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Implementation of innovation by manufacturers subcontracting to construction projects

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Abstract
Purpose
To explore the role played by manufacturers of patented products on construction projects.

Methodology
Four projects are reviewed to investigate the research question “How can manufacturers ensure the successful implementation of their product innovations on construction projects?”

Findings
Using a framework comprising six key innovation determinants, case-study analysis demonstrates the critical role played by relationships and knowledge-flows in creating conditions that support project-based innovation by manufacturers. Such conditions comprise:

1. advanced procurement systems,
2. robust internal firm competencies,
3. performance-based regulations,
4. effective technical support providers, and
5. project-imbedded manufacturers.

Research Limitations
The study was designed to meet industry needs and hence does not emphasise theoretical aspects.

Practical Implications
Manufacturers can improve the diffusion of their product innovations on construction projects by using relationship networks to promote the above conditions, or to locate contexts where such conditions prevail, or to leverage those conditions that are most favourable.

Originality
The paper addresses four gaps in the construction management literature (1) there is very little literature on the role of manufacturers in innovation on construction projects (2) the literature on subcontractors tends to assume easily substitutable supplies (3) there is a focus in the literature on large projects, and (4) the literature is dominated by quantitative studies. By undertaking a qualitative analysis of manufacturers of patented products subcontracting to small projects, this paper addresses the above shortcomings.

Keywords: innovation, manufacturers, subcontractors, Australia, construction projects, patents
Introduction
Manufacturers are recognized as key drivers of technical innovation in the construction industry. They invest far more in research and development (R&D) than contractors or consultants, and are subsequently more likely to develop product and process innovations (Gann, 1997 p.9). The effectiveness of their innovations, the ease with which they can be implemented, and the timeframes for adoption are influenced by the strength of their relationships with project participants and end users, and associated knowledge-flows (Gann, 2000; Larsson et al., 2006). Unfortunately, manufacturers supplying the construction industry often have poor relationships with project participants and end users, in part because manufacturing firms have not traditionally had a direct relationship with work on construction sites (Gann and Salter, 1997; Larsson et al., 2006). Construction demand for manufacturers’ products has been generated by them providing information primarily to consultants and specifiers, with manufacturers having few direct linkages to contractors and site work, resulting in constructability problems. This dynamic has constrained the contribution manufacturers make to construction projects. Indeed, Larson et al. (2006, p. 561) conclude that building component manufacturers, compared to other manufacturers, have relatively “[l]ow product development capacity [that] appears to be related to their low level of communication with actors in the building process”.

However, there is an emerging trend for manufacturers to be directly engaged in site work, providing the opportunity for closer relationships with project participants. The factors underlying this trend include the increasing complexity of: products offered by manufacturers, the required transformation of products on site, the required integration of products with other components, client demands for ‘total package’ solutions, and contractor requirements driven by quality assurance concerns (Gann and Salter 1998; 2000; Manley and Marceau 2002; Gibb and Isack 2003).

The four case studies presented in this paper exemplify this trend. They show how relationships, knowledge-flows and other innovation determinants associated with manufacturers subcontracting to construction projects influence the implementation of patented innovations. The paper uses descriptive methods to analyse this phenomenon and address the research question “How can manufacturers ensure the successful implementation of their product innovations on construction projects?”

The investigation of this research question addresses a number of significant gaps in the literature. Firstly, there is very little literature in the construction or management fields dealing with the role of manufacturers in promoting or implementing innovation on construction projects. As Larsson notes ‘suppliers of material components and processing equipment to building projects comprise one of the most neglected categories in research into innovation in the construction sectors’ (2006, p. 553). The work of David Gann and Ammon Salter is a key exception (Gann, 1997; Gann and Salter, 1998; Gann, 2000; Gann and Salter, 2000). Yet, more attention is needed, as the relationships between designers, contractors and suppliers need better explanation (Gann, 2000, p. 210). The qualitative study presented here responds to this need.

Secondly, literature on the role of subcontractors on projects is scant and assumes that subcontractors provide highly substitutable supplies/services. This tends to limit the focus to lowest cost subcontractor selection and exploitation (Hinze, 1994; Albino, 1997; Kumaraswamy, 2000; Dainty et al., 2001). The case studies reviewed here show evidence of another category of subcontractor: those that provide unique products and employ inimitable tacit knowledge. This type of construction industry participant has received even less attention than subcontractors in general, and the current paper redresses this situation.

Thirdly, there is an emphasis in the literature on very large construction projects, but as Hillebrandt (2006) suggests, “it is time attention was directed to the rest of the industry”. This paper does that, studying the dynamics of small projects.

Finally, there is typically an emphasis on quantitative studies in the literature. In adopting a case-study approach, this paper is a response to those like Winch (1998) who call for more fine-grained analysis of innovation processes in the construction industry. The qualitative
methods adopted here provide rich, detailed findings that complement the broad view provided by quantitative methods, such as statistical manipulation of innovation survey data (e.g. Reichstein et al., 2005).

**Methods**

Between 2003 and 2005, the BRITE Project of the Australian Cooperative Research Centre for Construction Innovation undertook 12 in-depth innovation case studies of building and road projects. The stakeholders involved in this research included over 100 businesses, 14 government organisations, eight industry associations and four universities. The purpose of the case studies was to demonstrate the benefits of innovation and highlight the nature of successful implementation strategies. The cases were nominated to the program through referrals from clients and through a public call for nominations. Approximately 100 cases were considered, all involving innovation on a construction project. The final 12 were selected on the basis that they best met the required criteria, in that they:

- demonstrated significant measured benefits from innovation, or the clear potential to assess such benefits
- highlighted a range of innovation challenges
- involved stakeholders who were willing to cooperate in the study
- described innovations of interest to the industry
- provided examples from different Australian states
- illustrated innovations across a spectrum of projects, including road, bridge and non-residential building projects
- exemplified a range of project sizes

The 12 projects were located in the most populous Australia states: New South Wales, Victoria, Queensland, Western Australia and South Australia. They ranged in value from AUS$13,000 to $280 million, and ranged in size from very small to very large. All showed evidence of measured benefits which arose from project-based innovation which overcame significant challenges.

The current paper is based on a subset of four of the 12 case studies, comprising the projects where the innovation documented was driven by manufacturers subcontracting to the projects. The unit of analysis is the construction project, with the focus on interactions between the parties involved, and between them and the broader economic environment. By coincidence, the four projects were all small in size, and the four manufacturers were all small- or medium-sized enterprises (SMEs).

The four case studies each involved interviews with three to seven different organisations involved in the project. This included the key project participants, comprising head contractors, subcontractors, consultants, clients and suppliers. Of the 18 interviews, 12 were in-person and six by telephone. The four manufacturers were all interviewed in-person. Each of the 18 interviews lasted approximately 90 minutes. They were semi-structured around topics covered by the conceptual framework adopted in this paper. The interviews were recorded electronically, with the consent of the interviewee, and later transcribed. The transcriptions of the four selected studies form the primary data set for the current paper.

**The value of case studies**

Although the value of qualitative studies is increasingly being recognised in the traditionally conservative field of construction management research, it is useful to briefly review the benefits of this method for the current study. Yin (2003) emphasises that case studies provide considerable insight in fields where there has been little previous research, as is the case here. The generalisability of these studies is maximised by narrowly defining the research population to improve the robustness of results. The population here comprises only manufacturers subcontracting to small Australian road and commercial building projects to implement patented innovations.

The optimal number of case studies to form robust conclusions is between four and 10, as this range is best suited to effective cross-case comparison (Eisenhardt, 1989). Generalisability is poor with fewer than four case studies, while more than 10 can create
problems because of the high volume of descriptive data to be coded and sorted. The number
of case studies conducted for the current research therefore represents the lower limit of the
recommended number.

**Content analysis**
Content analysis of the interview transcripts was conducted to identify themes common to the
ways in which manufacturers successfully implemented product innovation on construction
projects, ordered around the six factors identified in the conceptual framework at Figure i.
Content analysis is a popular methodology in the social sciences, involving the objective and
systematic review of communication content (Krippendorff, 2004). In this case, the case study
method enabled pattern matching of interview text across the four projects.

Because the research focus was relatively narrow and involved only a few case studies, there
was no advantage in using software for cognitive mapping (e.g., Decision Explorer) or pattern
recognition (e.g., QSR N6 - Nud.ist). The manual technique of text analysis offered greater
capacity to identify connections between innovation determinants, providing an observational
advantage that would have been sacrificed with computational analysis.

**Validity**
Multiple sources of evidence, in the form of the four case studies, were used to increase the
validity of findings, compared to a single case study approach. Further, the interviews were
conducted by the three senior researchers who were responsible for interpreting the results.
This helped to maintain the integrity of the analysis, as did reviewing the transcript of each
interview within a week of the interview being conducted.

The findings resulted from triangulation across four case studies, five stakeholder types
(clients, head contractors, subcontractors, consultants and suppliers), and four data types
(interviews, feedback, researcher observations and secondary data). The feedback process
involved the approval by all interviewees of the case study story generated by the
researchers. The secondary data included award submissions, magazine articles, internal
firm reports and workshop presentations. The validity of the conceptual framework is
supported in a wide range of international research articles on the topic of innovation
determinants, published between 1997 and 2004, and summarised in Blayse and Manley
(2004).

**Reliability**
The replication of research results based on a case study methodology can be compromised
by researcher subjectivity. Yin (2003) suggests that a formal protocol can be employed to
minimise this risk. For the current research, such a protocol included a conceptual model
(Figure i), field notes, speedy analysis of interview transcripts to aid recollection, and
triangulation across cases, data types and participant types. The clear specification of these
parameters is expected to aid replication in the future.

**Conceptual Background**
The research question, “How can manufacturers ensure the successful implementation of
their product innovations on construction projects?”, was analysed according to six innovation
determinants, derived from a large-scale review of the international literature on construction
innovation (Blayse and Manley, 2004), and shown in Figure i. These six determinants
encapsulate the key drivers and obstacles associated with project-based innovation. They
differ from those identified in mainstream economic, innovation and management literatures,
where the focus is firm-level innovation. Such literature tends to concentrate on the
manufacturing industry, and mass-produced goods distributed via arms-length market
transactions. In contrast, production in the construction industry is organised around
temporary coalitions of firms on unique projects. In this environment, the constellation and
quality of relationships within business networks are significantly more important to innovation
outcomes.
The four case studies reviewed here focus on the manufacturer’s role in the project environment. How do manufacturers work with the above influences to successfully implement their product innovations? The above framework helps guide this discussion. The key points associated with each innovation determinant are summarised below.

(1) Relationships and knowledge-flows
In the face of client dissatisfaction with project outcomes in many developed countries, such as the UK and Australia, various government-sponsored inquiries have been held, particularly since the early 1990s (Gyles, 1992; Latham, 1994; Egan, 1998; Fairclough, 2002; Cole, 2003). These have all focused on the quality of relationships and knowledge-flows, recognising their importance for performance. This focus is mirrored in the literature on construction management in key journals, such as Construction Management and Economics; Engineering, Construction and Architectural Management; and Journal of Construction Engineering and Management.

Relationships and knowledge-flows are important for innovation at all levels of economic activity, including internationally, nationally, inter-sectorally, sectorally, inter-firm, intra-firm, inter-project and intra-project. An inter-firm study by Drejer and Vinding (2006) provides a recent construction industry example of typical findings across these levels. Their work showed that firms using partnering and knowledge anchoring are more likely to be innovative than firms without such strategies. The discussion below of other innovation determinants highlights the ways in which relationships and knowledge-flows drive innovation success.

(2) Procurement systems
The importance of good relationships and robust knowledge-flows is highlighted in academic and practitioner discourse about ways to improve project procurement systems. For instance, emerging delivery approaches such as Project Alliances (Walker et al., 2002), Project Partnering (Larson et al., 1997; Chan, 2004) and ECI (Early Contractor Involvement) (Carillion, 2007; Queensland Department of Main Roads, 2007), all aim to improve relationships between clients, consultants and contractors, and make knowledge diffusion more efficient. An effective procurement system is increasingly seen as one that enhances relational quality and knowledge distribution. This has led to a shift toward contracts providing best value-for-money, away from those based on lowest cost, which are associated with adversarial relationships, cost overruns and delays (Egan, 1998; Wong et al., 2000).

(3) Competency of project actors
The notion of competency in the construction industry has derived from concerns about poor quality, business failures and skills shortages (Kangari, 1988; Gann and Senker, 1999 Langford et al., 2000; MacKenzie et al., 2000; Tam et al., 2000). Although these are all valid and enduring issues, an emerging dimension to the competency issue is the extent to which project actors have sufficient internal resources to reliably assess innovation ideas proposed by other actors (Gann, 2001). Known in the general business management literature as...
absorption capacity (Cohen and Levinthal, 1990), this competency influences the adoption rate of innovation and, ultimately, project outcomes.

(4) Regulatory conditions
The link between regulatory conditions and innovation outcomes was a key driver of the introduction of performance-based regulations during the 1990s in many OECD countries, such as the UK, US and Australia (Crew and Kleindorfer, 1996; Gann et al., 1998; Meacham et al., 2005). Performance-based regulations provide greater flexibility over prescriptive regulations by defining the ultimate performance that the regulating authority requires, rather than prescribing how that level of performance is to be achieved. This flexibility allows firms to experiment with different methods, potentially leading to more efficient or effective approaches (Gann et al., 1998).

(5) Technical support providers
The term ‘technical support providers’ refers to research institutes, universities, testing centres, government agencies, industry associations, and similar providers of support for development of a firm’s technical resources. Although the general business management literature has long emphasised the importance of links between firms and technical support providers (Bania et al., 1993; Schartinger et al., 2002), it is only recently, with Gann and Salters’ work, (Gann and Salter, 1998; Gann and Salter, 2000; Gann, 2001) that such links have been placed at the centre of discourse about performance improvement in the construction industry. Recognition of the importance of links between firms and technical support providers to innovation outcomes and, indeed, the economic performance of nations, has given rise to many government-backed programs aimed at fostering closer relationships. In the construction context, such programs have included Constructing Excellence in the UK, NRC Institute for Research in Construction (NRC-IRC) in Canada and the CRC for Construction Innovation in Australia.

(6) Manufacturers
Gann and Salter (Gann, 1997; Gann and Salter, 1998; Gann and Salter, 2000) explore the importance of manufacturers as a key supply-side determinant of project innovation in the construction industry. Gann (2000, p. 209) suggests that manufacturers can offer maximum value by having close relationships with both site workers and end users. Such relationships are currently improving through greater involvement of manufacturers on construction sites, due to the increasing complexity of the:

- products offered by manufacturers,
- required transformation of products on site,
- required integration of products with other components,
- client’s requirement for ‘total package’ solutions, and
- quality assurance concerns of contractors

(Gann and Salter, 1998; Gann and Salter, 2000; Manley and Marceau, 2002; Gibb and Isack 2003).

The four case studies
Figure ii shows the key features of the projects that are the focus of the four case studies used to examine how manufacturers can ensure the successful implementation of their product innovations on construction projects. Each case study involves:

- an Australian construction project with a small budget,
- innovation promoted by a small- or medium-sized advanced subcontractor who is also a manufacturer of a patented product, and
- problem-driven upgrade of a constructed facility, either a building, road or bridge.
Figure ii  Key Project Data

<table>
<thead>
<tr>
<th></th>
<th>Project A</th>
<th>Project B</th>
<th>Project C</th>
<th>Project D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of constructed facility</td>
<td>Small twin-lane bridge</td>
<td>Small single-storey commercial building</td>
<td>Large regional art gallery</td>
<td>Small access road for a regional facility</td>
</tr>
<tr>
<td>Project description</td>
<td>Repair of 12 metre length of 90 metre timber bridge deck</td>
<td>Stormwater management at a small community building</td>
<td>Improved air-conditioning at a large art gallery</td>
<td>Improved 16 km road through saturated ground</td>
</tr>
<tr>
<td>Budget</td>
<td>AUS $1m</td>
<td>AUS $13,000</td>
<td>AUS $100,000</td>
<td>AUS $4m</td>
</tr>
<tr>
<td>Completed</td>
<td>2003</td>
<td>2002</td>
<td>2004</td>
<td>2004</td>
</tr>
<tr>
<td>Innovation summary</td>
<td>Fibre-reinforced polymer (FRP) bridge deck</td>
<td>Managing stormwater with roof storage gutters and infiltration</td>
<td>Twin-coil air-conditioning to improve energy efficiency</td>
<td>A permeable road pavement meeting strict environment requirements</td>
</tr>
<tr>
<td>Core competency of manufacturer</td>
<td>Firm holds patents for composite bridge design using both concrete and composite fibre</td>
<td>Firm holds patents for collecting and storing water in a container at the drip line of roofs</td>
<td>Firm holds patents for twin-coil series pipe circuiting</td>
<td>Firm holds patents for tyre-reinforced permeable pavements</td>
</tr>
<tr>
<td>Size of manufacturer (full-time employees)</td>
<td>750</td>
<td>5</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Age of manufacturer (years)</td>
<td>18</td>
<td>10</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Main benefits achieved compared to business-as-usual</td>
<td>90% saved in traffic control costs</td>
<td>26% saved in mains water demand</td>
<td>30% saved in energy consumption</td>
<td>15% saved in total project costs</td>
</tr>
</tbody>
</table>

The project budgets ranged from AUS$13,000 to $4m, the manufacturers employed from five to 750 staff, and the firms had existed for six to 18 years at the time of the study. Hence, all the projects can be considered small and all the manufacturers can be considered established SMEs.

Discussion and Analysis
This section examines the dynamics surrounding the successful implementation of patented product innovation by manufacturers subcontracting to construction projects. The discussion is ordered around the six innovation determinants described earlier and the four case study projects. The case studies confirm the importance of the identified determinants and provide the opportunity to analyse in detail how they impact innovation implementation by manufacturers on construction projects.

Relationships, knowledge-flows and procurement systems
In all the projects examined, the manufacturers had developed relationships with the project clients over several months or years before the scope of the project was finalised. In all cases, the manufacturer was engaged via a preferred-supplier arrangement or value-driven tender selection, rather than via a lump-sum contract awarded by open tender. In all cases, the project specification was designed by the client around the performance standards of the manufacturer’s product. The relationship-building activities of the manufacturers had facilitated knowledge diffusion that engendered informed clients who were then willing to
specifically design procurement systems which enabled them to use the manufacturers’ unique products.

The generally high quality of relationships between the main project participants – manufacturers, clients, consultants and head contractors – probably had as much to do with pre-project interactions as with the use of non-traditional contracts. The relationships between manufacturers and project clients were developed during the R&D phases underpinning the patented technologies, to assist in designing the product to meet client needs.

In their role as subcontractors, the manufacturers’ primary relationship was with the project client, with the head contractor being of secondary importance. This interesting finding highlights the very different role that advanced, high value-adding subcontractors play, compared to subcontractors that offer relatively homogeneous products or services. For example, Project A was underpinned by five years of collaborative research between universities, government client agencies and the manufacturer. During this period, the two client agencies developed performance specifications for the manufacturer’s product that met the clients’ requirements. This was an effective commercialisation path for the innovator, avoiding many of the frustrations typically encountered by product innovators seeking to commercialise their technologies.

The Australian federal system of government often makes it hard for innovators in the construction industry to identify an appropriate path to commercialisation. It may be difficult to match their products to existing codes, difficult to determine the best approvals approach, and time-consuming to gain approval because of clashes and duplications caused by differing state standards. These problems were avoided by the manufacturer on Project A because of their very close relationship with key client agencies that have the authority to set their own standards.

The potential problem for manufacturers of poor access to site participants was avoided in Projects A to D by the manufacturers maintaining both R&D and operations divisions. The operations divisions provided installation services for the products, sharing tacit knowledge with site participants to optimise effectiveness. This also meant that the manufacturer had access to strong feedback loops to inform on-going R&D efforts.

The above observations highlight the extent to which effective relationship networks and communication strategies support the commercialisation efforts of manufacturers. It is also clear that ongoing relationships between project participants and clients can influence the type of procurement system used by project clients.

**Competency of project actors**
The capacity of Projects A to D to absorb the manufacturers’ innovations was bounded by the competency of key project actors; in these cases, the clients and head contractors. Although the competency of consultants is of doubtless importance to project outcomes, the case studies did not highlight a role for them in relation to the manufacturers’ innovations, possibly because the cases concerned problem-driven upgrades, rather than greenfield projects.

As discussed above, the manufacturers’ primary relationships were with the project clients, who were all public sector organisations with experience in commissioning work. These clients could be considered ‘innovation competent’ as they:

1. undertook internal R&D,
2. networked with specialist experts,
3. offered value-driven tender selection,
4. encouraged alternative tenders,
5. designed new forms of contract,
6. participated in technology demonstration programs,
7. prioritised relationship management on projects,
8. maintained knowledge bases that contributed to informed assessment of innovation ideas proposed to them,
9. had considerable experience in commissioning work,
10. had sufficient internal technical staff to accurately judge the value of new ideas, and
11. had good internal communication systems so that relationships with the manufacturers were well managed.

This set of competency criteria expands that provided earlier by Manley (2006). The innovation competence of the clients across these 11 areas meant that they were open to the ideas put forward by the manufacturers.

The role played by head contractors varied across the four projects. In Project A, the innovation competency of the builder was very high, because the manufacturer and the builder were two divisions within the one company. However, in Project B, the manufacturer needed to keep a close eye on the builder to ensure effective integration of their product. This manufacturer had found that builders were generally resistant to the change required by their technology. In order to reduce the cultural resistance of builders to its roof water-storage gutters, the manufacturer is now working with post-secondary trade schools to update curricula, a proactive means of improving the competency of builders to work with this particular technology.

On Project C, the head contractor played a more marginal role, as the manufacturer’s site operations were orchestrated directly by the client’s Energy Stakeholder Committee. In contrast, Project D was undertaken in a small regional community, where the head contractor, manufacturer and client had all worked together before, and had strong respect for each others’ competencies. Respect for the manufacturer allayed the client’s concerns about the risks involved in trying something new, and engendered head contractor support for the manufacturer’s ambitions to implement its technology.

The case studies show that competent clients and head contractors possess considerable absorption capacity, which increases their propensity to adopt ideas proposed by innovators. This capacity is moulded by a number of factors, including prior project experience, involvement in R&D, willingness to experiment with procurement systems, and dedication to robust supply-chain relationships.

Regulatory conditions
On Projects B and C, close relationships between the manufacturers and clients were driven by Australian government environmental regulations. The clients called for expressions of interest to help them meet Australian government mandates for resource use: on Project B to reduce water consumption, and on Project C to reduce energy consumption.

With much of Australia in drought, there are strong incentives to save water. For instance, at the time of writing, land developers in New South Wales are facing a 40% water reduction standard, and all new houses in South Australia must have 1000 litres of rainwater storage connected to a toilet cistern. Both regulations encouraged the development of water storage gutters on Project B.

Further, to reduce energy consumption, some state governments require their agencies to lease only those buildings with a five-star energy rating from the Australian Greenhouse Office, and under the South Australian Energy Efficiency Action Plan, energy consumption in government-owned buildings must be reduced. In addition, the Australian Building Code sets nationally uniform standards of minimum energy performance. These regulations assisted the development of a more efficient air conditioning system on Project C.

Various environmental rating schemes provide significant incentives for Australian construction firms to meet and exceed best practice. The profile of the schemes is high and the impact on reputations is significant. The four case studies exemplify in particular the influence of the high profile threat of significant and imminent climate change on R&D and innovation. Projects B and C both involved the clients assisting manufacturers to win government grants to develop their technologies. Both can be considered demonstration projects, undertaken by public sector clients to encourage greater private sector adoption of environmentally friendly technologies.
Non-environmental regulations are also influential. For example, Project A involved installation of a fibre-reinforced polymer (FRP) bridge deck, which is lighter than conventional bridge decks. Its adoption was partly driven by regulations concerning the load capacity of bridges.

Regulations clearly have a big impact on the innovation opportunities of manufacturers. The examples cited above can all be considered solutions developed in response to performance-based regulations that give firms considerable flexibility in meeting established standards. This flexibility created room for creativity, novelty, experimentation and efficiency-improving outcomes in the projects examined.

Technical support providers
The manufacturers associated with the projects had received considerable assistance from technical support providers. Universities and government agencies provided ideas, expert referrals, testing facilities, and external validation of claims about the new products. Government agencies also provided patent systems to protect intellectual property, tax concessions for R&D expenditure, and grants and mentors to assist in commercialisation. Industry associations ran award programs that recognised technical excellence and gave manufacturers reputational credit for their innovations.

The Project A manufacturer had worked for over five years with the university sector, investing millions of Australian dollars per year in R&D projects. The manufacturer first learned of the potential of fibre composite technology when a local university placed a graduate engineer with them. This was the start of a long-term collaboration with the university. Development of the technology was facilitated by the Australian Government’s R&D tax concession and Ausindustry grant program. Broader acceptance of the technology was encouraged by an award from the Institution of Engineers in 2002.

The Project B manufacturer had built relationships with two Australian universities with expertise in water conservation, to develop the firm’s water storage gutters for the roof line of houses. The universities also played an important role in confirming product performance claims, and validating the theory underlying design of the gutter system.

Leading up to the commissioning of Project C, a university had provided the manufacturer with resources to research and trial various versions of the manufacturer’s airconditioning technology. Market interest in the technology was enhanced by the manufacturer winning an award from the National Electrical and Communications Association in 2002.

Finally, the Project D manufacturer had used the government’s R&D tax concession to offset the cost of collaborative research with two local universities.

Each of the project manufacturers had also sought the protection of the patent system for their intellectual property. Nevertheless, the three smallest manufacturers were each concerned that they did not have sufficient resources to protect their patents. Two of them were developing strategies to establish joint ventures with larger firms to help them protect, develop and market their technologies.

Technical support for the research, development and commercialisation activities of the manufacturers appeared to have greatly accelerated diffusion of their technologies. It was also apparent that strong relationships between the manufacturers and providers of technical support, particularly government agencies, universities and industry associations, helped the manufacturers streamline offerings and develop complementary expertise, which ultimately assisted in maximising the return on investments made by technical support providers.

Manufacturers
As noted earlier, the literature emphasises that the contribution of manufacturers can be constrained by poor relationships between them and other participants in the building process. All the manufacturers in the projects reviewed here had very good relationships with their clients, and two had strong relationships with head contractors. Two of the manufacturers also had good relationships with material suppliers that helped ensure
continuity of supply, minimised costs and maximised quality. All the projects demonstrated the benefits of relationships engendered both during R&D phases, and on site when the manufacturers were engaged as subcontractors to install their products.

However, there was no evidence of direct relationships between the manufacturers and end-users. This is a problem because end-user needs may not be accurately represented by the projects’ clients. For example, on Project B the water storage gutter design did not take account of peak load on toilet cisterns at the conclusion of meetings. If the manufacturer had had a relationship with the manager who ran the facility, rectification costs could have been avoided. Lack of end-user consultation is a continuing problem in the construction industry, despite increasing acknowledgement of its costs (Larsson et al., 2006, p. 561).

The presence of the four manufacturers on construction projects was motivated by the requirement for complex transformation of the technologies on site. In addition, as the technologies were new, having only been implemented on a few occasions, the need for tacit knowledge during installation was high. This was particularly so because the products had to be integrated with other components.

The relationships maintained by the manufacturers were clearly underpinned by their presence on site, which in turn was underpinned by their ownership of proprietary products. That these products were new, complex, and needing to be integrated within bigger systems all reinforced the reliance of the project team on tacit knowledge held by the manufacturer.

Conclusions
The dynamics analysed in this paper demonstrate the critical role played by relationships and knowledge-flows in creating conditions that support project-based innovation by manufacturers. Such conditions comprise:

1. advanced procurement systems,
2. robust internal firm competencies,
3. performance-based regulations,
4. effective technical support providers, and
5. project-imbedded manufacturers.

Manufacturers can improve the diffusion of their product innovations on construction projects by using relationship networks to promote the above conditions, or to locate contexts where such conditions prevail, or to leverage those conditions that are most favourable. The manufacturers reviewed in the present study were highly sophisticated users of relationship strategies aimed at engendering the above conditions. Trust and respect between the manufacturers and project clients had developed over months or years prior to scoping of the projects, enabling the manufactures to negotiate favourable procurement systems, enhance client knowledge of their product innovations, and imbed themselves within the project.

In addressing the research question “How can manufacturers ensure the successful implementation of their product innovations on construction projects?” this paper has shed light on emerging trends, such as the move to manufacturers having a more direct and comprehensive presence on construction sites. A number of shortcomings in the literature have also been addressed, principally the lack of information about manufacturers supplying the construction industry. The paper also identifies and describes a category of subcontractors poorly recognised in the literature – subcontractors with unique products – that should be distinguished from subcontractors with substitutable products. Further, the paper shifts the focus away from ‘the big end of town’, towards the dynamics on small projects, where a single participant has far greater scope to influence outcomes by developing strategic relationships. The qualitative approach of case studies as used here has fostered a richness of analysis lacking in quantitative approaches, while at the same time creating the basis for further quantitative studies that can add value through statistical rigour.

This research gives rise to a number of interesting topics for further research. For instance, how is communication between a manufacturer, as a product-oriented company, and clients and head contractors, as project-oriented companies, influenced by their different modes of
operation? This paper has also left unexplored the role of manufacturers in reducing the need for site-based staff by prefabricating off-site. A new research study by the author will be investigating the extent of this trend and its impact on skills shortages. There is also more to be understood about the role of tacit knowledge in framing the innovation possibilities of manufacturers supplying construction projects. Finally, further research is required to investigate more fully the impact of interactions between the six determinants of project-based innovation identified here.

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References


