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Paper Title	Innovation Rates and Drivers in the Road Industry – The Case of Queensland
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Innovation Rates and Drivers in the Road Industry: The Case of Queensland, Australia

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Abstract

This paper examines the extent of innovation in the Queensland road industry, in terms of original and adoptive innovation. The drivers of innovation are also analysed, with reference to industry subsectors. The results help clarify our understanding of road industry performance, in terms of change trajectories, international competitiveness and leverage points for improvement.

Data is presented based on a 2002 survey of over 300 contractors, consultants, clients and suppliers. The report findings draw attention to the importance of ICT, business practice innovations, in-house innovation skills, and the key roles played by clients and product suppliers in driving innovation. Given that these drivers of industry performance are reflected in the literature, they should be singled out for attention in any effort to improve innovation performance in the road industry, or indeed in the construction industry generally.

Keywords: construction, innovation, road, adoption, technologies, practices

Introduction

In an increasingly knowledge economy, industry growth relies more than ever on continual innovation. A recent Commonwealth Government report suggested that 'innovation is the key to the future international competitiveness of all Australian industries' (DITR 2002, 33). Against this background, the current paper examines innovation rates and drivers in a critical industry sector – the Queensland road industry.

The Australian road industry accounted for half of one per cent of GDP in 2000-01 (ABS 8204.0, unpublished data).[1] Although this may not sound substantial, it is one of the largest contributions for any single Australian industry class.[2] Such comparisons indicate that the road industry is a significant contributor to national output; and Queensland is a major part of the national industry. Queensland is a large state of 1.7m km^2, nearly one quarter of the Australian land mass and only a little smaller than Indonesia, with a high population density along the southern coastal belt and many cites and towns of relatively low population density in much of the remaining area.

Queensland hosts a road network of considerable significance in both economic and social terms. Queensland is a large state with a high population density along the southern coastal belt and many cites and towns of relatively low population density in much of the remaining area. These population centres are often separated by long distances. This makes the quality and effectiveness of the road network particularly important, especially for moving freight, commuters and tourists throughout the state and to national and international transit centres. Innovation provides the key to improving road industry performance.

It is widely accepted in policy, business and academic circles that innovation is the main source of economic improvement for industries (eg. OECD 2000). Experience in OECD countries also clearly shows that innovation has a positive impact on profitability at the firm level (Guellec and Pattinson 2001, 92).

Innovations may arise from inventing highly novel, original and previously unseen technological products/services or managerial practices. More likely, however, especially for mature industries such as the road industry, innovations will be 'new' to the adopting organisation, but not necessarily new to the industry, country or world.

Adoption activity involves the diffusion of existing technologies and advanced practices among organisations. Adopting organisations are innovative organisations engaged in processes to improve their individual performance. Though less novel than original innovation, adoption activity is crucial for improved industry performance (eg. Anderson and Schaan 1999, 6). Further, adoption often involves *original* further development to attain maximum advantage in specific circumstances.

The report is based on an empirical investigation of innovation in the Queensland road industry. It focuses on innovation directions and drivers. The results help clarify our understanding of road industry performance, in terms of change trajectories, international competitiveness and leverage points for improvement.

Methodology

The study population was defined as 'participants in the Queensland road and bridge sector' and split into four sub-sectors:

1. clients – Queensland Department of Main Roads (QDMR) district offices and local governments;
2. contractors – private and public sector;
3. consultants; and
4. input suppliers – product suppliers and others.

[1] Current price estimates.
[2] 'Industry Class' refers to the 4-digit ANZSIC classification of industries.

Altogether, the study population comprised 335 organisations. The population list was derived from industry and professional association membership lists, together with QDMR pre-qualification lists. The population comprised all the organisations for whom the Queensland road and bridge industry is of major importance. Questionnaires, containing both open and closed questions, were sent to every organisation in the population, by standard mail, in April 2002. The questionnaires asked about innovation rates, types, strategies, drivers, obstacles and impacts. The objective was to assist QQDMR understand innovation processes within the industry, with a view to developing strategies to improve performance. The current paper reports on a sub-sector of results, looking at innovation directions and drivers.

The overall response rate to the questionnaire was 62 per cent, resulting in 208 responses. This can be considered exceptional for a voluntary mail survey. Saunders et al. (2000, 159) note that response rates for postal surveys can be as low as 15-20 per cent, and that 30 per cent is a reasonable rate. In 1999, Statistics Canada ran a similar survey in construction and related industries, in which response was a legal requirement. Yet their response rate was only 13 percentage points higher than for the present voluntary survey (see Anderson and Schaan 2001, 5).

Results and Discussion

The results reported here focus on innovation directions and drivers in the Queensland road industry, considering both adoptive innovation ('new' only to a particular business) and original innovation (involving novel development of previously unseen technologies and practices).

Innovation Directions

Respondents to the survey were asked to select the technologies and advanced practices they used from a prescribed list of up to 46 types (see Appendix A). Fourteen per cent of respondents, or 30 organisations, used more than three-quarters of the technologies and advanced practices listed.

The most popular adoptions are shown in Table 1.

Table 1: Top Ten Technologies and Practices Used by Respondents

Technology/Advanced Practice	Percent Respondents Queensland
Email	97%
Computer networks (LAN or WAN)	85%
Staff training budget	85%
Quality certification (eg ISO 9000)	85%
Geotextile fabrics	84%
Digital photography	81%
Written strategic plan	77%
Web site	76%
Computer-aided design (CAD)	74%
Computerised project management	67%

These technologies and practices were used by more than three-quarters of the sample, except for *CAD* and *computerised project management*. These results are encouraging, showing high usage rates in key technologies and practices, particularly information and communication technologies and practices. The emphasis on ICT suggests that the industry has been able to respond to various reports, in Australia and elsewhere, that rapid uptake of information and communication technologies (ICTs) is the key to improved industry performance (eg. Fairclough 2002; Egan 1998; Latham 1994 and Gyles 1992).

Results from the 1999 Statistics Canada survey of the engineering construction sector showed much lower adoption rates, as shown in Figure 1.[3] The Canadian results are for contractors in the entire engineering sector, which includes not only roads and bridges, but also relatively high-tech oil, gas, and industrial projects, for instance. The broader coverage of the Canadian results is therefore unlikely to produce lower innovation rates. The Queensland results shown in Figure 1 are for contractors only, to match the scope of the Canadian study.

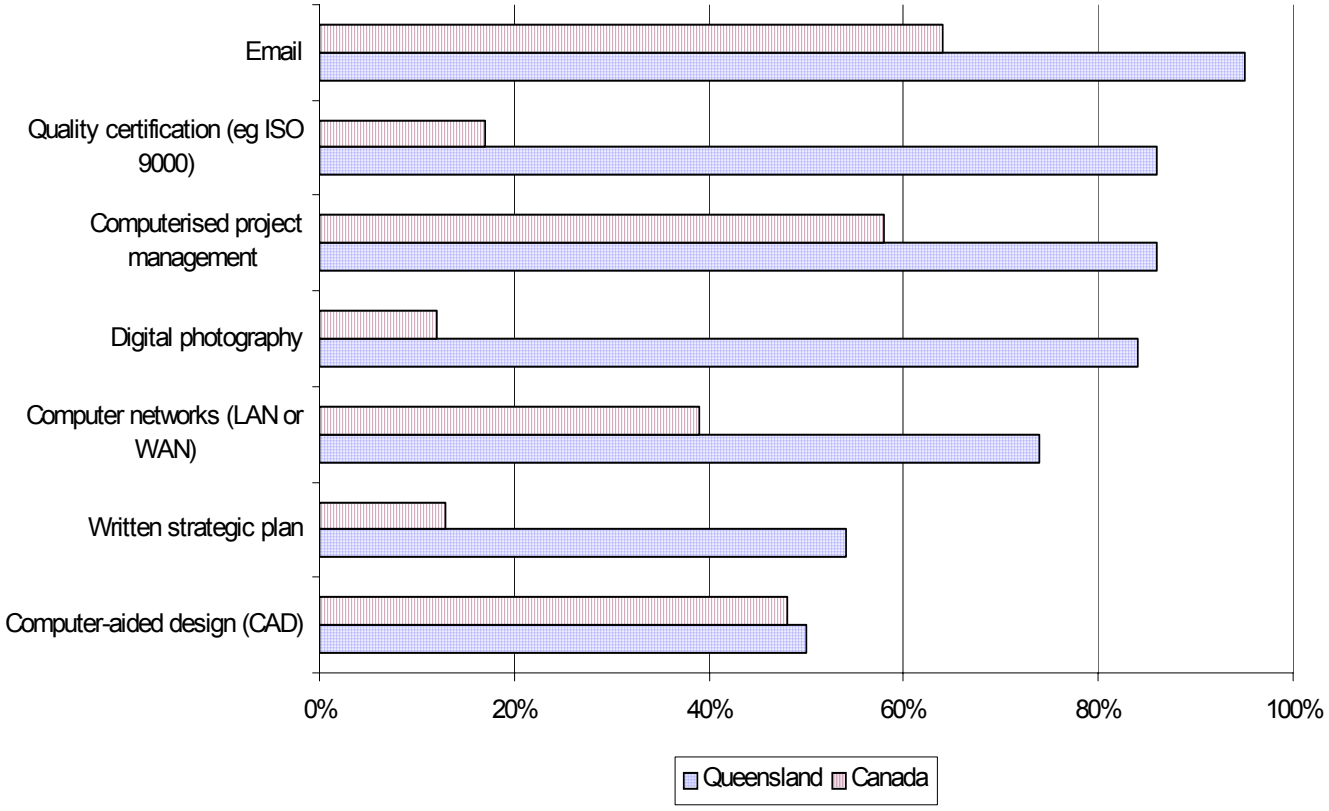

Figure 1: Queensland/Canada: Compared Adoption Rates for Commonly Listed Technologies and Advanced Practices[4]

Canadian data was drawn from Anderson and Schaan (2001), based on a sample of 1,800 establishments, compared to 208 organisations in the Queensland study. The Canadian study only considered organisations with revenue greater than $50,000 (Canadian). There was no size threshold in the Queensland study; therefore it is likely to

[3] Canada was the only country for which comparative data was found.
[4] The technologies and advanced practices shown are those that were listed in both surveys. Different survey contexts meant that the lists were very different.

include a higher proportion of smaller organisations, biasing adoption rates downward. Nevertheless, Queensland's adoption rates were higher than Canada's for all commonly listed technologies and practices, and *substantially* higher in most cases. The *extent* of Queensland's dominance is unlikely to be explained merely by the three year time difference.

The evidence suggests that contractors in the Queensland road and bridge industry may be more innovative than contractors in the Canadian engineering construction industry, though more rigorous comparison is required in order to draw robust conclusions. The Queensland usage rate for digital photography was seven times higher than that in Canada, five times higher for quality certification, four times higher for written strategic plans and nearly twice as high for computer networks. Queensland's usage rate for CAD was only slightly higher, indicating that, given the time difference, Canada is likely to be more advanced in this area.

Respondents were asked to nominate their one most successful adoption of a technology or advanced practice. The responses were allocated into broad categories of technologies and practices, as shown in Figure 2.

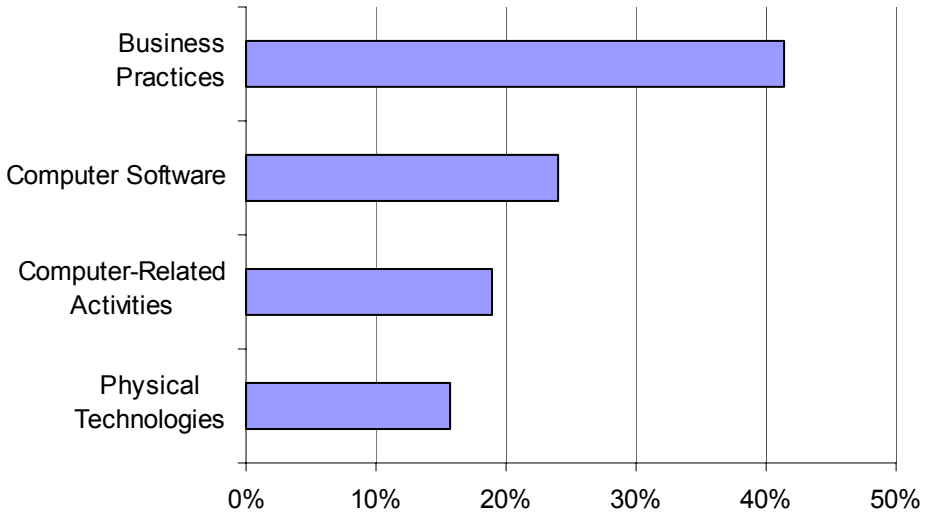

Figure 2: Broad Technologies and Practices Contributing Most to Organisation Success, by % of Respondents

Note: Physical technologies are materials, products, plant and equipment.

The dominance of *business practices* points strongly to the importance of non-technical improvements in innovation processes. *Business practices* include quality assurance systems, human resource practices, strategic plans, relationship management, on-going collaborative arrangements with other organisations, financial systems management, and health/environmental considerations. These 'soft' factors comprised a significant class of successful innovation.

This finding is consistent with previous studies which have concluded that business practice innovations, otherwise known as organisation innovations, are particularly important to business success. This importance is partly due to the role that business practice innovation plays in supporting technological innovation. 'Organisational change

almost always leads to, or is accompanied by, new products, improved quality, or the adoption of a more efficient process of production or delivery' (Hamdani 2001, 34).

Further, business practice innovation is more important in service industries, such as construction, than in the manufacturing industry (Hamdani 2002). This is particularly so given the challenges faced by the construction industry, in Australia and overseas (eg. Gyles 1991; Egan 1998; Cole 2002; Fairclough 2002). In order 'to cope with new challenges [in the construction industry] … firms have had to resort to *organisational* innovations both internally and through their relations with other firms' (Miozzo 2002, 3, emphasis added).

Finally, the emphasis in Figure 2 on computer technologies and practices reflects their emphasis in Figure 1. Not only are ICTs being rapidly adopted, they are providing good outcomes for organisations in the industry.

To some extent, the study found that all industry participants were innovative, in the sense that they had all adopted advanced technologies and practices. *High-end* innovators were defined as those respondents who had undertaken *original* innovation over the past three years, and respondents who had adopted more than three-quarters of the technologies and advanced practices listed in the questionnaire, termed top-quartile adopters.

Fifty-six respondents, or 27 per cent, reported that they had undertaken original innovation during the past three years. This result is consistent with the findings of another Australian study, that 27 per cent of Australian building and construction respondents had 'developed previously unseen products, services, technology, processes or management strategies/techniques' (PricewaterhouseCoopers 2002). These results are reporting on similar questions, both of which reflect the OECD measures of innovation (see OECD/Eurostat 1997). The literature notes that the building construction industry is generally less capital and knowledge intensive than the engineering construction industry (Marceau et al. 1997, 67). Therefore, as the national Australian study included the building sub-sector, it might have been expected that the rate of original innovation for the present study would be higher.

Respondents were asked to nominate their one most promising original innovation; the results are shown in Figure 3.

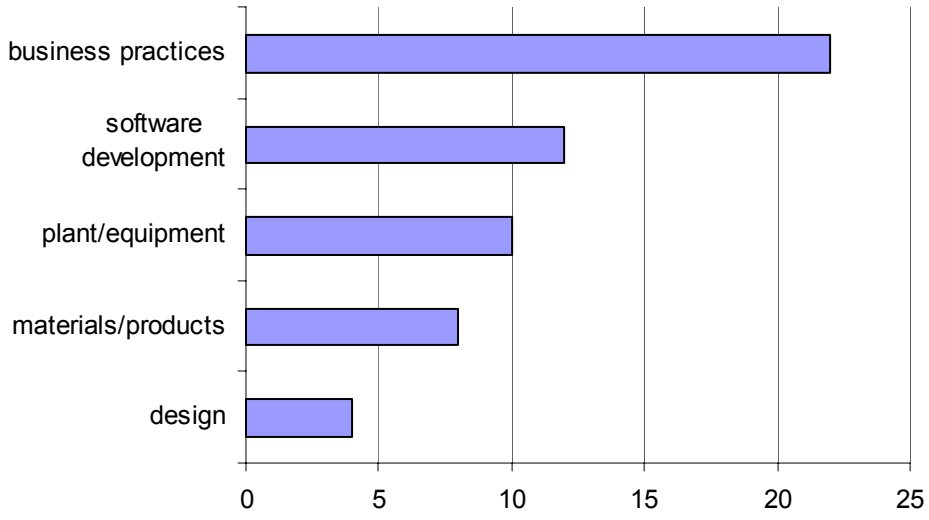

Figure 3: Type of 'Most Promising/Successful' Original Innovation, by Number of Respondents

Twenty-five original innovations, constituting thirty-nine percent of all original innovations nominated, involved business practice improvements (predominantly organisational changes). Given that innovation is often thought of as involving only technological improvements, this result again draws attention to the importance of *organisation* innovations, which rely more on management of 'people issues' than technological innovation. The importance of business practice innovation in Figure 3 is reflected in Figure 2, which reviewed the importance of adopted, rather than original, innovations. Both original and adopted innovations drew significantly on non-technical solutions to problems.

Only the rate of *technological* innovation can be compared with previous studies (involving the other categories shown in Figure 3 – software, plant, equipment, materials, products and some design innovations). For the present study this rate is 14 per cent; that is, only 30 of 208 respondents recorded technological innovation. This result compares poorly with the technological innovation rate of 26 per cent for the Australian manufacturing sector, measured by an Australian Bureau of Statistics survey in 1996-97 (ABS 1998, 6). However, this is not unexpected as the manufacturing sector is generally regarded as a centre of innovation within the economy, driving innovation through other sectors (eg. Marceau et al. 1999, 19; Cohen and Zysman 1987).

Innovation Drivers

Respondents were asked to nominate the main reason for adoption of their most successful technology or practice. Results revealed a very broad range of motivations, with 23 types of 'drivers' nominated by at least five respondents. Figure 4 shows the nine categories of response nominated by at least 10 respondents.

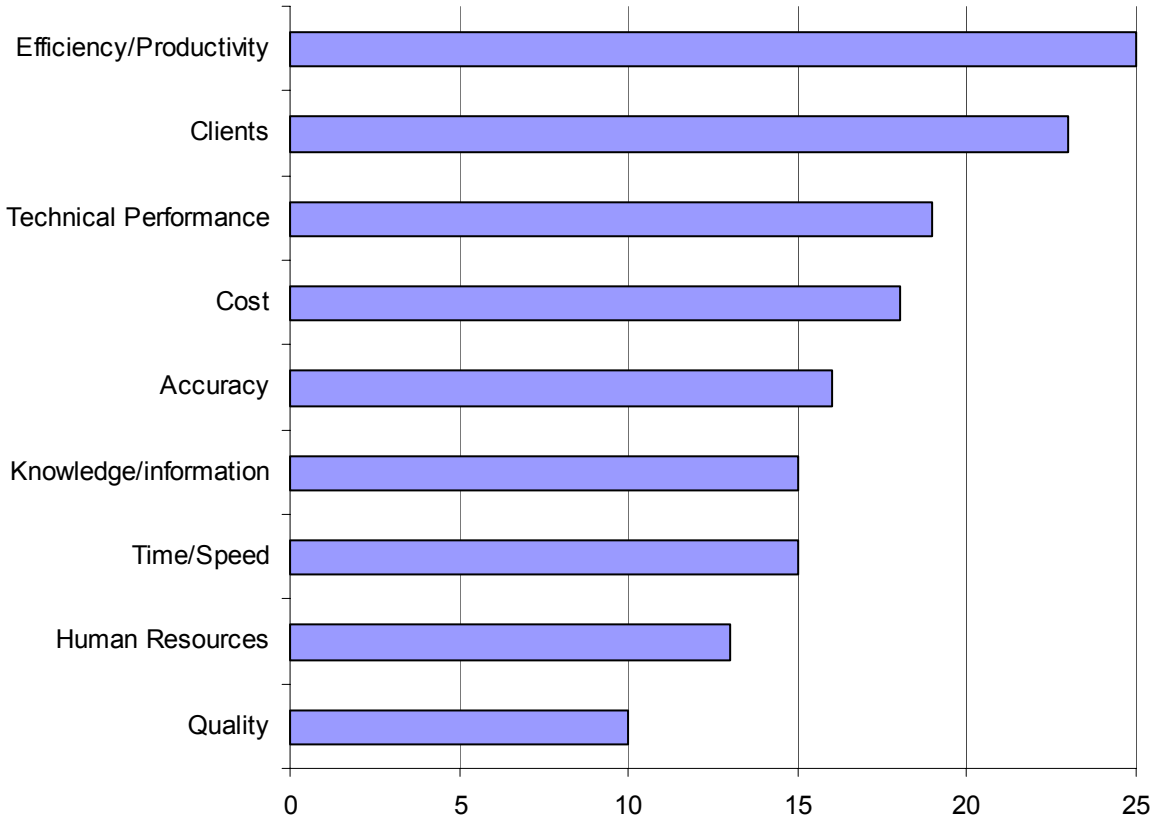

Figure 4: Reasons for Adoption of Most Successful Technology/Practice, by Number of Respondents

The most common driver was *efficiency/productivity*, nominated by 15 per cent of respondents to this question. Combining the financial performance drivers reveals that nearly one in four respondents nominated *efficiency/productivity* or *cost*. *Clients* was the second most important driver, nominated by 14 per cent of respondents. This is an important finding, confirming the pivotal role clients can play in promoting innovation along the supply-chain by demanding ever more innovative outputs.

An alternative view of drivers is provided by considering which industry sub-sectors are most innovative. Figure 5 reviews which industry sub-sectors are leaders in adoptive innovation.

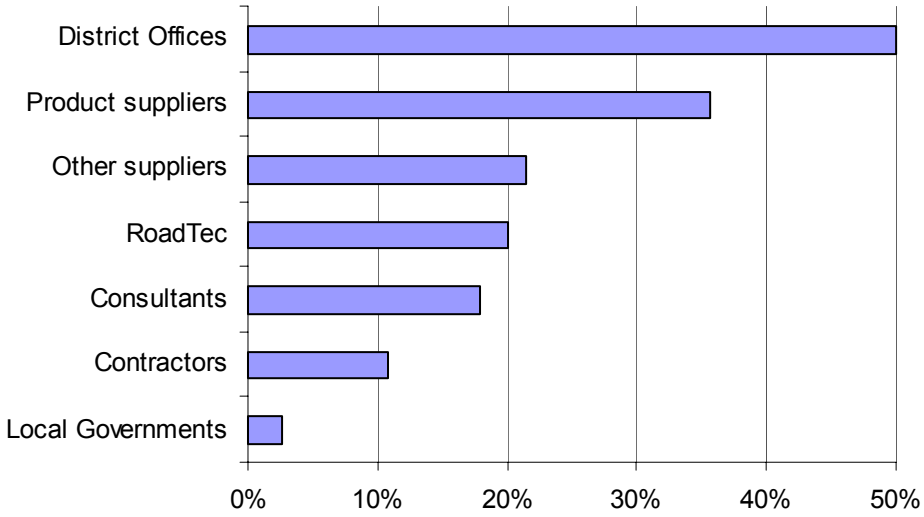

Figure 5: Proportion Top Quartile Adopters, by Industry Sub-Sectors

The most likely group to have adopted more than three-quarters of listed innovations is QDMR district offices, with 50 per cent of the 12 district respondents having done so. Comparing the two groups of clients surveyed, it is clear that QDMR districts are much more innovative than local governments, by this measure, and by the incidence of original innovation shown in Figure 6.

Reflecting their performance in relation to original innovation, product suppliers are also intensive innovation adopters; 36 per cent of the 14 suppliers of binders, cement and asphalt had adopted at least three-quarters of the technologies and advanced practices listed in the survey. Again, attention is drawn to the strategic role played by manufacturers in innovation systems.

Figure 6 reviews the most innovative sub-sectors in terms of *original* innovation.

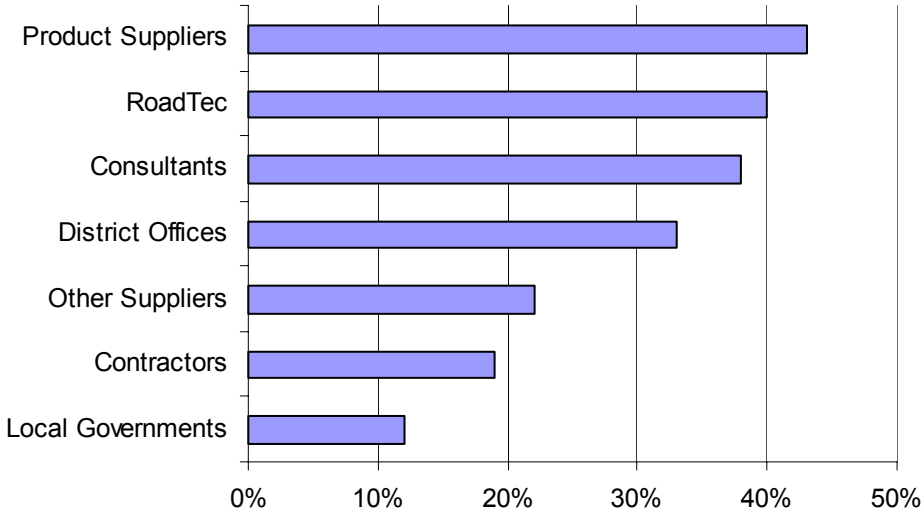

Figure 6: Proportion Original Innovators, by Industry Sub-Sectors

Product suppliers were the most likely group to have undertaken original innovation, with forty-three percent of the 14 product suppliers having done so. This reflects the finding noted above – that manufacturers are key drivers of innovation through supply chains (Marceau et al. 1999, 19). The product suppliers produced asphalt, binders and cement.

Cement suppliers were the least innovative of the three suppliers, which is surprising given the industry's well publicised R&D activities (eg. their trade stalls at QDMR symposia). It might be that the industry has difficulty commercialising its R&D. Further research would be required to determine whether this was the case.

Another perspective on 'who drives adoptive innovation?' is provided by examining the role of original innovators in adoption activity. Table 2 shows that original innovators dominate the group of top-quartile adopters.

Table 2: Proportion of Original Innovators in Adoption Quartiles

Quartile	Number of Original Innovators	Total Number of Respondents	Proportion Original innovators
Adopting less than ¼ of Listed Innovations	3	17	18%
Adopting more than ¾ of Listed Innovations	17	30	57%

Original innovators constituted less than one-fifth of businesses adopting *less than one-quarter* of listed innovations, whereas this group dominated the top quartile, which comprised businesses adopting *more than three-quarters* of listed innovations. In addition to looking at the representation of original innovators as a proportion of total respondents in the top quartile, their representation in this quartile can also be examined as a proportion of all original innovators. Table 3 looks at the relative likelihood of an original innovator being in the top quartile.

Table 3: Original Innovators and Others in the Top Adoption Quartile

	Original Innovators	Other Respondents
Number in Top Quartile - Adopting more than ¾ of Listed Innovations	17	13
Total Number of Respondents	56	152
Proportion	30%	8%

About one-third of original innovators adopted more than three-quarters of listed innovations, while only eight per cent of those who had not undertaken original innovation in the past three years were high-end innovation adopters.

These results suggest a positive correlation between propensity to develop original innovation and propensity to adopt existing innovations. The literature supports this finding with studies showing that the ability to successfully *adopt* innovations is strongly influenced by the existence of *in-house skills* required for original innovation (eg. Marceau et al. 1997, 69). Similarly, businesses involved in significant adoption activity are likely to encounter the need to customise technologies and practices to suit their needs. This process of customisation involves incremental original innovation, which may lead to development of 'substantially new' original innovations.[5]

[5] To be counted as an 'original innovator' in this and many other innovation studies, an organisation must have developed a 'substantially new' technology or business practice.

Conclusions

This study has shown that innovation rates in the Queensland road industry are internationally comparable, and similar to those found in the broader Australian construction industry. The direction of innovation emphasises ICTs, which can be seen as a positive response to recommendations provided by key inquiries into the construction industry – that ICT uptake should be increased as it is crucial to improvements in the industry's performance. Further, the direction of innovation has highlighted the importance of non-technological (business practice) advancements, otherwise known as 'organisation innovation'. Again, this indicates that the industry is well placed to improve efficiency and effectiveness, given emphasis in the literature on organisation innovation.

Clients are key drivers of adoptive innovation in the industry. As the public sector is the main client, there is a clear opportunity for strategic public policies aimed at encouraging the on-going development and adoption of advanced technologies and practices.

Product suppliers are the most likely industry subsector to be involved in generation of *original* innovation in the industry, reflecting findings in the literature regarding the importance of manufacturers in driving innovation. The district offices of the main client in the industry – QDMR – are the most likely industry subsector to have intensively adopted innovation. Again, attention is drawn to the influence public sector clients can have on industry performance.

Finally, the study has highlighted the close association between original innovation and adoptive activity. In order for organisations to be effective in adopting innovations developed elsewhere they need to have in-house skills in original innovation development in order to be able to successfully implement adopted innovations and adapt them for local conditions. This reflects findings in the literature that original innovation activity provides the skills required for successful adoption.

Overall, this report has drawn attention to the importance of ICT, business practice innovations, in-house innovation skills, and the key roles played by clients and product suppliers in driving innovation. Given that these drivers of industry performance are reflected in the literature, they should be singled out for attention in relevant public policy campaigns in the road industry, and indeed, in the construction industry generally.

Appendix A

Technology/Advanced Practices Listed in Questionnaire

3-D CAD files
Alliance contracts
Bio-remediation clean-up
Computer networks (LAN or WAN)
Computer-aided design
Computerised estimating software
Computerised inventory control
Computerised modelling
Computerised pavement/bridge investment analysis (eg. HDM4)
Computerised project management
Computerised visualisation techniques
Cost-Reimbursable-Performance-Incentive Contracts
Design and Construct Contracts
Design/Build/Fund/Operate (DBFO) Contracts or Public-Private Partnerships (PPPs)
Digital photography
Digital videos of road surface condition
Documentation of technological/organisational improvements developed by your organisation
Electronic distance measuring device (EDME)
Email
Fibre composites
Foam bitumen
Geotextile fabrics
Global Positioning System (GPS)
GPS-guided equipment
Health monitoring of road pavements/structures
High performance concrete
Intelligent transport systems
Laser-guided equipment
Long-term collaborative arrangements with other organisations
Managing Contractor
Noise inhibiting road surface materials
Office-to-site video links or video conferencing
On-line-remote-construction-management
Partnering on road projects
Paving/Rehabilitation Train
Pug mill cement/lime stabilisation processes
Quality certification (eg ISO 9000)
Re-cycling asphalt/concrete
Remote sensing and monitoring systems
Simulation technologies
Staff training budget
Stonemastic asphalt
Systems dependent on CAD files
Web site
Written evaluation of new ideas in order to develop options for your organisation
Written strategic plan

The total number of technologies and practices listed for the 180 non-suppliers was 46; for the 28 suppliers in the sample there were 20 listed, except for equipment distributors, for which there were only 14.

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