AEC INTERNATIONAL CONFERENCE 2012

ACCUMULATING INTELLECTUAL CAPITAL FOR A NOVEL HOUSING CONSTRUCTION SYSTEM IN INTEGRATED SUPPLY CHAIN ENVIRONMENTS

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In the 1980s an innovative concrete footing system was designed, tested, developed and constructed to address the problem of high variability in onsite materials management. The need to improve reliability in housing concrete footings was directly related to a business imperative. At the time the state manager of a large national housing developer was exploring ways to increase revenues through developing efficient on-site materials management. The genesis of the solution was borrowed and adapted from other situations. The human story of the creation, development and adaptation journey of the innovation had not been uncovered although the technical story was well documented. The Australian Housing Supply Chain Alliance commissioned a study so that lessons could be learned about the pathway for highly innovative firms seeking to explore and commercialise novel ideas. Eight detailed semi-structured interviews with ten participants from seven organisations were conducted combined with document analysis from organisational records and court reports. A narrative analysis was used to map fifty one stories from the ten key protagonists against the agenda setting, matching, redefining and routinising innovation process framework. Contributions of intellectual, social and culture capital were identified across the collaborating organisations clarify the innovator group capability. This paper focussed on the role of intellectual capital for the successful implementation of an innovative housing construction system. Intellectual capital was a very important theme arising from this study including sub themes; knowledge domains, like-mindedness, collective contributions, re-strategising and adaptability, formalisation and ownership of intellectual property, patents and disputes, demonstration of credibility and building of reputation through various artefacts.

Keywords: innovation, housing sector, intellectual capital, integrated supply chain

INTRODUCTION

The housing sector has always been seen as an important part of the economy and is considered a key indicator of the health of an economy. The construction industry typically represents between 6-12% of the GDP of an economy. In Australia in 2009 the residential sector accounted for approximately $70b and from 2000-2009 the average spend was 47% of the total spend in the construction industry (ABS, 2010) and this is not uncommon for many countries. With anticipated population growth the significance of housing infrastructure provision is expected to increase in the next two decades globally. In Australia the Australian National Housing Supply Council estimates that around 3.2 million additional dwellings will be required in the next 20 years to accommodate a population growth from 2008 to 2028. The current supply of housing is unable to keep pace with the current and anticipated demand for housing across Australia (Liu and London, 2011). The shortfall means we are faced with a crisis in our capacity to plan, design and construct to meet our nations needs unless we act to improve our capacity for a more efficient, effective and innovative supply system. It was within this context that a group of housing stakeholder organisations decided in 2010 to create an alliance to explore ways to transform the housing sector by undertaking research and development projects (London, 2011). This paper reports the results of a study funded by the engineering consultancy firm within the alliance.

Very little attention has been paid to the concept of integrated solutions and the research on supply chain management in housing construction. To date the housing supply debate has been largely focussed on housing demand, affordability and land supply. The development of integrated supply delivery solutions have not been extensively recognised in the Australian residential sector. Ad hoc examples and applications by some major building companies have seen some limited success. However, this has not been diffused throughout the sector and thus has had little real impact on overall sector performance and individual company competitiveness. Whole-scale industry improvement requires a concerted effort to undertake a stepwise change. A key to the solution is to investigate successful examples of integrated supply chains which have resulted in productivity and/or innovation performance improvements. The present research project is a first step in addressing the problems of the residential construction market using the "supply chain lens". The project aim is to explore an example of an innovation which was successfully delivered to the housing construction industry which required an integrated construction supply chain model.

CONSTRUCTION SUPPLY CHAIN THEORY

The supply chain management concept has gained the interest of the construction research community and policymakers through its successful implementation by manufacturing sectors to resolve firm performance problems (London, 2008). The supply chain is the upstream and downstream contractual relationships between firms who deliver a commodity (product and/or service) related to the core business of a construction project. Subsequently the supply chain once formed creates a flow of commodities, cash and information. The creation of the supply chain is impacted by the location of the individual firm within its competitive market. These markets have unique structural and behavioural economic characteristics. The upstream and downstream linkages are affected by the characteristics of these markets and in particular the ensuing power relationships which arise between tiers (London, 2005). The act of procurement is key to effective supply chain management. "Supply chain procurement is the strategic identification, creation and management of critical project supply chains and the key resources, within the contextual fabric of the construction supply and demand system, to achieve value for clients."(London, 2008). A central idea of supply chain theory is that holistic supply chain integration relies upon each firm at each tier in the supply chain knowing and aiming for a common objective. The common objective may be an innovation or it may be concerned with efficiency and effectiveness across the whole supply chain. One of the most significant problems is that once a supply chain becomes fragmented at each tier in the chain there is an outcome from a firm and that firm passes their product and/or service to the next firm at the next tier in the chain and a potential silo effect may begin to take place. Each firm has unique objectives and 'pushes' on to the next tier the outcome they assume the next tier can 'bear'. The outcome is generally the most efficient for the firm but may not necessarily completely satisfy the next tier's objectives [i.e. the customer's objectives]. It is almost certain that the firm would not be considering the objective of the whole chain nor any other levels in the chain at all. It raises the question who really can and will ensure holistic supply chain integration in such a fragmented environment such as the construction sector?

The fragmented nature of the supply chain is central to the concept of supply chain management where the concept of 'pull' vs. 'push' explores a different way of thinking about holistic supply chain performance outcomes alongside the individual outcomes at each tier. The final 'customer's objectives and desired outcome effectively 'pulls' through the products and/or services provided by each tier in the chain. Until quite recently there has been little empirical evidence on the channel organisation and the decision-making actions in relation to procurement at each level of various tiers in the supply chain (London, 2008). Therefore it has been difficult to see any real examples of where this concept has had any major impact or where improvements have been made. To achieve supply chain integration for innovation the organisations need to have the right strategic environment to support innovations. The 'right' strategic environment is affected by the underlying economic and business environment. Organisations may have the will and desire to 'integrate' or 'coordinate' or 'innovate' however underlying structural conditions may be a barrier to such aspirations. The underlying economic market structure that an organisation is located within affects their behaviours with their clients and then also with their suppliers. The supply chain becomes a series of inter-connected markets whereby the power to influence the upstream and downstream relationship is impacted by the power that they can exert which is affected by the power relationship that they have within their market. The structure-conduct-performance SCP theory is well known and one of the cornerstones of the theory of industrial organisation economics. It has been systematically explored and extended to the construction supply chain. The theory holds true for the construction industry supply chain. SCP is a static perspective whereas the construction industry is more dynamic with short term changing market conditions on every different project but there are also more pervasive longer term market conditions that each unique project relationship is embedded within. This is described in much more detail in London (2008)'s book Construction Supply Chain Economics. For this study this background theory contextualises the business context of the relationship between actors involved in the innovation case study.

Much rhetoric states that supply chain management will solve problems, however, there is much more to understand beyond this. There are a range of tools and techniques that can be applied from other sectors that are 'tried and true' to achieve more cohesive supply chains. However, it is critical that an understanding of the sector specific challenges associated with the unique housing sector supply chain problems are addressed as well. One would anticipate that to create, develop and diffuse an innovation in a fragmented industry such as the residential sector would require collaborative efforts between firms along supply chains. It would also require a champion or group of champions who have enough resources and 'pull' to enable the development of the innovation. Beyond these propositions we do not know any more detail of the characteristics of the innovation process or methodology which would integrate the supply chain and achieve innovation creation and/or diffusion.

INNOVATION DIFFUSION THEORY

Rogers' theory of Innovation Diffusion (1962; 1995) provides an initial framework through which examination of the diffusion of an innovation can be examined. Rogers (1995) defines the diffusion of innovations as the process by which knowledge of an innovation is transmitted through communication channels, over time, among the members of a social system. Rogers (2003) outlined the innovation process as consisting of a sequence of five stages including:

- agenda-setting: a broad organisational problem is identified which generates a search for innovations.
- matching: the problem from the organisation's agenda is conceptually matched with the innovation to determine how well they align.
- redefining: the innovation is adapted based on the organisation's needs and structure
- clarifying: the innovation has been spread more widely in an organisation involving individuals seeking answers to reduce uncertainty
- routinising: the innovation has become synonymous with the regular activities of an organisation, which completes the innovation process.

The identification of the stages in the innovation process has been useful for understanding how to effectively introduce new ideas in organisations because through this we are able to gain insights into the main sequence of decisions, activities and events in the process. Within this framework diffusion is largely measured through the degree of adoption within a system. Adopters are categorised by Rogers' as innovators, early adopters, early majority or laggards. Further to this there are two key phases in relation to the diffusion of an innovation: First is the creation of the innovation and that process by the 'innovators' and second the adoption by others in the industry and the process of diffusion of the innovation. The adopter categorisation by Rogers is particularly applicable to the second phase of the innovation diffusion process whereby adopters can largely be grouped into one of the four categories of innovators. This simplistic classification by Rogers, however, places all participants involved with the creation of an innovation into the broad "innovator" group which does not capture the specific characteristics of the different participants within this group and the process undertaken to create the innovation.

Some past work in diffusion has been conducted in relation to the construction industry and it is important to briefly discuss these. London et al (2007) and Walker et al (2005) explored e-business and information technology adoption in the Australian construction sector using concepts from Roger's innovation diffusion theory. Specifically London et al (2007) explored late adopters and laggards of technology whilst Walker et al (2005) explored early adopters of technology in the construction industry. Manley and McFallan (2006; 2008) conducted research on high vs low innovators in the construction industry with a focus on the commercial building and civil engineering sectors which excluded the residential sector. Their particular contribution was an identification of the business strategies used for effective implementation of innovations within organisations. This piece of work however did not explicitly map the process pathway for innovation creation, development, adaptation and diffusion by an innovator group. The study investigated how new ideas were introduced successfully within organisations rather than innovation creation and development across organisations. The actual process undertaken by an innovator group in the creation of innovations has received little attention in the construction research community. The present research extends the work of past research by addressing two research gaps. Firstly the unit of analysis explored in this study is the *process* undertaken by the innovator group to deliver an innovation to the housing construction industry. Secondly this research examines the first phase of the innovation diffusion process which is the creation of the innovation and that process undertaken by the 'innovators'. The innovator group is differentiated from the other adopter groups in that participants are actively engaged in the creation and development of the innovation. Innovator group participants are not simply adopting an innovation which has already been designed, tested, evaluated and implemented. The "innovator group" explored in this study include those players who were engaged with the creation, development and adaptation of the waffle footing system innovation.

METHODOLOGY

The empirical study was organized in three phases: exploratory description of case study, critique of process, and development of integrated supply chain methodology. A total of seven organisations were involved in this study with one interview conducted per organisation with the exception of the engineering firm, C5. Two interviews were conducted with C5. Eight in-depth interviews were conducted for this study. Table 1 (refer to appendix) presents details relating to the interview participants. The duration of the interviews was between 60-180 minutes. The participants were asked questions relating to four key areas; their role in their organisation and their role in relation to the waffle footing innovation, key events in the innovation process, barriers and enablers which hindered or drove the innovation process and key players in the process. The narrative inquiry approach was used in this study. Narrative inquiry is well suited to uncover stories to highlight the organisational, communication and economic factors impacting on the creation, development and adaptation of the innovation. The key actions and events which influenced decisions made were systematically identified to connect and map the consequences of those events over time against the creation, development and adaptation of the innovation (Riessman, 1993). The specific technique of story analysis was used for data analysis. Story analysis offered a way of connecting different stories from key protagonists to understand the innovation process and in particular changes that took place over time (Bell, 1993). The narrative analysis technique is explained in more detail in the research report (London and Siva, 2012).

The unit of analysis is the cluster of organisations that are involved in the innovation and the collection of stories that describe the various experiences of the participants. The interviews were recorded, transcribed and subjected to four stages of analysis including:

- Description of the stories from each participant in isolation in relation to their experiences during the creation of the innovation process
- Collecting and connecting the stories and then matching to the five stages of the innovation process from all participants
- Description of barriers and enablers to the innovation process
- A description of the pathway for the creation, development, adaptation and diffusion of this particular innovation.

RESULTS

The waffle pod footing system story begins in the early 1980s in Adelaide, South Australia. The state manager of a large national housing developer (C1) was exploring ways to increase revenues through developing efficient on-site materials management. The commonly found clay soil of medium to high reactivity in Adelaide, which undergoes shrinkage and swelling movements present a particular problem for footing systems and as a result, building construction. This soil reactivity has a more significant effect on housing in Adelaide compared to other parts of Australia as a result of the combination of reactive clays and the arid climate (APO, 2011). The problem was the variability between the concrete volume specified in design and concrete volume used in actual site construction. The variability arose because of soil conditions and subcontractor construction skills. The waffle slab had been used in high-rise multi-storey buildings and car parks and so the idea was to translate that system to the residential footing system. The waffle footing system was seen as an economical solution to the problem of differential movements of reactive clay soils by reducing variability in concrete design specification versus onsite construction. It is a system to replace the traditional concrete raft slab. It involves a series of hollowed-out box-like members separated by spacers and positioned together by reinforcing rods and mesh with concrete poured over the hollow members.

The housing developer (C1) and engineering firm (C5) were central in the initial creation of the innovation. A number of other key players also contributed to the creation, development and adaptation of the footing system including a building materials supplier (C3), a footings contractor (C2), a plastic spacer manufacturer (C4), an industry association (C6) and a polystyrene supplier (C7). The footing system originated in South Australia and some 18 months after the first installation in 1985 had spread to the other states of Queensland, New South Wales and Victoria. A number of key events contributed to the credibility and widespread diffusion of the waffle footing system during this time. Figure 1 (refer to appendices) maps the key events into the three phases of creation, development and adaptation. At different times throughout the creation, development and adaptation of the innovation various key players moved in and out of the cluster. Alliances and business ventures were constantly formed and reformed in response to the needs of the specific phase of the innovation process. Furthermore challenges surrounding the formalisation and ownership of intellectual property during the adaptation phase evolved as a very important series of events. The formalisation and ownership of intellectual capital through patents emerged in the story of the waffle footing system as a very important series of events as we proceeded into the data collection phase of the project. Intellectual capital refers to the knowledge base of the group of firms in terms of expertise, skills, experiences and competences in the creation, development and adaptation of the waffle footing system innovation. Firms often have informal intellectual capital – that is ‘this is the way we do things here’, however, with such a commitment to developing a new product and process associated with the waffle system there developed a need to formalise the intellectual capital. The motivation behind formalising the intellectual capital embedded in an innovative product or process is to protect the parties’ stake and thus define ownership of intellectual property. Figure 2 (refer to appendices) provides a summary of the patent disputes and court cases which resulted from various participants seeking to formalise and take ownership of intellectual capital relating to the waffle footing innovation. Confirmation was sought from other data sources in order to verify specific details relating to the patent disputes and court cases. Specifically Federal Court transcripts and Patent Application documents were identified through public databases. Following this a document analysis of the various court transcripts and patent applications was undertaken. The story of the patent disputes highlights that innovative products and the creators of an innovations will require protection of intellectual property. The intellectual property forms an important part of the intellectual capital of an organisation. The lack of protection of intellectual property offered by the existing system of patents in Australia does not appear to be a conducive environment for innovative behaviour. Furthermore there does not seem to be any incentive which rewards innovative behaviour at an industry level. The creation of innovative products rely upon the efforts of a select few organisations.

DISCUSSION

Numerous similarities between the participants' experiences on the waffle footing innovation and the five stages of the innovation process became apparent during the interviews. The first stage of the analysis involved categorising the participants from the seven organisations' stories into the five stages of the innovation process; namely, agenda-setting, matching, redefining, clarifying and routinising. Following this a comparative analysis between the seven organisations in how they experienced the five stages of the innovation process was conducted to ascertain common themes. Nine key themes were identified (refer to Table 2 in appendices). A number of themes arose in relation to enablers which facilitated the creation, development, adaptation and diffusion of the innovation. Enablers tended to be discussed in the form of trust, relationships, credible artefacts, credentials, knowledge and intellectual property which resided in the different firms within the supply chain at different phases of the innovation process (refer to Table 3 in appendices). These various enablers can be grouped into social, cultural and intellectual capital. This paper focused on the significant role of intellectual capital for an innovative housing construction system.

Intellectual capital

The management of intellectual capital for the greater benefit of the innovator group and ultimately the innovation was a critical aspect of the successful implementation of the innovation. Two key themes were identified in relation to the innovator group's management of intellectual capital; identification and integration of knowledge domains and formalisation of intellectual capital. Different skills and capacities attributed to the various players in the innovator group in the form of specific knowledge domains is a dominant reference to intellectual capital on this study. During the initial phase, the knowledge domains of engineering structural design and materials performance, costing, building flow and construction methodology were critical in the creation of the waffle footing innovation. The effective integration of the various knowledge domains in order to create the waffle footing system innovation was critical and C1 played the key coordinating role:

> *"…this is what you have a strategic alliance partners to do. I was just the poor old builder…all I was there for was just to control the building flow…We knew we had to get research-based information to support this development…I realised we had to go through a series of significant changes in getting regulations altered …and I couldn't do that…So we used our engineers for doing this" (State building manager, Housing developer - C1)*

The management of inter-firm supply chain relationships in terms of knowledge domains was central. There was a need to identify the specific processes required to develop the innovation, to identify where the knowledge domains resided and to match players with the appropriate skills and capacity to tasks accordingly. Given the novelty of the system, C1 explained that not only was there a need to acquire "research-based" information to support its development, but it was also important to obtain the necessary regulatory approvals to which C1 relied upon the expertise and competences of C5. It was this clear awareness of the specific requirements for development of the innovation and identification of the knowledge domains of supply chain players and an understanding of how to gain access to that intellectual capital through the use of social capital which facilitated the creation and development of the innovation. It is important to note that although the state building manager refers to himself as "just the poor old builder" there is a significant element of intellectual capital involved in "controlling the building flow'" and also in creating the environment for the innovation to flourish. He explained that his understanding of people management was something he achieved through prior experiences of working internationally in the United Kingdom and South Africa.

C1's accumulation of intellectual capital through experiential knowledge was thus a key contribution to the creation and development of the waffle footing innovation. Specifically he was able to undertake leadership in the development of strategies for accumulating the required resources and then the accumulation of social capital in exchange for other forms of capital, "this is what you have a strategic alliance partners to do". As the innovation became more established and refined the intellectual capital created by and within the innovator group became increasingly apparent through a number of measurable indicators such as patents and publications. A measurable indicator of the intellectual capital of the system was the patents which were granted to a number of key players including the plastic spacer manufacturer, C4 and the engineering firm, C5 for various components associated with the waffle footing system. The history of the waffle footing system was chequered with litigations and patent disputes with participants seeking to own exclusive rights of the innovation's intellectual capital.

> *"So that [litigations] was a major stuff up because people did have the fear that if they used it would they get bitten on the bum later on. And that sort of stymied the whole thing in the early stages and it didn't need that" (Sales representative, Building materials supplier – C3)*
> *"Each one of those patent decisions really led to… the manufacturers hesitated…and then there was another patent dispute and it hesitated" (EPS supplier – C7)*

Achieving formal recognition of the intellectual capital created by the innovation through patenting was seen by the innovator group as something which would help with its commercialisation. The the dynamics of ownership and control over that intellectual capital resulted in a largely adversarial environment, which was felt to be not particularly conducive for the implementation of the innovation.

One of the key barriers raised consistently by all participants except the housing developer, C1 and the industry association, C6 included the complications associated with protection and formalisation of their intellectual capital related to the innovation. This is perhaps something that is unique to the experiences of the innovator group since innovation adopters would not have issues concerning protection of intellectual property given the lack of intellectual investment that they make. As the system began to gain acceptance, the engineering firm, C5, who designed the waffle footing system sought to protect their intellectual property by developing a patent on the system. The process was fraught with difficulty and was considered "a major stuff up" which was characterised by litigation. A key player within the innovator group, C4, who developed a plastic spacer attempted to patent the system to claim it as his own.

> *"And once the system started to move then all this other junk started to develop…the people that had the spacers were saying that the royalties should come to them. And the people who had the waffle pods were saying that the royalties should come to them…it was a major stuff up" (Sales representative, Building materials supplier - C3)*

At the same time, as the waffle footing system was gaining increased widespread uptake in the industry, more and more companies started to re-invent the innovation to market as their own product. C4 and C5 explained how these companies were infringing on their patents. The managing director of the engineering firm, C5 indicated that the manner in which the firm dealt with the infringements was by developing interim arrangements with the companies as a way of making them acknowledge the existence of the patent:

"We had a lot of interim arrangements where we tried to do a deal with someone to bring them onboard so that at least they acknowledged the patent existed even if they half broke it and did whatever they wanted to without paying us royalties…but it helped promote the system…" (Managing director, Engineering firm - C5)

The participants' opinions were mixed in relation to the effects of the infringements and patent disputes on the implementation of the footing system. Even though the managing director from the engineering firm, C5 seemed to think that the infringements helped to promote the waffle footing system, the EPS supplier, C7 and building materials supplier, C3 were of the perception that the disputes hindered the diffusion of the system:

"It was chequered with litigation… in fact the litigation probably harmed the product as such. It slowed its introduction and people's greed got in the way" (Sales representative, EPS supplier - C7)
"people were a little bit loathed to go with the system because they had the fear that they might get involved somehow in the litigations in some shape or form" (Sales representative, Building materials supplier - C3)

According to the building materials supplier, C3 and the EPS supplier, C7, this background chequered with litigation instilled a degree of fear in the minds of those potentially seeking to adopt the innovation. Indeed this may have been the case for the building materials supplier, C3 who did not proceed to renew its licensed distribution agreement with C5 to promote the distribution of the waffle footing system due to its "messy" background. Despite the mixed opinions of participants in terms of the impact that the litigations had on the adoption of the system, the participants were in agreement that they found it difficult to deal with the "language" and system of patents and litigations arising from it:

"you've got to read the lawyer stuff and you've got to read it ten times... So our main trial would've been court cases and infringements and the way patents work …" (Co-owner, plastic spacer manufacturer, C4)
"You're involved in another world…even though you're ignorant of infringing, that's it…We're manufacturers .. suddenly find ourselves sitting with patent lawyers and the clock's running, very expensive" (EPS supplier, C7)

The participants (plastic spacer manufacturer, C4, EPS supplier, C7 and engineering firm, C5) unexpectedly found themselves "in another world" faced with the challenge of dealing with areas beyond their expertise. They were forced to deal issues which seemed foreign to them. One of the key challenges in dealing with issues beyond their legal capacity involved having to employ the services of other professionals and more specifically the high costs associated with the legal fees. While it is unclear whether the patent disputes and litigations may have hindered the successful diffusion of the footing system it does raise another important issue in relation to the protection of intellectual property for those who were central to its creation as highlighted by C5:

"If anything Australia needs to do is change the system of patents because its not fair to someone like me who's started off something that's so popular that gets nothing out of it because of some crook" (Managing director – retired, Engineering firm - C5)

The lack of protection of intellectual property offered by the existing system of patents in Australia does not appear to be a conducive environment for innovative behaviour. There does not seem to be any incentive which rewards innovative behaviour. This is perhaps quite a significant issue which needs to be considered particularly in an industry where the pace of innovation is low.

CONCLUSION

This study has highlighted the importance of human capital in supply chain actor integration in the early start up phase of creating innovations. However it has moved beyond this simplistic rhetoric and has examined in detail the type of human capital and the way in which they are transformed through activities of investment, accumulation and exchange. This paper focussed on the role of intellectual capital for a specific innovation in the Australian housing sector. Intellectual capital was a very important theme arising from this study and identifying key knowledge domains required by the innovator group in creating the innovation was of primary importance. The mapping of the location of the required intellectual capital within those knowledge domains and then the strategizing to develop a cluster of actors whose collective contributions will achieve the design, construction and distribution of the innovation is also an important finding. The gathering together of like-minded actors within the innovator group who share creative instincts and problem solving philosophies as well as a desire that something radically different should and can be achieved in an extremely challenging and confronting sector. The individual capabilities of the core champion driving the innovation is founded in re-strategising and adaptability capabilities when faced with barriers. The importance of this case study is that this was an innovation of national significance. The dissemination of this case study to the housing sector as part of the cultural heritage of the sector is important to demonstrate the challenges of innovation within a largely successful innovation implementation. The public dissemination is also important so that the challenges can be communicated to government regulators on the difficulties within the patent system and that largely small innovative firms are seriously hindered in attempts at protecting their intellectual property in Australia currently and are generally ill equipped to deal with the legal frameworks. It is important though to evaluate the current patent regime as this study was conducted on something that occurred some two decades ago and there may have been substantial changes to the system. This could form part of future research. Regardless of this limitation the detailed analysis has provided clear direction for industry and organisations as they may attempt the creation of an innovative process, product and/or system in terms of greater clarity and more detail on the accepted innovation process in relation to how to manage social, cultural and intellectual capital.

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APPENDICES

Table 1 Summary of Case Studies: Organisation type, position, role and location

Case study	Organisation type	Participants position in organisation at time of innovation	Role in relation to waffle footing system innovation	Size of organisation	Location
C1	Large housing developer	State manager	Supply experimental/ prototype sites Coordinate inter firm supply chain relationships to create and develop the system	>450 employees	Australia-wide
C2	Footings contractor	Managing director	Construct footing system for experimental/ prototype sites	>50	South Australia
C3	Building materials supplier	Sales representative	Manufacture, promote and distribute the system	>2500 employees	Australia-wide and internationally the United States, New Zealand, the Phillippines and Chile
C4	Plastic spacer manufacturer	Managing director Managing director	Manufacture a key component of the system, ie plastic spacer	<10 employees	South Australia
C5	Engineering consultant firm	Managing director Managing director	Provide engineering design for the system Monitor and test experimental sites Obtain approvals/ accreditations for the system	>100 employees	South Australia, Victoria
C6	Polystyrene supplier	Managing Director Sales representative	Distribute the system in Victoria	>1000	Victoria
C7	Industry Association	Regional manager	Promote the system in Queensland	Members represent >80% of the industries' output	Queensland

Table 2: Cross case comparison: key themes in relation to five stages of innovation process

Stages of innovation process		Case studies						
	Key themes	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**
Agenda-setting	Opportunistic surveillance	√	√	√	√	√	√	√
	Performance gap	√				√	√	√

Matching	Establishing fit between problem and innovation	√	√	√	√	√	√	√
Redefining	Changes to organisation/innovation	√	√	√	√	√		√
	Developing alliances to integrate resources	√	√	√	√	√	√	√
Clarifying	Convincing diffusion within organisation		√					
Routinising	Enablers to diffusion across organisations	√	√	√	√	√	√	√
	Barriers to diffusion across organisations		√	√	√	√	√	√
	Adaptations/re-inventions		√	√	√	√		√

Table 3: Enablers for the creation, development and adaptation of the waffle footing system innovation: Social, cultural and intellectual capital

Enablers							
Social capital	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**
Mutual understanding and trust based on business motivation	√	√			√		
Development of alliances/relationships to access required resources	√		√		√	√	√
Cultural capital	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**
Acquisition of recognisable artefacts in developing reputation	√				√	√	√
Accessing credentials and authority through association	√				√	√	√
Intellectual capital	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**
Identification and integration of knowledge domains	√	√		√	√	√	√
Intellectual property	√	√		√	√	√	√

Figure 1: Chronological history of the waffle footing system innovation

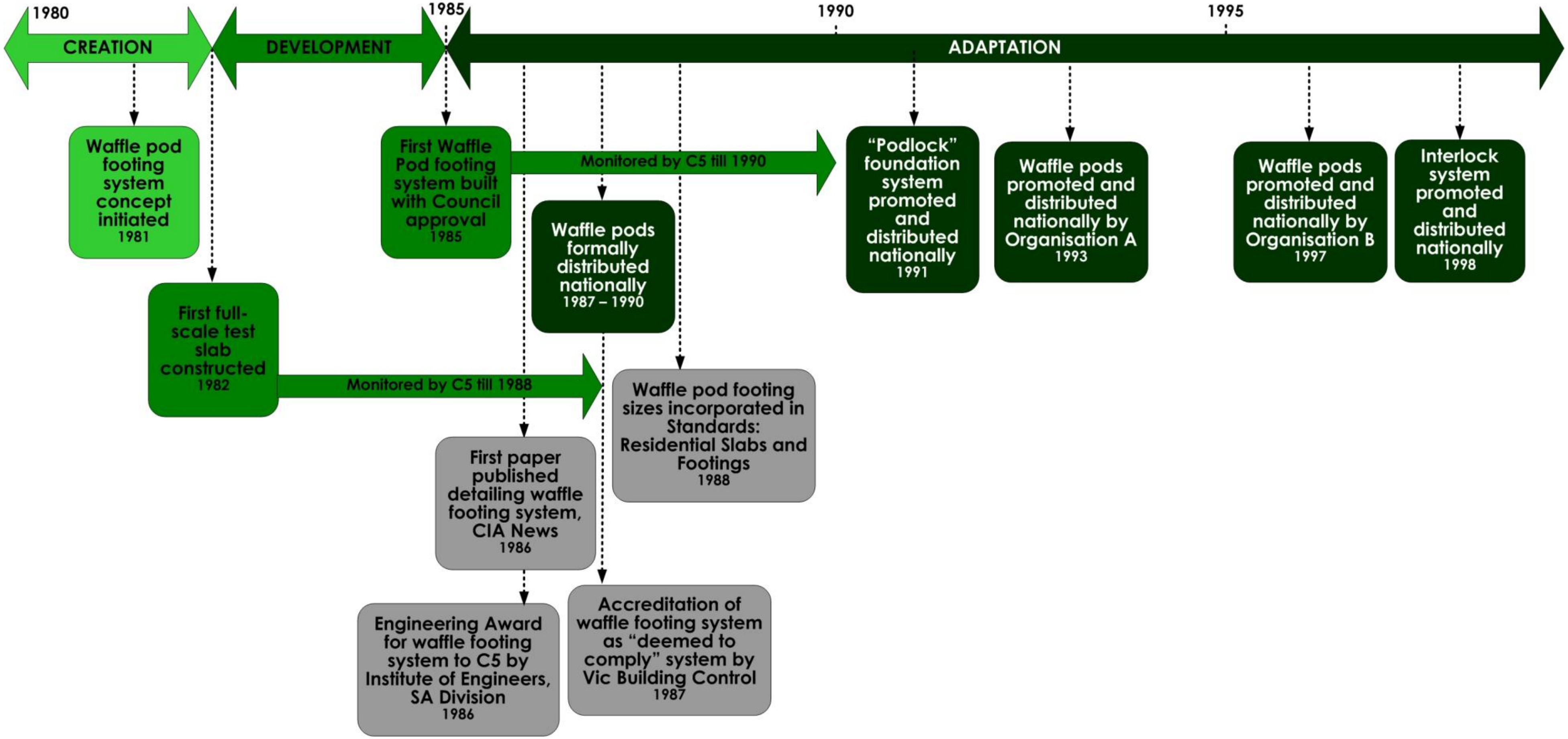
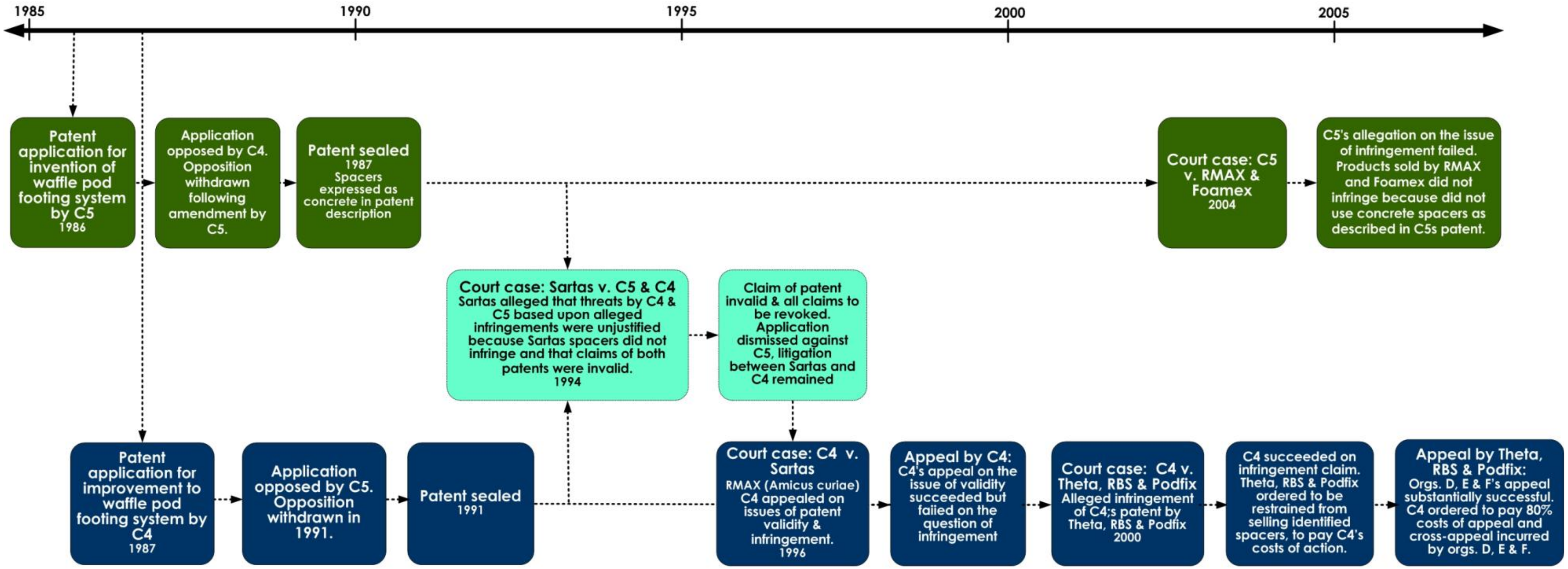


Figure 2 Challenges in formalisation of innovation intellectual capital: patent disputes and court cases



LEGEND

- Patent disputes related to the engineering firm, C5
- Patent disputes related to the plastic spacer manufacturer, C4
- Patent disputes related to both the engineering firm, C5 and the plastic spacer manufacturer, C4

ORGANISATIONS

C4:	Plastic spacer manufacturer
C5:	Engineering firm
Sartas:	Manufacturer & Distributor of plastic spacers
RMAX:	Large manufacturer of expanded polystyrene (EPS) and supplier of EPS to waffle pod manufacturers
Foamex:	Large manufacturer & supplier of EPS products including waffle pods
Theta:	Manufacturer & Distributor of plastic spacers
RBS:	Manufacturer & Distributor of plastic spacers
Podfix:	Manufacturer & Distributor of plastic spacers