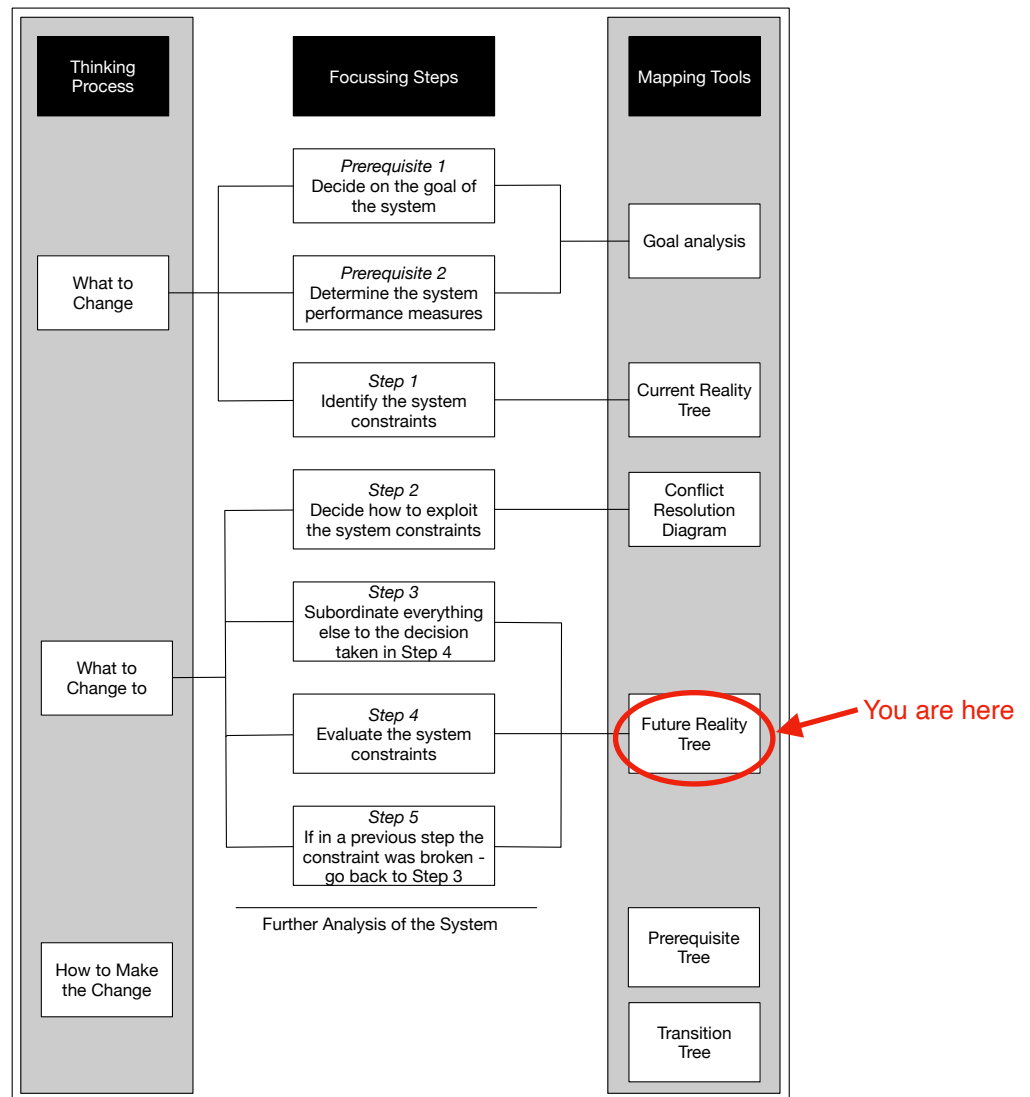
Figure 7.1 Theory of Constraints Methodology Map - Place Locator - Future Reality Tree

7.1 Future Reality Tree (FRT)

As demonstrated through this research, a simple "measurement only' change in a system does not guarantee a change the ability of the system to meet new demands. The system itself needs to change, and as a result of the Constraints analysis, it is the legislation guiding the system of funding Australian university research commercialisation, that requires the change. Currently within Australian universities, the Government, although providing funding for research, does not provide resources for commercial development of this research, while seeking to exploit the research outcomes by requiring "better" commercial transfer by universities (i.e. wants more without additional input of resources). At the same

time, Universities continue to do exactly what they are mandated to do through their governance documents (educate, research and disseminate knowledge). Tension is caused between the two systems, with government enabling research funding for the university, with the university left to manage this funding within a historical governmentally mandated structure, i.e. a closed loop atypical self-serving system (Edwards et al. 2018), and in turn, managing industry collaboration and the development of commercial outcomes for transfer within the bounds of this governance (Cheah & You 2016; Etzkowitz 2013). It could be argued that the provision of Australian Government funding for ARC Linkage funding or ARC Category 4 funding aimed at Cooperative Research Centres (CRC) addresses the funding of university research commercialisation. Likewise, the Australian Government Tax Incentive provided to industry is a reimbursement of Research and Development (R&D) costs incurred through research undertaken. However, these instances of funding are focussed on specific research projects, not the outcome of general university research and deemed outside of the scope of this study (Section 2.2.1).

This research suggests that an alternative solution to this tension would be too, instead, fund industry for the research and have industry seek partnerships with a university to undertake this funded research. This research is undertaken with a view that, research output transfers to the industry, satisfying the "principal" (Government) of the atypical system with "better" commercial transfer. The realignment would not require a change to the fundamental legislation that has been well developed globally to ensure the clear identification and purpose of a University. Simply, change the process of research funding to more closely align with the teachings of QMS and ISO standards where the system is focused on the customer. The findings of this research suggest a realignment of university research funding to be sourced from the Australian Government by industry to enable an industry/university collaboration, rather than the current practice where funding is sourced by the University. This alteration will positively impact on the current ambiguous customer focus within the university system and develop a stronger link

between the funder and the output, in turn, injecting research output for a customer focus into the system. This change is not unprecedented and is evident in prior global helix models of university collaboration, and National System of Innovation that consider industry to have the lead role (Etzkowitz & Leydesdorff 2000) (Section 7.2). Enabling the market orientated portion of the community (industry) to take an active roll in the Research & Development of the Nation. The results of this research (Section 6.2) were tested for logic and effectiveness through the development of the TOC Thinking Process tool of a Future Reality Tree (FRT).

7.1.1 Testing the Change

The Future Reality Tree (FRT) was constructed using the results from the Current Reality Tree (Section 6.1.1) and the elevation analysis of the Root Cause undertaken through the Conflict Resolution Diagram (Section 6.2). The purpose of the FRT is to test the effectiveness of the proposed injection into the system to establish if the change will result in the desired effect (Objective) before resource is committed (Chou et al. 2012; Dettmer 1997; Librelato et al. 2013; Reid & Cormier 2003). The steps in the FRT process are outlined in Section 4.3.3.4. To enable a change in any system, changes to the current status quo are needed (Chou et al. 2012; Eidelwein et al. 2018; Mabin & Davis 2010; Reid & Cormier 2003), to this end, the FRT is built using Expected Effects (EE) and Desired Effects (DE) to positively build change into the system (Dettmer 1997). The Desired Effects are sourced from converting the previously identified UDE from identified constraints to positive statements to enable the development of Expected Effects. Table 7.1 outlines the conversions made to the UDE to enable the change within the system.

Development of Desired Effects (DE)			
Undesirable Effect (UDE)	**Description**	**Desirable Effect (DE)**	**Description**
UDE 1	There is a low commercial transfer of publicly funded research to industry	**DE 1**	Higher commercial transfer of publicly funded research outcomes to industry
UDE 2	No practice of customer focus by Stakeholders	**DE 2**	Customer focus
UDE 3	Practices enable a siloed and passive environment	**DE 3**	Focussed practices
UDE 4	"Common" stakeholders have no knowledge of the whole research commercialisation system	**DE 4**	Greater clarity of the whole system (system simplified)
UDE 5	Multiple Goals within the system	**DE 5**	Focussed Goal of university research
UDE 6	"Common" stakeholders find it difficult to form collaborative university-industry relationships for research projects	**DE 6**	Supported system to form collaborative university-industry relationships for research projects

Table 7.1 Development of Desired Effects (DE) (Dettmer 1997)

The FRT is constructed and read from the bottom to top (Section 4.3.3.4) (Dettmer 1997; Reid & Cormier 2003) and the mapping process begins with the acknowledgment of the current reality, which is, *Legislation does not require university to commercialise,* and the change (Injection) that is planned for the system, *Legislation is changed to fund industry for university/industry research collaboration.* The viability of the change is investigated through the mapping of the positive steps (i.e, DE and EE) needed to obtain the Objective - *University develops research outcomes relevant to knowledge development, teaching and commercial transfer* (Figure 7.2). The mapping identifies the positive steps along with any negative outcomes that are now identified by the change in the process (Negative Arms). It is important to note that this research identified an initial negative arm (highlighted by a dashed border) that even with these changes, there is not a guarantee that "better", or even more, Intellectual Property may be developed by industry and expectation of the output of the new system would need to be addressed in the funding legislation. It is assumed that the university would be involved in the commercialisation process, however this may not be the case. Industry's own commercialisation processes are outside of the scope of this work.
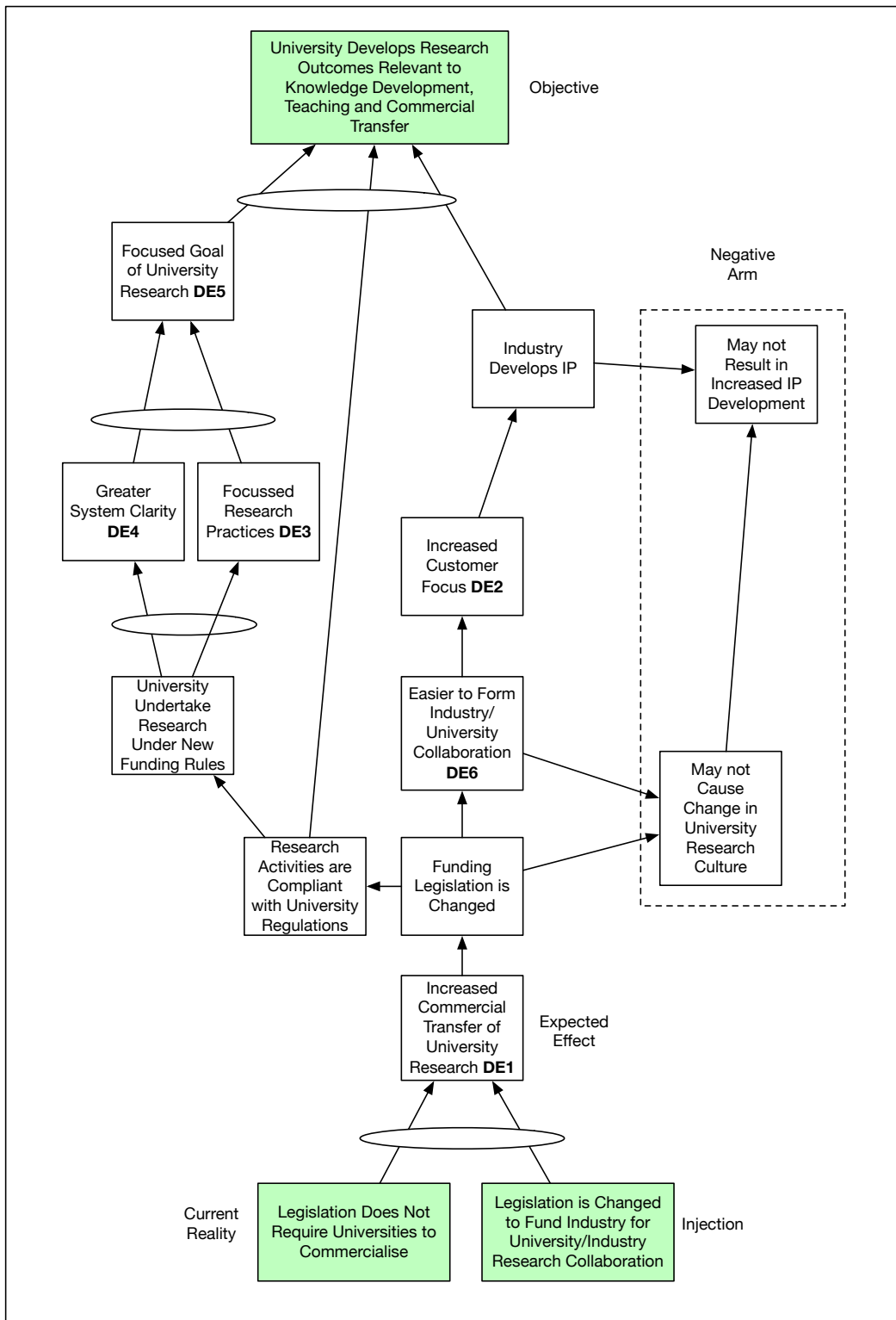
Figure 7.2 Future Reality Tree

The FRT demonstrates that the Objective (Section 6.2) satisfies the current legislative requirement of the university and, in addition, enables development of an environment of "better" commercial transfer of research to industry through changed

legislation and funding path of the university research system. The realigned system would see industry funded for university research partnerships and the development of a customer focused University research system. This outcome positively addresses *Proposition* 2 - *A disconnect exists within the expectations of the number and value of the outcomes of research between the initial funder, the researchers and the university.*

7.2 Causing the Change in the System

A system that is focussed on the customer and has clear communication with all stakeholders about the intent of the publicly funded research commercialisation activities has little waste, a strong understanding of its purpose and is competitive, measurable and growing. If the Theory of Constraints rules of throughput, efficiency and maximum value for money (Goldratt 2016) are applied, post the Thinking Process analysis, and the system is realigned to only have one input, (i.e. one path for the money), then the system will naturally become customer focussed and function as a pull system. Figure 7.3 illustrates the change in the way a university is funded for research (FUNDING ZONE) enacting a change in the 'intent' of a university, demonstrating a singular path for funding within the atypical system of publicly funded university research.

VALUE CREATION ZONE (PROCESS)

Researchers

Commercialisation Personnel

University

Students

Homologation (The Output)

Value Flow

FUNDING ZONE

Australian Government Research Funding

$ Flow of Funding- "Input"

Payment for "Commercialised" IP

$ Flow of Tax

3rd Party "IP" Recipient

Transfer of IP to 3rd Party Recipient

Governance

Australian Government *HE Act 2003*

State Governments *Act of Incorporation*

Australian Universities *Strategic Plan, Policies & Processes*

LEGEND

● The flow of major player's communication

● The flow of money

● The flow of value / product of the system

RECOGNITION AND ADMINISTRATION ZONE

Figure 7.3 - Proposed Change in the System of University Research Government Funding

This research has established that universities in Australia list their intent as teaching, research and the dissemination of knowledge, however, their Strategic Plans enable a tangible outcome of publicly available university research commercial output in the form of Intellectual Property. The suggested realignment, illustrated in Figure 7.3, would cause a change in the way universities are viewed by the government, industry and the general community. More importantly, this change in the system will enable the university to address the 'common axiom' of the community (including government) that universities commercial transfer research output to industry at a level that is commensurate with a reasonable return on public investment (Section 1.0).

7.3 Summary

In previous chapters this research established that the goal of an Australian university is to teach, research and disseminate knowledge, however the funder, the enabler of some of this process, is requiring further outcomes, in the form of "better" commercial transfer of research outcomes to industry, without further financial support. Chapter 6 analysed the finding from the constraint mapping. The result was an injection into the system of changing the legislation governing the process of funding university research. This was deemed a win-win solution as it protected the integrity of university education and enabled a tighter focus on the customer of the university research output (industry). This chapter tested the proposed change that is needed within the system to identify logic and resource capability and concluded that the change would enable the system to be focussed on providing research output that is used in industry, addressing the funders requirement. However, the process also acknowledged that greater control of the funding by industry may not change the rate at which industry undertakes commercialisation, and simply provides them with more opportunity. Chapter 8 provides the final conclusions of this thesis with suggestions for further work.

CHAPTER 8 - CONCLUSION AND RECOMMENDATIONS FOR FURTHER WORK

8.0 Conclusion

This research set out to identify constraints in the system of publicly funded university research that hinder the commercial transfer of research outcomes to industry. This thesis addressed the problem by answering the research question "*What are the internal or external system or resource constraints in publicly funded university research within Australian Universities that restrict output from that research being commercially transferred to industry*" by addressing three propositions. The first proposition (P 1) was to establish if publicly funded research commercialisation was a system and could therefore be mapped and measured. The investigation identified that the publicly funded university research commercialisation is a system that is Aytpical having a plural of customer that hinder customer focus, and, a system principal (funder) that funds the system, but its not the recipient of the value (output).

The second proposition (P 2) investigated the disconnect in the expectations of the number and value of the outcomes of research between the initial funder, the researchers, the university and industry and identified inward facing, siloed systems, low knowledge of the whole system and a lack of focus on the customer. The lack of customer focus is driven by a gap in the system between the legislated requirements of a university; the practical activities of research commercialisation and the outcome required by the funder of the system (Australian Government).

Finally the third proposition (P 3) mapped the internal and external constraints in the system of university scientific research that hinder the research outcome being commercially transferred to industry. This research identified 50 constraining issues in the system that were collated into six constraint themes (UDE) - *low commercial*

transfer of research; no practice of customer focus; practices enable a siloed and passive environment; low knowledge of the system; plural stakeholder goals & difficulty in forming collaborative networks. The UDE were mapped, and identified the Root Cause as a mismatch in the legislation governing universities and their activities.

To enable this investigation a robust methodology was sourced that would be able to identify constraints in the system from the stance of practices and policies. The methodology considered most appropriate to identify constraints in the system is a comparative case study analysis on three universities (Section 4.1.1) using the Theory of Constraints Thinking Process (Section 4.2.3) (Dettmer 1997; Goldratt 1990). A multiple case study approach allowed the study to undertake a factual mapping and analysis of the current phenomenon using university participants, to discover the "how" and "why" of the system (Yin 2014). This research was undertaken on 3 of the 42 Australian universities and is treated as a pilot study, to test the research process. To undertake a this constraints mapping on all 42 Australian universities would be outside of the time constraints of this research project.

The Theory of Constraints Thinking Process provided rigour in the research methodology through a guided system of analysis using multiple steps in the Thinking Process (Figure 4.4) that continually seek the Root Cause of the issue, this rigour is often missing with more simple comparison mapping. Although, initially seemingly complex to apply, the process identified within its staged units, the effect constraints had on the system. The main advantages of cause and effect mapping using the Theory of Constraints analysis is the ability to identify both resource and policy constraints and the deep detail level that the maps can be developed to until the Root Cause of the constraint is identified, not just individual constraint themselves.

This research discovered that research commercialisation within an Australian University was not well supported by the Incorporated Acts, Strategic Plans or

Policy, nor is it a stand alone practice, instead it was incorporated into the Policies of Intellectual Property Management (Section 5.3) and validated only when there was a research discovery reported within the university. Put simply, that the operating systems of Australian universities are not designed to deliver more Intellectual Property into industry, rather, manage any IP that might be the outcome of research, and, is perfectly designed to do exactly what it does. For the universities to commercially transfer more research output, a holistic change is needed in the system, both internally and externally.

The legislation governing an Australian University is not aligned with the political sentiment of the day, which is "better" commercial transfer for university research. This tension has enabled siloed and inward facing closed loop systems to develop, with little link to the whole system; supporting departmental reporting and individuals career progression needs over a clear focus on the commercial development of research. Put simply, the Australian university operating systems are not currently designed to deliver more Intellectual Property into Australian business.

A realignment of the legislation governing funding to industry applying for and receiving funding for industry/university partnership would change the focus of the research programs within universities to a more customer focussed system, an in turn, the opportunity for commercial transfer of university research (Figure 7.3). This realignment could be abstracted to other government programs, for example, humanitarian aid, where little money makes it to the person in crisis in some multinational charities (Edwards 2018). Imagine what would happen if the village itself was funded for the wells and had to pay the government and contractors. The skill level and output within the individual village would be much higher. The same can be applied to the system of university research commercial transfer by changing the system to focus on the customer.

Overall it may be concluded that, whereas there is no shortage of world class research being undertaken within Australian universities, a systems change, from the

Act of Parliament to the measure of fulfilment of the Act, is necessary if more research is to transfer successfully and meaningfully into Australian industry. Put simply, this is not a question of Kaizen (continually improving the system), but rather Kaikaku (radical change). It is also not unreasonable to suggest that a cultural change is necessary in defining, and measuring what, within a 21st Century global economy, an Australian university is, what it does and how it is rewarded at all levels.

8.1 Recommendations for Further Work

To better understand the implications of these results, future studies could address:

- The further development of the change this research suggested using the final two steps in the process. The Prerequisite Tree to identify goals that must be met to enable change, along with any obstacles to the implementation that might be met. Then the Transition Tree to enable the development of an action plan of step-by-step instructions to eliminate the root cause in the new system.

- In addition to the need for change management, this research identified a barrier in the transparency of the communication used between university and industry. Further research on the development of a common rhetoric for industry and university to enable more transparent planning of collaborative research would assist the development of the change suggested in this research.

- The Theory of Constraints Thinking Process can appear complex at times, there is opportunity to develop this methodology into a targeted measurement tool aligned with the atypical nature of universities and similar organisations. Effectively taking current governmental measurement from instances of "what" happened to understanding "why" it happened and gaining further insight into the system.

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APPENDICES

Appendix A - University Research Funding

APPENDIX A - AUSTRALIAN UNIVERSITY GOVERNMENT FUNDING FOR RESEARCH 2010 - 2018

		2010	2011	2012	2013	2014	2015	2016	2017	2018
1	Data Sourced from # Universities	39	39	38	38	37	38	37		
2	UNIVERSITY OPERATING INCOME	21,532,290,000	23,051,396,000	24,630,124,000	25,843,026,000	27,162,321,000	28,130,050,000	29,644,779,000	31,483,807,000	33,741,910,000
3	GOVERNMENT GRANTS (RESEARCH AND OPERATING) does not include student support i.e. HECS etc	9,321,203,000	9,981,865,000	10,923,092,000	10,929,480,000	11,221,373,000	11,253,977,000	11,578,833,000	11,616,026,000	11,985,759,000
4	Public research funding from the govt - not including RBG	3,071,505,649	3,250,226,751	3,412,808,169	3,556,037,415	3,739,768,492	3,724,605,752	3,785,382,933	3,934,621,864	4,169,794,130
5	RESEARCH BLOCK GRANTS	1,423,771,359	1,515,622,000	1,632,101,168	1,668,973,662	1,721,873,284	1,770,449,139	1,814,429,393	1,890,820,960	1,921,099,156
6	RBG - # of uni	41	41	41	41	41	41	42	42	42
7	AUSTRALIAN RESEARCH COUNCIL (Category 1 not NHMRC or Med future)	789,487,827	916,820,789	1,025,685,986	1,073,373,495	1,161,646,172	1,001,158,158	933,523,429	968,604,656	977,405,802
8	ARC CAT	591,351,753	683,942,490	768,040,642	777,681,488	869,377,156	722,282,074	677,022,921	697,759,212	641,462,650
9	DISCOVERY	502,044,335	509,194,744	529,623,320	502,206,680	491,679,093	405,306,538	440,878,153	435,026,291	434,948,973
10	LINKAGE	224,018,873	446,402,961	193,192,564	174,753,554	505,486,100	152,514,489	143,111,405	392,217,690	138,135,663
11	Discovery and linkage total	726,063,208	955,597,705	722,815,884	676,960,234	997,165,193	557,821,027	583,989,558	827,243,981	573,084,636
12	NHMRC	591,351,753	546,108,273	576,557,954	610,353,360	636,777,026	628,399,732	615,157,112	617,738,729	685,311,194
13	Other Government Funding (CAT 2 3 4 donations Phil industry)									
14	Total BRG & ARC (not medical)	2,213,259,186	2,432,442,789	2,657,787,154	2,742,347,157	2,883,519,456	2,771,607,297	2,747,952,822	2,859,425,616	2,898,504,958
15	TOTAL Public research funding from the govt including RBG	4,495,277,008	4,765,848,751	5,044,909,337	5,225,011,077	5,461,641,776	5,495,054,891	5,599,812,326	5,825,442,824	6,090,893,286
16	% govt funding of total operating cost (3/2)	43.30%	43.30%	44.30%	42.30%	41.30%	40.00%	39.10%	36.90%	35.50%
17	% of govt funding that is aimed at research - CGS and RBG (13/3)	48.20%	47.70%	46.20%	47.80%	48.70%	48.80%	48.40%	50.20%	50.80%
18	Of the govt funding that is aimed at research, the % that is RBG (5/13)	31.70%	31.80%	32.40%	31.90%	31.50%	32.20%	32.40%	32.50%	31.50%
19	Of the govt funding that is aimed at research the % that is ARC D&L% (7/13)	16.20%	20.10%	14.30%	13.00%	18.30%	10.20%	10.40%	14.20%	9.40%
20	Of the total govt funding aimed at research % that is NHMRC	13.20%	11.50%	11.40%	11.70%	11.70%	11.40%	11.00%	10.60%	11.30%

Appendix A - Australian University Government Funding for Research 2010 - 2018 (Sourced: DESE 2015a; 2015b; 2015c; 2015d; 2015e; 2017; 2018; 2019b; 2020a; NHMRC 2020a; 2020b

Appendix B - Operating Income and Research

APPENDIX B - OPERATING INCOME AND RESEARCH 2012 - 2020 (7July2020)	2010	2011	2012	2013	2014	2015	2016	2017	2018
UNIVERSITY OPERATING INCOME	21,532,290,000	23,051,396,000	24,630,124,000	25,843,026,000	27,162,321,000	28,130,050,000	29,644,779,000	31,483,807,000	33,741,910,000
Other (Licences etc) -	1,469,845,000	1,660,714,000	1,596,002,000	1,843,337,000	1,773,777,000	1,900,642,000	1,880,905,000	1,964,384,000	Note 1
Note: Other income includes royalties, trademarks and licenses and the share of net result of associates and joint ventures accounted for using the equity method.									
Commercial Transfer Revenue as a % of University Operating Income	7%	7%	6%	7%	7%	7%	6%	6%	
Royalties, Licences and trademarks	96,230,000	90,761,000	85,212,000	102,269,000	121,414,000	142,754,000	131,510,000	120,303,000	127,704,000
% Royalties, Licences and trademarks of operating income	0.45%	0.39%	0.35%	0.40%	0.45%	0.51%	0.44%	0.38%	0.38%

48% of the government funding provided to a university is aimed at research, this is made up of the Competitive Grant Scheme and Research Block Grants

Funding from the government represents 40% of university operating cost

The income from research commercial transfer, i.e. roayities licences and trademarks represents totals 7% of the unviersity operating income

Note 1. Change of formatting of reports and this figure has changed its compilation

Appendix B - Operating Income an Research 2012 - 2020 (sourced: DESE 2015a; 2015b; 2015c; 2015d; 2015e; 2017; 2018; 2019b; 2020a)

Appendix C - Financial Statements for Case Universities

OPERATING INCOME	The Mature University									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	AVERAGE
Operating income ($'000). Total Revenues from Continuing Operations	1,327,543	1,469,752	1,479,235	1,543,126	1,658,927	1,671,811	1,819,468	2,018,976	2,130,219	1,679,895
Total Aust Govt Financial Assistance (includes HECS/HELP)			852,538	882,666	915,948	902,398	907,034			892,117
Australian Government Grants TOTAL (included in the figure above) a breakup provided below to Other Financial Assistance			698,225	697,857	718,083	698,850	702,959			703,195
Commonwealth Grants Scheme and Other Grants			250,195	265,257	270,010	274,849	291,150			270,292
Scholarships			22,804	24,823	26,062	26,448	26,761			25,380
Education Research Grants			130,028	127,450	130,310	135,792	137,320			132,180
Education Investment Fund and one-off capital grants			17,827	7,450	10,850	0	0			7,225
Australian Research Council			72,568	73,096	74,406	67,575	61,684			69,866
Other Australian Government Financial Assistance			204,803	199,781	206,445	194,186	186,044			198,252
Royalties, Trademarks and Licenses	1,938	4,521	5,694	4,025	6,164	4,701	3,428	1,921	1,414	4,802
Consultancy and Contracts			50,981	56,217	55,852	60,246	62,114			57,082
ARC is % of Operating income	0	0	4.9	4.7	4.5	4	3.4			4.31
ARC is % of Total Aust Govt Grants			10.4	10.5	10.4	9.7	8.8			9.93
Australian Government Grants for education (check this) as a % of operating income	0	0	47.2	45.2	43.3	41.8	38.6			43.23
Royalties, Trademarks and Licenses as a % of Operating Income	0.15	0.31	0.38	0.26	0.37	0.28	0.19%	0.10%	0.07%	0.2
Consultancy and Contracts as a % of Operating Income	0	0	3.45	3.64	3.37	3.6	3.41			3.49

OPERATING INCOME	The Young University									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	AVERAGE
Operating income ($'000). Total Revenues from Continuing Operations	523,684	524,702	637,147	650,083	741,210	731,450	763,667	800,489	909,269	704,711
Total Aust Govt Financial Assistance (includes HECS/HELP)			495,734	518,563	550,187	563,270	569,250			539,401
Australian Government Grants TOTAL (included in the figure above) a breakup provided below to Other Financial Assistance			325,841	318,615	339,758	341,954	345,493			334,332
Commonwealth Grants Scheme and Other Grants			273,638	275,080	292,147	303,186	311,973			291,205
Scholarships			3,371	3,120	3,365	3,662	3,804			3,464
Education Research Grants			13,525	13,367	13,518	13,907	14,532			13,770
Education Investment Fund and one-off capital grants			12,574	7,074	5,024	100	0			4,954
Australian Research Council			6,828	7,502	9,934	8,204	7,705			8,035
Other Australian Government Financial Assistance			15,905	12,472	15,770	12,895	7,479			12,904
Royalties, Trademarks and Licenses	168	236	185	168	89	194	262	260	168	180
Consultancy and Contracts			11,259	13,026	11,695	14,171	17,923			13,615
ARC is % of Operating income			1.1	1.2	1.3	1.1	1			1.14
ARC is % of Total Aust Govt Grants			2.1	2.4	2.9	2.4	2.2			2.4
Australian Government Grants for education (check this) as a % of operating income			51.1	49	45.8	46.8	45.2			47.6
Royalties, Trademarks and Licenses as a % of Operating Income	0.03	0.04	0.03	0.03	0.01	0.03	0.03	0.03	0.02	0.03
Consultancy and Contracts as a % of Operating Income			1.77	2	1.58	1.94	2.35			1.93

OPERATING INCOME	The Establishing University									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	AVERAGE
Operating income ($'000). Total Revenues from Continuing Operations	225,026	228,974	268,588	276,725	307,647	369,675	320,856	320,551	328,505	308,698
Total Aust Govt Financial Assistance (includes HECS/HELP)			197,899	205,882	231,385	229,588	243,546			221,660
Australian Government Grants TOTAL (included in the figure above) a breakup provided below to Other Financial Assistance			142,255	142,626	159,626	151,994	162,519			151,804
Commonwealth Grants Scheme and Other Grants			116,344	116,907	121,385	132,166	143,011			125,963
Scholarships			1,888	2,216	1,771	1,928	2,074			1,975
Education Research Grants			4,833	5,103	5,570	6,086	6,558			5,630
Education Investment Fund and one-off capital grants			11,024	8,902	22,006	0	0			8,386
Australian Research Council			154	158	77	110	240			148
Other Australian Government Financial Assistance			8,012	9,340	8,817	11,704	10,636			9,702
Royalties, Trademarks and Licenses	0	0	0	0	0	0	0	62	16	0
Consultancy and Contracts			1,037	748	792	1,058	3,426			1,412
ARC is % of Operating income			0.1	0.1	0	0	0.1			0.05
ARC is % of Total Aust Govt Grants			0.1	0.1	0	0.1	0.1			0.1
Australian Government Grants for education (check this) as a % of operating income			53	51.5	51.9	41.1	50.7			49.63
Royalties, Trademarks and Licenses as a % of Operating Income	0	0	0	0	0	0	0	0	0	0
Consultancy and Contracts as a % of Operating Income			0.39	0.27	0.26	0.29	1.07			0.45

Appendix C - Financial Statements for the three Case Universities (sourced: DESE 2015a; 2015b; 2015c; 2015d; 2015e; 2017; 2018; 2019b; 2020a)

Appendix D - University Objectives listed in Acts of Incorporation

APPENDIX D - OBJECTIVES OF AUSTRALIAN UNIVERSITIES SOURCED FROM THEIR ACTS OF INCORPORATION

	Establish a University	Manage a University	Teaching & Learning	Education	Provide Courses	Conferring Degrees	Equip Students for Career	Research	Advance Knowledge for Govt, Industry, Commerce, Community	Disseminate Knowledge & Promote Scholarship	Support the Needs of the Surrounding Area & Community	Facilities & Resources for Students & Staff	Commercially Exploit - Facilities, Knowledge, Research & Study	Collaborate with other Uni's	Liaise with Industry	Public Discourse	Aboriginal and Torres Strait Islanders	Governance, Equity and Social Justice	Generate Revenue	Faith	Notes
CSU			1		1	1		1		1	1	1	1		1	1		1	1		
CURTIN				1	1	1		1			1	1	1		1	1	1	1			
BATCHELOR			1	1		1	1	1		1	1		1	1			1	1			
DEAKIN			1	1	1	1	1	1		1	1		1			1	1	1	1		
LaTrobe			1	1	1	1	1	1		1			1			1			1		
MACQUARIE			1	1	1		1	1	1	1	1	1				1	1	1			
MURDOCH			1	1	1	1		1		1	1	1	1			1					
RMIT			1	1		1	1	1		1	1	1	1			1	1	1			
SCU			1	1	1	1	1	1		1	1	1	1			1	1	1			
SWINBURNE			1	1		1		1		1		1				1					
CANBERRA			1		1	1		1			1	1	1			1	1	1			
MELBOURNE			1	1		1	1	1		1	1	1	1			1	1	1	1		
UNE			1		1	1		1		1	1		1			1		1	1		
UNSW			1	1	1	1		1		1	1		1			1		1	1		
UoN			1		1	1		1	1	1	1	1	1			1		1	1		
USyd			1		1	1		1	1	1		1	1			1		1			
UTS			1		1	1		1		1		1	1			1		1	1		
UOW			1		1	1	1	1		1			1			1	1	1	1		
VU			1	1		1		1		1	1	1	1			1					
WSU			1		1	1		1		1	1	1	1			1		1			
ACU	1																				Note 1
ANU		1	1		1			1			1										Note 2
BOND						1				1											Note 3
CQU			1	1	1	1		1	1	1	1	1	1	1							
CDU								1	1	1	1	1	1	1	1				1		
ECU			1	1				1	1	1	1	1									
FEDERATION			1		1	1	1	1	1	1	1	1					1				
FLINDERS				1	1	1		1		1	1	1									
GRIFFITH				1	1	1		1	1	1	1										
JCU				1	1	1		1		1	1	1					1	1			
MONASH			1	1	1	1	1	1		1	1										
QUT				1	1				1												
TORRENS		1						1													
ADELAIDE			1	1		1		1	1	1											
Divinity			1	1				1		1			1							1	
UNDA			1		1			1	1	1	1		1							1	
UQ			1	1	1			1	1	1	1	1	1						1		
UniSA			1	1	1	1			1		1	1	1				1				
USQ				1		1		1	1	1		1	1								
UTAS			1		1	1		1	1	1		1	1								Note 4
USC				1	1	1						1	1								
UWA																					Note 5
	1	2	27	26	22	30	8	42	10	32	25	30	29	3	4	19	10	17	9	2	

Note 1 The objects of this Act are to provide statutory recognition of the Australian Catholic University as a university and to facilitate its operation within New South Wales

Note 2 This University had no mention of education or research in their objectives

Note 3 CQU specifically listed that courses needed to match the communities need

Note 4 UTAS was the only university that listed 'to foster or promote the commercialisation of any intellectual property (6.fa)'

Note 5 Does not have objectives in the Act. The act is about the governing body

Appendix D - University Objectives listed in Acts of Incorporation (sourced: Individual Acts)

Appendix E - Australian University Listing

APPENDIX E - AUSTRALIAN UNIVERSITIES DEFINED IN HIGHER EDUCATION SUPPORT ACT 2003					
University	Abbreviation	Act	Current Act Date	State	Link to the Act
Table A providers					
Central Queensland University	CQU	Central Queensland University Act 1998	13-Oct-17	QLD	https://www.legislation.qld.gov.au/view/html/inforce/current/act-1998-002
Charles Darwin University	CDU	Charles Darwin University Act	12-Apr-17	NT	https://legislation.nt.gov.au/Legislation/CHARLES-DARWIN-UNIVERSITY-ACT
Charles Sturt University	CSU	Charles Sturt University Act 1989	1-Jul-17	NSW	https://legislation.nsw.gov.au/#/view/act/1989/76
Curtin University of Technology	CURTIN	Curtin University Act 1966	1-Oct-17	WA	https://www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_235_homepage.html
Deakin University	DEAKIN	Deakin University Act 2009	1-Jan-16	VIC	http://www.legislation.vic.gov.au/Domino/Web_Notes/LDMS/PubStatbook.nsf/51dea49770555ea6ca256da4001b90cd/502E5C60BC7E878ECA25767F000FB16B/$FILE/09-071a.pdf
Edith Cowan University	ECU	Edith Cowan University Act 1984	1-Oct-17	WA	https://www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_282_currencies.html
Federation University Australia	FEDERATION	Federation University Act 2010	1-Jan-16	VIC	http://www.legislation.vic.gov.au/Domino/Web_Notes/LDMS/LTObject_Store/ltobjst8.nsf/DDE300B846EED9C7CA257616000A3571/FED743E3FAC925F9CA257C5100037BC3/$FILE/10-5aa010%20authorised.pdf
Griffith University	GRIFFITH	Griffith University Act 1998	13-Oct-17	QLD	https://www.legislation.qld.gov.au/view/pdf/2017-10-13/act-1998-003
James Cook University	JCU	James Cook University Act 1997	13-Oct-17	QLD	https://www.legislation.qld.gov.au/view/pdf/2017-10-13/act-1997-045
La Trobe University	LaTrobe	La Trobe University Act 2009	1-Jan-16	VIC	http://www.legislation.vic.gov.au/Domino/Web_Notes/LDMS/LTObject_Store/LTObjSt2.nsf/dde300b846eed9c7ca257616000a3571/522bae4c51f620d4ca2577610024a09a/$FILE/09-75a001.pdf
Macquarie University	MACQUARIE	Macquarie University Act 1989	1-Jul-17	NSW	https://legislation.nsw.gov.au/#/view/act/1989/126
Monash University	MONASH	Monash University Act 2009	1-Jan-16	VIC	http://www.legislation.vic.gov.au/Domino/Web_Notes/LDMS/LTObject_Store/LTObjSt7.nsf/DDE300B846EED9C7CA257616000A3571/35C4A199A77DAFCFCA257AE1001B847D/$FILE/09-76a005bookmarked.pdf
Murdoch University	MURDOCH	Murdoch University Act 1973	1-Oct-17	WA	https://www.legislation.wa.gov.au/legislation/prod/filestore.nsf/FileURL/mrdoc_37112.pdf/$FILE/Murdoch%20University%20Act%201973%20-%20%5B03-d0-00%5D.pdf?OpenElement
Queensland University of Technology	QUT	Queensland University of Technology Act 1998	13-Oct-17	QLD	https://www.legislation.qld.gov.au/view/pdf/2017-10-13/act-1998-004
Royal Melbourne Institute of Technology	RMIT	Royal Melbourne Institute of Technology Act 2010	1-Jan-16	VIC	http://mams.rmit.edu.au/bm0b6e2mhz0az.pdf

APPENDIX E - AUSTRALIAN UNIVERSITIES DEFINED IN HIGHER EDUCATION SUPPORT ACT 2003					
University	Abbreviation	Act	Current Act Date	State	Link to the Act
Table A providers					
Southern Cross University	SCU	Southern Cross University Act 1993	14-Jan-18	NSW	https://legislation.nsw.gov.au/inforce/82fba56f-68aa-6322-cb17-e856e05b310f/1993-69.pdf
Swinburne University of Technology	SWINBURNE	Swinburne University of Technology Act 2010	1-Jan-16	VIC	http://www.legislation.vic.gov.au/domino/Web_Notes/LDMS/LTObject_Store/ltobjst9.nsf/DDE300B846EED9C7CA257616000A3571/572C2759B531A742CA257F2A00022891/$FILE/10-4aa006%20authorised.pdf
The Australian National University	ANU	Australian National University Act 1991	1-Jul-14	ACT	https://www.legislation.gov.au/Details/C2014C00377
The Flinders University of South Australia	FLINDERS	Flinders University Act 1966	10-Oct-17	SA	https://www.legislation.sa.gov.au/LZ/C/A/Flinders%20University%20Act%201966.aspx
The University of Adelaide	ADELAIDE	University of Adelaide Act 1971	10-Oct-17	SA	https://www.legislation.sa.gov.au/LZ/C/A/UNIVERSITY%20OF%20ADELAIDE%20ACT%201971/CURRENT/1971.41.AUTH.PDF
The University of Melbourne	MELBOURNE	University of Melbourne Act 2009	1-Dec-09	VIC	http://www.legislation.vic.gov.au/domino/web_notes/ldms/pubstatbook.nsf/edfb620cf7503d1aca256da4001b08af/489fcdb5278f3602ca25767f00102b11/$file/09-078a.pdf
The University of Queensland	UQ	University of Queensland Act 1998	13-Oct-17	QLD	https://www.legislation.qld.gov.au/view/pdf/2017-10-13/act-1998-005
The University of Sydney	USyd	University of Sydney Act 1989	1-Dec-17	NSW	https://www.legislation.nsw.gov.au/#/view/act/1989/124
The University of Western Australia	UWA	University of Western Australia Act 1911	1-Oct-17	WA	https://www.legislation.wa.gov.au/legislation/prod/filestore.nsf/FileURL/mrdoc_37114.pdf/$FILE/University%20of%20Western%20Australia%20Act%201911%20-%20%5B05-g0-00%5D.pdf?OpenElement
University of Canberra	CANBERRA	University of Canberra Act 1989	9-Mar-17	ACT	http://www.legislation.act.gov.au/a/alt_a1989-179co/
University of Newcastle	UoN	University of Newcastle Act 1989	1-Jul-17	NSW	https://www.legislation.nsw.gov.au/#/view/act/1989/68
University of New England	UNE	University of New England Act 1993	1-Jul-17	NSW	https://legislation.nsw.gov.au/inforce/32960f45-cd10-ee06-ee97-a0a3b5f892d6/1993-68.pdf
University of New South Wales	UNSW	University of New South Wales Act 1989	1-Jul-17	NSW	https://legislation.nsw.gov.au/#/view/act/1989/125
University of South Australia	UniSA	University of South Australia Act 1990	31-Dec-08	SA	https://legislation.sa.gov.au/LZ/C/A/UNIVERSITY%20OF%20SOUTH%20AUSTRALIA%20ACT%201990/CURRENT/1990.60.UN.PDF
University of Southern Queensland	USQ	University of Southern Queensland Act 1998	13-Oct-17	QLD	https://www.legislation.qld.gov.au/view/pdf/2017-10-13/act-1998-006
University of Tasmania	UTAS	University of Tasmania Act 1992	1-Jan-13	TAS	https://www.legislation.tas.gov.au/view/html/inforce/current/act-1992-051

APPENDIX E - AUSTRALIAN UNIVERSITIES DEFINED IN HIGHER EDUCATION SUPPORT ACT 2003					
University	Abbreviation	Act	Current Act Date	State	Link to the Act
Table A providers					
University of Technology, Sydney	UTS	University of Technology Sydney Act 1989	7-Dec-17	NSW	https://www.legislation.nsw.gov.au/#/view/act/1989/69
University of the Sunshine Coast	USC	University of the Sunshine Coast Act 1998	13-Oct-17	QLD	https://www.legislation.qld.gov.au/view/pdf/2017-10-13/act-1998-047
University of Western Sydney	WSU	Western Sydney University Act 1997 no. 116	1-Jul-17	NSW	https://www.legislation.nsw.gov.au/#/view/act/1997/116
University of Wollongong	UOW	University of Wollongong Act 1989	1-Jul-17	NSW	https://legislation.nsw.gov.au/#/view/act/1989/127
Victoria University	VU	Victoria University Act 2010	1-Jan-16	VIC	http://www.legislation.vic.gov.au/Domino/Web_Notes/LDMS/LTObject_Store/LTObjSt5.nsf/DDE300B846EED9C7CA257616000A3571/F9A1C9895B6F5C33CA2577900017DC70/$FILE/10-14a001.pdf
Australian Catholic University	ACU	Australian Catholic University Act 1990	18-Nov-92	NSW	https://www.legislation.nsw.gov.au/acts/1990-110.pdf
Batchelor Institute of Indigenous Tertiary Education	BIITE	Batchelor Institute of Indigenous Tertiary Education Act 1999	14-May-12	NT	https://legislation.nt.gov.au/en/Legislation/BATCHELOR-INSTITUTE-OF-INDIGENOUS-TERTIARY-EDUCATION-ACT-1999
Table B providers					
Bond University	BOND	Bond University Act 1987	27-Jul-01	QLD	https://www.legislation.qld.gov.au/view/pdf/2001-07-27/act-1987-019
The University of Notre Dame Australia	UNDA	University of Notre Dame Australia Act 1989	2-Jan-17	WA	https://www.legislation.wa.gov.au/legislation/prod/filestore.nsf/FileURL/mrdoc_29529.pdf/$FILE/University%20Of%20Notre%20Dame%20Australia%20Act%201989%20-%20%5B02-e0-00%5D.pdf?OpenElement
MCD University of Divinity	MCD or Divinity	University of Divinity Act 1910	1-Jan-17	VIC	https://www.divinity.edu.au/university-of-divinity/governance/the-act-and-regulations/
Torrens University Australia	TORRENS	Torrens University Australia Act 2013	1-Nov-13	SA	https://www.legislation.sa.gov.au/LZ/C/A/TORRENS%20UNIVERSITY%20AUSTRALIA%20ACT%202013/CURRENT/2013.43.UN.PDF

Appendix E - Australian Universities (HE Act 2003 pp.15-16; DESE 2019c; Individual University Acts)

Note:

Table A providers are Public Universities, and Table B providers are private universities (DESE 2019c; TEQSA 2018)

University Abbreviations are the most commonly used in the literature

Date of incorporation sourced from individual University Acts of Incorporation

Appendix F - University Commercialisation Revenue Allocations

Appendix F - University Commercialisation Revenue Allocations					
	Researcher(s)	**Faculty**	**Commercialisation Department**	**University as a whole**	**Notes**
Note: All distribution takes place after development and future costs are deducted					
Australian Catholic University	70.0%	10.0%		20.0%	For the first $25,000
	50.0%	15%		35%	For the next $75,000
	30.0%	20.0%		50%	For over $100,000
Australian National University	100%		0%	0%	Up to $50,000
	50.0%		25%	25%	Over $50,000
Bond University	40.0%			60.0%	
Central Queensland University	100%	0%	0%	0%	First $20,000 pa
	50.0%	20.0%	10.0%	20.0%	$20,001 - $80,000 pa
	40.0%	20.0%	15%	25%	$90,001 - $150,000 pa
	35%	15%	20.0%	30.0%	Further amounts
Charles Darwin University	100%			0%	Up to $25,000 pa
	Half			Half	$25,000 - $100,000 pa
	Third			2 Thirds	Over $100,000
Charles Sturt University	50.0%	25%		25%	
Curtin University	50.0%			50.0%	
Deakin University	Third	Third		Third	
Edith Cowan University	50.0%	25%		25%	
Federation University					No Information
Flinders University	100%	0%		0%	$0 - $15,000 pa
	60.0%	20.0%		20.0%	$15,000 - $50,000 pa
	50.0%	25%		25%	$50,000 - $100,000 pa
	40.0%	30.0%		30.0%	Over $100,000 pa
Griffith University	50.0%	12.5%	12.5%	25%	
James Cook University	40.0%	30.0%		30.0%	
La Trobe University	Contribution towards research costs			Contribution towards costs	
Macquarie University	50.0%			50.0%	
Monash University	Third	Third		Third	
Murdoch University	50.0%			50.0%	
Queensland University of Technology	Third	Third	Third (blubox)		
Royal Melbourne Institute of Technology (RMIT)					Information Password Protected
Southern Cross University	Third	Third		Third	
Swinburne University of Technology					Outlined in Sub-regulations (2) and (3) and terms of agreements between researchers and the university
Torrens University Australia	50.0%			50.0%	
University of Adelaide	Third	Third		Third	
University of Canberra	40.0%	30.0%		30.0%	
University of Divinity					No commercialisation plan
University of Melbourne	40%	40%		20%	
University of New England	Third			2 Thirds	
University of New South Wales	Third		Third (NSi)	Third with specific allocations within the UNSW	

Appendix F - University Commercialisation Revenue Allocations cont.

Appendix F - University Commercialisation Revenue Allocations					
	Researcher(s)	**Faculty**	**Commercialisation Department**	**University as a whole**	**Notes**
Note: All distribution takes place after development and future costs are deducted					
University of Newcastle	100%			0%	First $50,000 of net returns
	65%			35%	Portion of Net Returns between $50,000 and $100,000
	50.0%			50.0%	Portion of Net Returns exceeding $100,000
University of Notre Dame Australia	85%			15%	Of the first $50,000 of Net Revenue
	65%			35%	Of the next $100,000 Net Revenue
	50.0%			50.0%	Of all cumulative Net Revenue thereafter
University of Queensland	Third	Third		Third	
University of South Australia	40.0%	20.0%	40% UniSA Ventures		
University of Southern Queensland	Third	Third		Third	
University of Sydney	First $250,000				
	Third	Third		Third	After first $250,000
University of Tasmania	50.0%	20.0%		30.0%	
University of Technology Sydney	Third	Third		Third	
University of the Sunshine Coast	50.0%	25%		25%	
University of Western Australia	85%			15%	Up to $100,000
	50.0%			50.0%	Over $100,000
University of Wollongong	50%			50%	
Victoria University	40.0%	30.0%		30.0%	
Western Sydney University	40%	30%	30% (REDI)		

Appendix F - University Research Revenue Allocations(source: University Policies)

Appendix G - Summary of Government Funding and Research Outputs

Appendix G - Summary of Government Funding and Research Outputs	2010	2011	2012	2013	2014	2015	2016	Average 2010 - 2016
Universities reporting results out of 42	39	39	38	38	37	38	37	38
Total LOA's Executed per year	345	305	319	431	617	480	754	464.43
Total Active LOA's in Universities	1711	1924	1134	1611	1609	2073	2643	1815
Total Active LOA's Yielding Income	444	445	434	618	419	613	576	507
Proportion of total LOA's creating Income	26	23	38	38	26	30	22	30
Average LOA's executed per year per university respondent	8.8	7.8	8.4	11.3	16.7	12.6	20.4	11
Total Income from LOA's	$49,390,000	$54,081,000	$33,115,000	$70,690,000	$57,599,000	$59,521,000	$83,032,340	$58,204,049
Average LOA Income per year per university respondent	$1,266,410	$1,386,692	$871,447	$1,860,263	$1,556,730	$1,566,342	$2,244,117	$1,536,000
Total Startup Companies issued-information for 2010-2011 was for 38 universities	15	14	12	21	5	29		16
Average Spinoffs per year per Aust University	0.39	0.37	0.32	0.55	0.14	0.76		0.42
Invention Disclosures in total per year	1328	1295	971	1044	957	982	1124	1100
Average invention disclosures per university per year	34.1	33.2	25.6	27.5	25.9	25.8	30.4	28.9
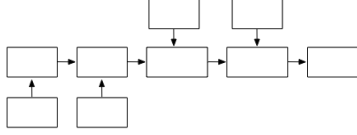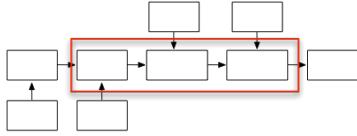
Notes: Although there are 42 universities within Australia, the NSRC statistics are only on the responding universities.

LOA = Licences, Options and Assignments

Appendix G - Summary of Government Funding and Research Options (source: DISER 2019)

Appendix H - Interview Questions

Q#	Question	Discussion	Type of Question for Data Collection
Identifying Information			
1	Are you involved with some element of Publicly Funded University Research Commercialisation (PFURC) Process at a university?	Yes – Which University - able to be interviewed No - thank you for your time	Yes/No
2	What is your definition of commercialisation?	Looking for a verbal definition to address **Proposition 4.** *Research output performance is directly correlated to the KPI the University Department needs to achieve.* It is thought that commercialisation means different things to different people and universities.	*Short answer, qualitative*
3	Why does the university you are involved in do commercialisation?		*Short answer, qualitative*
4	How are you are your university measured on it?		*Short answer, qualitative*
5	Who measures you and your university?		*Short answer, qualitative*
6	Where do you source the research funding from? Does it usually include a allocation for commercialisation?		*Short answer, qualitative*

Q#	Question	Discussion	Type of Question for Data Collection
Perceptual Information			
7	Draw the whole process of publicly funded university research commercialisation in the university you are involved in.	 This question will lead to a discussion on whom the participant reports to and why they report the information. Ask the participant to explain the drawing, asking if the drawing depicts their job (similarities and differences), are there enough resources (people/time/materials/ office space) (Walker 1997), how fragile is the system. **Use the drawing to identify key stakeholders.** It is thought that each participant within the system will have a different perception (lens on how they view the process) on what the weakness is, the strength is, and what is needed to address the strength and weakness. The question on resources and fragility may identify further key stakeholders not identified earlier. This question was sourced from Freeman and Liedtka (1997 cited in Knoll et al 2017).	*Drawing and Verbal Process Description* *Materials: paper, pencils, markers, eraser, sticky-tape*
8	Identify the portion that you (the participant) are responsible for		*Short answer, qualitative*
Actual Information			
The following questions are in relation to the section of the process the participant is responsible for.			
9	What do you do?		*Short answer, qualitative*
10	Who pays you?		*Short answer, qualitative*
11	What do they pay you for?		*Short answer, qualitative*
12	Who do you pay?		*Short answer, qualitative*
13	What do you pay them for?		*Short answer, qualitative*

Q#	Question	Discussion	Type of Question for Data Collection
Additional Questions			
14	What happens to the research outcomes that do not go to the commercialisation unit (i.e. where do they go), prompt for % that does not move onto the commercialisation department?		*Short answer, qualitative*
15	What happens to the research outcomes that are rejected by the commercialisation unit (i.e. where do they go) prompt for % that are rejected. Does this correlate with the commercialisation department answer?		*Short answer, qualitative*
16	How are you rewarded for transferring an outcome to industry? Promotion, IP Ownership (who owns the IP), Other?		*Short answer, qualitative*
17	Is there anything else you would like to add?		

Appendix H - Interview Questions

Appendix I - Participant information on the research

University of Southern Queensland

Participant Information for USQ
Research Project
Interview and Online Survey

Research Team Contact Details	

Principal Investigator Details

Ms Pauline Joanne Ross
Email: u1036507@umail.usq.edu.au
Telephone:
Mobile: 0418 666 752

Supervisor Details

Dr Steven Goh
Email: steven.goh@usq.edu.au
Telephone: (07) 4631 1446
Mobile: 0412 628 798

Dr Eric Kong
Email: kongeric@usq.edu.au
Telephone: (07) 4631 1257

Description	

This research is being undertaken as part of a PhD Project entitled *Mapping the Supply Network and Resource Constraints of Publicly Funded University Scientific Research Commercialisation within Australia.*

The purpose of this research is to investigate the commercialisation process of publicly funded university scientific research in Australian universities and, through mapping, identify any constraints in the system that are hindering the transfer of publicly funded research outcome intellectual property (IP) to industry for commercial gain. The research will be in two parts. Part A will be face-to-face interviews is to map the system and identify constraints. Part B is an online survey to enable a measurement of the participants perception of the perceived impact of the constraint on the eventual commercial outcome.

The research team requests your assistance with this research as little is understood of the constraints within the university commercialisation system and how these constraints impact on research intellectual property being successfully transferred to industry for commercial gain. The aim of the face-to-face interviews is to establish a mapping of the process from the view of the stakeholders within the process, concentrating on the activities undertaken and how these activities move through the system. After analysis of the mapping information provided through the interviews, participants will be asked to undertake a short online survey to enable an analysis of a correlation between the constraints and the success or failure of the commercialisation process.

universities.   To mitigate this all data will be de-identified to ensure that an individual, a project or an institution cannot be identified.

It is not thought that participant involvement in this research would cause any social harm as involvement is voluntary, it will be kept confidential and not reported to any other participant of the research or stakeholder within the commercialisation system.

It is not thought that there will be any physical, psychological, economic or legal risks greater than inconvenience or discomfort as the participants are reporting on a system (business process) not their personal involvement or opinion of the system.

All participants are able to opt out of the research, without bias, and have their data destroyed before publication of the research results.

Privacy and Confidentiality

Part A:

The names of individual persons are not required in any of the responses.

Audio recording:
- At the end of the interview a recorded summary of the interview information will be undertaken to enable the participant to verify the responses.
- The recording will not be used for any other purpose other than providing data for the PhD project.
- The recording will only be accessed by the research team and the professional transcribing organisation.
- If you choose to not have the interview recorded, manual notes will be taken throughout the interview.

Part B:
The names of individual persons are not required in any of the responses.

Any data collected as a part of this project will be stored securely as per University of Southern Queensland's Research Data Management policy.

All comments and responses will be treated confidentially unless required by law.

Consent to Participate

We would like to ask you to sign a written consent form (enclosed) to confirm your agreement to participate in this project. Please return your signed consent form to a member of the Research Team prior to participating in your interview.

Additionally, clicking on the 'Submit' button at the conclusion of the online survey is accepted as an indication of your consent to submit the survey data.

Questions or Further Information about the Project

Please refer to the Research Team Contact Details at the top of the form to have any questions answered or to request further information about this project.

Concerns or Complaints Regarding the Conduct of the Project

The research aims to produce a theoretical mapping of the publicly funded university scientific research commercialisation process with constraints and their perceived importance. This information will be used to assist universities undertaking a review of their commercialisation process or applying for public funding for research projects that have an outcome of intellectual property transfer into industry for commercial gain.

Thank you for taking the time to help with this research project. Please keep this sheet for your information.

Participation

Part A:
Your participation will involve undertaking a face-to-face interview that will take approximately one hour of your time.

The face-to-face interview will take place at a time and venue that is convenient to you.

Questions will include your definition of commercialisation within the university context and a description of the publicly funded university scientific research commercialisation process within your university and the part that you play.

The interview will be audio recorded and later transcribed by a professional transcription service. Participants are able to opt out of any of the recordings and choose more analogue methods of note taking such as paper and pencil with notes being taken by the principal investigator.

Part B:
Your participation will involve completion of an online survey that will take approximately ten minutes of your time.

Questions will include understanding the relationship between the position of the constraint within the process of university research commercialisation and the relationship between the perceived impact of the constraint and the success or failure of transfer of the research outcome to industry.

Your participation in this project is entirely voluntary. If you do not wish to take part you are not obliged to. If you decide to take part and later change your mind, you are free to withdraw from the project up to publication of the results. You may also request that any data collected about you be destroyed. If you do wish to withdraw from this project or withdraw data collected about you, please contact the Research Team (contact details at the top of this form).

Your decision whether you take part, or not to take part, or to take part and then withdraw, will in no way impact your current or future relationship with the University of Southern Queensland or Western Sydney University.

Expected Benefits

It is expected that through participation in interviews for this research, that the participants may, as a result of their discussions, see alternative or improved systems for their own part in the commercialisation process.

Additionally, the outcome of this research may enable Australian universities to identify constraints that may assist with the successful transfer of intellectual property to industry for commercial gain. This, in turn, will potentially assist in the development of new industries or the sustainability of current industry for industry in general.

Risks

There is a risk that the participants will be concerned about the privacy and confidentiality of the data collected. This may be through the sharing of the data, or the possibility the individual may be able to be identified through their specific role in the process and the sample size of the research is only three

Appendix J - Participant consent

University of Southern Queensland

Consent Form for USQ Research Project
Interview and Online Survey

Project Details

Title of Project:	Mapping the Supply Network and Resource Constraints of Publicly Funded University Scientific Research Commercialisation within Australia
Human Research Ethics Approval Number:	H17REA234

Research Team Contact Details

Principal Investigator Details

Ms Pauline Joanne Ross
Email: u1036507@umail.usq.edu.au
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Other Investigator Details

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Mobile: 0412 628 798

Dr Eric Kong
Email: kongeric@usq.edu.au
Telephone: (07) 4631 1257

Statement of Consent

By signing below, you are indicating that you:

- Have read and understood the information document regarding this project.

- Have had any questions answered to your satisfaction.

- Understand that if you have any additional questions you can contact the research team.

- Understand that you are free to withdraw at any time, without comment or penalty.

- Understand that you can contact the University of Southern Queensland Ethics Coordinator on (07) 4631 2690 or email ethics@usq.edu.au if you do have any concern or complaint about the ethical conduct of this project.

- Are over 18 years of age.

- Agree to participate in the project.

Participant Name	
Participant Signature	
Date	

Please return this sheet to a Research Team member prior to undertaking the questionnaire.

Page **1** of **1**

Appendix J - Participant Consent

Appendix K - Ethics Approval

OFFICE OF RESEARCH
Human Research Ethics Committee
PHONE +61 7 4631 2690| FAX +61 7 4631 5555
EMAIL human.ethics@usq.edu.au

UNIVERSITY
OF SOUTHERN
QUEENSLAND

27 November 2017

Ms Pauline Ross

Dear Pauline

The USQ Human Research Ethics Committee has recently reviewed your responses to the conditions placed upon the ethical approval for the project outlined below. Your proposal is now deemed to meet the requirements of the *National Statement on Ethical Conduct in Human Research (2007)* and full ethical approval has been granted.

Approval No.	H17REA234
Project Title	Mapping the Supply Network and Resource Constraints of Publicly Funded University Scientific Research Commercialisation within Australia
Approval date	27/11/2017
Expiry date	27/11/2020
HREC Decision	**Approved**

The standard conditions of this approval are:
  (a) Conduct the project strictly in accordance with the proposal submitted and granted ethics approval, including any amendments made to the proposal required by the HREC
  (b) Advise (email: human.ethics@usq.edu.au) immediately of any complaints or other issues in relation to the project which may warrant review of the ethical approval of the project
  (c) Make submission for approval of amendments to the approved project before implementing such changes
  (d) Provide a 'progress report' for every year of approval
  (e) Provide a 'final report' when the project is complete
  (f) Advise in writing if the project has been discontinued, using a 'final report'

For (c) to (f) forms are available on the USQ ethics website:
http://www.usq.edu.au/research/support-development/research-services/research-integrity-ethics/human/forms

Yours sincerely,

Dr Mark Emmerson
Ethics Officer

Appendix L - Policy Components

Appendix L – Australian University IP Management Policy Components

University	Does the policy mention commercialisation by the University	IDENTIFY & REPORT — Identification of IP (notification)	DECISION — Decision on proceeding	IP PROTECTION — IP Ownership	Discussion of commercialisation process with creator and uni (responsibility) management of IP	Assigning/Commercialisation by creators/inventors	Restriction on Commercialisation or IP use within the decision process	Managing publication and commercialisation objectives	Open Access	Indigenous IP and traditional knowledge	educate staff on ip identification and management	REVENUE/COST — Distribution of revenue	Cost centre determination	OUTCOME FOR IP — Moral rights	Disputes	University decides not to commercialise	Spinoff Company	TIME — Time for the Process	SALES — Finding an industry Partner
ACU	calls it development of IP	1	1		1							1		1	1				
ANU	procedure for IP protection and commercialisation	1	1									1	1		1	1			
BATCHELOR	Policies not publicly listed																		
BOND	yes - exploitation of IP	1		1	1							1			1				
CQU	yes IP and moral rights	1		1			1					1		1	1				
CDU	yes - commercial exploitation	1		1	1							1		1		1			
CSU	yes	1	1	1							1	1							
CURTIN	yes - listed in the procedures	1	1	1	1							1		1	1		1		
DEAKIN	yes - policy and procedures	1	1	1							1	1			1	1			
ECU	yes	1	1							1		1							
FEDERATION	No																		
FLINDERS	yes	1	1	1	1							1		1	1				
GRIFFITH	yes - points to procedures and strategy (3 docs)	1		1	1							1	1			1			
JCU	yes	1		1								1				1			
LaTrobe	yes	1		1	1							1							
MACQUARIE	yes	1	1	1								1			1				
MONASH	yes but some info unable to access	1		1								1			1				
MURDOCH	yes	1		1								1			1				
QUT	yes	1	1	1	1			1		1		1		1	1				
RMIT	yes - cannot get access to procedures p/word protected	1	1	1	1						1	1			1				
SCU	yes	1	1	1								1		1	1				
SWINBURNE	yes -	1		1						1		1		1		1			
TORRENS	yes -	1		1						1		1							
ADELADE	yes	1	1	1	1					1		1			1				
CANBERRA	yes	1	1									1							
Divinity																			
MELBOURNE	some - disbursed amongst a lot of policies	1	1	1								1							
UNE	yes - knowledge transfer	1	1	1	1							1		1	1	1			
UNSW	yes - exploitation of IP	1	1	1	1			1				1		1	1	1			
UoN	yes	1	1			1	1					1		1	1	1			
UNDA	Yes	1	1	1		1			1			1		1	1				
UQ	yes	1		1	1							1			1	1			
UniSA	recording and managing IP	1	1	1	1					1		1			1				
USQ	commercial exploitation	1	1	1	1							1		1	1				
USyd	yes	1	1	1								1		1	1				
UTAS	no - under review	1	1		1		1	1				1	1	1	1	1			
UTS	Yes	1	1	1		1						1			1				
USC	Yes	1	1	1	1							1			1				
UWA	No	1	1		1			1				1							
UOW	Yes	1	1	1	1							1		1	1	1	1		
VU	Yes	1	1	1								1			1				
WSU	Yes	1	1	1	1							1		1	1	1			
Total		35	27	25	16	3	2	4	2	7	3	34	3	13	27	13	2		

Appendix L - Breakdown of the Intellectual Property Management Policies (Individual University Policies)

Appendix M -Policies that Address Commercialisation of Research

Appendix M - Australian University Policies that Address the Process of Commercialisation of Research			
University	**Policy**	**Updated**	**Link**
Australian Catholic University	Intellectual Property Policy	Jun-18	https://policies.acu.edu.au/__data/assets/pdf_file/0011/2289566/IP_Policy_Final.pdf
Bond University	Intellectual Property Policy TLR 6.02	4-Nov-16	https://bond.edu.au/files/958/TLR602.pdf
Central Queensland University	Policy: Intellectual Property and Moral Rights	22-Jun-16	https://www.cqu.edu.au/policy?collection=policy&form=policy&query=intellectual+property&facetScope=f.Subject%257CU%3Dstudent%26f.Category%257CP%3Dpolicy&sort=
Charles Darwin University	Intellectual Property Policy	15-Dec-17	http://www.cdu.edu.au/governance/doclibrary/pol-025.pdf
Charles Sturt University	Intellectual Property Policy	1/2/18	https://policy.csu.edu.au/document/view-current.php?id=155
Curtin University	Intellectual Property Policy	1-Mar-17	http://policies.curtin.edu.au/local/docs/policy/Intellectual_Property_Policy.pdf
Deakin University	Intellectual Property (Staff) Policy	2-Oct-17	https://policy.deakin.edu.au/document/view-current.php?id=57
Deakin University	Intellectual Property (Student) Policy	2-Oct-17	https://policy.deakin.edu.au/document/view-current.php?id=138
Edith Cowan University	Policy Title: Intellectual Property PL234	1-Nov-17	http://intranet.ecu.edu.au/research/for-research-students/research-journey/forms-policies-and-guidelines
Federation University	IP Policy and Procedures under review		http://policy.federation.edu.au/category_list.php?catalogue_id=127
Flinders University	Intellectual Property Policy (PENDING REVIEW)	4-Apr-16	http://www.flinders.edu.au/ppmanual/research/intellectual-property.cfm
Griffith University	Intellectual Property Policy including Annexure A: University Commercialisation Procedures	3-Apr-17	http://policies.griffith.edu.au/pdf/Intellectual%20Property%20Policy.pdf
James Cook University	Intellectual Property Policy and Procedure	23-Feb-17	https://www.jcu.edu.au/policy/research-management/intellectual-property-policy-and-procedure
La Trobe University	Intellectual Property Policy plus Section 4 of the Policy - Procedures	28-Nov-16	
Macquarie University	Intellectual Property Policy	30-Oct-14	https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policies/intellectual-property
Monash University	Commercialisation, Revenue Sharing Provisions and Dispute Resolution Policy	14-Sep-17	https://www.monash.edu/__data/assets/pdf_file/0007/1168927/IP-Policy.pdf
Murdoch University	Intellectual Property Regulations	document has been archived	mhttp://library.murdoch.edu.au/Copyright-matters/Intellectual-propertyhttp://library.murdoch.edu.au/Copyright-matters/Intellectual-property/
Queensland University of Technology	D/3.1 Intellectual Property	30-Sep-17	http://www.mopp.qut.edu.au/D/D_03_01.jsp
Royal Melbourne Institute of Technology	Intellectual Property Policy		does not list anything more than the committee responsibilities
Southern Cross University	Intellectual Property Rights Policy	no date	https://policies.scu.edu.au/view.current.php?id=00017
Swinburne University of Technology	no ip policy only regulations		
Torrens University Australia	PL_AC_006: Copyright Compliance and Intellectual Policy	19-Jul-17	http://www.torrens.edu.au/wp-content/uploads/sites/12/2016/08/G60-Intellectual-Property-Policy.pdf
University of Adelaide	Intellectual Property Policy	15 Aug 2017	https://www.adelaide.edu.au/policies/1263/?dsn=policy.document;field=data;id=2122;m=view
University of Canberra	Intellectual Property Policy	22-Jun-16	https://www.canberra.edu.au/Policies/PolicyProcedure/Index/109
University of Divinity	no policies on Intellectual Property		
University of Melbourne	Intellectual Property Policy (MPF1320)	2-Dec-16	https://policy.unimelb.edu.au/MPF1320
University of New England	Knowledge Assets and Intellectual Property Policy - Section 3 of the Policy is the Procedures	current - on website	https://policies.une.edu.au/view.current.php?id=00117
University of New South Wales	Intellectual Property (IP) Policy	6-Mar-13	https://www.gs.unsw.edu.au/policy/documents/ippolicy.pdf
University of Newcastle	Intellectual Property Policy	7-Jul-15	https://www.newcastle.edu.au/about-uon/governance-and-leadership/policy-library/document?RecordNumber=D09_2007P
University of Notre Dame Australia	Policy: Intellectual Property - Schedule 1 is the Procedure for Patent Applications and Commercialisation	1-Sep-06	http://www.nd.edu.au/downloads/current-students/studentadministration/policy-intellectual-property-06sept.pdf
University of Queensland	Intellectual Property for Staff, Students and Visitors Policy 4.10.13	19-May-16	https://ppl.app.uq.edu.au/content/4.10.13-intellectual-property-staff-students-and-visitors
University of South Australia	Intellectual Property: Ownership and Management Policy	16-Dec-16	https://i.unisa.edu.au/policies-and-procedures/university-policies/research/res-22/
University of Southern Queensland	Intellectual Property Policy and Procedure	15-Aug-11	https://policy.usq.edu.au/documents/13345PL
University of Sydney	Intellectual Property Policy 2016	10-May-16	http://sydney.edu.au/policies/showdoc.aspx?recnum=PDOC2016/418&RendNum=0
University of Tasmania	Intellectual Property (GLP4)	8-Apr-15	http://www.utas.edu.au/university-council/university-governance/governance-level-principles/intellectual-property-glp4
University of Technology Sydney	Intellectual Property Policy	2-Jul-14	http://www.gsu.uts.edu.au/policies/intellectual-property-policy.html
University of the Sunshine Coast	Intellectual Property - Governing Policy	23-Sep-11	https://www.usc.edu.au/explore/policies-and-procedures/intellectual-property-governing-policy
University of Western Australia	University Policy on: Intellectual Property	procedures or regulations	http://www.governance.uwa.edu.au/procedures/policies/policies-and-procedures?method=document&id=UP07%2F49
University of Wollongong	Intellectual Property IP Policy	22-Aug-17	https://www.uow.edu.au/about/policy/UOW058689.html
Victoria University	Intellectual Property Regulations	10-Sep-14	https://policy.vu.edu.au/view.current.php?id=00153
Western Sydney University	Intellectual Property Policy	only available on website	https://policies.westernsydney.edu.au/view.current.php?id=85

Appendix M - Intellectual Property Management Policies (source: Individual University)

Appendix N - Intent to Commercialise - Act, Strategy & Policy

Appendix N - A Mapping of the Intent to Commercialise

Column groups: **INCORPORATED ACT** (Undertake Research, Commerialise, Commercially Exploit - Facilities, Knowledge, Research & Study) · **UNIVERSITY STRATEGIC PLAN** (Undertake Research, Seek Research Partnership/business/govt/research inst/community, Want impact, Want to commercialise, Want to increase research revenue from funding industry or philanthropic, Increasing citation ranking) · **POLICY INTENT FOR IP MANAGEMENT** — IDENTIFY (Identify IP and Notify), IP PROTECTION BY UNI (IP Ownership, Restrictions while in decision mode, Educate staff on IP Protection), INVESTIGATE VIABILITY (IP development discussion with researcher & uni, Manage publication and commerce), IP DEVELMENT (Revenue Distribution, Moral Rights, Disputes, Uni not commercialise), FINDING AN INDUSTRY PARTNER - SALES (Finding an industry partner (SALES), Spinoff company) · **TIME** (Time for the process) · Does the policy mention commercialisation by the University

Uni	Undertake Research	Commerialise	Commercially Exploit	Undertake Research	Seek Research Partnership	Want impact	Want to commercialise	Want to increase research revenue	Increasing citation ranking	Identify IP and Notify	IP Ownership	Restrictions while in decision mode	Educate staff on IP Protection	IP development discussion	Manage publication and commerce	Revenue Distribution	Moral Rights	Disputes	Uni not commercialise	Finding industry partner	Spinoff company	Time	Does the policy mention commercialisation by the University
ACU	1									1				1		1	1	1	1				calls it development of IP / procedure for IP protection and commercialisation
ANU	1		1	1	1		1			1						1		1	1				
BATCHELOR	1		1	1	1																		
BOND	1		1	1	1	1				1		1		1		1		1					- exploitation of IP
CQU	1		1	1	1	1	1				1			1		1	1	1					yes IP and moral rights
CDU	1		1	1	1	1		1		1	1					1			1				yes - commercial exploitation
CSU	1		1	1	1	1				1	1		1										yes
CURTIN	1		1	1	1	1	1			1	1			1		1		1			1		yes - listed in the procedures
DEAKIN	1		1	1	1	1	1	1	1	1	1					1		1					yes - policy and procedures
ECU	1		1	1	1	1	1			1	1		1			1		1					yes
FEDERATION	1			1	1	1																	No
FLINDERS	1			1	1	1				1				1		1	1	1					yes
GRIFFITH	1		1	1	1	1				1	1			1		1							yes - points to procedures and strategy (3 docs)
JCU	1		1	1	1	1				1	1			1		1	1	1	1				yes
LaTrobe	1		1	1	1	1		1		1	1			1		1	1	1	1				yes
MACQUARIE	1		1	1	1	1				1	1					1		1					yes
MONASH	1		1	1	1	1	1	1		1	1			1		1	1	1					yes but some info unable to access
MURDOCH	1		1	1	1	1	1	1		1	1					1	1	1					yes
QUT	1		1	1	1	1				1	1			1	1	1	1	1					yes
RMIT	1			1	1	1				1	1			1		1							yes - cannot get access to procedures pword protected
SCU	1		1	1	1					1	1		1	1		1		1					yes
SWINBURNE	1			1	1					1	1					1	1		1				yes -
TORRENS	1			1	1		1	1		1	1			1		1	1	1	1				yes -
ADELAIDE	1		1	1	1			1		1						1		1					yes
CANBERRA	1		1	1	1		1			1	1					1	1	1					yes
Divinity	1			1			1		1														
MELBOURNE	1		1	1	1	1		1		1	1			1		1	1	1					some - disbursed amongst a lot of policies
UNE	1		1	1	1	1	1			1	1			1		1	1	1	1				yes - knowledge transfer
UNSW	1		1	1	1	1				1	1					1	1	1					yes - exploitation of IP
UoN	1		1	1	1	1				1	1					1	1	1					yes
UNDA	1			1	1	1	1			1	1				1	1	1	1					yes
UO	1		1	1	1	1	1		1	1	1							1					yes
UniSA	1			1	1	1	1	1		1	1					1	1	1					recording and managing IP
USQ	1		1	1	1	1		1		1	1			1		1	1	1					commercial exploitation
USyd	1		1	1	1	1				1	1					1	1	1					yes
UTAS	1	1	1	1	1	1	1			1	1	1			1	1	1	1					no - under review
USC	1		1	1	1	1	1			1				1		1	1	1					Yes
UWA	1			1	1	1		1		1	1			1		1							Yes
UOW	1			1	1	1			1	1	1				1	1	1	1					No
VU	1		1	1	1	1				1	1			1		1	1	1			1		Yes
WSU	1			1	1	1		1		1	1				1	1		1					Yes
Total	**42**	**1**	**29**	**42**	**38**	**30**	**11**	**12**	**6**	**35**	**25**	**2**	**3**	**16**	**4**	**34**	**13**	**26**	**13**	**0**	**2**	**0**	

Appendix N - Intent to Commercialised (source: Individual University)

Appendix O - Decision Makers in the Policies

Appendix O - Decision Makers in the Policies																																
	IDENTIFY	IP PROTECTION BY UNI																														
University	Report IP	Initial Decision to Proceed and Protect IP While Investigating					Manage Protection						Investigate Viability								Development of the IP						Finding Industry Partner					
	R	R	F	C	U	D	R	C	D	U	L	I	R	F	C	D	U	L	E	I	R	C	D	U	L	I	R	C	D	U	L	I
ACU																																
ANU	1	1	1	1			1									1					1	1										
BATCHELOR																																
BOND	1	1		1						1			1			1								1				1				
CQU	1	1		1		1										1								1								
CDU	1				1												1							1								
CSU	1	1		1		1									1	1								1				1				
CURTIN	1	1		1			1						1		1															1		
DEAKIN	1	1		1									1		1									1								
ECU	1	1		1			1	1					1		1									1								
FEDERATION																																
FLINDERS	1	1	1			1							1			1								1								
GRIFFITH	1	1		1			1	1					1		1									1								
JCU	1	1		1			1						1								1											
LaTrobe	1	1		1			1								1				1					1								
MACQUARIE																																
MONASH																																
MURDOCH	1	1		1			1						1		1									1								
QUT	1	1		1			1									1							1									
RMIT																																
SCU	1	1		1	1					1					1			1						1								
SWINBURNE																																
TORRENS	1				1		1																	1								
ADELAIDE	1	1		1			1	1													1	1										
CANBERRA	1	1		1	1		1	1		1					1			1	1		1							1				
Divinity																																
MELBOURNE			1					1							1						1											
UNE	1	1				1									1	1			1					1			1	1				
UNSW	1	1		1			1	1					1		1						1											
UoN	1	1			1		1		1				1		1	1												1				
UNDA	1	1					1						1				1							1					1			
UQ	1	1		1	1										1		1							1								
UniSA	1	1		1			1	1					1		1						1						1	1				
USQ	1	1	1	1		1	1	1					1		1	1			1		1	1						1				
USyd	1	1	1	1				1					1		1													1				
UTAS																																
UTS	1	1				1	1			1			1					1						1								
USC	1														1			1			1	1								1		
UWA	1	1				1							1	1		1					1	1										
UOW	1	1		1						1					1						1							1				
VU	1	1			1		1			1			1`			1							1						1			
WSU	1	1		1	1		1	1	1				1		1						1	1					1					
Total	32	29	4	23	8	8	19	11	2	6	0	0	18	1	22	6	8	5	1	0	1	#	#	11	0	0	2	9	2	2	0	0

LEGEND	
Researcher	R
Commercialise Unit - whether internal or a TTO	C
DVC - research	D
Legal & Accounts	L
Industry	I
Faculty	F
University	U
External IP Professional	E

Appendix O - Decision Makers in the Policies (source: Individual University Policies)