

KNOWLEDGE FLOWS IN THE ROAD INDUSTRY – QUEENSLAND’S EXPERIENCE

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ABSTRACT

This paper is based on empirical data obtained from a large scale survey of the Queensland road industry in 2002. The survey focused on innovation activity in the industry and this paper examines a key part of that study – knowledge flows. This focus responds to the rapidly increasing knowledge intensity of successful and sustainable economic activity in the 21st century. Knowledge ‘flows’ and networking, both within organisations and between them, are seen as key elements in successful innovation processes. In turn, innovation is widely regarded as a key driver of economic growth and environmental sustainability.

The paper reports on knowledge flows between industry participants as revealed in the survey of over 200 contractors, consultants, clients and suppliers. Two types of knowledge flows are discussed – the first involves communication patterns, and the second involves the sources of new ideas about technologies and advanced practices. The tracing of these knowledge flows amounts to mapping business networks.

The objectives of this paper are to:

- measure the level of networking between organisations;
- identify the key nodes in networks;
- map the patterns of usage of key nodes by industry sub-sector, region and business size; and
- determine whether there is a relationship between level of networking by an organisation and innovation adoption rates.

The most important finding of the study is that business networking, both in terms of consultation patterns and sources of new ideas of innovation, is positively related to innovation levels, measured by adoption activity. Participation in business networks is one of the key features that differentiates innovative businesses from other businesses.

The paper concludes by highlighting the value, for industry participants, of comprehensive relationships with the key nodes identified by the study.

INTRODUCTION

Key observers note that we are witnessing a new era of economic growth in which the rate of knowledge accumulation rivals that associated with the industrial revolution (see eg. Tegart et al. 1997, 9). Indeed, the Massachusetts Institute of Technology recently concluded that ‘fact-based knowledge doubles every 18 months...and by 2010 it will double about every four weeks’ (Neville 1998, 16).

In this context, robust knowledge flows are required between organisations in order to maximise innovation opportunities (Miozzo and Dewick forthcoming 2002). The increasing complexity of

technical developments and advanced practices requires a wide range of competencies for effective adoption or invention. Such competencies are rarely held within any one organisation. Therefore, it is important for an organisation to have robust external linkages.

As many studies have shown (eg. OECD 1996), personal contact is a key means of maintaining external linkages and enhancing innovation performance. Personal contact assists in acquiring critical tacit knowledge, which is often required to maximise the benefits of adopted technologies/practices (Patel and Pavitt 1995, 18). The value of 'explicit' knowledge bases also relies on tacit knowledge to help with interpretation and adaptation to specific circumstances.

This paper focuses on two types of knowledge flows – consultation patterns (dealing with personal contact and tacit knowledge) and sources of ideas about technologies and practices (helping to identify the main knowledge sources in the industry). The tracing of these knowledge flows amounts to mapping business networks, which can assist in the development of policy to enhance innovation performance.

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- map the patterns of usage of key nodes by industry sub-sector, region and business size; and
- determine whether there is a relationship between level of networking by an organisation and innovation adoption rates.

The study has been prompted by the rapidly escalating importance of knowledge and innovation in modern economies (eg. Nonaka and Teece 2001; McKinsey 2001; Metcalfe and Miles 2000, OECD 2000), and renewed interest in the potential contribution to be made by so-called *mature* industries, such as the road industry (eg. Smith 1998). Against this background we set out to gauge the performance of the Queensland road industry as an innovation system.

The data presented in this paper is based on a survey described in the next section. Design of the study was based on a conceptual model developed to integrate key insights from a number of inter-related academic disciplines, including innovation systems (eg. OECD 2000, 1996), networks (eg. Freeman 1991), value-chains (eg. Walters and Lancaster 2000) and clusters (eg. Porter 1998). The model is described in detail in Manley (2001b). For the present purposes, it is suffice to note that the model helped identify the key players to be surveyed and the scope of innovation features examined. This paper reports on a key feature – knowledge flows.

METHODOLOGY

The study population was defined as 'participants in the Queensland road and bridge sector', who can be split into four sub-groups:

1. clients – DMR district offices and local governments;
2. contractors – private and public sector;
3. consultants; and
4. input suppliers – product suppliers and others.

Altogether, the study population comprised 335 organisations. The population list was derived from industry and professional association membership lists, together with DMR pre-qualification lists. The population comprised all the organisations for whom the Queensland road and bridge industry is of major importance. The questionnaires were sent to every organisation in the population, by standard mail, in April 2002.

The overall response rate 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). The high response rate for the present study is indicative of a general industry interest in innovation issues.

The knowledge flow section of the survey focused on the sources of information for making adoption decisions, and consultation between industry participants. Respondents ticked the most valued sources of ideas and consultative partners based on supplied lists. Innovation levels were measured via a list of prescribed technologies and advanced practices. These lists were in turn based on comprehensive pilot testing.

RESULTS AND DISCUSSION

Consultation Patterns Between Organisations

The main view of communication networks, or knowledge flows, was provided by the survey question: 'How often would *your* organisation consult (talk to) the following organisations regarding road performance?'. **Figure 1** below shows those types of organisations contacted 'often' by at least ten survey respondents. This amounted to 11 of the 20 types of organisation listed. The full list is shown in Appendix A.

In this context, a well performing industry is one in which there are high levels of communication between industry participants. Figure 1 identifies those organisations most frequently contacted by industry participants. These organisations are key nodes in consultation networks. Key nodes have access to significant tacit information and can potentially build up significant knowledge bases that can be used to drive innovation through the network.

The data shows strong levels of communication between key participants, which would support the innovation activities of the industry. However, the overall knowledge generating capacity of the network would probably improve if knowledge intensive organisations, such as ARRB, were better integrated into communication networks.

The most frequently consulted groups within the industry were DMR district offices and local governments; over half of respondents frequently communicated with these main clients. The importance of clients in leading innovation activity was highlighted in the previous report in this series, particularly in relation to project-based industries, such as road and bridge construction (see Manley 2001b). In this context, experienced clients, such as DMR and local governments, can act as stable nodes of knowledge accumulation, demanding ever improving value-for-money based on continuity of experience. Clients are a popular target for industry consultation because of their role in providing work. However, it is likely that in liaising with industry participants about up-coming work and associated matters, clients also find opportunities to champion innovation. This would be especially so for DMR because it has retained a large in-house workforce, and hence has access to an extraordinarily deep and broad technical skill base.

Figure 1 shows that suppliers are also at the centre of considerable interaction within the industry. Forty-three per cent of all respondents often consulted with suppliers. This is understandable, and useful for promotion of innovation, given that suppliers feature in the survey as high-end innovators (see Manley 2002). These findings are consistent with previous studies (eg. Marceau et al. 1997) which have highlighted the importance of suppliers in innovation networks, particularly suppliers of manufactured outputs, such as product suppliers.

This discussion highlights that the three key consultation nodes – DMR districts, local governments and suppliers – are likely to be significant knowledge repositories and innovation *drivers*. On the other hand, their central position in the network gives them ample opportunity to develop tacit knowledge to assist with their *own* innovation efforts. Although the data supports the existence of this dynamic for DMR districts and suppliers, with both showing good relative innovation performance, it seems that local governments could do more to maximise the opportunities that their position in the network affords, as they do not rank highly as innovators in the industry (see Manley 2002).

Figure 1 is based on a list of 20 business types covering clients, technical support providers, specifiers, regulators and peak road-user organisations. None of the peak user organisations are shown in the chart because none were nominated by at least 10 respondents. This low level of interaction may impede the innovation performance of the industry given findings in the literature that ‘users may often take the lead in stimulating and organising innovation’. Indeed, ‘so important is the interaction with users that it has become one of the key topics in the research [literature]’ (Freeman 1994, 470).

The survey sought to measure the extent of *informal* interaction between businesses, including users. Previous international studies have found that ‘*informal* flows of information between users and suppliers were actually more important than *formal* arrangements’ (Freeman 1994, 471), reinforcing the need for robust consultation with users. ‘Users’ in the present context include more than the immediate clients such as DMR; ultimate road-users constitute potentially important innovation drivers. Given that DMR policies emphasise consultation with road users on a project-by-project basis, it may be that the survey is picking up a lack of ongoing consultation with peak user-groups, which, if pursued, may promote improved innovation performance.

Further information about respondents who nominated the three most frequently consulted industry groups – MR districts, local governments and suppliers – was obtained by disaggregating them by sub-sector, region and size. Given the structure of the industry (see Manley 2002), it is not surprising that the respondents nominating these organisations were most likely to be:

- from the local government sub-sector;
- from the south-east region; and
- large organisations.

The only exception to this was the finding from analysis by sub-sector that there are strong knowledge flows between contractors and suppliers, with contractors constituting one-quarter of all respondents nominating suppliers, while representing only 18 per cent of the survey sample. This result is likely to again reflect the importance of product suppliers (that is, manufacturers) in innovation systems. This time, attention is drawn to networks between *contractors* and suppliers, with the former seeking to improve their competitive advantage by keeping up-to-date with the latest technical developments.

The remainder of the analysis in this section looks at the *likelihood of a particular group* communicating regularly with the three key network nodes – MR districts, local governments and suppliers. The analysis below is ordered by sub-sector, region and organisation size.

Sub-Sector

Table 1: Propensity to ‘Consult Often’ with the Three Key Groups, by Sub-Sector

| Group | Product Suppliers | Other Suppliers | Consultants | Contractors | Local Gov’ts | District Offices | RoadTek |
|----------------------|-------------------|-----------------|-------------|-------------|--------------|------------------|---------|
| Suppliers | 23% | 29% | 33% | 61% | 36% | 58% | 79% |
| DMR District Offices | 36% | 29% | 46% | 37% | 67% | 83% | 71% |
| Local Governments | 23% | 50% | 51% | 27% | 73% | 83% | 36% |

The two most dense knowledge flows within the industry are between DMR district offices, and between DMR district offices and local governments. Ten of the 12 DMR respondents, or 83 per cent, frequently contacted both other district offices and local governments. The heavy knowledge flows *between* districts are useful and understandable given the wealth of experience and expertise held within the districts. Local governments have a lower rate of frequent contact between themselves (73 per cent). The district offices are a closer-knit group, which would contribute positively to innovation outcomes for DMR, reflecting as it does extensive diffusion of tacit knowledge.

The results also show that DMR district offices are more likely to contact local governments than the other way around (with 83 per cent of district offices frequently contacting local governments and only 67 per cent of local governments frequently contacting district offices). District offices are also more likely to communicate with local governments (83 per cent) than a local government is likely to communicate with another local government (73 per cent).

Although the percentage likelihoods for district offices are calculated on a much lower sample size, it does seem that DMR district offices communicate more extensively between themselves and that they have a greater interest in local governments than the other way around.

Referring again to Figure 1, 43 per cent of all respondents frequently consulted with suppliers; while Table 1 shows that RoadTek offices were the most likely industry group to do so. Eleven of the 14 RoadTek respondents to this question, 79 per cent, spoke often to suppliers. Contractors (61 per cent) and DMR district offices (58 per cent) were the next most likely groups to often contact suppliers. These figures suggest that key industry groups are actively keeping up to date with latest developments in materials, products and equipment.

Focusing on those sub-sectors with low consultation rates, it may be that higher levels of communication *between* suppliers would assist in bringing potential innovations to light; similarly, higher levels of communication between consultants and suppliers may assist in more innovative use of construction resources. Finally, the close association between DMR district offices and local governments (discussed above) may augment local government linkages with suppliers, with DMR offices passing on information.

Region

Table 2: Propensity to ‘Consult Often’ with the Three Key Groups, by Region

| Group | Central | Northern | South East | Southern |
|----------------------|---------|----------|------------|----------|
| Suppliers | 47% | 38% | 41% | 42% |
| DMR District Offices | 63% | 55% | 45% | 67% |
| Local Governments | 73% | 44% | 43% | 70% |

There was little regional difference in propensity to ‘consult often’ with the three key groups, except for the propensity to consult local governments. Over 70 per cent of organisations in both the southern and central regions frequently communicated with local governments; however, only 44 per cent of organisations in the north and 43 per cent of organisations in the south-east did so. Communications with local governments appeared to be less important in the northern and south-east districts. It is not possible to gauge the optimality of this situation in the absence of more detailed research.

Organisation Size

Table 3: Propensity to ‘Consult Often’ with the Three Key Groups, by Size of Organisation

| Group | Large | Small |
|----------------------|-------|-------|
| Suppliers | 46% | 42% |
| DMR District Offices | 59% | 46% |
| Local Government | 57% | 49% |

Table 3 shows that the propensity to ‘consult often’ with the three key groups was higher amongst large organisations. The biggest difference was in communications with DMR district offices; 59 per cent of large organisations frequently contacted DMR district offices, while only 46 per cent of small organisations did so. Given that personal contact between organisations has been shown to improve innovation outcomes (see earlier discussion), this result is consistent with findings in the literature that large firms are more innovative than small firms (eg. Seaden et al. 2001; ABS 8116.0). Government policy may be required to improve the presence of small organisations in communication networks.

To examine whether there was a relationship between high levels of consultation and innovation in the survey results, chi-square testing of differences was carried out. Testing showed that significantly more highly adoptive businesses (those which had adopted more than three-quarters of technologies and advanced practices listed in the questionnaire) than businesses with lower adoption rates had often consulted five or more of the listed groups. This demonstrates a link between higher levels of innovativeness and higher levels of networking. This finding reflects conclusions in the literature that ‘the establishment of external linkages has a positive effect on technology adoption’ (Arundel and Sonntag 1999, 20) and that ‘innovation is best understood as a collective phenomenon’ (Basri 2000, 2).

Sources of New Ideas

Another view of communication networks, or knowledge flows, is provided by reviewing the sources of new ideas consulted by organisations. Respondent’s were asked: ‘Please rate the importance of the following sources of new **ideas** about technologies or practices, for *your* organisation.’

Figure 2 shows the sources of new ideas about technologies or practices listed in the survey and their importance to the industry. Three sources of ideas were considered of ‘high’ or ‘very high’ importance by more than half the respondents:

- In-house (58 per cent);
- Previous projects (54 per cent); and
- Professional, industry or trade associations (53 per cent).

The importance of in-house sources would seem to reflect the depth and breadth of experience and skills held within individual organisational groups. Additionally, effective harnessing of knowledge gained from previous projects is clearly critical to effective innovation given the discontinuous nature of production processes in construction. In this context, umbrella associations can act as stable nodes of knowledge accumulation.

Suppliers were the next most highly regarded source of new ideas (48 per cent), while conferences/workshops, clients, DMR, and technical support providers also featured strongly. Again, user associations failed to feature significantly in information networks, despite the importance of strong linkages with final users for fostering innovation, as discussed earlier.

The remainder of the analysis looks at the *likelihood of a particular group* nominating the three key sources.¹ The data is expressed in terms of ‘propensity to value’, which refers to the propensity of a group to rank the importance of a particular source as ‘high/very high’.

Sub-Sector

Table 4: Propensity to Value the Three Key Sources, by Sub-Sector

| Source | Product suppliers | Other suppliers | Consultants | Contractors | Local Gov’t | DMR District Offices | RoadTek |
|---------------------------------------|-------------------|-----------------|-------------|-------------|-------------|----------------------|------------|
| In-house | 50% | 58% | 64% | 67% | 45% | 75% | 80% |
| Previous projects | 29% | 25% | 53% | 61% | 55% | 67% | 67% |
| Professional or industry associations | 38% | 69% | 49% | 56% | 58% | 33% | 47% |

Twelve of 15 RoadTek offices (80 per cent) rated the importance of their own organisation for new ideas about technologies or practices as high or very high. RoadTek, along with DMR district offices, was also the most likely sub-sector to gain benefit from previous projects. Other suppliers, contractors and local governments all relied heavily on industry or professional associations for new ideas about technologies and business practices. To some extent, this may reflect the importance of industry associations to smaller organisations.

Region

Table 5: Propensity to Value the Three Key Sources, by Region

| Source | Central | Northern | South East | Southern |
|---------------------------------------|---------|------------|------------|----------|
| In-house | 56% | 55% | 57% | 61% |
| Previous projects | 59% | 65% | 43% | 57% |
| Professional or industry associations | 55% | 55% | 57% | 50% |

There was little regional difference in propensity to value the three key sources of new ideas, except the relatively strong emphasis respondents from the northern region placed on previous

¹ Examination of the results based on disaggregation of respondents by sub-sector, region and size matched representations in the sample. The respondents nominating the three main sources – in-house, previous projects and associations – were most likely to be large organisations from the local government sub-sector and the south east region.

projects. This may reflect the challenging road and bridge building conditions which exist in Northern Queensland, with difficult soil types, high rainfall, rugged terrain and complex cultural considerations. Under these conditions, the experience gained on previous projects in the same region would be highly valuable.

Organisation Size

Table 6: Propensity to Value the Three Key Sources, by Size

| Source | Large | Small |
|------------------------------------|------------|-------|
| In-house | 60% | 56% |
| Previous projects | 58% | 49% |
| Professional/industry associations | 50% | 55% |

Table 6 shows that the propensity to value the three key sources of ideas was mostly higher among large organisations. The biggest difference in ‘propensity to value’ was in reliance on previous projects: 58 per cent of large organisations valued previous projects highly or very highly as a key source of ideas about technologies and practices, while only 49 per cent of small organisations did so. This may reflect the lead role played by large organisations on projects, yielding greater access to knowledge flows. Table 6 also shows that small organisations are more likely to rely on umbrella associations, reflecting their more limited resources.

Again, difference testing was carried out, to investigate whether there was a relationship between extensive consultation of sources of ideas and innovativeness. The testing showed that highly adoptive businesses (those which had adopted more than three quarters of technologies and advanced practices listed in the questionnaire) were significantly more likely than those with lower adoption rates to have rated seven or more of the 13 idea sources as of high/very high importance. This again supports conclusions in the literature that a business’s external linkages support its innovation efforts.

CONCLUSIONS

This study has found that business networking, both in terms of consultation patterns and sources of new ideas of innovation, is positively related to innovation levels, measured by adoption activity. Participation in business networks is one of the key features that differentiates innovative businesses from other businesses.

The types of businesses most consulted by industry participants were found to be DMR district offices, local governments and suppliers. Manley (2002) shows that DMR district offices and suppliers have been able to capitalise on their access to knowledge flows afforded by their key roles in networking. These two groups report high internal innovation levels.

DMR district offices, RoadTek and suppliers featured strongly in the analysis of networking by industry sub-sector. Further, the study found that large firms were more strongly involved in knowledge flows, while overall there was relatively minor regional difference in networking activity.

Despite highlighting the value of networking with *external* organisations, the study also demonstrated that certain types of organisations, with deep knowledge assets, benefited significantly from *internal* networking. This was most true of RoadTek businesses. Knowledge flows from previous projects were also demonstrated as significant, while professional/industry associations emerged as another key node in networks.

The key nodes identified above both benefit from their significant exposure to other industry participants, and have the potential to drive innovation through the industry, using their comprehensive industry linkages.

Clearly industry participants would be well advised to develop and expand their relationships with key network nodes and large businesses. Government policy can assist in this regard, by enhancing the convenience of such relationships (for example through organising workshops and engaging in other network enhancing activities).

APPENDIX A

Types of Organisations Listed to Trace Consultation Patterns

| |
|---|
| Technical Support Providers and Specifiers /Regulators/ /Standards Organisations ... regarding how they can help you provide conforming and/or better products/services/roads |
| Universities and colleges |
| Suppliers |
| Australian Road Research Board (ARRB) |
| Commonwealth Scientific and Industrial Research Organisation (CSIRO) |
| Construction Training Centre, Salisbury |
| Main Roads - Districts |
| Main Roads – Central Units |
| Main Roads – RoadTek (including RTCS) |
| Environment Protection Agency |
| Local Governments |
| Local Government Association of Queensland (LGAQ) |
| Queensland State Road Authority - Main Roads |
| Queensland Department of Natural Resources and Mines |
| Queensland Transport |
| Standards Australia |
| Other regional, state, national , or international organisations, please specify... |
| Peak User Organisations regarding their requirements for an effective road system |
| Australian Road Train Association |
| Livestock Transporters Association of Qld. |
| Queensland Conservation Council, Smog Busters |
| Queensland Trucking Association |
| Royal Automobile Club of Queensland |
| Other regional, state, national or international organisations, please specify... |

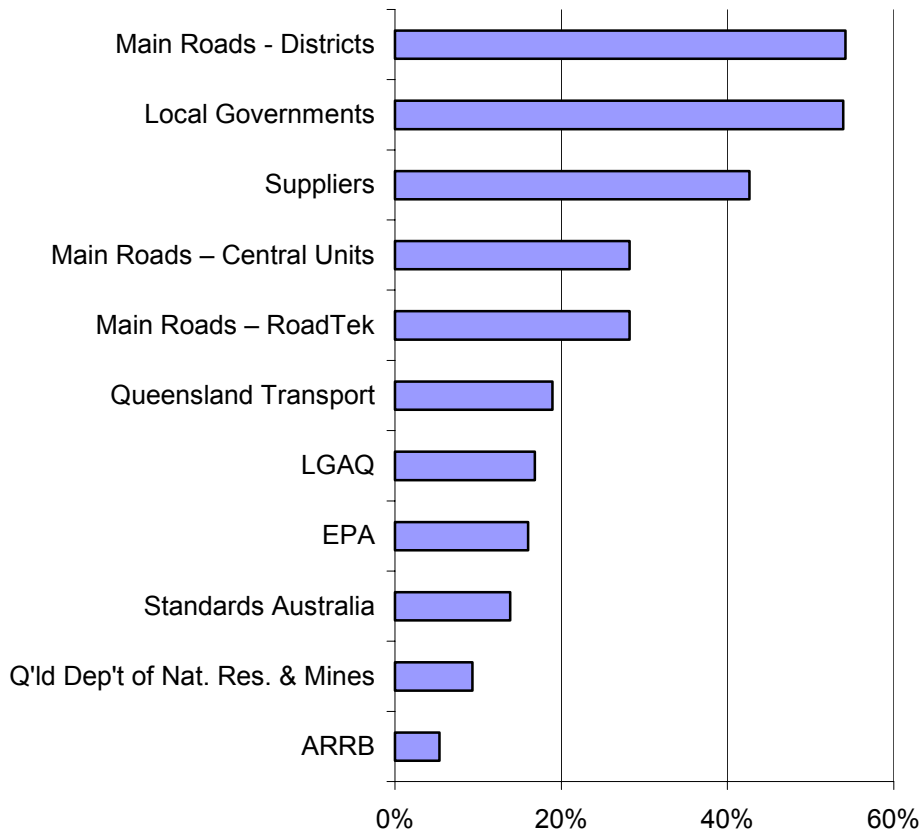


Figure 1: Key Industry Organisations, by % of Respondents Consulting Them Often

Note: Organisations shown are those which were nominated by at least 10 respondents. LGAQ – Local Government Association of Queensland. EPA – Environmental Protection Agency. Qld Dep't of Nat. Res. & Mines - Queensland Department of Natural Resources and Mines. ARRB – Australian Road Research Board.

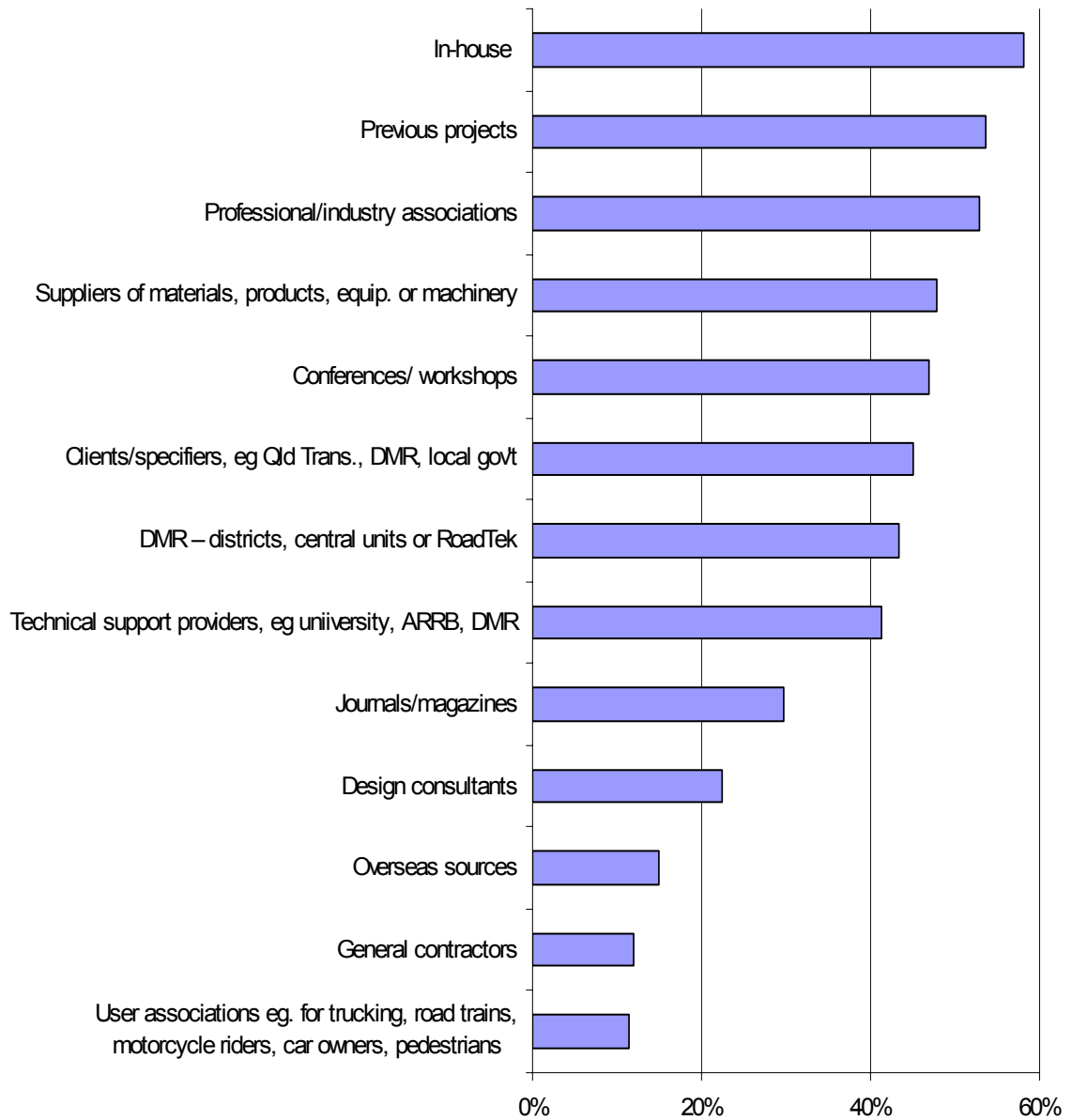


Figure 2: Sources of New Ideas, by % of Respondents Rating Their Importance High/Very High

Note: Qld Trans. is Queensland Transport.

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