CRC Construction Innovation
BUILDING OUR FUTURE

Final Report
Public Policy Implications of Construction Innovation Research

Research Project No: 2004-032-A-3

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PREFACE

Historically, research organisations have often been called to give an account of the quantity of the outputs of their organisations, which are typically measured in terms of the number of innovations, publications and students. In recent years, research organisations have been asked to account for quality of their research, which is typically measured in terms of the impact of the research. While citations in high ranking journals are one measure of this, another is to examine the influence of research and innovations on industry and government. The impact of innovation on public policy is an under researched area, which this report seeks to partially address through an examination of the public policy implications of *Construction Innovation* research.

This report is deliverable for the Construction Industry Business Environment project, which has been generously funded by the CRC for Construction Innovation.

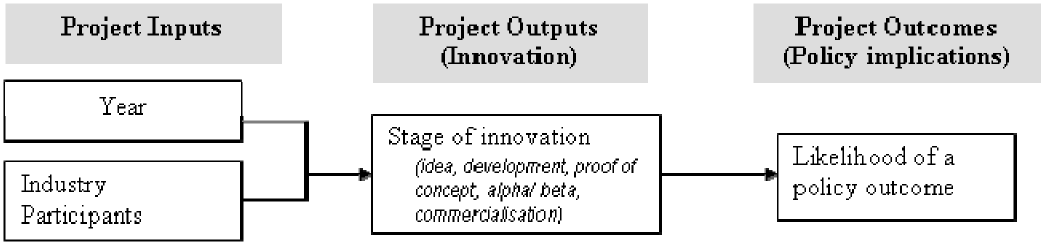
EXECUTIVE SUMMARY

This report undertakes an exploratory analysis of *Construction* Innovation research projects in order to answer the question "What are the public policy implications of *Construction Innovation* research?"

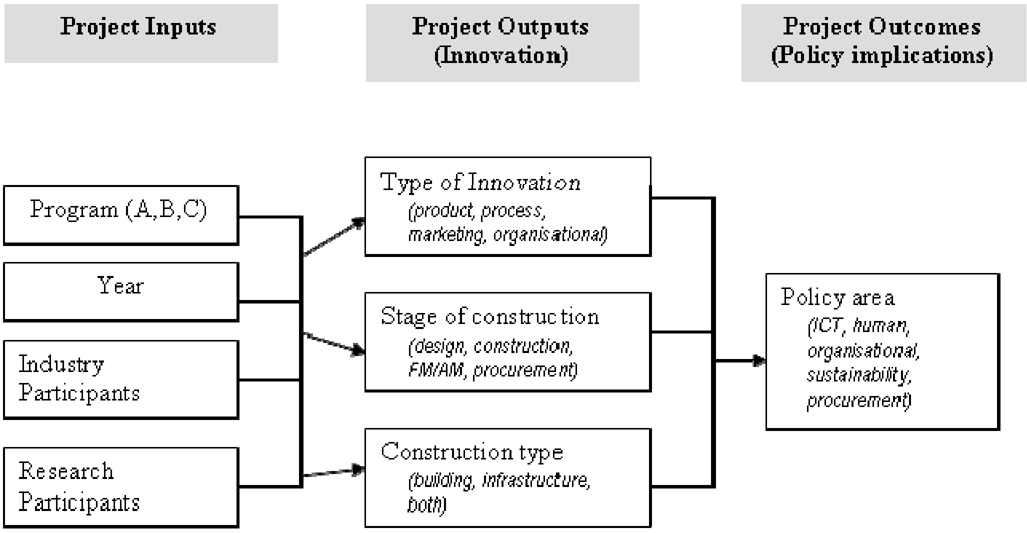
As this research has no known precedent, an evaluation framework was drawn from program evaluation approaches within government, which identifies the inputs, outputs and outcomes of various programs. Content analysis of each project was undertaken in order to enable analysis of the research projects and to undertake quantitative analysis in order to identify any correlations between project variables.

Inputs to research projects were identified as the year of the project, the amount of support the project was given (in terms of budget and in-kind support) together with the number of different types of participants (industry, government, and research). The outputs of each project were coded according to the type of innovation (product, process and organisational), the stage of innovation (idea, development, proof of concept, alpha / beta, and commercialisation / utilisation); stage of construction (design, construction, maintenance, and procurement); and type of construction (buildings, infrastructure, or both buildings and infrastructure). The outcomes of the project were coded according to the policy area, together with the perceived likelihood and benefit of any policy intervention.

Following regression analysis the initial model was tested and simplified, an updated version of which is included below. The most likely outcome is that as years progressed a number of research projects tested, developed and completed a number of innovations. As the years progressed, the perceived likelihood of *Construction Innovation* research having a policy impact increased.

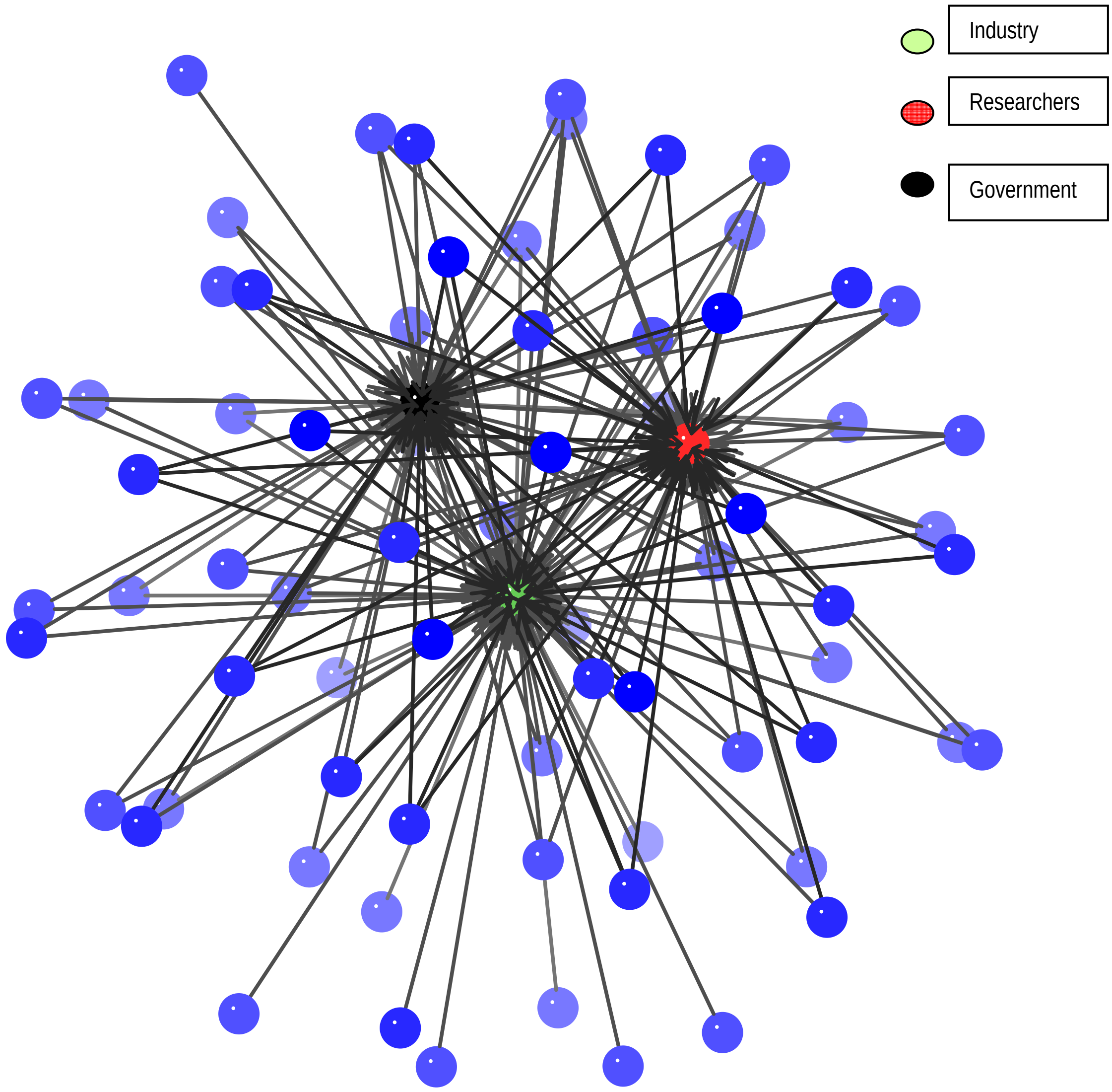


A number of other relationships were also demonstrated using various statistical techniques. However, the remainder of the relationships could not be simplified due to the relatively small sample size.



This research project has demonstrated that:

- Project inputs, particularly participants and programs, have a statistically significant relationship to the type of innovation developed within the project
- Various types of innovations have a statistically significant relationship with policy areas. This holds true even when project inputs have been controlled for. In particular the stage of innovation is the best predictor of a policy outcome, compared to other variables.
- The projects that where the most efficient at producing a policy influence were those that focussed on human factors, such as occupational health and safety, as a policy area.
- A unique form of relationship between project participants (government, industry and research) termed a triple helix has been demonstrated (see figure below).



1. INTRODUCTION

Construction regulation is often seen as an overarching **framework** in which the industry operates and under which innovation occurs (for example see Figure 2 below). The construction industry in Australia has consistently argued that this regulatory framework hinders innovation due to overregulation (Price Waterhouse Coopers 2002; Manley 2004; Hampson & Brandon 2004). Seaden & Manseau (2001) argue that government in Australia is fragmented, risk averse, innovation resistant and not heavily involved in construction innovation apart from R&D funding. Thus the focus of much construction innovation research to date has thus tended to suggest a negative relationship between government policy and innovation in Australia.

This approach, however, has two draw backs. Firstly, by focussing methodologically on industry opinion, such research tends to ignore the specific involvement of government in innovation projects. The BRITE project has performed a sterling job cataloguing large numerous instances in which government has promoted innovation – and the themes of successive international conferences have been on the role of clients, including government clients, as drivers of innovation. Secondly, much research has focussed on the innovation process itself, and paid little attention to the impact innovations might have upon public policy. It is this gap in the research literature that this report addresses.

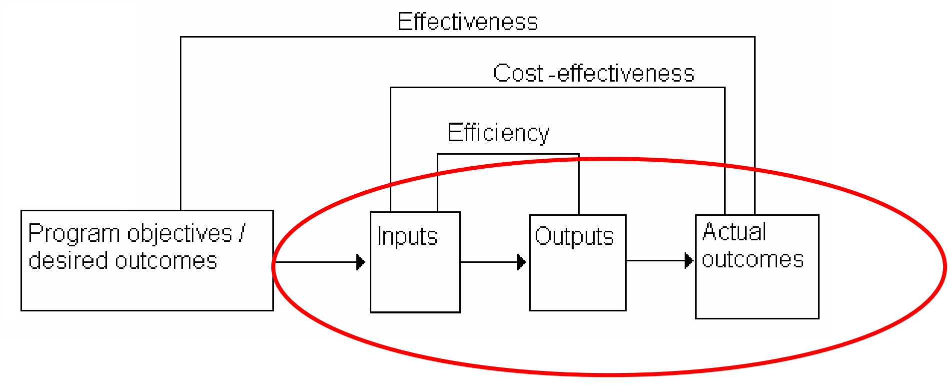
The CRC for Construction Innovation (hereafter referred to as *Construction Innovation)* is a collaborative research initiative involving multiple industry, research and government organisations. This joint venture was established to foster innovation in the construction sector, and has developed a significant track record in this regard. This report examines a total of 75 projects which have been funded by the *Construction Innovation* all of which focus on developing a specific aspect of innovation. This report is a deliverable by a research project (Construction Industry Business Environment) which seeks, in part, to identify the policy implications of these innovations. An outline of the project and its phases can be found in Attachment A.

The research outlined in this project therefore has practical, theoretical as well as policy implications.

2. LITERATURE REVIEW

As the public policy implications of research is an under researched area in itself, a framework was needed to examine the policy implications. Within public policy research, evaluation frameworks are sometimes used to examine the effectiveness of various initiatives.

Figure 1: Policy Evaluation (adapted from Department of Finance 1994, p.8)



According to the framework provided in Figure 1, by focussing on the relationship between inputs, outputs and outcomes, a framework for evaluating the policy implications of *Construction Innovation* research is possible.

2.1. INPUTS INTO *CONSTRUCTION INNOVATION* RESEARCH PROJECTS

Within the CRC a number of research programs have been established with the view to developing a number of research projects. In order to do this, research projects are provided with both in-kind support (principally in time, but also physical resources), and specific budgets. With the framework provided by the research programs these constitute the primary <u>inputs</u> to the innovation process. The year is also treated as an input, as the increased capability of *Construction Innovation* to deliver research projects, and increased relationships between research partners is likely to result in increased performance of the research portfolio. Thus the input variables for each *Construction Innovation* project would include:

- Total Support (both financial and inkind) [1]
- Participants (research, industry and government)
- Research Program (A, B & C)
- Year

2.2. INNOVATION (OUTPUTS OF *CONSTRUCTION INNOVATION* RESEACH PROJECTS)

The specific types of <u>outputs</u> for each research project are the innovations themselves. It is obviously beyond the scope of a single research project to examine and explain all the minute possible details of the research program, and how these might relate to specific policies across multiple jurisdictions. Instead, it is possible to evaluate the various types and stages of of innovation.

There are a large variety of definitions of innovation. However, one that has gained some currency in the academic literature is that of Freeman:

> "Innovation …is the actual use of non-trivial change and improvement in a process, product or system that is novel to the institution developing the change" (Freeman 1989, cited by Slaughter 1998, p.226).

2.2.1. Types of innovation

Such a definition is useful in exploratory analysis within organisations, but is less useful when attempting to assess multiple existing examples of specific innovation, such as those that exist within *Construction Innovation* projects. Fortunately the Organisation for Economic Cooperation and Development (hereafter OECD) has developed guidelines to assist researchers as they seek to collect and interpret innovation data[2] which include the following definitions for different categories of innovation:

[1] In kind and budget were initially treated as separate variables. However, due to the high degree of correlation between them, (0.734, p<0.000) these variables where added together into a new variable – Total Support.

[2] Guidelines for Collecting and Interpreting Innovation Data (OECD 2005).

- A *product innovation* is … a good or service that is new or significantly improved with respect to its characteristics or intended uses (OECD 2005, p.48).
- A *process innovation* – is the implementation of a new significantly improved production or delivery method (OECD 2005, p.49).
- A *marketing innovation* is the implementation of a new marketing method involving significant changes in product design or in product design or packaging, product placement, product promotion or pricing (OECD 2005, p. 49).
- An *organisational innovation* is the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations (OECD 2005, p.51).

These types of innovation have been adopted in the coding process for *Construction Innovation*.

2.2.2. Stage of Innovation

While important, simply noting that a particular project focussed on delivering a specific type of innovation is surely insufficient. An innovation will typically go through a number of stages before it is ready for general use. While there are a number of different stages posited for innovation products, the following stages will be used in this project:

- Idea conceptualisation and initial analysis stage
- Development of the idea
- Commercialisation to proof of concept stage
- Commercialisation to alpha and beta stages (pre release)
- Commercialisation – final version and utilisation

While innovation can be coded according to type of innovation and stage of innovation, this does not classify the construction aspects of the innovation, particularly the type of construction or the phase of construction which the innovation is aimed at improving.

2.2.3. Phases of Construction

For *construction* innovation, a project can be conceptualised as being conducted in a number of phases. So when an innovation relates to construction, this may relate to a specific phase of construction. The specific phases of construction which projects were coded against are:

- Design
- Construction
- Facilities / asset management, whole of life, and re-life
- Procurement (as this can include all of the previous phases)

2.2.4. Type of construction

Within the CRC for Construction Innovation various partners and projects focus on specific types of construction. For this project, three possible applications of the innovation have been identified:

- Infrastructure - Those innovations that specifically focus on infrastructure
- Buildings - Those innovations that specifically focus on buildings
- Both - Those innovations which could be applied to both buildings and infrastructure.

Thus the output variables for each *Construction Innovation* project would include:

- Type of innovation (*product, process, marketing, organisational*)
- Phase of construction (*design, construction, facilities / asset management, procurement*)
- Type of construction (*infrastructure, buildings, both infrastructure and buildings*)
- Stage of innovation (*idea, development, proof of concept, alpha/beta, commercialisation / utilisation*)

Together these categorical variables provide a robust description of the outputs of research projects which can be correlated against the inputs, discussed earlier, and the outcomes – which are the public policy implications of the research.

2.3. PUBLIC POLICY IMPLICATIONS OF *CONSTRUCTION INNOVATION* RESEARCH (OUTCOMES)

As with innovation a variety of definitions have been proffered in the literature for public policy. One of the most frequently quoted definitions for public policy is that of Dye (1998): policy is everything that governments choose, or choose not, to do. There is in fact considerable debate in the literature concerning what public policy is and what it is not, and how to influence it (for a more detailed overview see Brown and Furneaux 2006a). This project has adopted the following definition of public policy:

- Public policy is a deliberate action that utilises governmental authority and institutions, and typically commits resources (money and services), in order to clarify public values and support preferred outcomes for government (adapted from Considine 1994:3-4).

Instead of entering into a definitional debate, this project will utilise the notion of policy instruments and policy areas as fruitful ways of resolving the complex constellation of policy issues which need to be resolved.

2.3.1. Policy areas

The research question to assess the policy implications of CRC research is quite difficult to achieve in a single report. There are multiple layers of government, with multiple areas of policy concerning the construction industry (for an overview see Brown and Furneaux 2006b). Thus every one of the 75 projects examined in this report which are funded by *Construction Innovation* could potentially need to be examined against 1 federal, 8 state, and 300 odd local councils, all of which have differing policy settings, and regimes for a given policy area.

Consequently, the public policy implications have been coded into a limited number of policy areas in order to reduce the complexity of the task. These areas are:

- Information and communication technology (ICT) policy
- OH&S and other human policy areas (e.g. ethics)
- Organisational and industry policy
- Sustainability
- Procurement and asset management

2.3.2. Policy Impact

While policy area is important, the benefits and likelihood of any policy implementation need to also be assessed. In order to do this, the perceived impact of a particular innovation must also be considered against the particular instrument chosen to give effect to a particular policy. There are in fact a limited number of instruments with which government can implement policy. The following list is adapted from Hood (1983: 168):

- Policy through advocacy –using information available to the government to educate or persuade;
- Policy through money – using spending and taxing powers to shape activity beyond government;
- Policy through direct government action – delivering services through public agencies
- Policy through law – legislation, regulation, policy and official authority

(adapted from Hood 1983, p.168).

Each innovation was coded against each of these policy instruments on two scales – the perceived benefits of government enacting policy, and the perceived likelihood that the government would enact policy. For benefit, a likert scale ranging from 'little benefit' to huge benefit' was created for each policy instrument. Likewise for likelihood, a likert scale ranging from 'highly unlikely' to 'already occurred' was created for each policy instrument.

The challenge of such an approach is that specific types of innovation may be more suited to a particular type of policy instrument, or the likelihood of different types of policy instrument could also vary. Consequently, an aggregate score from all policy instruments was calculated to give a Total Benefit score and a Total likelihood scale.

Thus the outcomes of each project were coded against policy area, total benefit and total likelihood. Together this provides a more robust assessment of the policy implications of *Construction Innovation* research than just policy area on its own. Thus the outcome variables (policy implications) for each *Construction Innovation* project would include:

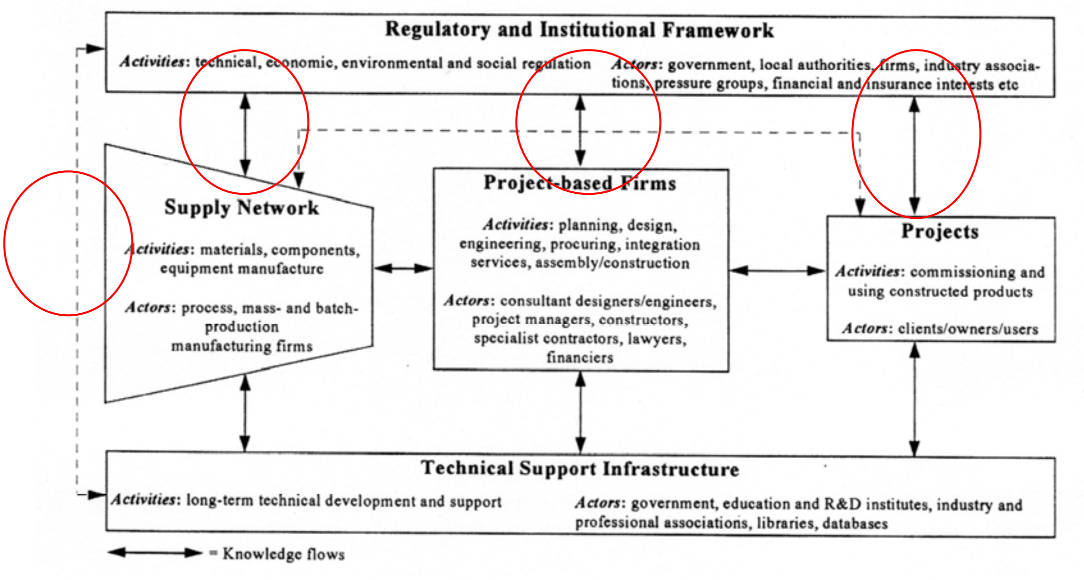
- Policy area (ICT, OH&S, Organisational and industry, Sustainability, Procurement)
- Perceived Total Benefit
- Perceived Total Likelihood

2.4. RELATIONSHIP BETWEEN INNOVATION AND POLICY

Interest in the interaction between innovation and public policy has increased rapidly in recent years (for a survey of innovation in policy itself, see Osborne and Brown 2005). However, much of the construction innovation literature however, tends to focus upon the relationship that public policy has upon innovation, rather than the influence of innovation on policy. As noted in the introduction, this research report aims to partially address this gap in the literature.

Consider for example the following example of how this relationship is visualised in the literature:

Figure 2 - Relationship between regulation and innovation (Gann & Salter 2000: 960)



The figure advanced by Gann and Salter (2000) suggest that there is an interaction (note the two way arrows) between regulation and innovation. While the impact of regulation on innovation has been well articulated elsewhere, the examination of any influence that innovation can have upon policy has been quite limited.

2.5. RESEARCH QUESTIONS

This research project seeks to fill the gap identified in the literature concerning the influence of innovation upon policy.

- "What relationship exists, if any, between *Construction Innovation* research – particularly the inputs, outputs and outcomes of innovation?"

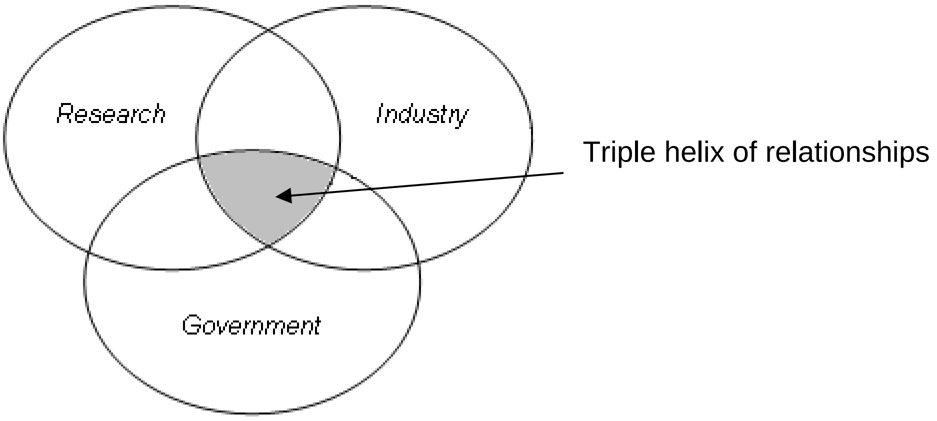
While exploring possible relationships between inputs, outputs and outcomes, a body of information will also be developed concerning the operations of *Construction Innovation* itself. This data may prove valuable to *Construction Innovation* in its own right.

A second issue, which is related to the inputs of innovation, is the idea that the CRC's themselves are innovations which involve relationships between industry, government and research organisations.

2.5.1. Cooperative Research Centres as examples of 'triple helix' innovation relationships

Leydesdorff & Meyer (2003) argue that government, industry and research institutions are capable of forming a **triple helix** of relationships which can constitute an interactive knowledge production system which can lead to strong innovation. Turpin and Garrett-Jones (2003) argue that Cooperative Research Centres (CRC's) are an important aspect of developing innovation in a range of industries. Indeed the CRC for Construction Innovation is an example of a collaborative approach to innovation between government, industry and university. This 'triple-helix' of relationships is argued to produce a new way of developing knowledge and innovation (Leyesdorff & Etzkowitz 1996). Under triple-helix arrangements, there are a complex set of organisational ties, which result in a reduction of barriers between government-industry-university, and are often facilitated by an intermediary organisation (Leyesdorff & Etzkowitz 1998). In this case study the intermediate organisation is the *Construction Innovation*.

Figure 3 - Triple Helix of Innovation - (Adapted from Etzkowitz & Leydesdorff 2000).



As each sector relates to the other two, an array of communications, networks, and organisations can be expected to arise (Etzkowitz & Leydesdorff 2000, 2003). It is out of this complex set of interactions that innovation is seen to develop. There is little evidence of explorations of triple helix arrangements, in Australia, which is surprising given the role of CRCs in the development innovation across various industry sectors. In fact, research on construction innovation has asserted the opposite – arguing that there is little evidence of government being involved in research and development activities beyond funding such activities. From the outset this report would argue that *Construction Innovation* fosters interaction between organisational partners, including government, in order to develop various types of innovations. However, the specific form that these relationships take, and whether these relationships could be considered a 'triple helix' set of relationships is unclear. Consequently, a subsequent question of this report is to examine:

- "Are government departments involved in research projects, beyond a just funding?"
- "Does the relationship of participants involved in *Construction Innovation* research constitute a triple helix?"

The interrelationships between government, industry and researchers are important for the provision of innovations as well as enhancing the potential policy impact of any research, as government would participate in the development of the research, and may help to identify potential policy outcomes.

2.6. MODEL FOR RELATIONSHIPS BETWEEN THE INNOVATIONS DEVELOPED BY RESEARCH PROJECTS AND POLICY IN THE CRC FOR CONSTRUCTION INNOVATION

Important note:

It is very important to note that while statistical techniques have been used to analyse the data, the research projects examined here can not be seen to be the product of a random process. That is to say, any correlations found are quite likely to be the product of the internal processes within the CRC itself. For example, the types of research projects which are accepted within a given research program, are likely to be accepted because they are of interest to the researchers and industry proponents who are members of that research program. The innovation is therefore not random in the statistical sense, but is due to the predisposition and existing normative and cognitive framework of the program members. For example, research projects which were in Program A, which involves business researchers and industry participants interested in business and organisational related research, would be considered likely to produce organisational types of innovation. Thus the innovation is directly related to the program which sponsored it, and such correlations should not come as a surprise. In fact, the larger surprise would be if there was <u>not</u> a correlation.

So from a research perspective, the main value of the report is not so much the novelty of finding that any correlations exist. Instead, the main value may prove to be an evaluation of the research program of the CRC itself, which would have value for reporting, and for potential future re-bids of the CRC.

The possible relationship between the resources of *Construction Innovation*, innovation and policy is hypothesised below:

Figure 4 – Hypothesised Relationship between project inputs, outputs and outcomes (policy implications)

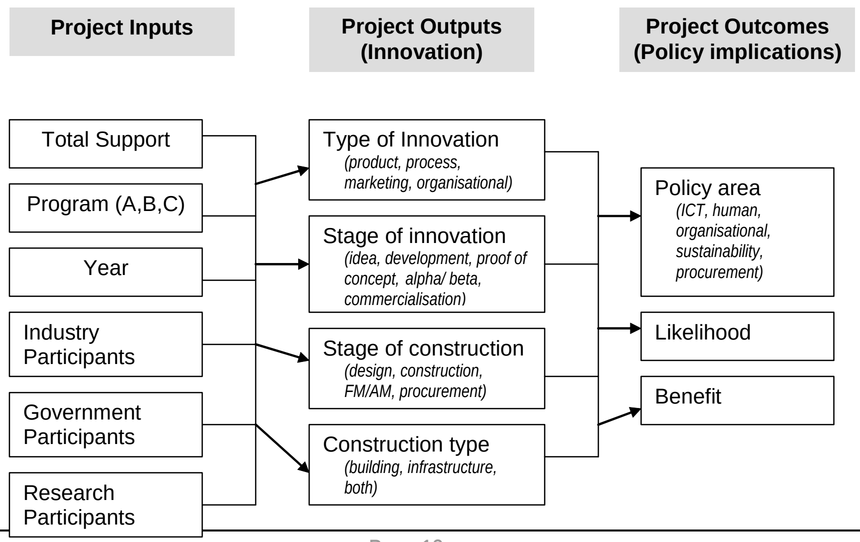


Table 1 - Summary of variables

<table>
<tr><th>Independent Variables</th><th>Mediating / Moderating variables</th><th>Dependant Variables</th></tr>
<tr><td>Inputs to project</td><td>Project Outputs</td><td>Policy Outcomes</td></tr>
<tr><td>Total Support (scale)
(In-kind plus budget)</td><td rowspan="4">Type of Innovation (Nominal)
o Product innovation
o Process innovation
o Marketing innovation
o Organisational innovation

Stage of Innovation (Nominal)
o Idea conceptualisation and initial analysis stage
o Development of the idea
o Proof of concept stage
o Alpha and beta stages (pre release)
o Commercialisation – final version and utilisation

Stage of Construction (Nominal)
o Design
o Construction
o Facilities / asset management, whole of life, re-life
o Procurement

Type of Construction (Nominal)
o Building
o Infrastructure
o Both</td><td rowspan="4">Policy area (Nominal)
o Information and communication technology (ICT) policy
o OH&S and other human policy areas (eg ethics)
o Organisational and industry policy
o Sustainability
o Procurement and asset management

Policy Impact (Scale)
o Estimated total likelihood of policy outcome
o Estimated total benefit of policy implementation</td></tr>
<tr><td>Participants: (scale)
o Government
o Industry
o Researchers</td></tr>
<tr><td>Program (nominal)
o A, B, C</td></tr>
<tr><td>Year Approved (scale)</td></tr>
</table>

2.7. RESEARCH QUESTIONS

As noted above, this research report seeks to answer the question:

- “What relationship exists, if any, between *Construction Innovation* research – particularly the inputs, outputs and outcomes of innovation”

A number of research questions arise from the research question and the foregoing literature. (These are not true hypotheses in the creation of a falsifiable hypothesis as the data is not random and some relationship is likely.

- What are the relationships, if any, between the project inputs?
- What are the relationships, if any, between the inputs and the outputs (innovation)?
- What are the relationships, if any, between the various elements of the innovation?
- What are the relationships, if any, between outputs and outcomes?
- What are the relationships, if any, between outcomes and inputs?
- Can a triple helix of relationships be demonstrated to exist between government, industry and research participants involved in *Construction Innovation* projects?

As this is exploratory research, the null hypothesis in all cases is that there is no relationship. Any non-trivial significant relationships found will be reported. As noted above, such relationships are not likely to be random events as the innovations are the result of a set of coordinated actions within the CRC itself.

3. RESEARCH METHODS

This research investigates the relationship between resource allocation, innovation and public policy within a specific instance or case – *Construction Innovation.* Case studies enable the analysis of a particular issue or innovation as it relates to an organisation or industry, and can provide strong recommendations for improvements in theory, technology or policy. Case studies have been called for as a way of advancing public policy practice (Osborne & Brown 2005). A case study has been defined as "a method for learning about a complex instance, based on a comprehensive understanding of that instance obtained by extensive descriptions and analysis of that instance taken as a whole and in its context" (U.S. General Accounting Office 1990, cited in Mertens 2005:237). In depth analysis of the projects funded by *Construction Innovation* was undertaken in order to identify the potential policy implications of the innovations developed in the projects.

Case studies typically follow the process below:

- Seek patterns of data to develop the issues;
- Triangulate key observations and bases for interpretation;
- Select alternative interpretations to pursue;
- Develop assertions or generalisations about the case (Stake 2003:155).

The generalisations from case studies are typically generalisations back to theory, particularly in relation to exploratory analysis which identifies new and testable hypotheses. Additionally, replication of method is an important outcome from case studies, as the methodology followed in one case study can be replicated in different case studies, thereby enabling cross case comparisons.

3.1. CONTENT ANALYSIS

The primary methodology for examining the policy implications of the various research projects of *Construction Innovation* is the use of content analysis. Content analysis is a technique for gathering and analysing the content of text (Neuman 2000: 292), and is an approach that has wide applicability in policy related research studies (Marinetto 1999: 68). One of the strengths of content analysis is that it is unobtrusive and non-reactive, and is viewed as an objective way of obtaining quantitative data of the content of various forms of communication (Marshall & Rossman 1999: 117).

Content analysis in this project is descriptive rather than interpretive (Bauer 2000: 135), particularly as the "concreteness of materials studied in content analysis strengthens the likelihood of reliability" (Babbie 2004: 324). A key element of content analysis is the use of a coding system to quantify the data into an analysable format. Coding systems in content analysis can identify numerous characteristics of text content, such as the frequency of certain type of information (Neuman 2000).

A full outline of the coding system developed for this report and variables can be found in Attachment C.

The population of the sample is all of the projects of *Construction Innovation* and thus forms a census of all available data.

Data was initially coded into an MS Access database, for the data entry phase. Data was then exported into SPSS for advanced statistical analysis.

3.2. DATA CONSTRAINTS AND CONSIDERATIONS

The specific nature of individual projects are of a sensitive nature – particularly project budgets, the names of individuals and organisations involved, and the actual intellectual property resulting from these projects. Consequently this level of detail is not reported within this report, and analysis is aggregated at a higher level – by program, by type of innovation, by policy area, etc. It is hoped that this shall allow for advanced statistical analysis of the policy implications of *Construction Innovation,* while at the same time respecting privacy and intellectual property, and contractual obligations and arrangements.

As will be seen below, a large number of correlations were found in the data set. Trivial data has not been discussed, unless it relates to the research undertaken here, or would be of value to the CRC. In some cases, a lack of correlation is also reported if this has significance to the operations of the CRC or for the research questions.

An important issue should be noted in relation to this project, as the total population of research projects was 75. Consequently, anticipated effects which are not evident statistically may be due to the lack of power from the small sample size. Consequently, correlations which are significant at the 0.1 level or better have been reported in preference to the typical reporting of 0.05 or better due to the small sample size.

4. DISCUSSION & ANALYSIS

There are a total of 75 projects within *Construction Innovation* which are analysed here. This small sample size was aggravated by small sub-portions of data – which made analysis difficult.

The discussion relates specifically to each of the research questions. Specifically :

- 4.1 – Relationships between independent variables
- 4.2 – Relationships between the independent variables and the mediating variables
- 4.3 – Relationships between the mediating variables
- 4.4 – Relationships between the mediating variables and the dependant variables
- 4.5 – Relationships between the dependant variables
- 4.6 – Relationships between the dependant variables and the independent variables
- 4.7 – Multiple regression analysis to test the mediation variables effect on the independent variables

As the sample size was quite small, fairly robust tools for analysing data has been utilised. For categorical data, chi squares were used. For comparing scale and ordinal data, bivariate correlations were performed. For comparison of scale data and categorical data, analysis of variance (anova) was performed. To test for the mediation effect of innovation on the dependent variables (policy area) binominal regression was undertaken. To assess the mediation effect of innovation on the likelihood of a policy outcome, multiple linear regression was performed. The findings of these analyses are discussed below.

4.1. – RELATIONSHIPS BETWEEN INDEPENDENT VARIABLES

Descriptive analysis of the independent variables was undertaken:

4.1.1. Descriptive analysis of independent variables

Table 2 – Descriptive statistics of independent variables

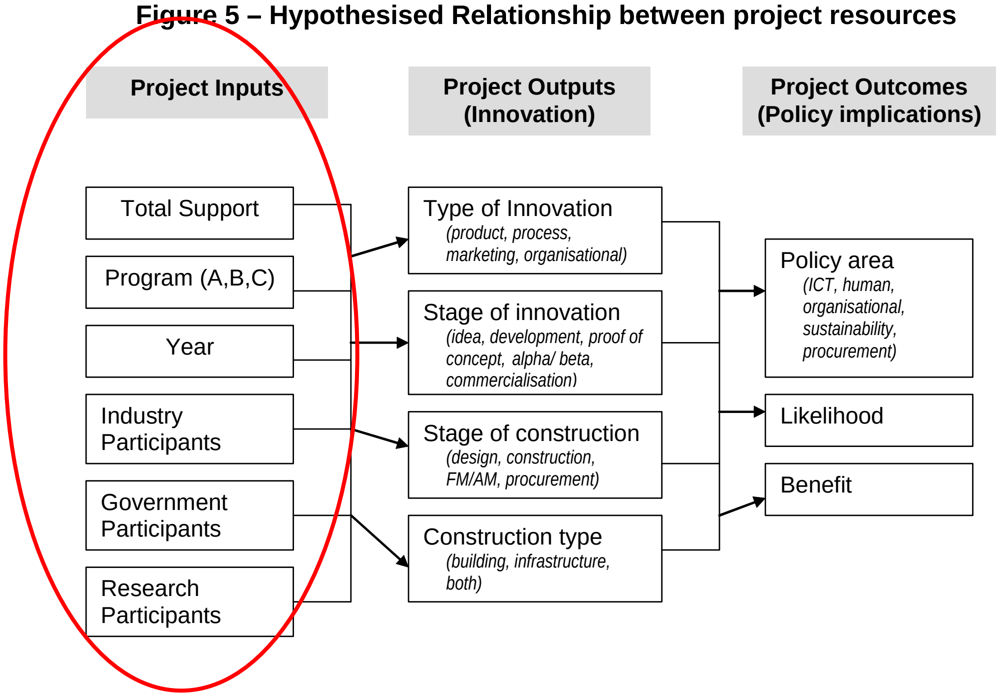
	Minimum	Maximum	Sum	Mean	Std. Deviation
Year Approved	2001	2006		-	-
Government Participants	0	10	188	2.51	2.429
Industry Participants	0	6	101	1.35	1.390
Research participants	0	17	457	6.09	3.771
Total Support	2	$2,730,850	$36,989,962	$493199^	$464,673^
Valid N (listwise)					

N=75 ^ rounded to nearest dollar

4.1.2. Hypothesised relationships between independent variables

The set of project inputs are what are typically classified as independent variables in statistical analysis. The independent variables are of two types: Program is a nominal variable, while the rest are scale variables.

Figure 5 – Hypothesised Relationship between project resources



Bivariate correlations are possible between scale variables, and analysis of variance is required to examine relationships between scale variables and nominal variables.

4.1.3. Bivariate analysis of independent variables

Bivariate correlation analysis was undertaken in order the show possible relationships between the variables. [3] Correlation analysis is used in cases where the strength and direction of the linear relationship between two scale variables (Palant 2002). These are shown below in Table 3.

Table 3 - Bivariate correlation of scale variables

		Year Approved	Government Participants	Industry Participants	Research participants	TotalSupport
Year Approved	Pearson Correlation	-				
	Sig. (2-tailed)					
Government Participants	Pearson Correlation	-.291*	-			
	Sig. (2-tailed)	.011				
Industry Participants	Pearson Correlation	-.444**	.071	-		
	Sig. (2-tailed)	.000	.543			
Research participants	Pearson Correlation	-.348**	.372**	.308**	-	
	Sig. (2-tailed)	.002	.001	.007		
TotalSupport	Pearson Correlation	-.292*	.198	.492**	.483**	-
	Sig. (2-tailed)	.011	.088	.000	.000	

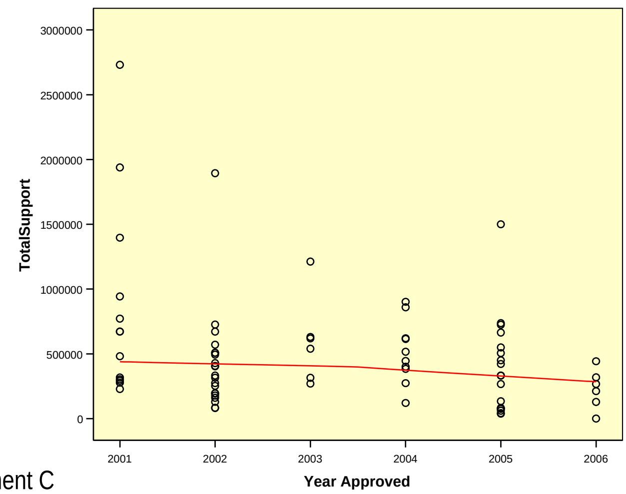
* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

These correlations are discussed further below

Relationship between project funding and year

There is a weak though significant negative correlation between in-kind support for research projects and year (-0.292, $p<.01$), and consequently in total support for research projects (-0.292, $p<.05$) over time. This can be demonstrated in Figure 8, which shows the total support declining slightly over time.

Figure 6 - Project contributions per year

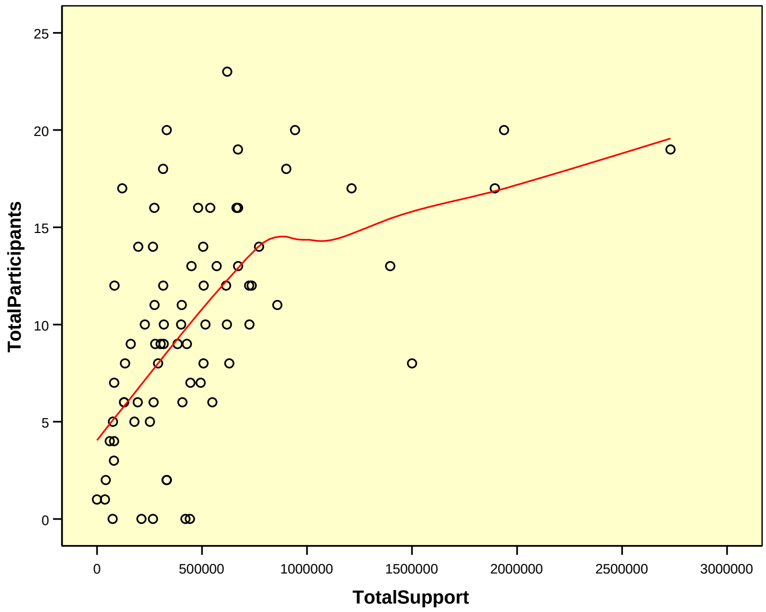


Finding 1 - There is a decline in the average total support for research projects over time.

[3] A full list of all bivariate correlations can be found in Attachment C

Relationship between total support and total participants

Figure 7 – relationship between total support and total participants



There is a significant relationship between total support and total participants (.523, *p*=001).

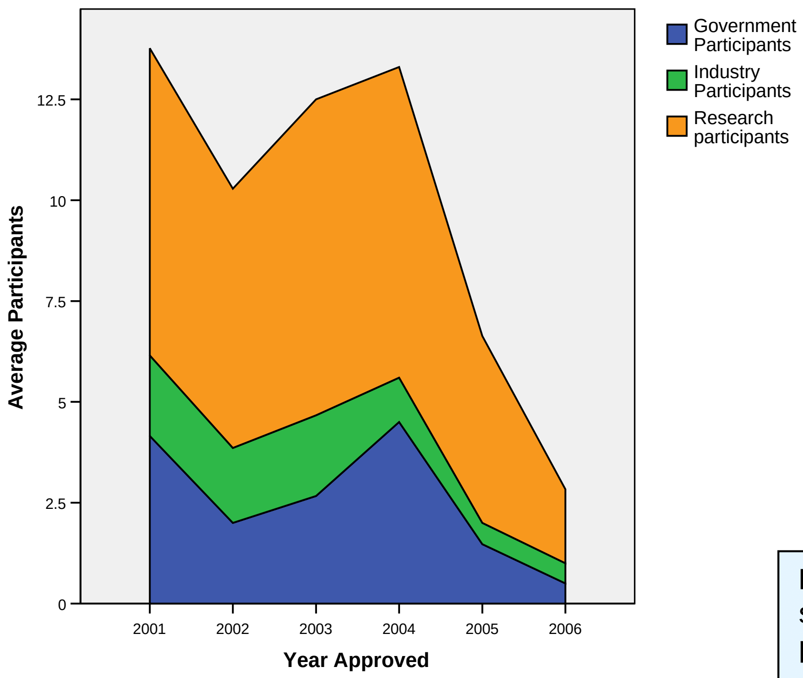
This relationship is almost linear up to about 15 participants. Once a project gains more than 15 participants, the relationship changes and the amount of support the project garners significantly increases (see Figure 7).

Finding 2 – There is a significant positive relationship between total support and the number of participants in the project.

Relationship between participation rates and year of approval

Bivariate correlations were undertaken between participation rates and the year of project approval (see Figure 8).

Figure 8 - Relationship between participation rates and year of approval



There average number of participants involved per project declined significantly over the 5 year period (-0.453, $p < 0.001$).

Participation by researchers (-.358, $p<.01$), government (-.364, $p<.01$) and industry (-.472, $p<.001$) all declined significantly over the period.

Finding 3 - There was a significant decline in participation rates over time.

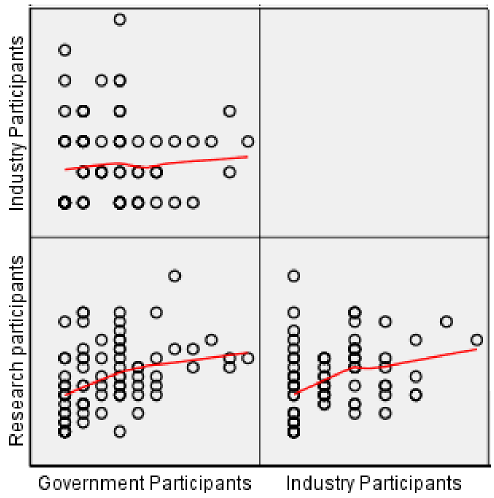
All types of participants (researchers, government and industry) declined over time.

Relationship between participants involved in projects

Bivariate correlations show that there is a significant and positive relationship between government participants and research participants (0.423, p=0.001). There was also a significant and positive relationship between the number of industry participants and the number of research participants (0.334, p=.007). The correlation, between the number of industry participants and government participation on research projects was trending towards being significant (0.543, p=.071)[4] (see Figure 9).

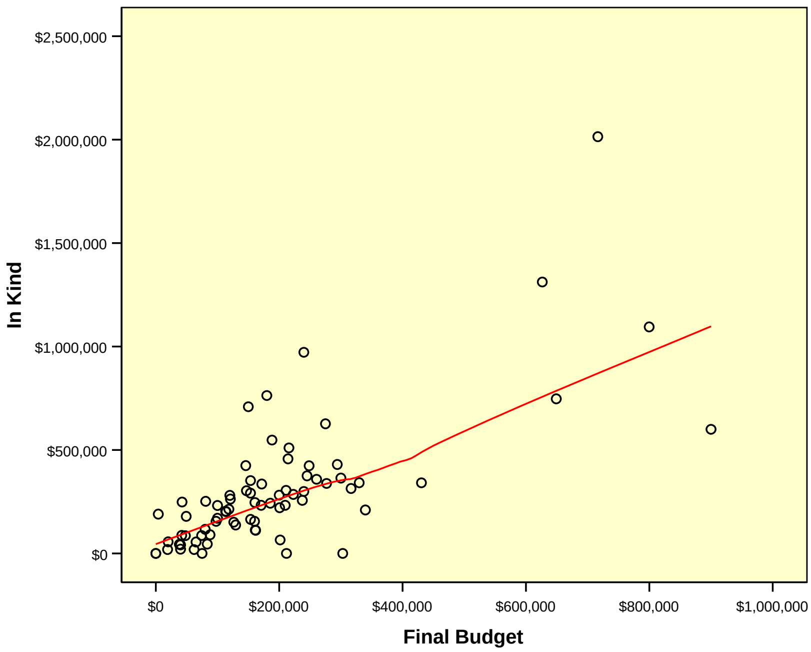
Figure 9 - Relationship between participants on projects

Finding 4 - There is a significant relationship between participants of all types. This is discussed further in the section related to the triple helix.



Relationship between in kind contributions and project budget

Figure 10 - Relationship between in kind and budget contributions



Bivariate analysis indicates a positive and significant relationship (0.715, p<0.001) between budget and in-kind (see Figure 10).

As noted in the introduction, this is likely to be due to the internal processes within the CRC, not due to random events.

Consequently, this finding is most useful as confirmation of management practice.

[4] As noted in the introduction, due to the small sample size, a relationship is considered significant if it is less than 0.1.

The strength of the relationship between in-kind and budget (0.715, $p<.001$) indicates that caution needs to be undertaken on regression analysis with these variables, as there is a high correlation. Consequently, an aggregate measure of total support will be used in regression analyses.

Finding 5 - There is a positive and significant relationship between project budget and in kind contributions. The relationship is so strong that an aggregate variable was created.

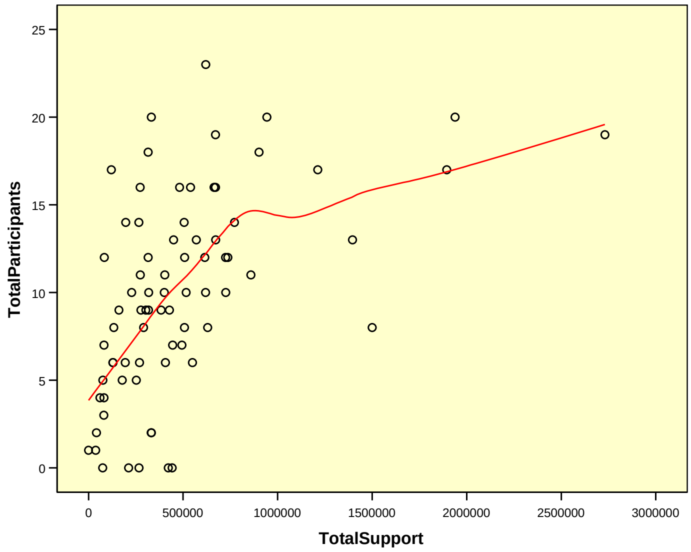
Relationship between project participation rates and total contributions

Bivariate correlation between the total support and the total participation rates, indicates a strong relationship (.523, p=.000).

The relationship is virtually linear until total support is more than $1M, at which point there is a break in the relationship and the rate of support increases significantly with relatively small increases in the number of participants. Thus it is closest to a step shape of relationship (see Figure 11).

Finding 6 - There is a positive and significant relationship between project participation rates and Total Support (both in-kind & budget).

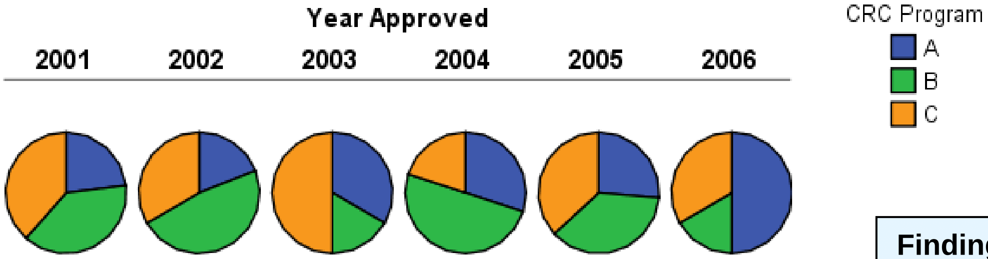
Figure 11 - Relationship between total participation



Relationship between projects approved, year and program

When the project approval rate is compared across programs, the differences are not statistically significant. Differences for individual years tend to even out over time (see Figure 12).

Figure 12 – Project approvals per year and program

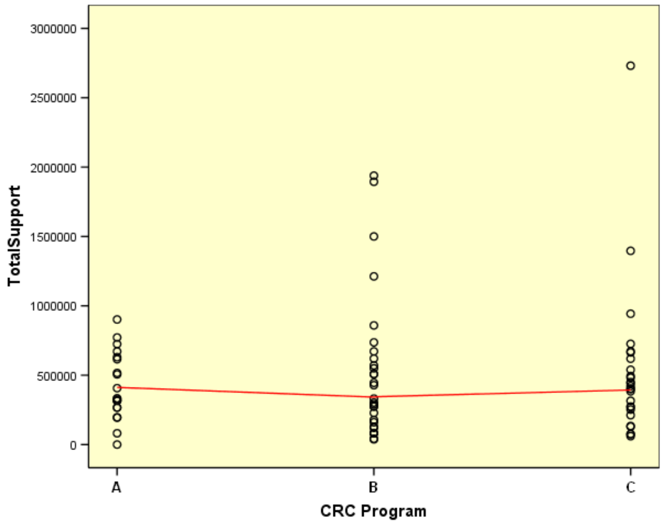


Finding 7 - There is no statistically significant relationship between project approval year and program.

Relationship between project funding and program

Bivariate correlations did not show any significant correlation between the project funding received, and the program which received the funding, or the year of funding (see Figure 13).

Figure 13 - Relationship between program and funding[5]



There is no significant difference in average funding between CRC programs. That is to say that the average funding for each program was the same.

Program B and C seem to have the capacity to attract significant funding for specific projects compared to Program A, although this may reflect strategic decisions by the CRC.

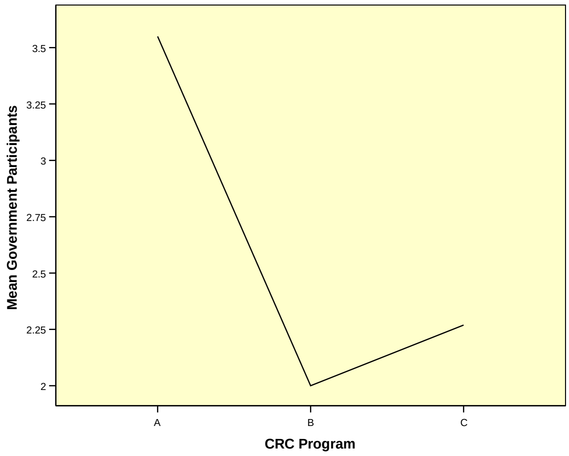
Finding 8 - There is no statistically significant relationship between Total Support and Program.

4.1.4. Analysis of variance between dependant variables

Relationship between participation rates and program

An ANOVA was undertaken to test for a relationship between participation rates in the various *Construction Innovation* programs. There were no statistically significant differences between the number of industry participants, research participants or industry participants involved in projects.

Figure 14 – Average Government Participants per program



An analysis of variance was undertaken on the number of government participants involved in CRC programs [$F(2, 72)=2.72$, $p=.073$)]. The effect size, calculated using eta squared, was .07 which is a medium effect. Post-hoc comparisons using the Tukey HSD test indicated that the average number of government participants in Program A (M=3.55, SD=3.154) was significantly higher than Program B (M=2.00, SD=1.832) (see Figure 14). The number of government participants in Program C did not differ significantly from either Program A or B (M=2.27, SD=2.219).

Finding 9 – There were more government participants, on average, in Program A projects when compared to Program B and C projects, with correlation trending to significance.

[5] All scatterplots in this report which have trendlines which utilise Loess methodology (iterative weighted least squares). Each trend line is adjusted to fit 95% of data points, and includes an Epanechnikov kernel (probability) function.

4.1.5. Summary of relationships between independent variables

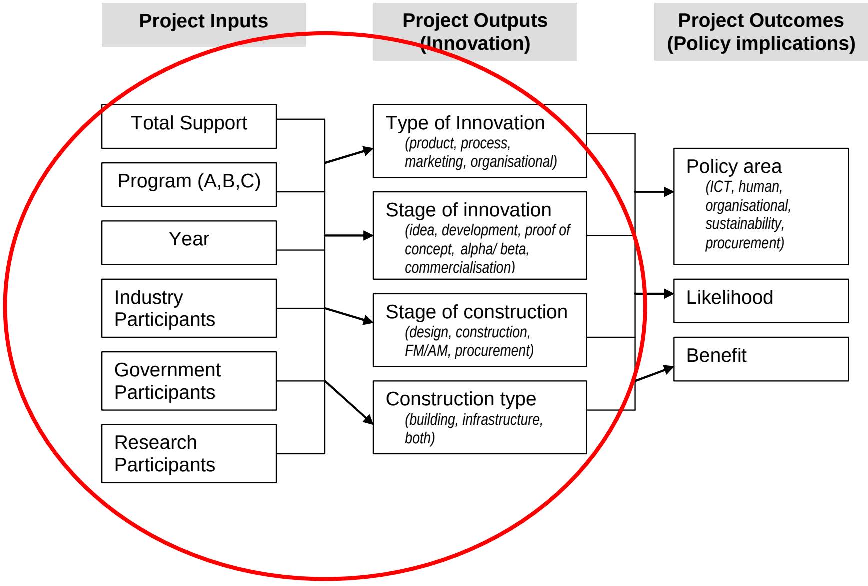
There are a number of interesting correlations between the independent variables. The main findings are that:

- Total support for research projects declines over time
- Participation rates decline over time
- There is a positive relationship between the number of participants and the amount of support a project garners
- There is a very strong correlation between in-kind support and budget, such that a new variable had to be created due to collinarity effects.
- More government participants are involved in Program A than other programs.
- The average funding for research projects did not vary significantly across research projects.

Such interactions are interesting, however, they do not demonstrate how the independent variables might interact with the mediating variables. This is addressed in the next section.

4.2. RELATIONSHIPS BETWEEN THE INDEPENDENT VARIABLES AND THE MEDIATING VARIABLES

Figure 15 – Hypothesised Relationship between project inputs and project outputs



4.2.1. Chi square analysis of relationships between mediating variables and independent variable

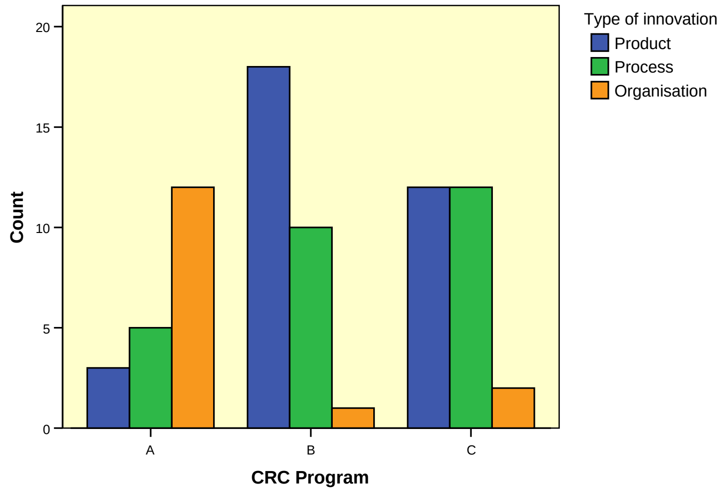
As Table 1 has shown, there is a significant number of nominal variables which can act as mediating variables. Analysis of these types of variables to the independent nominal variable of Program requires Chi square analysis.

Relationship between Program and Type of innovation

A Chi square of the relationship between program and type of innovation was undertaken. This demonstrated that there was a significant relationship between program and innovation (Chi square=29.379, *p*=.000; Phi=.262, *p*=.000). Largely this is due to Program B principally producing product innovation, and Program A producing organisational innovation (see Figure 16).

Figure 16 – Relationship between CRC program and type of innovation

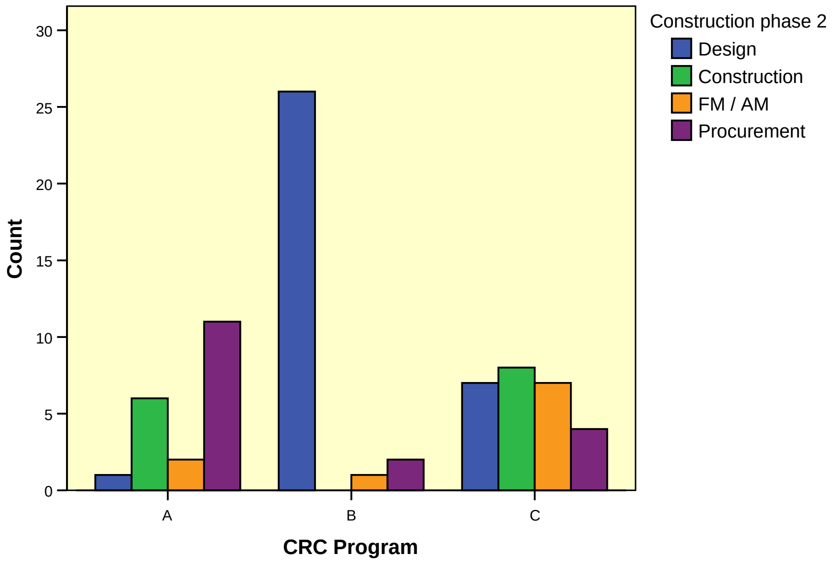
Finding 10 – Program A delivered mainly organisational innovation, and Program B delivered mainly product innovation compared to other types of innovation.



Relationship between CRC Program and Construction Phase

A Chi square analysis was undertaken to examine any relationship between CRC program and Construction phase. This was significant (Chi quare = 49.425, p=000; Phi=.812, p=.000). The majority of this influence was due to the emphasis of Program B on the design phase of construction (90% of all projects). Program A also devoted considerable attention to procurement (55% of projects) (see Figure 17).

Figure 17 – relationship between CRC program and construction phase

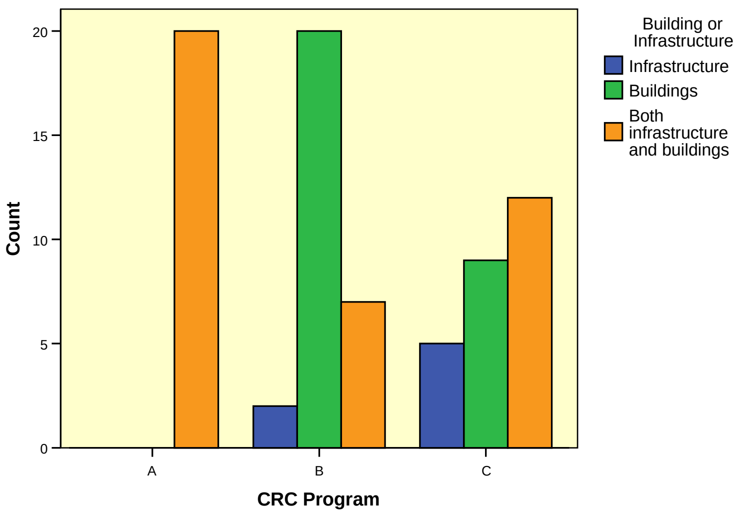


Finding 11 – Program B delivered innovations predominantly focussed on the design phase of construction. Program A focussed significant attention on procurement.

Relationship between CRC program and construction type

Chi square analysis was conducted between CRC program and type of construction in order to identify any relationships. There were differences between CRC programs on the type of construction innovation focussed on (Chi Square=32.871, *p*=000; Phi=.662, *p*=.000). Again Program A focussed on innovations which are of benefit for both buildings and infrastructure (100%), where as project B focussed on projects which delivered innovations specifically for buildings (69%) (see Figure 18).

Figure 18 – Relationship between CRC Program and construction type



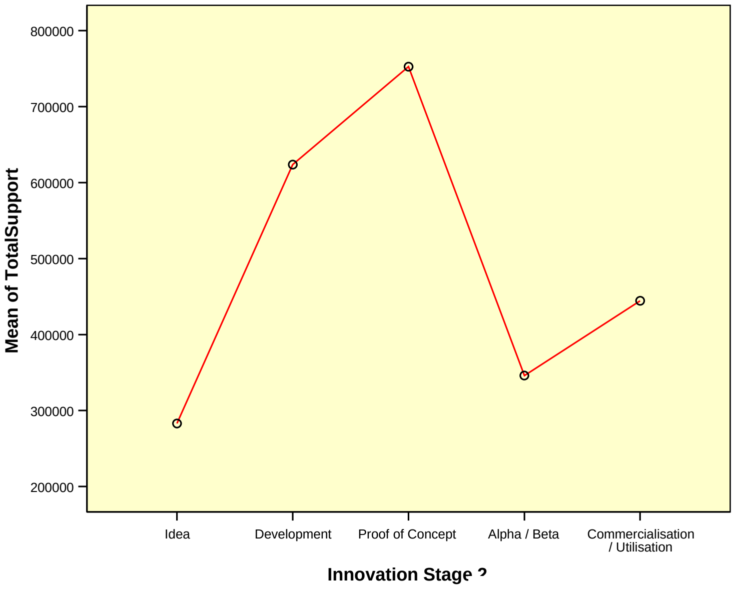
Finding 12 –

Program A delivered projects relevant to both buildings and infrastructure construction. Program B delivered projects predominantly for building construction.

4.2.2. Analysis of variance between mediating variables and independent variables

Relationship between total support and stage of innovation

Figure 19 – Relationship of Stage of innovation to total support



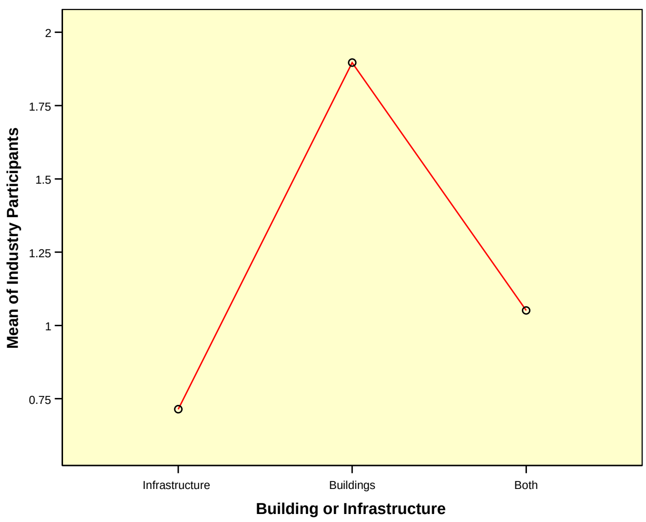
An analysis of variance was undertaken to determine the relationship between total project support (budget plus in-kind) and the stage of innovation. There was a difference in the average total support received by a project and the stage of innovation [F(4, 70)=3.118, *p*=.028)]. The effect size, calculated using eta squared, was .16 which is a large effect. Post-hoc comparisons using the Tukey HSD test indicated that the average total support for projects which developed innovations to proof of concept stage (M=$752,535, SD=$707,096) was significantly higher than projects at the idea stage of innovation (M=282,978, SD=$208,095). The difference between average total support for other stages of innovation was not statistically significant (see Figure 19).

> **Finding 13 –** Innovations at proof of concept stage received more funding on average than projects at the idea stage.

Relationship between industry participants and type of construction.

An analysis of variance was undertaken between industry participants and type of construction, There was a difference in the average number of industry participants in research projects which focussed on different types of construction [F(2, 72)=4.210 , *p*=.019)]. The effect size, calculated using eta squared, was .010 which is a medium effect. Post-hoc comparisons using the Tukey HSD test indicated that the average number of industry participants in projects focused on innovation for building (M=1.9, SD=1.611) was significantly more than the number of industry participants involved in projects which focussed on infrastructure (M=0.71, SD=0.756), or projects which could benefit both buildings and infrastructure (M=1.35 , SD=1.390) (see Figure 20).

Figure 20 – relationship between industry participants and type of construction

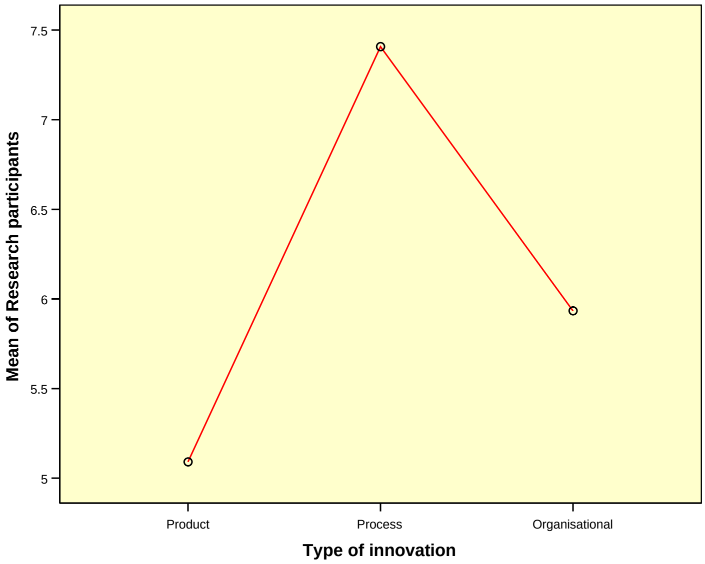


> **Finding 14 –** A statistically greater number of industry participants were involved in projects which focussed on innovations relevant to buildings, compared to this which focussed on infrastructure or both buildings and infrastructure.

Relationship between research participants and type of innovation

An analysis of variance was undertaken to examine the relationship between the number of research participants and type of innovation.

Figure 21 – Relationship between type of innovation and number of research participants



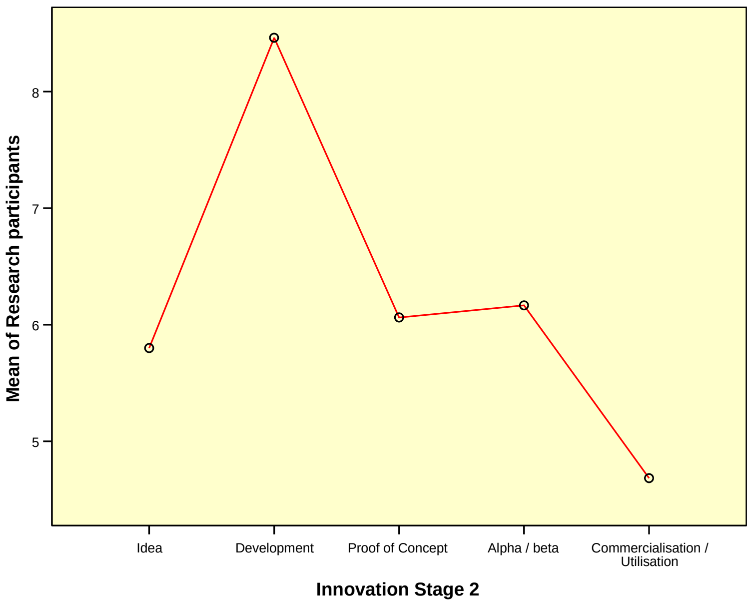
There was a difference in the average number of research participants involved in projects with different innovation types trending towards significance [F(2, 72)= 2.969, *p*=.058)]. The effect size, calculated using eta squared, was .08 which is a medium effect. Post-hoc comparisons using the Tukey HSD test indicated that the average number of research participants in process innovation (M=7.41, SD=2.978) was significantly higher than product innovation (M=5.09, SD=4.186). The number of research participants in organisational innovation did not differ significantly from either product or process innovation (M=5.93, SD= 3.595) (see Figure 21).

> **Finding 15** – On average, a higher number of research participants where involved in process innovations, compared to other forms of innovation

Relationship between number of research participants and the stage of innovation

An analysis of variance was undertaken to determine the relationship between the number of research participants and the stage of innovation.

Figure 22 – Relationship between research participants and stage of innovation



There was a difference in the average number of research participants in different stages of innovation trending towards significance [F(4, 70)=2.084, *p*=.092)]. The effect size, calculated using eta squared, was .11 which is a medium effect. Post-hoc comparisons using the Tukey HSD test indicated that the average number of research participants in development stage of innovation (M=5.08, SD=3.913) was significantly higher than the number involved in commercialisation stage (M=4.68, SD=3.667) (see Figure 22)The number of researchers involved in other stages of innovation did not did not differ significantly from other stages.

Finding 16 – More researchers where involved in the development phase of an innovation than in other stages of innovation.

Relationship between number of research participants and type of construction

Figure 23 – Relationship between number of researchers and the type of construction

An analysis of variance was undertaken to determine the relationship between the number research participants and the stage of innovation.

There was a difference in the average number of research participants in projects examining different types of construction which trends towards significance [$F(2, 72)=2.567$, $p=.084$)]. The effect size, calculated using eta squared, was .06 which is a medium effect. Post-hoc comparisons using the Tukey HSD test indicated that the average number of research participants involved in research focussing on buildings (M=7.31, SD=4.089) was significantly higher than research which focussed on both buildings and infrastructure (M=5.33, SD=3.504). The number of research participants in projects which focussed on infrastructure did not vary significantly from other research projects (see Figure 23).

Finding 17 – More research participants where involved on average in research related to buildings, than those projects which involved in research on infrastructure or bother buildings and infrastructure.

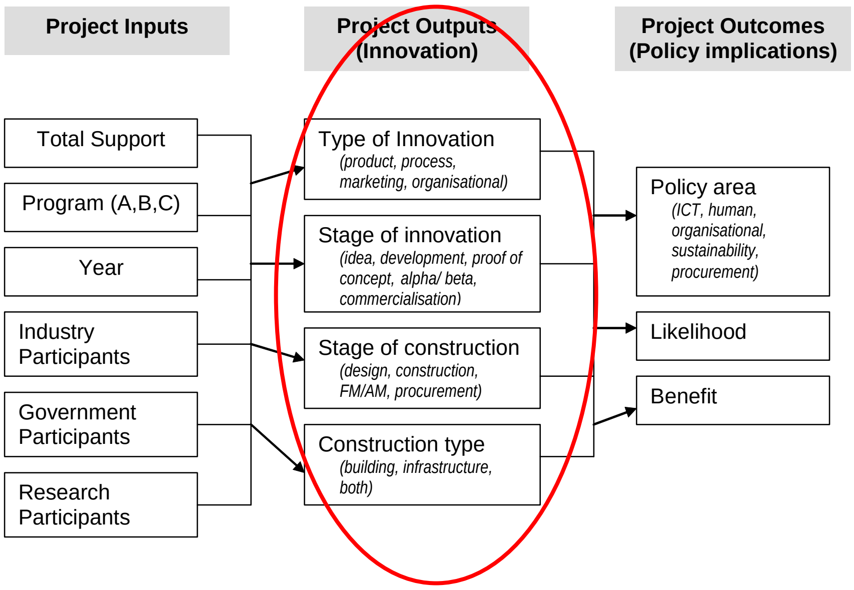
4.2.3. Summary of relationships between independent variables and mediating variables

- Program A delivered mainly organisational innovations, focussed on the procurement and delivery phase of construction
- whereas Program B delivered mainly product innovations and focussed on the design phase of construction
- Projects at the proof of concept stage of innovation received more funding on average than projects at other phases of innovation
- On average there were more industry participants involved in projects which focussed on buildings than on other construction types
- On average there were more research participants involved in projects which focussed on building innovation, process innovation, and the development stage of innovation.

4.3. RELATIONSHIPS BETWEEN THE MEDIATING VARIABLES

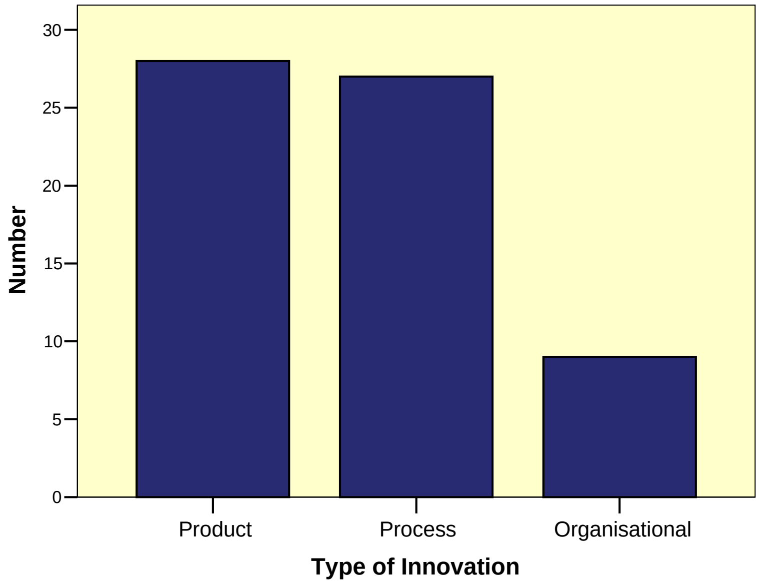
A large number of categorical variables where identified as project outputs which might mediate between the project inputs and any policy implications. Possible correlations between these variables need to be investigated.

Figure 24 – Hypothesised Relationship between project outputs



Relationship of dependant variable to mediating variable (project inputs to innovation)

Figure 25 – Number of innovations by type



Each project was coded into the main type of innovation. In order to facilitate analysis, this variable was coded into separate dummy variables: product innovation, process innovation, and organisational innovation. While marking innovation is a possible innovation type (OECD 2005), no CRC project fitted this type of innovation. Analysis was not done on this variable as it effectively became a constant in the model.

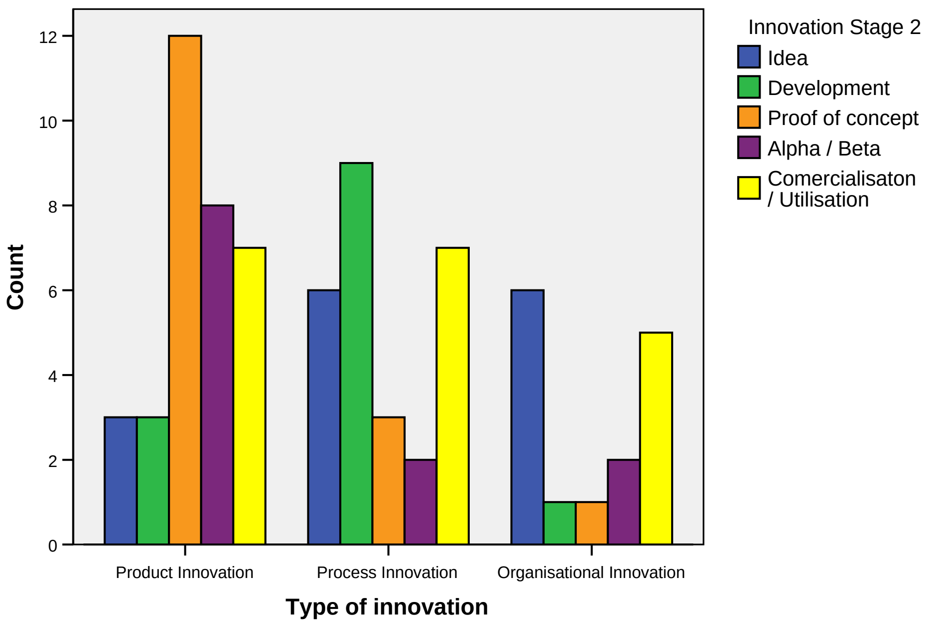
4.3.1. Chi square of relationships between mediating variables

Chi square analysis was undertaken to explore any relationship between nominal mediating variables.

Relationship between type of innovation and innovation stage

A Chi square was undertaken to ascertain any relationship(s) between type of innovation and innovation stage. This test proved significant (Chi square=20.943, *p*=.007; Phi=.528, *p*=.007). The majority of this influence was from product innovations at the proof of concept stage (see Figure 26).

Figure 26 – relationship between type of innovation and stage of innovation



Finding 18 –

75% of all product innovations were at the proof of concept stage.

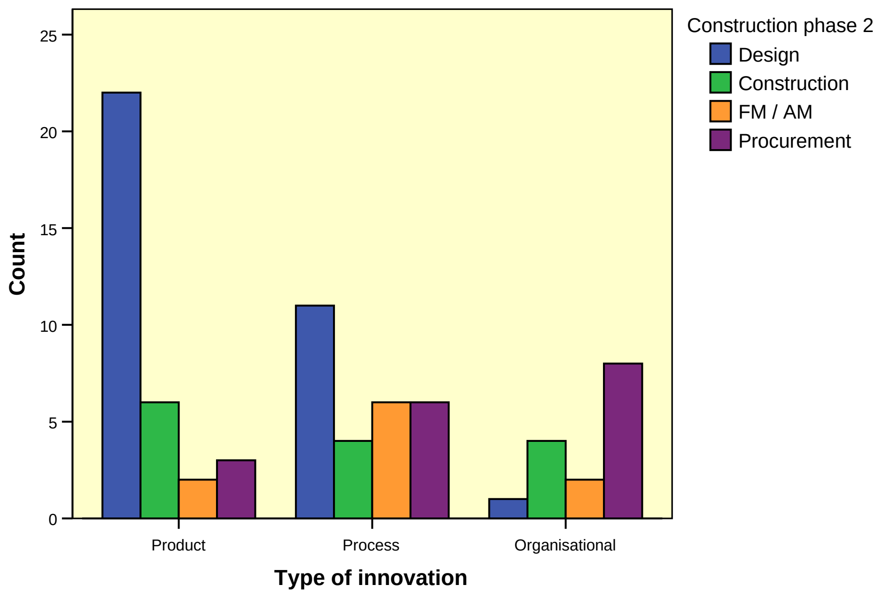
Relationship between the Construction phase and the type of innovation

A chi square was undertaken to examine the relationship between the phase of construction and the type of innovation. This was significant (Chi square=20.937, *p*=.002; Phi=.528; *p*=.002). Most of this effect was from product innovations which focussed on the design phase of innovation (see Figure 27).

Finding 19 –

65% of all product innovation related to the design phase of construction. 41% of process innovations also focussed on the design phase. 54% of organisational innovation focussed on procurement.

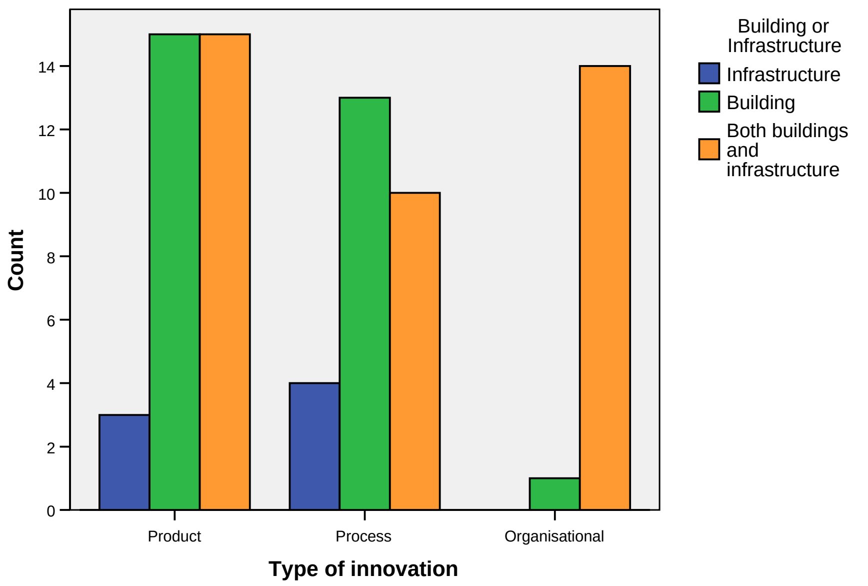
Figure 27 – relationship between construction phase and type of construction



Type of innovation and type of construction

A chi square was undertaken to examine the relationship between the type of innovation (product, process and organisational innovation) and the type of construction activity (building, infrastructure, or both). This relationship was significant (Chi square=13.627, *p*=.008; Phi=.426, *p*=.008) (see Figure 28).

Figure 28 – Relationship between type of innovation and type of construction



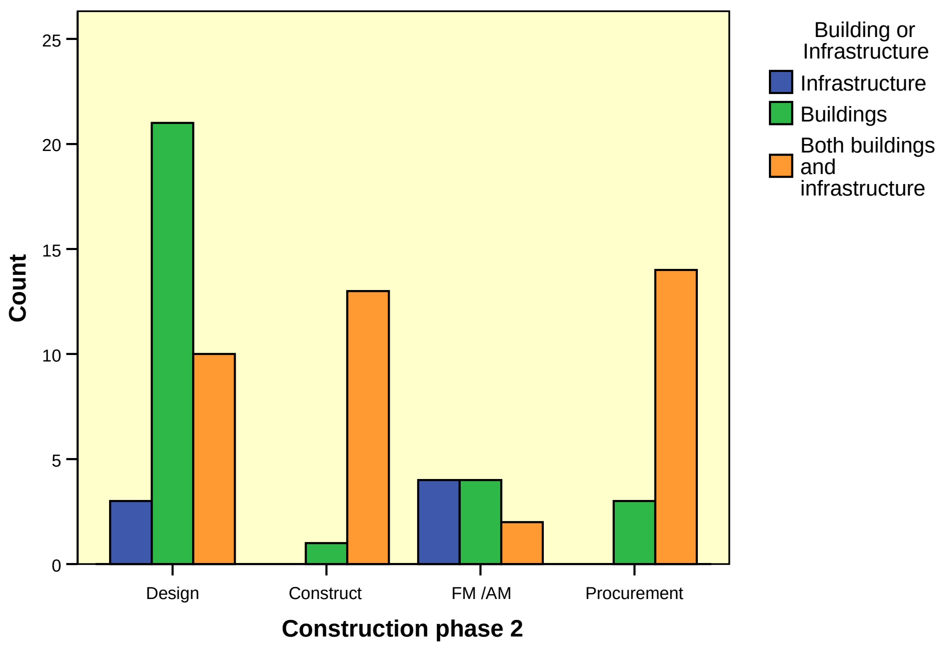
Finding 20 – Product innovation focussed on buildings innovations, and innovations which were relevant to both buildings and infrastructure.

Organisational innovation delivered innovation relevant for both buildings and infrastructure.

Relationship between construction phase and type of construction

A Chi square analysis was undertaken to examine the relationship between construction phase (Design, construct, FM/AM, Procurement) and type of construction (building, infrastructure or both). A significant relationship was found (Chi square=36.027, *p*=.000; Phi=.693, *p*=.000) (see Figure 29).

Figure 29 – Relationship between construction phase and type of construction



Finding 21 – Innovations which would benefit building construction were heavily focussed on the design stage of construction, although there was also an emphasis on innovations which could benefit both buildings and infrastructure. Innovations which focussed on the construction phase of were relevant for both buildings and infrastructure. Procurement was relevant for both buildings and infrastructure.

4.3.2. Summary of relationships between mediating variables

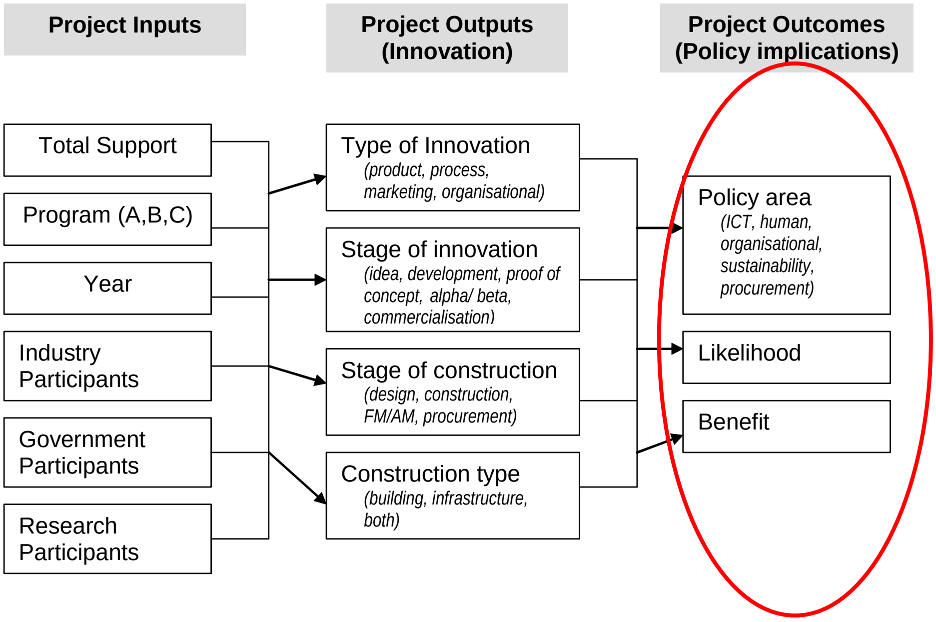
- The majority of all product innovations were at the proof of concept stage of innovation, and were related to the design phase of construction. Innovations were relevant to both buildings and infrastructure.

- The a significant amount (41%) of process innovations were also focussed on the design phase of construction.

- 54% of organisational innovation focussed on procurement and were predominantly relevant for both buildings and infrastructure.

4.4. Relationships between the dependant variables

Figure 30 – Hypothesised Relationship between project project outcomes (policy implications)

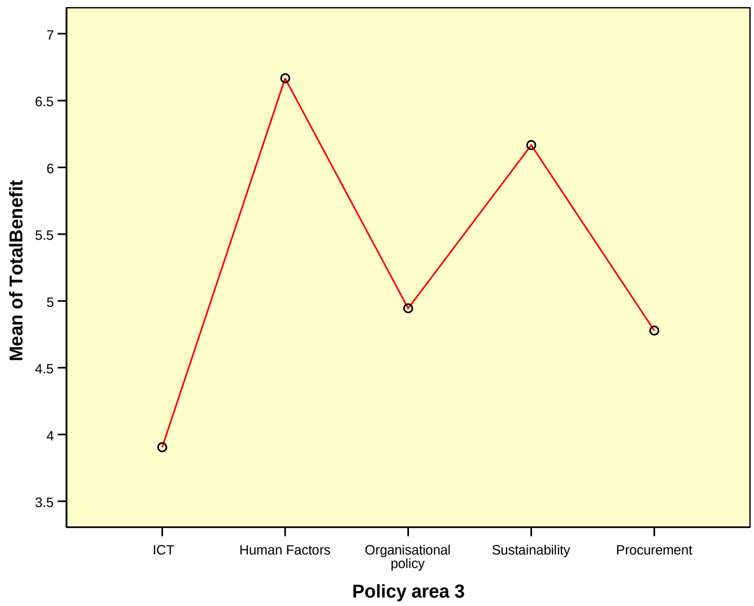


Relationship between total perceived benefit and policy area

Analysis of variance was undertaken to examine any relationship between the total perceived benefit and policy area.

There a difference in the average perceived benefit for different types policy areas [F(4, 70)=3.000, *p*=.024)]. The effect size, calculated using eta squared, was .15 which is a large effect. Post-hoc comparisons using the Tukey HSD test indicated that the average perceived benefit of Human factors (M=6.67, SD=3.571) and sustainability (M=5.13, SD=2.611) are both greater than is greater than ICT policy (M=3.9, SD=2.3) (see Figure 31). Other policy areas did not have significant variations.

Figure 31 – relationship between perceived benefit and policy area

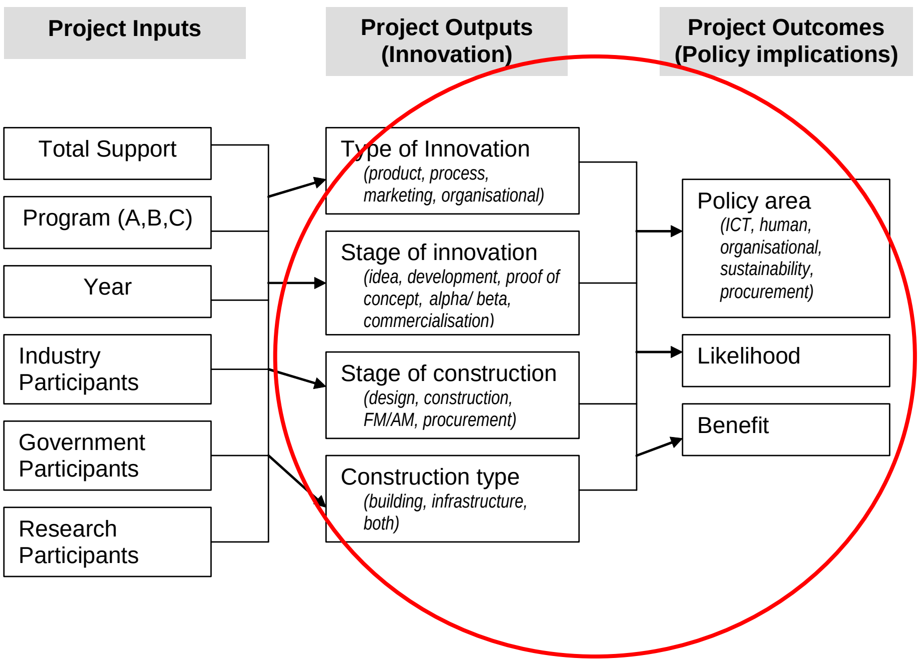


Finding 22 – Projects which delivered innovations relevant to human factors and sustainability were perceived to have statistically significantly more benefit compared to other policy areas.

4.5. – Relationships between the mediating variables and the dependant variables

A number of potential relationships between dependent and mediating variables were explored through analysis of variance and chi squares.

Figure 32 – Hypothesised Relationship between project outputs and project outcomes

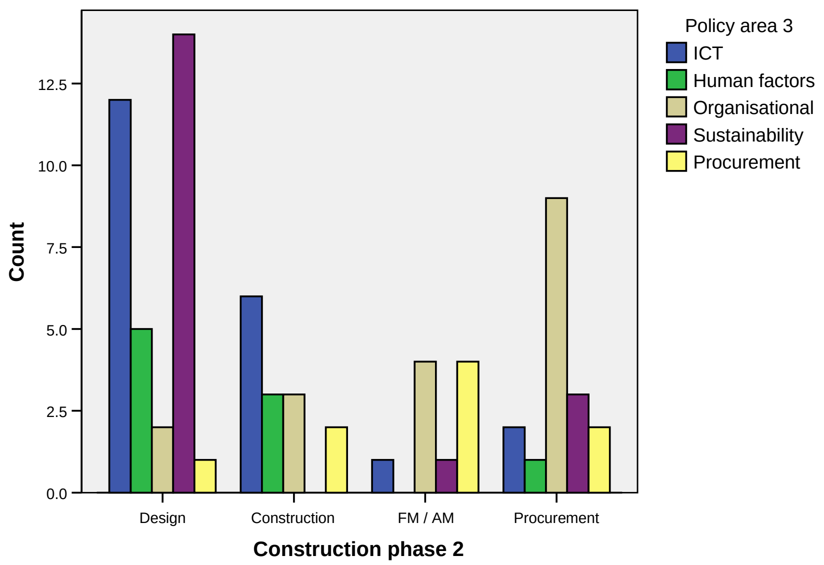


4.5.1. Chi squares of relationships between dependant variables and mediating variables

Chi square of nominal variables where undertaken.

Relationship between policy area and construction phase

Figure 33 – Relationship between policy area and construction phase



A Chi square analysis was undertaken to examine the relationship between policy area and construction phase. A significant relationship was found (36.733, *p*=.000; Phi=.700, *p*=.000) (see Figure 33).

Finding 23 –

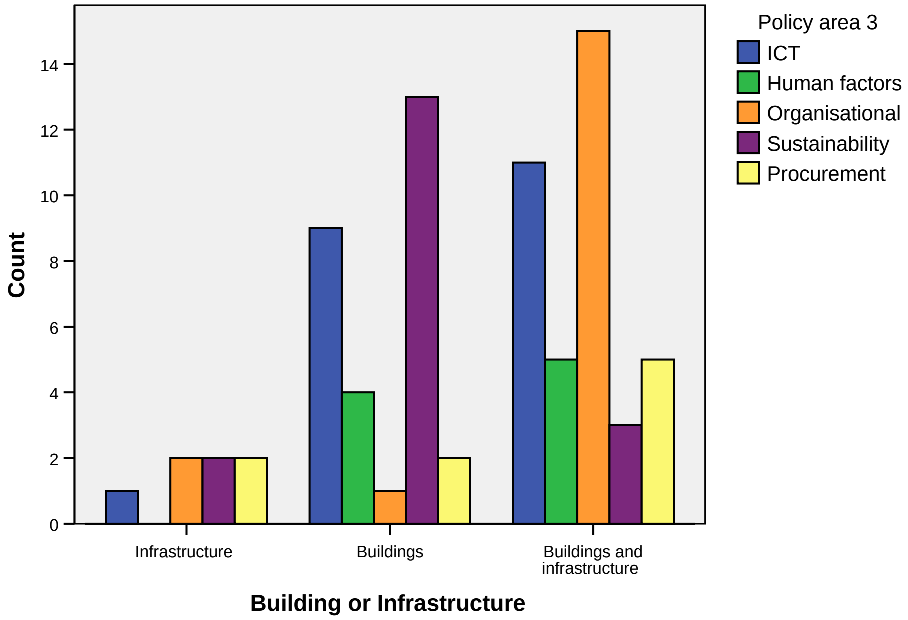
There is a strong relationship between the design phase and ICT and sustainability areas of public policy.

Likelihood and type of innovation

Likelihood and type of innovation were not statistically associated with each other. In other words, no one type of policy innovation was considered more likely than another to influence public policy.

Relationship between policy area and type of construction

Figure 34 – relationship between policy area and type of innovation



A chi square analysis was undertaken to examine the relationship between policy area and type of construction. A significant relationship was found (Chi square=21.946, *p*=.005; Phi=.541, *p*=.005) (see Figure 34).

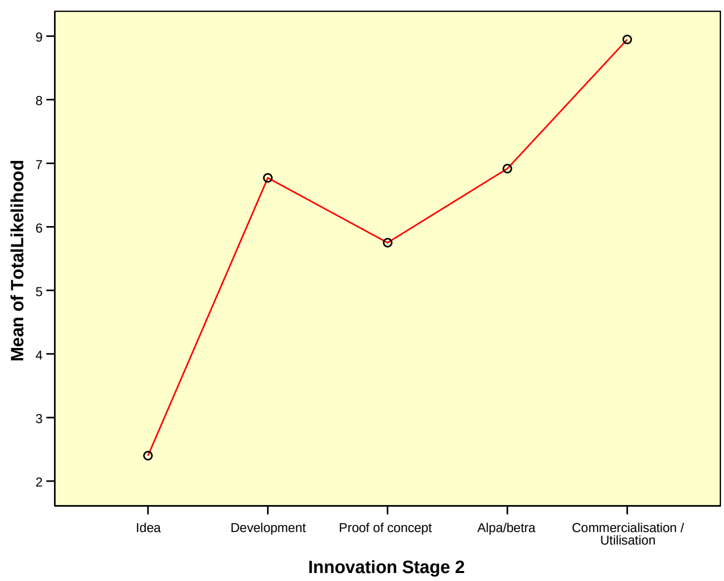
Finding 24 – Innovation which focused on buildings as a construction type were strongly related to sustainability, and ICT policy areas. Innovation which was relevant to both buildings and infrastructure was related to ICT and organisational policy areas.

4.5.2. Analysis of variables between dependent and mediating variables

Analysis of variance was undertaken to explore possible relationships between nominal and ordinal variables.

Relationship between innovation stage and the likelihood that innovation will influence policy

Figure 35 – stage of innovation and the likelihood



An analysis of variance was undertaken to examine the relationship between the stage of innovation and the likelihood that there would be a policy outcome.

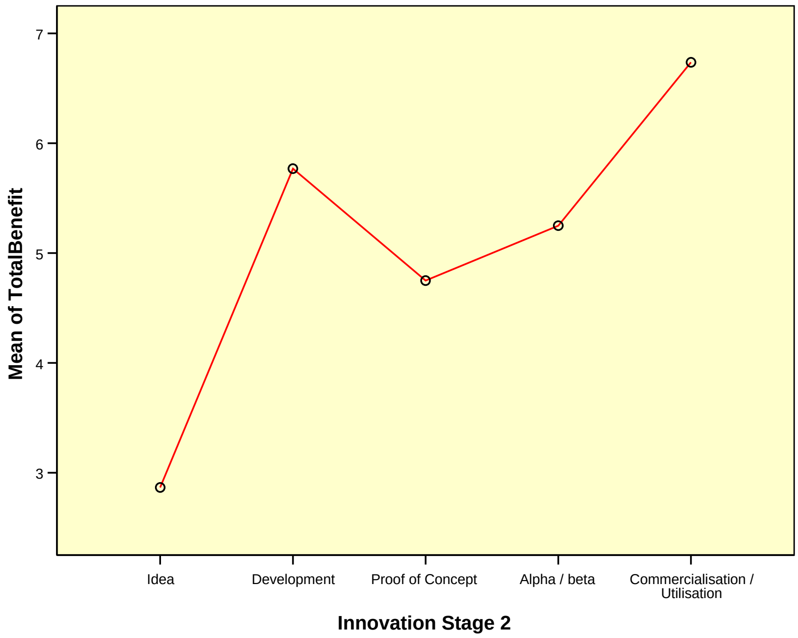
There was a difference in the stage of innovation and the perceived likelihood of a policy outcome [F(4, 70)=6.307, *p*=.000)]. The effect size, calculated using eta squared, was .26 which is a large effect. Post-hoc comparisons using the Tukey HSD test indicated that the average likelihood of policy outcomes for innovation at development (M=6.77, SD=4.567), alpha/beta (M=6.92, SD=2.875) and commercialisation (M=8.95, SD=3.391), were all higher than innovation at the idea stage. (M=2.40, SD=4.306) (see Figure 35). There was not statistically significant difference between innovation at the proof of concept stage and any other stage of innovation.

Finding 25 – Projects later in the development stages were considered more likely to have a policy influence, than those at the idea stage of innovation.

Relationship between total perceived benefit and innovation stage

An analysis of variance was undertaken to assess the relationship between the total perceived benefits from a policy in a particular area and the stage of innovation.

Figure 36 – relationship between total perceived benefit and innovation stage



There was difference in the average benefits of innovation at different stages of development [F(4, 70)=6.307, *p*=.000)]. The effect size, calculated using eta squared, was .26 which is a large effect. Post-hoc comparisons using the Tukey HSD test indicated that the average perceived benefit of policy for innovation in the idea stage (M=2.87, SD=2.503) is considerably less than Innovation at the development stage, (M=5.77, SD=2.976), alpha / beta stage (M= 5.25, SD=1.485), or commercialisation / utilisation phase (M=5.13, SD=2.611).

The perceived benefit of innovation at the proof of concept stage (M=4.75, SD=2.266) was also less than innovation at the commercialisation phase (M=5.13, SD=2.611) (see Figure 36).

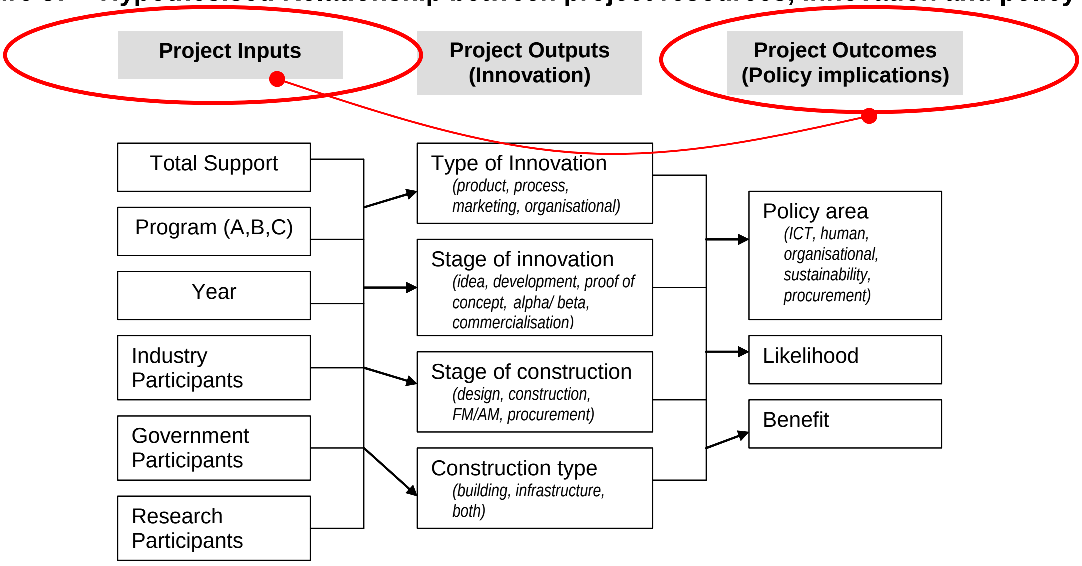
Finding 26 – Projects later in the development stages were considered more likely to have a policy influence, than those at the idea stage of innovation.

4.5.3. Summary of relationships between dependent and mediating variables

- There is a strong relationship between innovations which focussed on the design phase of construction, and both ICT and sustainability areas of public policy
- Innovations which focussed on buildings had a strong relationship with sustainability are of public policy, whereas innovations which were relevant to both buildings and innovations were relevant to organisational areas of public policy.
- Innovations at later stages of development were considered more likely to have a positive influence and benefit on public policy than innovations in the idea stage of development.

4.6. RELATIONSHIPS BETWEEN THE DEPENDANT VARIABLES AND THE INDEPENDENT VARIABLES

Figure 37 – Hypothesised Relationship between project resources, innovation and policy

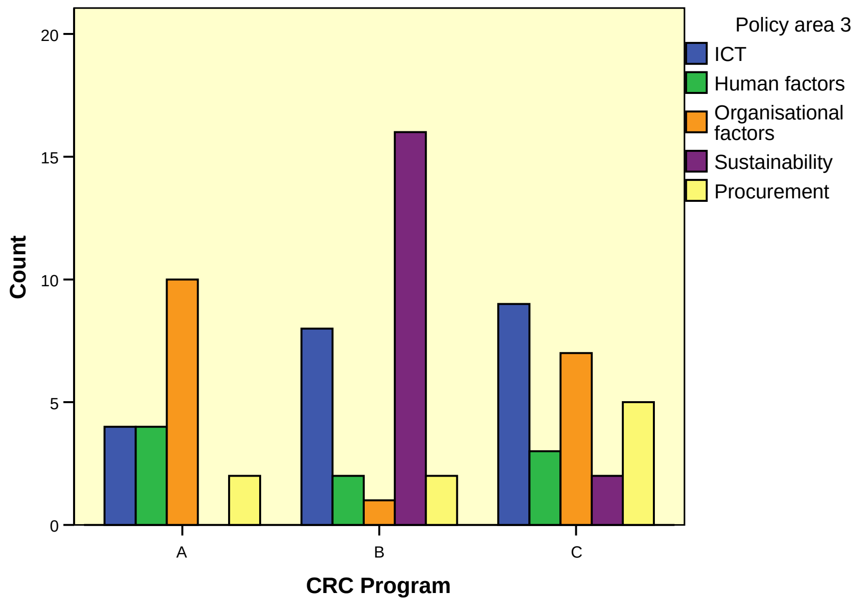


While a hypothesised relationship has been set up at the beginning of the research project, it is possible that there are other effects from the project inputs themselves upon the policy area, policy likelihood or policy benefit. It is important to test for these effects prior to testing for the effects of the mediation variable (if any).

Relationship between CRC Program and Policy area

A Chi square analysis was undertaken to examine the relationship between CRC program, and policy area. A signification relationship was found (Chi square 34.647, p=.000; Phi=.626, p=.000). 50% of the projects in Program A focussed on organisational policy where as Program B focussed 52% of its projects on sustainability projects (see Figure 38 below).

Figure 38 – relationship between CRC program and policy area .

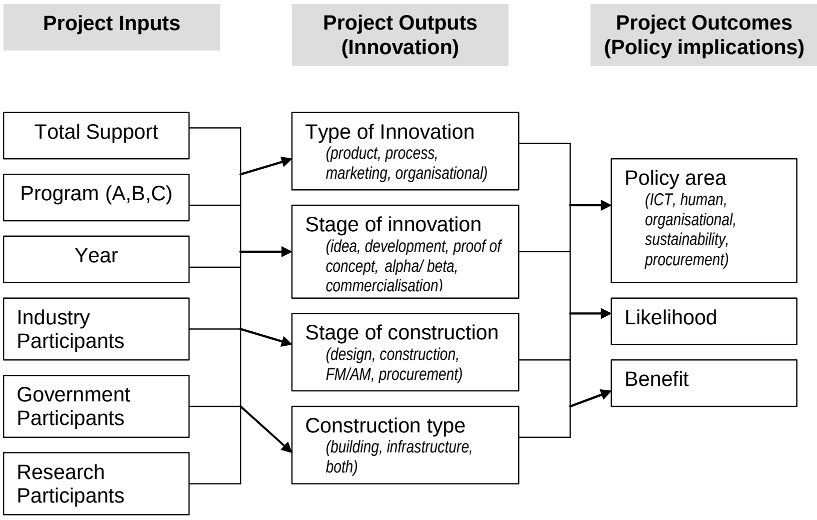


Finding 27 – There was a significant focus in program B on innovations with an implication for sustainability policy and in Program A on organisational policy.

4.7. MULTIPLE REGRESSION ANALYSIS TO TEST THE MEDIATION VARIABLES EFFECT ON THE INDEPENDENT VARIABLES

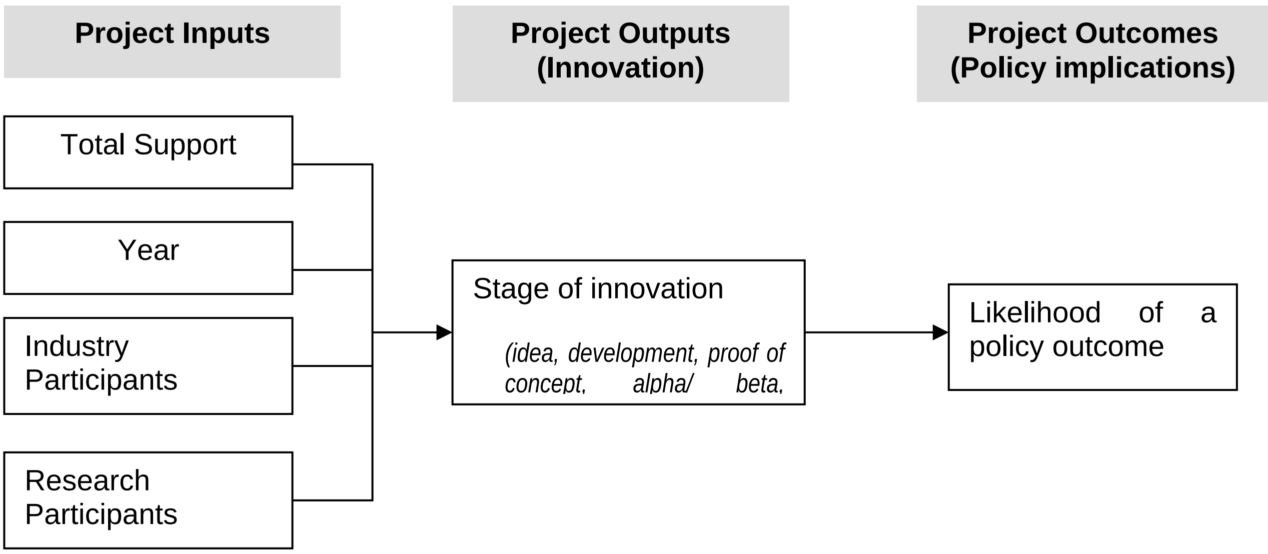
At the outset of this research paper, a set of relationships were posited which are summarised in the following diagram:

Figure 39 – Original model of relationship between variables



As shown above, not all of these relationships were significant. From all of the correlations, chi squares and analysis of variance noted above, a revised and simplified model of relationships is possible to be articulated (see Figure 39 below).

Figure 40 - Revised Model 1 of relationships following initial analysis



While a relationship between stage of innovation and the perceived benefit of policy, this was not related to any o the independent variables, and therefore has not been included in the regression model.

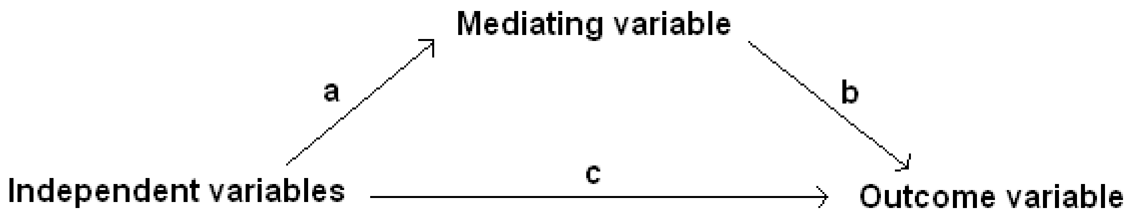
In order to test this model of the innovation process and the implications of this research upon policy, then regression analysis needs to be undertaken in order to test for the relationships.

> In general, a given variable may be said to function as a mediator to the extent that it accounts for the relation between the predictor and the criterion (Barron & Kenny 1986: 1176).

Regression analysis has already been taken above, which shows a relationship between the project inputs and innovation, and between innovation and the policy implications. However, is there a relationship between inputs and policy likelihood?

Consider the following diagram (Figure 40), which demonstrates the logic of mediation:

Figure 41 – Testing mediating variables (adapted from Barron & Kenny 1986)



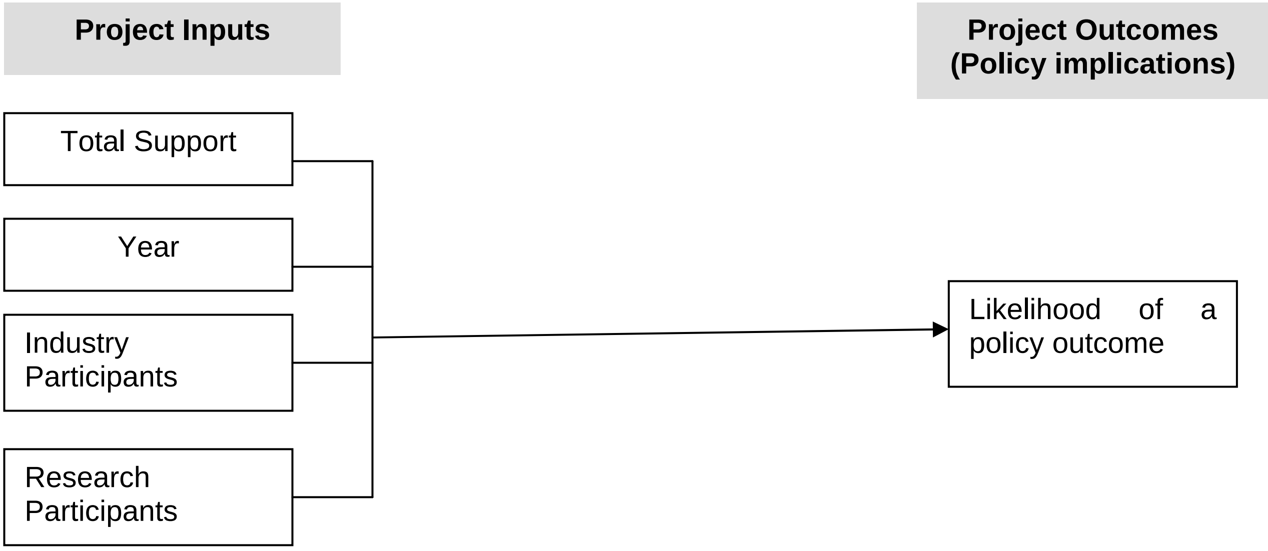
Relationship ‘**a**’ has already been shown in the analysis of variance above, as has relationship ‘**b**’. In other words there is a relationship the mediating variable (innovation stage) and the independent variables (project inputs). A relationship between the outcome variable (policy likelihood) and the mediating variable (innovation stage), has also been demonstrated. What needs to be determined is point ‘**c**’ – whether there is a relationship between the outcome variable (policy likelihood) and the independent variable (project inputs). Assuming that a relationship is found, does the relationship still hold, even if the mediating variable is inserted into the model? If the relationship ‘**c**’ is shown to exist, and this then disappears once the mediating equation is entered into the model, then the innovation stage has been demonstrated to be the main source of the policy implications.

Barron and Kenny (1986) suggest that regression analysis is needed to determine the effect of any mediating variables on dependant variables. A two stage regression analysis should be able to determine the influence of inputs on policy likelihood, and to examine what happens to this relationship once innovation is introduced to the model.

4.7.1. Linear multiple regression analysis

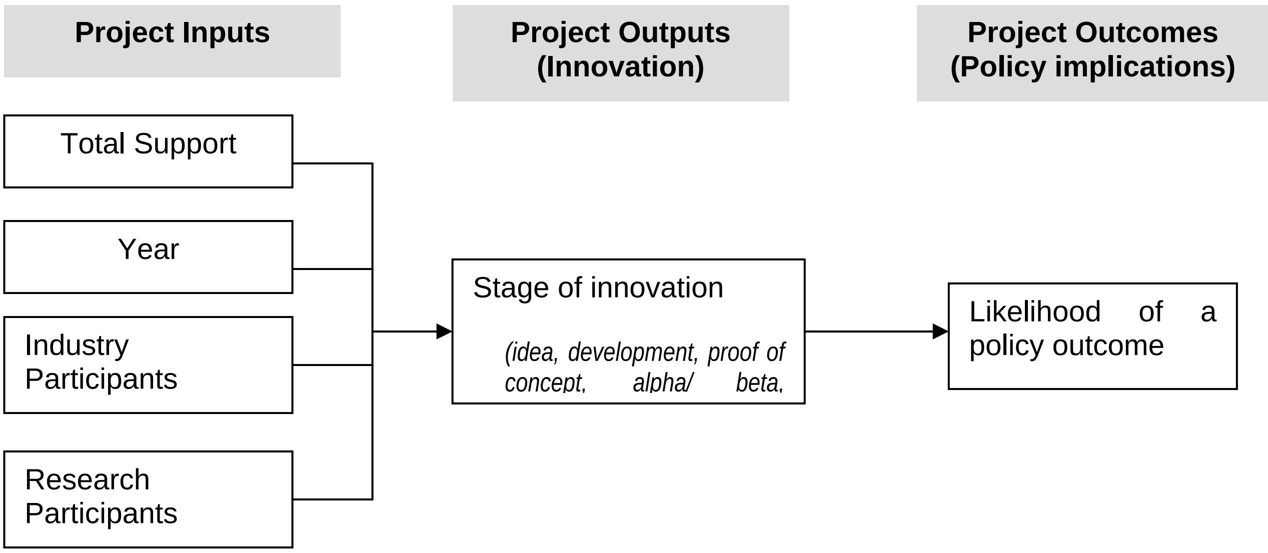
As noted above, regression analysis enables the determination of whether innovation is a mediating variable in the equation. This is tested in a two step process. The first step undertakes correlation between the dependent variables (project inputs) and the dependent variable (policy implications). In effect the model being tested is below:

Figure 42 – Step 1 of full regression model



After relationships in step 1 have been examined, the next set of relationships are entered into the model in order to assess whether they affect the first set of relationships. The model being tested is below:

Figure 43 - Second step of the full regression



- In Step One the independent variables are entered into the model
- In Step Two, the mediating variables are introduced into the model

If there is a relationship at Step One which is removed after Step Two, then the mediating variables are indeed mediating between the independent and dependant variables.

4.7.2. *Results of Linear multiple regression*

Linear regression analysis was conducted on the total likelihood of the policy impact. The model summary is provided in Table 4 below:

Table 4 - Model Summary

Model	R	R Square	Change Statistics				
			R Square Change	F Change	df1	df2	Sig. F Change
1	.419(a)	.175	.175	3.723	4	70	.008
2	.591(b)	.350	.174	4.423	4	66	.003

Step 1 the following variables were entered

TotalSupport, Year Approved, Research participants, Industry Participants(a)

Step 2 – the following dummy variables were entered

AlphBetaOrNot, FinalOrNot, DevelOrNot, ProofOrNot

The model was thus significant.

The changes to individual constants in model one and two are discussed below:

Table 5 - Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	Sig.
		B	Std. Error	Beta	
Step 1					
	Year Approved	.731	.327	.279	.029
	Industry Participants	-.863	.423	-.273	.045
Step 2	(Constant)				
	Industry Participants	-.733	.401	-.232	.072
	IS: Development#	3.913	1.500	.339	.011
	IS: Proof of concept#	3.046	1.473	.286	.043
	IS: Alpha / Beta#	4.183	1.476	.351	.006
	IS: Commercialisation / utilisation#	5.539	1.373	.552	.000

a Dependent Variable: TotalLikelihood
dummy variable coded from Innovation stage (IS)

Testing for mediation

While Model one is significant [*F*(4, 74)=3.723, *p*=.008)], model 2 is slightly more significant and has a slightly larger effect [*F*(8, 72)=4.437, *p*=.000)]. Importantly for a multiple regression the IVs of year (*Beta*=.279, *p*=.029) and industry participants (*Beta*=-.273, *p*=.045), were significant in model 1. That is they both have a significant effect of roughly the same size on the DV.

Stage of Innovation

Analysis of variance showed that stage of innovation was significantly related to the likelihood of a policy outcome. This holds true, even when other significant correlations are taken into account. Dummy variables were created to test for each of the stages of innovation, comparing these with the idea stage of innovation. Each stage of innovation has a significant positive relationship with the likelihood of a policy outcome: development (*Beta*=.339, *p*=.011), proof of concept (*B*=.286, *p*=.043), alpha / beta (*B*=.351, *p*=.006), and Commercialisation / utilisation (*B*=.552, *p*=.000).

Innovations which were more advanced in their development cycle (ie alpha / beta and commercialised) were more likely to have a policy impact than those innovation which were earlier in their development stage.

Finding 28 – Innovations late in the development process are more perceived to be likely to have an influence on public policy than those earlier in their cycle, even after controlling for other input variables.

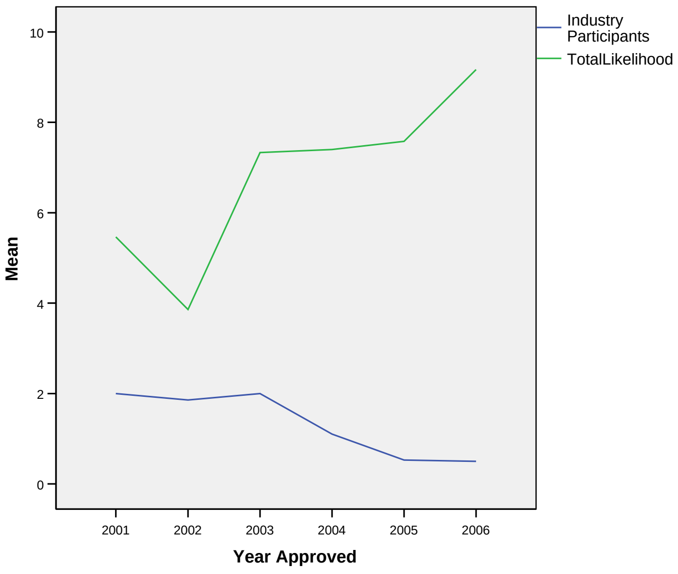
Industry participants

In Model 1, industry participants had a significant negative effect on the likelihood of a policy outcome industry participants (*Beta*= -.273, *p*=.045). In other words, the more industry participants involved in a project the less likely a policy outcome would be achieved. Under Model 2, once the mediating variable of stage of innovation is introduced, the effect is reduced, although it is still significant (*Beta*= -.232, *p*=.072).

Stage of innovation reduced the effect of industry participants on the likelihood of a policy outcome, however this effect was still significant. This may be due to the fact that the overall numbers of industry participants decreased over the life of the CRC. Given that the likelihood of a public policy increased over time, this relationship may have more to do with time factors than anything else (see Figure 43).

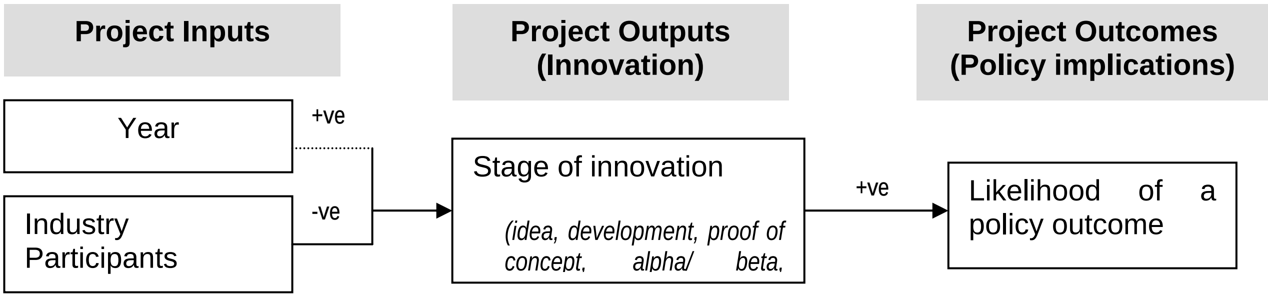
Finding 29 – the number of industry participants was negatively related to the perceived likelihood that a policy outcome will be achieved. This is likely to mainly be due to time.

Figure 44 – average of industry participants and average likelihood of a policy outcome over time



A revised model is possible following the regression analysis.

Figure 45 – revised model following a regression analysis



Independent variables which became no longer significant following regression

In Model 1, year had a significant effect on the likelihood of a policy outcome (*Beta*=.279, *p*=.029) However, in model 2, once the Mediating variable of stage of innovation is introduced, the significance and effect of year approved (*Beta*=.177, *p*=.145) is reduced and is not longer significant. It is possible that a significant effect would be seen given a larger sample size. This is logical as the longer the CRC has been running, the more likely it is to build the research base with which to make a difference at a policy level.

Thus while year is significantly related to the likelihood of a policy outcome, this effect is partially mediated by the stage of the innovation.

Total Support

In Model 1, total support has an effect which is significant on the likelihood of a policy outcome (*Beta*=.222, *p*=.107). This would make sense as the more resources a project has, is likely to enhance the impact of the project on policy. However, once stage of innovation was introduced into the model as a mediating variable, the effect and significance decreased (*Beta*=.116, *p*=.408).

Thus stage of innovation mediated the relationship between total support and likelihood of policy outcome. Stage of innovation had a stronger and more significant effect.

Research participants

While research participants had a significant bivariate correlation with likelihood of a policy outcome, this was not evident once other variables were controlled for (*Beta*= -.012, *p*=.923).

Thus, the main predictors of the likelihood of a policy outcome are the stage of innovation. However, as the number of industry participants increased in a project, the likelihood of a public policy outcome would be achieved. As noted above, the number of industry participants reduced over time, whereas the perceived likelihood of a policy outcome increased over time. So while the two events are statistically correlated, caution should be observed in attributing correlation.

The simplified story would thus be that as year progressed, innovations progressed in the their innovation stages. Innovations later in their development stage are more likely to have a policy outcome. Influence and benefit of innovations on policy, are likely to be due to time.

Figure 46 – Benefit and likelihood over time

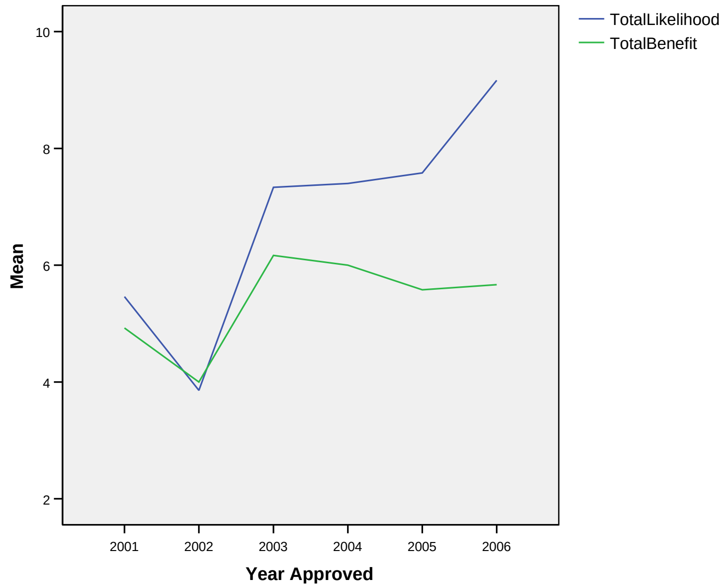
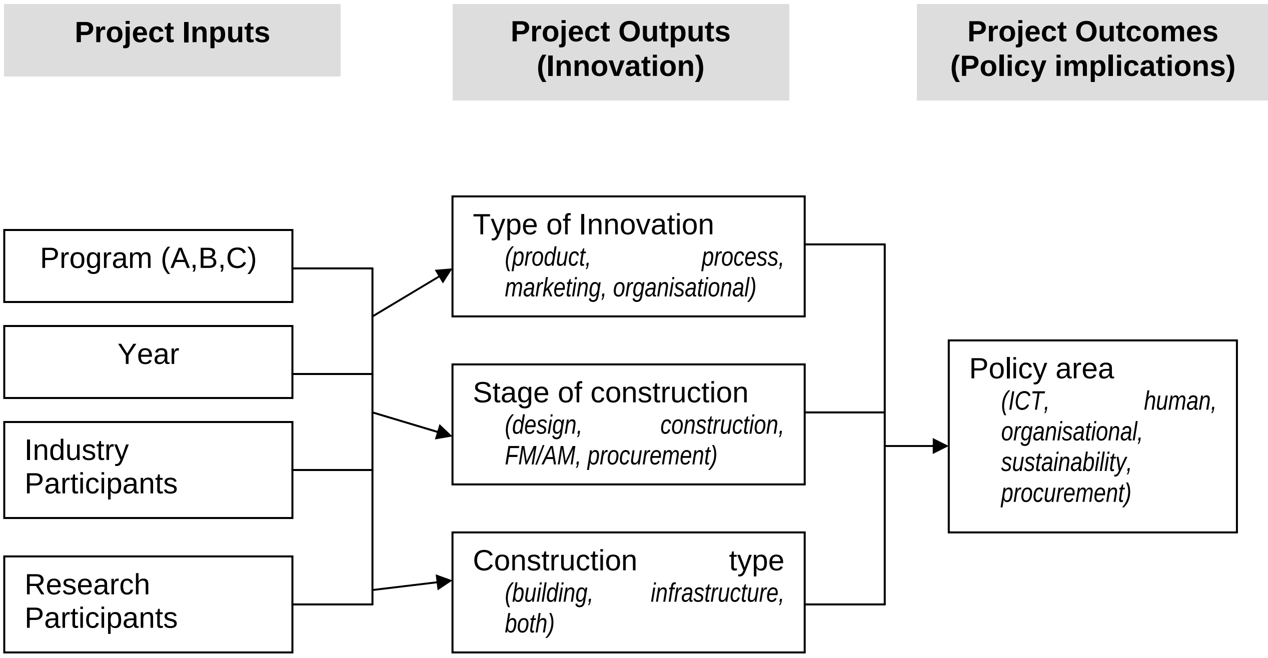


Figure 47 – Revised model 2 – following analysis of variance and chi square.



It is not possible to conduct regression analyses on these variables due to the large numbers of categorical variables as mediators, and the small sample size.

Consequently, the chi squares, bivariate analysis and analysis of variance already conducted will have to suffice for the statistical analysis of the variables.

It is possible to test for the efficiency and effectiveness of various outputs and outcomes, as suggested in the policy evaluation model:

Figure 48: Policy Evaluation (adapted from Department of Finance 1994, p.8)

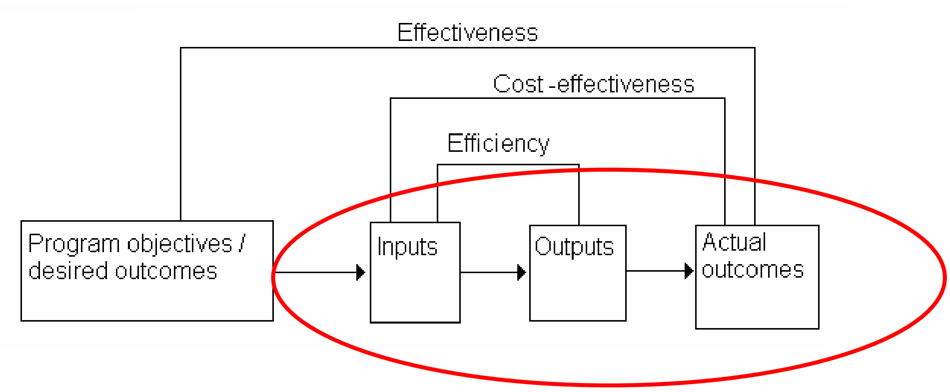


Table 6 - Costs of different types of innovation

	N	Mean	Std. Deviation	Minimum	Maximum
Product innovation	33	$475,876.88	548,835.609	$2	$2,730,850
Process innovation	27	$542,502.33	457,613.254	$81,872	$1,894,495
Organisational Innovation	15	$442,564.13	236,110.030	$81,540	$901,612

Organisational innovations were the most efficient, compared to product or process innovation, however, the difference was not statistically significant.

Table 7 – Costs of different stages of construction

	N	Mean	Std. Deviation	Minimum	Maximum
Design	34	$434,232.41	461,110.349	$38,000	$1,938,489
Construction	14	$563,131.21	684,809.708	$2	$2,730,850
Maintenance	10	$569,761.50	334,309.534	$252,569	$1,396,316
Procurement	17	$508,506.35	317,208.109	$196,624	$1,500,000

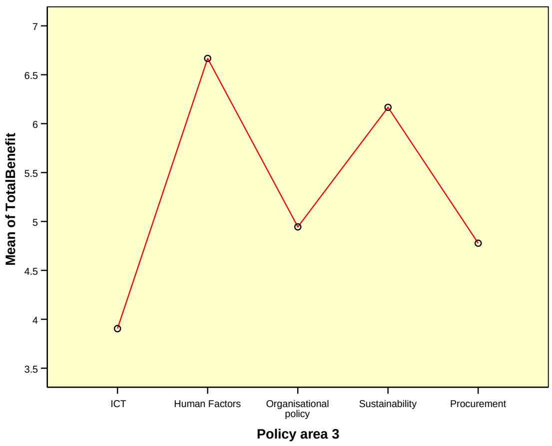
Table 8 – Costs by policy area

	N	Mean	Std. Deviation	Minimum	Maximum
ICT	21	$534,247.48	643784.395	$38,000	$2,730,850
Human	9	$307,962.11	245567.496	$2	$724,539
Organisational	18	$447,488.94	234854.848	$75,001	$901,612
Sustainability	18	$578,757.06	510058.941	$42,001	$1,938,489
Procurement	9	$502,964.22	408008.267	$81,872	$1,396,316

Given that human factors and sustainability are considered to have the most likelihood of a policy impact (see Figure 31), human factors innovations delivered the greatest potential impact for the least amount of cost, followed by sustainability (see Figures 49a and 49b below). In efficiency terms, projects which delivered ICT innovations were the least efficient, as they were the second most expensive, and yet delivered the least amount of benefit and were the least likely to achieve such a benefit. Sustainability innovations, while delivering significant policy benefit and likelihood, also cost the most on average.

Consequently, it is possible to compute the relative efficiency of the various policy areas, by calculating the total cost, and divide this by the estimated likelihood and benefit of a policy outcome. The results of this are shown on Figures 50a and 50b, below. Again human factors are the most efficient policy areas in terms of policy impact, and ICT is the least efficient.

Figure 49a and 49b – likelihood and benefit by policy area



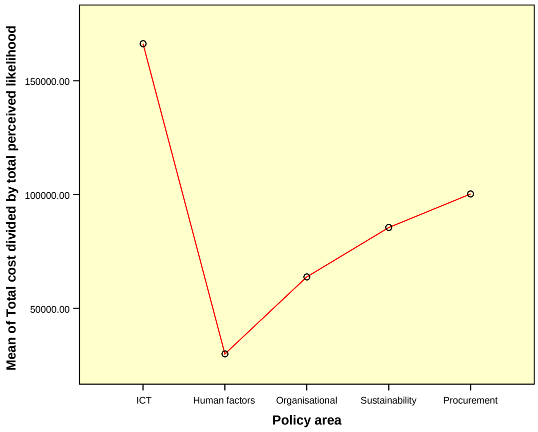
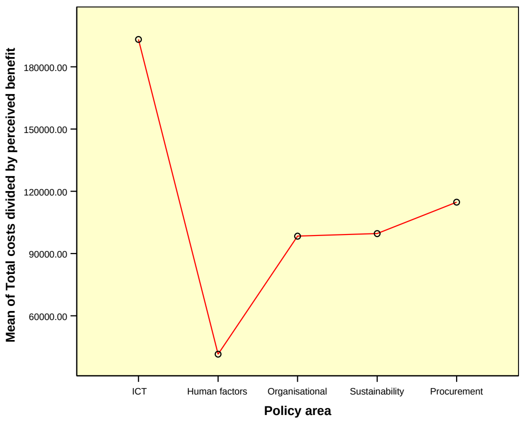
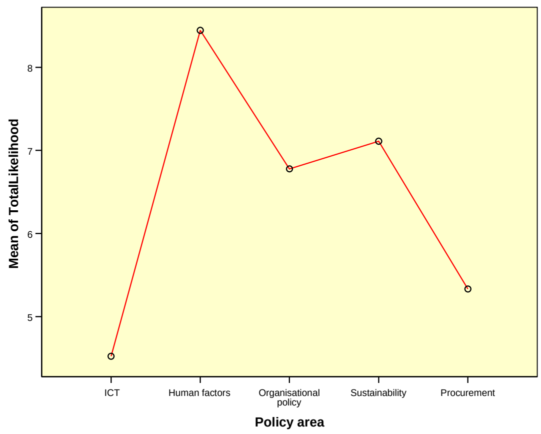


Figure 50a & 50b – total support as a factor of the total benefit and likelihood





Finding 30 – The policy area of human factors delivered the greatest benefit and likelihood of a policy outcome for the least total cost.

4.8. TEST FOR EXISTENCE OF A TRIPLE HELIX OF RELATIONSHIPS

The triple helix of innovation has been an intriguing concept in the innovation literature. The notion that government, industry and researchers could relate to each other in a “triple helix” of relationships has excited the imaginations of numerous researchers. How such relationships might be represented has posed more of a challenge. Moreover, Manseau and Seaden (2001) have asserted that government is not involved in research and development activities beyond their funding. This research project has shown that there are variations in the number of different types of participants in various research projects (see minimums in Table 11 below).

Table 9 – differences between participants

	Minimum	Maximum	Sum	Mean	Std. Deviation
Government Participants	0	10	188	2.51	2.429
Industry Participants	0	6	101	1.35	1.390
Research participants	0	17	457	6.09	3.771

N=75

The minimum is important as it is possible for a particular type of participant to be absent from specific projects. However, aside from had drawings of what a triple helix might look like, representation of a triple helix has not been attempted hitherto. While exploring the data, it became evident to the research team that there was a very strong relationship between different types of researchers. These correlations can be seen in Table 12 below.

Table 10 - Bivariate correlation of participants

		Government Participants	Industry Participants	Research participants
Government Participants	Pearson Correlation	-		
	Sig. (2-tailed)			
Industry Participants	Pearson Correlation	.071	-	
	Sig. (2-tailed)	.543		
Research participants	Pearson Correlation	.372**	.308**	-
	Sig. (2-tailed)	.001	.007	

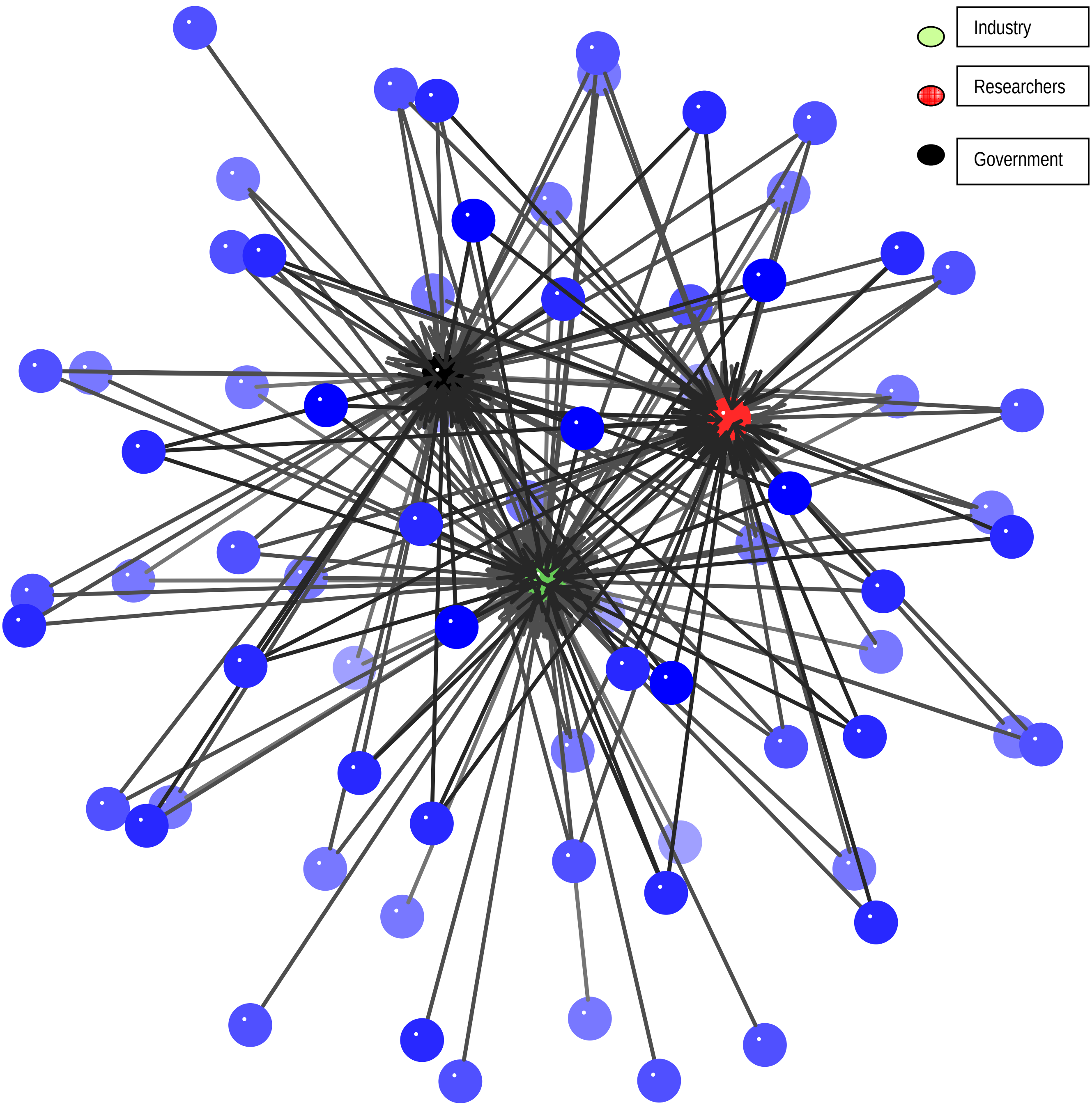
* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Finding 31 – There was a positive and significant relationship between the number of different types of participants. The relationship is strongest between industry and research participants, and government and researcher participants.

Using social network analysis it is possible to graphically represent the relationships between different types of participants in research projects, and thereby determine demonstrate the relationship between researchers, government and industry on innovation projects.

UCI Net (Borgatti, Everett, and Freeman 2002) was used to graph the relationships between researchers, government and industry participants in research projects. This data was exported to Mage kin order to convert the 2D image into a 3D image, based on the network data. The output of this process is included in Figure 51 below:

Figure 51 – Social Network analysis of participants involved in CRC projects



In this 3D drawing, the blue dots represent the individual projects. The large dots in the centre are the different types of participants – red for researchers, green for industry, and black for government.

Finding 32 – Industry, government and researchers all collaborating in research projects, although the number of various participants varies from project to project.

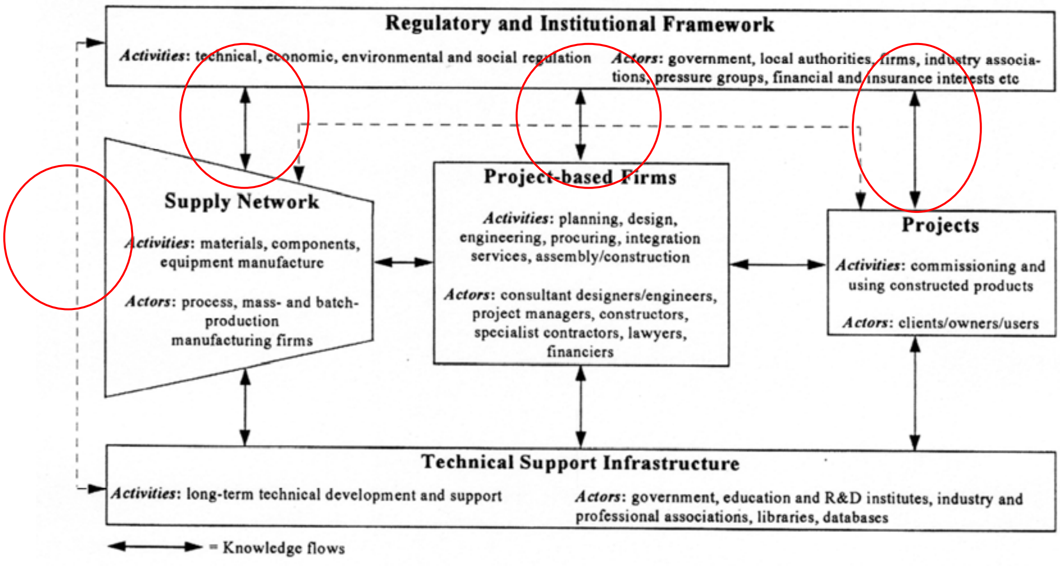
Government does not just fund construction innovation, as government participants are actively engaged in research projects.

5. IMPLICATIONS OF THE RESEARCH

5.1.1. Implications for Gann and Salter (innovation as a system)

Gann and Salter (2000) suggested a relationship between innovation and the regulatory environment in which this innovation occurs.

Figure 52 – Relationship between regulation and innovation (Gann & Salter 2000: 960)



This research has extended this model of innovation by demonstrating the there is a potential for innovation to have a relationship with specific areas of policy. While this may seem intuitive the current model of Gann and Salter (2000) (above), this research project has demonstrated that there is potential for research projects to have an influence on public policy.

5.1.2. Implications of the research for the triple helix approach to innovation

While some authors have argued that government in Australia is not involved in construction innovation, apart from funding research, this project has shown that government is an active participant in research projects conducted by *Construction Innovation. Research* undertaken in this project herein asserts that, such a relationship exists, and moreover, is able to depict the relationship in such a manner that supports the hypothesis of Leydesdorff and Etzkowitz (2003) that a triple helix of relationships is possible between government industry and researchers.

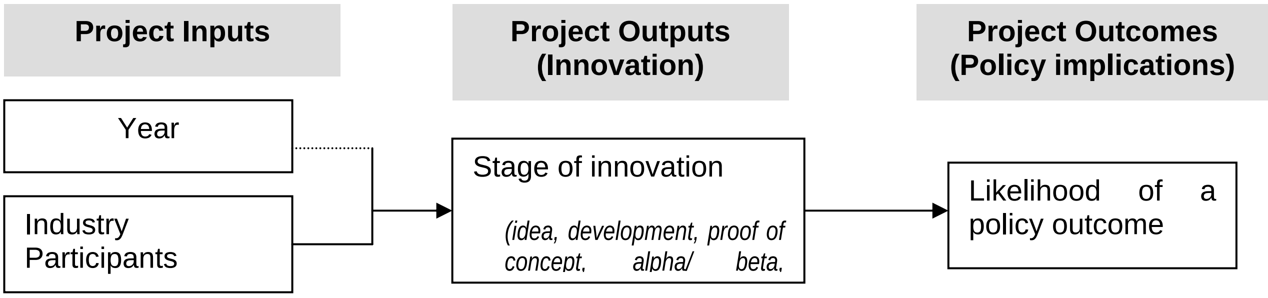
5.1.3. Implications for future research

This research project has begun to unpack the relationships between *Construction Innovation* research and public policy. It is interesting that two main areas were perceived to have the greatest likelihood of a policy impact and greatest benefit of such an impact (human factors such as OH&S and sustainability). These two areas have proved to be influential in a number of jurisdictions, with OH&S and sustainability delivering considerable interest from government and industry in *Construction Innovation* research.

6. CONCLUSION

This research project sought to examine the relationship between project inputs and innovation, and innovation and policy inputs. A model was posited and tested, an updated version of which is included below (Figure 53).

Figure 53 – Updated model of the policy implications of innovation



This research project has demonstrated that:

- Project inputs, particularly participants and programs, have a statistically significant relationship to the type of innovation developed within the project
- Various types of innovations have a statistically significant relationship with policy areas. This holds true even when project inputs have been controlled for. In particular the stage of innovation is the best predictor of a policy outcome, compared to other variables.
- A triple helix of relationships between project participants (government, industry and research) has been demonstrated.

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8. ATTACHMENT A – CIBE PROJECT PHASES

As outlined in the project agreement, there are three stages to the CIBE project. While each utilise similar processes, it is important to outline each of these discrete phases.

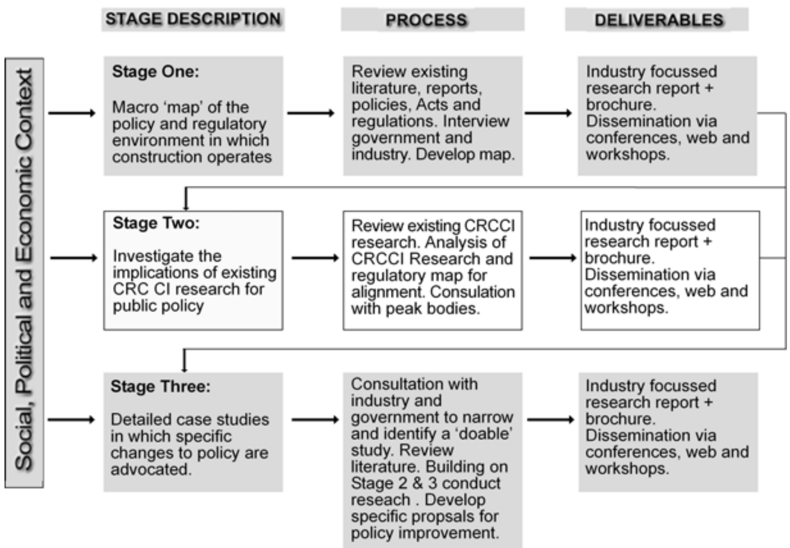
Stage 1 of the Project will complete a brief review of the context (social, political, and economic) of the construction industry, examine the similarities and differences of content between the various policies and regulations at national and state levels, and provide a rationale for the current regulatory framework. Intergovernmental arrangements and obvious areas of overlap or gaps will be identified. Primary methodology in this case is policy analysis (document analysis), although some semi-structured interviews will be required.

Stage 2 involves a detailed analysis of the policy implications of completed and current CRC CI research projects, and how application of this research could result in efficiencies and improved productivity for government and industry. Semi-structured interviews and textual analysis – comparing the research to the policy map. This stage will explicitly explore the notion of the triple helix to innovations developed within the CRC CI. This stage will utilise document analysis and interview studies.

Stage 3 analyses specific policy areas in which a coordinated approach across all levels of government would benefit the construction industry. Case study areas were identified in consultation with CRC Construction Innovation partner organisations. The perceived impact by key stakeholders of current regulatory framework in relation to productivity and innovation will be identified in consultation with stakeholders. A public inquiry approach will be utilised in relation to the case studies. Submissions from stakeholders will be sought, and data will be collected through interviews, focus groups, and secondary text analysis. Best practice examples in each area will be noted were possible. The terms of reference for such an enquiry will be established by the CIBE project team. Barriers and enablers for coherent policymaking, productivity gains and innovation will also be identified. The outcome of each study will be a series of recommendations which promote coordination between jurisdictions in Australia and reduce the effects of the overlap noted above. Each study will follow a case study methodology, and will involve, focus groups, semi-structured interviews, and document analysis.

The initial areas identified for **case studies** include:

1) Training and capability for the construction industry;
2) Occupational Health and Safety;
3) eBusiness (and related ICT implications for construction and property businesses);
4) Procurement (including supply chain, risk mitigation, tendering, and contractual arrangements);
5) Environmental sustainability.



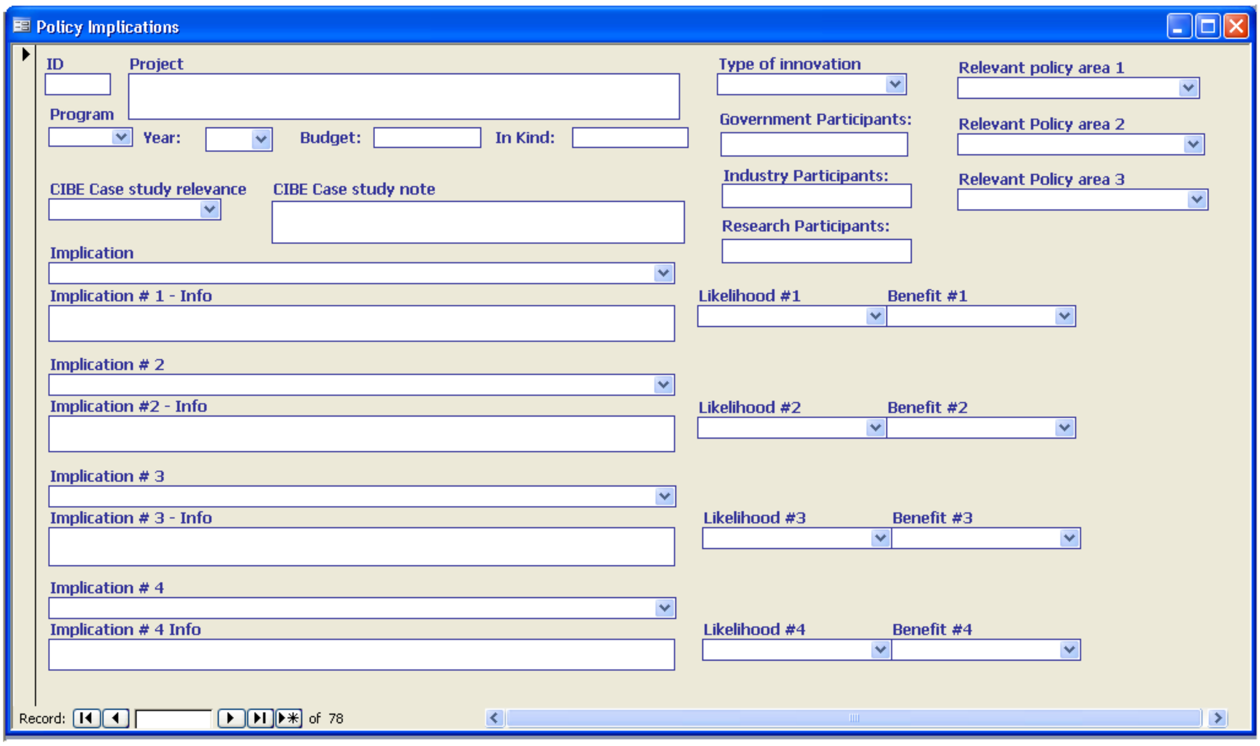
These case studies will be narrowed in consultation with industry and government, and could include exemplar projects that demonstrate the benefits of specific ICT tools for government and industry. This file relates to stage 2 of the process. An outline of the various stages, their processes and deliverables is found adjacent.

9. ATTACHMENT B – LIST OF PROJECTS

2001-002-B - Life Cycle Modelling and Design Knowledge Development in Virtual Environments - [Gero, Usyd]
2001-003-C - Value Alignment Process for Project Delivery - [Sidwell, QUT]
2001-004-A - Knowledge Management and Innovation Diffusion - [Walker, RMIT]
2001-005-B - Indoor Environments: Design, Productivity and Health - [Bell, QUT]
2001-006-B - Environmental Assessment Systems for Commercial Buildings - Newton, CSIRO]
2001-007-C - Managing Information Flows with Models and Virtual Environments - [Drogemuller, CSIRO]
2001-008-C - Project Team Integration: Communication, Coordination and Decision Support - [Kajewski, QUT]
2001-010-C - Investment Decision Framework for Infrastructure Asset Management - [Kumar, RMIT]
2001-011-C - Evaluation of Functional Performance in Commercial Buildings - Boyd, QUT]
2001-012-A - Innovation Potential, Directions and Implementation in the Building and Construction Product System - [Manley, QUT]
2001-013-B - Sustainability and the Future Building Code of Australia - [Ashe, ABCB]
2001-014-B - Automated Code Checking - [Drogemuller, CSIRO]
2001-016-A - Critical Success Factors for ICT Mediated Supply Chains - [Brewer, UN]
2002-004-B - Noise Management in Urban Environments - [De Silva, RMIT]
2002-005-C - Decision Support Tools for Concrete Infrastructure Rehabilitation - [Setunge, RMIT]
2002-010-B - Component Life: Delphi Approach to Life Prediction of Building Material Components - [Cole, CSIRO]
2002-020-C - Tenant Risk Profiling - [Ross, QUT]
2002-022-A - Value in Project Delivery Systems: Facilitating a Change in Culture - [Rowlinson, QUT]
2002-024-B - Team Collaboration in High Bandwidth Virtual Environments - [Maher, USyd]
2002-035-C - Feasibility Study Linking Best-Value Procurement Assessment to Outcome Performance Indicators - [Dalrymple, RMIT]
2002-043-B - Smart Building for Healthy & Sustainable Workplaces - [Foliente, CSIRO]
2002-051-B - Right-Sizing Airconditioning Systems - [Moller, CSIRO]
2002-052-C - Value in Project Delivery Systems - Project Diagnostics - [Tsoukas, ARUP]
2002-053-C - Way Finding in the Built Environment - [Hogan, BCV]
2002-056-C - Contract Planning Workbench - [Drogemuller, CSIRO]
2002-057-C - Enabling Team Collaboration with Pervasive & Mobile Computing - [Kajewski, QUT]
2002-059-B - Case Based Reasoning in Construction and Infrastructure Projects - [Cole, CSIRO]
2002-060-B - Parametric Building Development During Early Design - [Crawford, CSIRO]
2002-062-A - Ethical Construction Procurement - [Lenard, UN]
2002-063-B - Sustainable Subdivisions: 1 - Energy and Water Efficient Design - [Ambrose, CSIRO]
2002-066-A - Internationalisation of Construction Industry Design Firms - [London, UN]
2002-067-A - eBusiness - Security & Legal Issues - [Betts, QUT]
2002-075-B - Integrated Sustainable Housing Development - [Yang, QUT]
2002-077-B - Sustainable Subdivisions: Ventilation - [Miller, CSIRO]
2003-003-A - eBusiness Adoption - [London, UN]
2003-026-C - Delivering a Re-Life Project - [Sidwell, QUT]
2003-028-B - Regenerating Construction to Enhance Sustainability - [Newton, CSIRO]
2003-029-C - Maintenance Cost Prediction for Roads - [Kumar, RMIT]
2003-037-C - Stage 2 - Managing Information Flows with 3D Models - [Drogemuller, CSIRO]
2003-050-A - Construction Site Safety Culture - [Cipolla, John Holland]
2004-003-B - Microclimatic Impacts on the Built Environment - [Kraatz, BCC]
2004-006-B - Virtual Prototypes Enhancing Performance - [Tucker, CSIRO]
2004-011-B - Code Checking - Phase 2 - [Ding, CSIRO]
2004-014-B - SpecNotes and Viewer Extension - [Egan, CSIRO]
2004-016-A - Supply Chain Sustainability - [London, UN]
2004-018-C - Sustainable Infrastructure for Aggressive Environments - [Setunge, RMIT]
2004-021-A - Building Research Innovation Technology and Environment (BRITE) - [Manley, QUT]
2004-028-C - Way Finding in the Built Environment - Phase 2 & 3 - [Hogan, Building Commission]
2004-032-A - Construction Industry Business Environment (CIBE) - [Brown, QUT]
2004-033-B - Indoor Air Quality Estimator - [Tucker, CSIRO]
2005-001-C - Sydney Opera House - FM Exemplar Project - [Morris, Rider Hunt]
2005-002-E - IT Enabled Business Strategies - [Betts, QUT]
2005-003-B - Learning System for Life Prediction of Infrastructure - [Corrigan, CSIRO]
2005-004-C - Off-Site Manufacture in Australia - [Fussell, QDPW]
2005-008-C - Automated Estimating for Civil Concrete Structures - [Droegmuller, CSIRO]
2005-015-B - Your Building - [Newton, CSIRO]

2005-016-A - BSITE: Mobilising Construction - [Wakefield, RMIT]
2005-017-A - Modelling Construction Business Performance - [Gallery, QUT]
2005-018-B - Background Applications for Byggforsk - [Droegmuller, CSIRO]
2005-021-B - 3D CAD Simulations for Slavenburg Holding - [Jones, QDPW]
2005-022-E - eLearning Modules for Building Construction - [Betts, QUT]
2005-023-E - eDesignConstruct - SME Skill and Knowledge Development Stage 1 - [London, UN]
2005-025-A - Electronic Contract Administration - Legal and Security Issues - [Christensen, QUT]
2005-027-A - Safer Construction - [Fleming, John Holland Group]
2005-029-D - Project diagnostics - [Tsoukas, Rider Hunt]
2005-031-D - LCA Design Commercialisation- [Egan, CSIRO]
2005-032-D - Urban Noise Management Software Development [,]
2005-033-C - Business Drivers for BIM - [Wakefield, RMIT]
2006-006-D - Commercialisation Technical Activities - [Ding, CSIRO]
2006-029-E - Relationship Management in Project Delivery - [Scott]
2006-034-C - Procurement Method Toolkit - [,]
2006-035-D - Automated Scheduler Development [,]
2006-036-A - Multi-outcome Construction Policies - [Austin, Curtin]
2006-037-D - Automated Estimator Commercialisation [,]
2006-039-A - Managing Knowledge in an outsourcing environment - [,]

10. ATTACHMENT C - DATABASE FORM



Independent Variables
A number of descriptive variables were used to determine the relationship between resource allocation and innovation. These were:

	Type of Variable	Purpose
Project title	Unique identifier	To distinguish the projects from each other
Year approved	Scale	To allow grouping of projects by year
Research Program	Nominal	To allow grouping of projects by program
Government participants	Scale	Number of government participants in each project
Industry participants	Scale	Number of industry participants in each project
Research participants	Scale	Number of research participants in each project
Total support	Scale	Combined tally of the total budget and in kind support for the project

Mediating Variable

In this research project, the type of innovation is seen as a moderating variable, as it is the specific research itself which is likely to have an impact upon the policy outcomes, rather than the number of researchers for example.

	Type of Variable	Purpose
Innovation Type	Nominal	To identify the type of innovation being undertaken in projects (product, process and organisational)
Stage of Innovation	Nominal	To identify the stage of the innovation (idea, development, proof of concept, alpha/beta, utilisation)
Type of construction	Nominal	To identify whether the innovation focussed on infrastructure, buildings, or both.
Phase of construction	Nominal	To identify which phase of construction the innovation is focussed on (design, construction, asset management, procurement).

Dependant Variable

Policy area was seen as a dependant variable as the objective was to identify the policy implications of *Construction Innovation* research.

	Type of Variable	Purpose
Policy Area	Nominal	To identify the main policy area of policy innovation (ICT, human policies such as OH&S, organisational, sustainability, procurement)
Perceived benefit	Ordinal	Each innovation was scored from little benefit to great benefit a 5 point likert scale across 4 policy instruments (education, finance, action, regulation). This variable report the combined tally of the total perceived benefit of policies related to the innovation.
Perceived Likelihood	Ordinal	Each innovation was scored from unlikely to highly likely on a 5 point likert scale across 4 policy instruments (education, finance, action, regulation). This variable is a combined tally of the total perceived likelihood of a policy outcome related to the innovation.

11. ATTACHMENT D - FULL TABLE OF BIVARIATE CORRELATIONS BETWEEN CONTINUOUS VARIABLES

Correlations

		Year Approved	Government Participants	Industry Participants	Research participants	Total Participants	In Kind	Final Budget	TotalSupport	TotalBenefit	Total Likelihood
Year Approved	Pearson Correlation	1	-.291*	-.444**	-.348**	-.461**	-.311**	-.208	-.292*	.199	.340**
	Sig. (2-tailed)		.011	.000	.002	.000	.007	.073	.011	.087	.003
	N	75	75	75	75	75	75	75	75	75	75
Government Participants	Pearson Correlation	-.291*	1	.071	.372**	.689**	.226	.114	.198	.117	.152
	Sig. (2-tailed)	.011		.543	.001	.000	.052	.329	.088	.317	.192
	N	75	75	75	75	75	75	75	75	75	75
Industry Participants	Pearson Correlation	-.444**	.071	1	.308**	.477**	.517**	.361**	.492**	-.058	-.291*
	Sig. (2-tailed)	.000	.543		.007	.000	.000	.001	.000	.624	.011
	N	75	75	75	75	75	75	75	75	75	75
Research participants	Pearson Correlation	-.348**	.372**	.308**	1	.894**	.474**	.417**	.483**	.018	-.086
	Sig. (2-tailed)	.002	.001	.007		.000	.000	.000	.000	.879	.462
	N	75	75	75	75	75	75	75	75	75	75
TotalParticipants	Pearson Correlation	-.461**	.689**	.477**	.894**	1	.535**	.412**	.523**	.048	-.063
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000	.000	.685	.591
	N	75	75	75	75	75	75	75	75	75	75
In Kind	Pearson Correlation	-.311**	.226	.517**	.474**	.535**	1	.734**	.967**	.064	-.063
	Sig. (2-tailed)	.007	.052	.000	.000	.000		.000	.000	.587	.589
	N	75	75	75	75	75	75	75	75	75	75
Final Budget	Pearson Correlation	-.208	.114	.361**	.417**	.412**	.734**	1	.883**	.133	.116
	Sig. (2-tailed)	.073	.329	.001	.000	.000	.000		.000	.256	.320
	N	75	75	75	75	75	75	75	75	75	75
TotalSupport	Pearson Correlation	-.292*	.198	.492**	.483**	.523**	.967**	.883**	1	.094	.000
	Sig. (2-tailed)	.011	.088	.000	.000	.000	.000	.000		.420	.997
	N	75	75	75	75	75	75	75	75	75	75
TotalBenefit	Pearson Correlation	.199	.117	-.058	.018	.048	.064	.133	.094	1	.777**
	Sig. (2-tailed)	.087	.317	.624	.879	.685	.587	.256	.420		.000
	N	75	75	75	75	75	75	75	75	75	75
TotalLikelihood	Pearson Correlation	.340**	.152	-.291*	-.086	-.063	-.063	.116	.000	.777**	1
	Sig. (2-tailed)	.003	.192	.011	.462	.591	.589	.320	.997	.000	
	N	75	75	75	75	75	75	75	75	75	75

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

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