1-1-1999

# The commercialisation of small firm technologies in Western Australia : A case for user-producer interaction and the integration of large industrial users with small technology producers

Michelle Navaratnam
*Edith Cowan University*

# USE OF THESIS

## CONFIDENTIAL INFORMATION

The evaluation upon which this research was based is yet to be published. Until publication of this evaluation, this thesis remains **CONFIDENTIAL** and is not publicly available until otherwise advised by the authors of the evaluation.

[redacted]

**The commercialisation of small firm technologies in Western Australia: A case for user-producer interaction and the integration of large industrial users with small technology producers.**

Michelle Navaratnam, B.Bus (Marketing)

Edith Cowan University
Faculty of Business and Public Management

This thesis is presented for the degree of Master of Business (Marketing)

Date of Submission: March 1999

## ABSTRACT

The purpose of this study was to:

- examine how grantee firms of the Western Australian Innovation Support Scheme (WAISS) have overcome their impediments to commercialisation;
- examine how the process of user-producer interaction has enabled grantee firms to commercialise their technologies;
- examine the process of user-producer interaction with large and/or small industrial users, and the subsequent benefits derived;
- examine the entry barriers faced by grantee firms in forming interactions with large industrial users.

The study examined the literature involving the role of small firms in the development and commercialisation of new technologies. The study adopted a multiple, holistic case study design using qualitative methodology. A theoretical pathway constructed from arguments presented within the literature was the basis upon which the cases were analysed.

The cases have demonstrated that the adoption of strategies promoting user-producer interaction through a dyadic problem-solving style approach with industrial users have enabled small firms to commercialise their technologies in industry.

The cases have found that those firms interacting with large industrial users have experienced extensive product diversification and market expansion opportunities as opposed to those firms interacting with small industrial users. In addition to the product diversification and market expansion opportunities acquired through interactions with these large industrial users, it was clear that the large-scale marketing and distribution resources of these industrial users also enabled small

firms to attract other industrial users, both domestically and internationally. This ultimately led to further product diversification and market expansion opportunities.

Those firms that interacted with small industrial users experienced either minimal or no product diversification and market expansion opportunities because of the 'small firm' characteristics of these users. This meant that as 'small firms' these industrial users also faced constraints with regards to the availability of marketing resources and distribution channels, and were therefore unable to attract the interests of industrial users within large-scale markets.

Those firms that experienced either minimal or no product diversification and market expansion opportunities have faced entry barriers typical to small firms when trying to find large industrial users for their technologies. They have been unable to attract the interests of large industrial users as a result of the high risk factors associated with the newness of their technologies and their credibility as a newly established firm.

The study's main finding reveals that the commercialisation of small firm technologies, the commercial extent derived for these technologies, and the overcoming of barriers faced by the small firm, was dependent on the social orientation of user-producer interaction in conjunction with the dyadic information exchanges of technological opportunities and user needs.

I certify that this thesis does not, to the best of my knowledge and belief:

i. Incorporate without acknowledgment any material previously submitted for a degree or diploma in any institution of higher education;
ii. Contain any material previously published or written by another person except where due reference is made in the text; or
iii. Contain any defamatory material.

[redacted]

# TABLE OF CONTENTS

## CHAPTER ONE: INTRODUCTION



## CHAPTER TWO: THE ROLE OF SMALL FIRMS IN THE DEVELOPMENT AND COMMERCIALISATION OF NEW TECHNOLOGIES

## CHAPTER THREE: METHODOLOGY



## CHAPTER FOUR: THE CASE STUDIES



## CHAPTER FIVE: CROSS-CASE ANALYSIS

## CHAPTER SIX: CONCLUSION

## LIST OF FIGURES AND TABLES

## LIST OF APPENDICES

## ACKNOWLEDGEMENTS

I am truly grateful for the invaluable support and encouragement of my supervisor, Dr. Marc Saupin.

Special thanks to Dr. Nadine Henley, the ISTP at Murdoch University, and the Department of Commerce and Trade. Thanks also to the managers of the firms that participated in the case research.

Finally, but certainly not in the least, I thank God, my family and my friends.

# CHAPTER ONE

# INTRODUCTION

## 1.0 Background to the Study

A majority of technology-based, small firms within Western Australia (WA) are responsible for the research and development (R&D) of leading-edge technologies. The Western Australian Department of Commerce and Trade's R&D Directory records 500 small firms within WA committed to the R&D of these technologies. Their commitment to R&D has encouraged the State Government to implement a series of funding programmes to assist them in this area. Since 1988 State Government contributions to Western Australian technology-based, small firms have amounted to approximately $4.6 million (Marinova, Phillimore & Saupin, 1998, p.3). An overview of these programmes and their contribution to industrial R&D is provided in Appendix One.

Despite their capabilities in the development of leading-edge technologies, most small firms face a number of impediments attributed to a lack of resources and skills, that often prevents them from commercialising their technologies in industry. This problem is not peculiar to Western Australian firms but something faced by technology-based, small firms in general (Rothwell and Zegveld, 1982; Rothwell and Dodgson, 1994).

In July 1998 an evaluation of the current State Government funding programme for industrial R&D - the Western Australian Innovation Support Scheme (WAISS) - was conducted by members of the Institute for Science and Technology Policy (ISTP) from Murdoch University.

WAISS is a competitive granting program that provides grants between $20,000 and $50,000 on a matching dollar for dollar basis for technology-based firms (Marinova et al, 1998, p.18).

The main objective of the WAISS was to:

- Increase investments in industrial R&D projects with a high potential for commercialisation (Marinova et al, 1998, p10).

The WAISS evaluation included the assessment of grantee firms, sampled unsuccessful applicants and sampled non-applicants, which will be discussed in greater detail in the methodology chapter.

It was the group of grantee firms that was of interest to this study due to their reflected commitment to industrial R&D through the reception of funds from the State Government's largest industrial R&D funding scheme.

The aims of the WAISS evaluation included:

- Whether the scheme had achieved its objectives;
- An examination of the achievements by grantee firms;
- An examination of other benefits experienced by grantee firms;
- An examination of the resource impact on applicants;
- Whether the scheme was administered efficiently and effectively;

- Whether there were new investments within the State;
- Whether there was an increase in networks between researchers and industry; and
- An examination of the level of technology transfer to industry amongst the sample group of firms.

(Marinova et al, 1998, p4)

From the above aims, this study was concerned with whether WAISS had achieved its main objective, that is, an increase in investment in industrial R&D amongst grantee firms, and commercialisation of their technologies.

The evaluation found that the WAISS was successful in terms of achieving its main objective, where $3.20 was invested in R&D by grantee firms for every WAISS dollar received, and where a high rate of commercialisation was experienced for their technologies (Marinova et al, 1998, p.94).

Since it is widely accepted that direct investments in industrial R&D do not always have a direct affect on commercialisation (Hall, 1984, p.268), the broad objective of this thesis is to analyse how the grantee firms have commercialised their technologies.

## 1.1 Scope of the Study

To the researcher's knowledge, there is a current lack of strategies within the business marketing, industrial marketing, and high-technology marketing literature, that are available for technology-based, resource-scarce, small firms to commercialise their technologies in industry (Gross et al, 1993; Haas, 1986, Shanklin and Ryans, 1984; 1989). The marketing literature has addressed strategies for firms operating with an appropriate level of resources and skills to market their technologies, and therefore to attract a scope of potential industrial users.

These strategies do not, however, address the realistic circumstances experienced by the small firm, where a lack of resources and skills to adopt these strategies prevents the attraction of potential industrial users to their technologies (Porter, 1990a, p.205).

A strategy known as 'user-producer interaction', which is a marketing strategy that has been developed through the innovation literature (Saupin, 1997; Rothwell, 1972; Lundvall, 1985; Maidique & Zirger, 1984) deals with this issue by enabling the commercialisation of technologies by resource-scarce, small firms. User-producer interaction is the interaction between technology producers and industrial users that involves the communication of information about technological opportunities and user-needs (Lundvall, 1993, p. 285).

This study argues that the commercial opportunities derived through 'user-producer interaction' increases when technology-based, resource scarce, small firms interact with large industrial users who have the "complementary assets" (Teece, 1986) able to promote extensive product diversification and market expansion opportunities.

However, though there are advantages for both small technology producers and large industrial users to interact, there are barriers that may prevent interactions from taking place. These barriers will be discussed later in more detail.

## 1.2 Objectives of the Study

- To examine how grantee firms have overcome their impediments to commercialisation;
- To examine how the process of user-producer interaction has enabled grantee firms to commercialise their technologies;
- To examine the process of user-producer interaction with large and/or small industrial users, and the subsequent benefits derived;
- To examine the entry barriers faced by grantee firms in forming interactions with large industrial users.

## 1.3 Research Questions

1. How have grantee firms overcome their impediments?
2. How does the process of user-producer interaction facilitate the commercialisation of grantee firm technologies?
3. How does user-producer interaction with large industrial users affect the commercial extent of technologies as opposed to interactions with small industrial users?
4. How have entry barriers affected user-producer interactions with large industrial users?
5. Given that all firms demonstrate user-producer interaction to commercialise their technologies, why are some firms more successful than others?

## 1.4 Significance of the Research

This research has practical implications for the technology marketing practices of technology-based, resource-scarce, small firms who experience difficulties in commercialising their technologies in industry.

The research investigates a strategy termed user-producer interaction that:

- May enable small firms to step beyond their impediments enabling the commercialisation of their technologies.
- May enable small firms to become more prominent in their role of stimulating innovation and competition within large industrial sectors, creating employment and leveraging economic activity (ACOST, 1990, p.1);
- May reduce the globally high failure rates associated with the development of new technologies (Barclay & Benson, 1987) ; and
- Overall, may advance technological growth and social welfare within the Western Australian, as well as national and international economies.

## 1.5 Definition of Terms

***Complementary assets*** refer to "large-scale marketing and distribution channels, competitive manufacturing resources, after-sales support and specialist interconnected technologies" (Teece, 1986).

***Entry barriers*** are the risks associated with procuring new technologies from new technology producers from the perspective of the large firm. These barriers are external to the small firm (Hartley and Hutton, 1989).

***Grantee firms*** include those firms that have received the WAISS grant.

***Impediments*** are constraints internal to the small firm. This includes difficulties acquiring intellectual property rights, scale economies, finance and infrastructure capital, and external communications.

***Leading-edge technologies*** are basic technologies that are largely external to existing companies and market structures (Rothwell, 1983, p.6).

***Small firms*** in WA generally comprise between 1 to 500 employees.

***User-producer interaction*** is the interaction between technology producers and industrial users that involves the communication of information about technological opportunities and user-needs (Lundvall, 1993, p.285).

## 1.6 Organisation of the Study

The thesis is divided into six chapters:

This chapter has set out the background to this study, the study's scope, objectives, research questions and significance. A definition of terms used within this study has also been provided.

Chapter two forms the literature framed by the role of small firms in the development and commercialisation of new technologies.

Chapter three discusses the methodology setting out the methods and procedures used within the context of this study. It presents the research design, research setting, subjects of examination, data collection methods, data analysis measures and ethical considerations. The theoretical pathway adopted by this study is also presented.

Chapter four forms the case studies administered for the research. A comprehensive summary of each case is provided using the theoretical pathway outlined in chapter three.

Chapter five involves a cross-case analysis of the case firms where the cases are combined and analysed based on the theoretical pathway and the arguments presented within the literature.

Chapter six forms the conclusion to the study. The chapter presents an overview of the study, a summary of main findings, the limitations and further areas of research, concluding with implications for the technology marketing practices of technology-based, resource-scarce, small firms.

| |
|---|
| The next chapter forms the literature review framed by the role of small firms in the development and commercialisation of new technologies and is the basis upon which the theoretical pathway within this study was constructed. |

# CHAPTER TWO

# THE ROLE OF SMALL FIRMS IN THE DEVELOPMENT AND COMMERCIALISATION OF NEW TECHNOLOGIES

## 2.0 Introduction

This chapter focuses on the literature of small firms in the development and commercialisation of new technologies. Despite their technological capabilities, it is revealed that many small firms face impediments that may prevent the commercialisation of their technologies in industry.

To the researcher's knowledge, the marketing literature has not addressed strategies available for technology-based, resource-scarce, small firms to commercialise their technologies.

This thesis argues that a strategy of 'user-producer interaction', a marketing strategy that has been addressed within the innovation literature, may facilitate the commercialisation of small firm technologies (Saupin, 1997; Rothwell, 1972; Lundvall, 1985; Maidique & Zirger, 1984). This strategy demonstrates how small technology producers interacting with industrial users through the exchange of technological opportunities and user needs may acquire product-market fit and the simultaneous commercialisation of technologies (Lundvall, 1993, p.285).

The extent of commercialisation is argued to increase when small technology producers interact with large industrial users who have the "complementary assets" able to create extensive product diversification and market expansion opportunities for the technology-based, small firm (Teece, 1986).

There are, however, entry barriers faced by the small firm in forming interactions with large industrial users. These barriers include the risks involved in the adoption of new technologies from new technology-based firms.

## 2.1 The Role of Small Firms in the Development of New Technologies

Increasing attention has been paid to the role of small firms in the development of new technologies. According to the Advisory Council On Science and Technology (ACOST, 1990) small firms are responsible for the creation of leading-edge technologies that promote the depths of competition within large industrial sectors. ACOST supports its reasoning, citing the influence of small firms in major technological developments within the automobile, microelectronics and biotechnology industries. Dodgson (1987) also acknowledges the influence of small firms within information technology and new materials technology.

It is their ability to stimulate competition within industry that has influenced global research policy statements to place more emphasis on small firms in technological and industrial development (Rothwell and Zegveld, 1981).[1]

There are a number of government research programmes that have been developed to stimulate small firm technological activities. In the United States, the Small Business Innovation Research (SBIR) Programme contributes around 2 billion US dollars per year to support the R&D activities of technology-based, small firms.[2] In the United Kingdom, the Special Merit Award for Research and Technology (SMART) Scheme, a major programme supporting small technology firms contributes approximately 10 million pounds per year for investment in R&D activities (ACOST, 1990, p.ix).

In WA, though government funds for small firm R&D are substantially lower due to a smaller industrial and economic base, the importance of small firms in the generation of new technologies is similarly recognised. The Western Australian Research and Development Scheme (WAISS) is the State's current major initiative in support of small firm R&D. So far A$3 million has been contributed to the technological activities of small firms.[3]

The acknowledgment of small firms in the development of new technologies and their subjection to major policy initiatives springs from an ongoing debate as to whether large, or small firms, are responsible for a major share of innovations. Advocates for large firms claim that large size and market power are factors responsible for

---

[1] Small technology-based firms are also known for their effects on job creation (Storey, 1982), for regional economic regeneration and for leveraging national rates of technological innovation (Rothwell, 1984).
[2] See National SBIR Conferences (1998).
[3] See Appendix One.

technological activity, while those in support of small firms argue that small firms are more efficient at technological development due to unique behavioural and organisational characteristics (Rothwell, 1984).

There has been research attempting to resolve this debate aiming to provide some direction as to which firm may have the highest technological potential. Chakrabarti (1991) using a sample of 248 small firms in the US through correlational analysis, found smaller firms to be more efficient in generating new technologies than their larger competitors. Alternatively Tether, Smith & Thwaites (1997) re-examining the evidence provided by the Science Policy Research Unit (SPRU) Innovations Database between 1975-1983, found small firms to be a less significant source of new technologies than was originally conceived.

Rothwell's findings cited in ACOST (1990, p.20) may, however, prove more significance. In his study of 4,400 significant innovations made by British firms between 1945 and 1983, 37% of innovations arose from firms employing less than 500 individuals, and 23% from firms employing less than 100 individuals. His study also suggested that small firms are more effective at innovating. For example, firms employing between 100 and 499 employees who accounted for approximately 2% of UK industrial R&D produced 20% of total innovations.

Rothwell's findings afford small firms a technological advantage over their larger competitors. However, he is careful to admit that these findings are inconclusive unless technological strengths at varying stages of a product life cycle across different industrial sectors are independently researched (Rothwell, 1983). Taking the phase of development and use of the technology as significant factors, Roberts (1989) argued that small firms are more likely to be responsible in the earlier phases of a new technology (technology development), while large firms are likely to be more prominent in later phases (marketing and distribution).[4]

For the purpose of this study, it is argued that small firms play a significant role in what Freeman, Clark & Soete (1982) has referred to as 'entrepreneurial innovation' derived from Schumpeter's analysis of the technological capabilities of small firms. Rothwell (1983, p.6) defines entrepreneurial innovation as "the development of new basic technologies that are largely exogenous to existing companies and market structures". According to Ettlie and Rubenstein (1987) this means that small firms are responsible for the development of radical technologies, that is, leading-edge technologies.

The significance of small firms in the creation of leading-edge technologies ultimately depends on their communications with the external environment in order to commercialise their technologies within industry, and to remain competitive. Barber, Metcalfe & Porteous (1989, p.2) emphasised that small firms must continuously realign their technological activities in accordance to new technological developments and market needs that are external to the firm to successfully develop and commercialise their technologies.

This is where small firm technological activities are often inhibited. Many small firms face impediments that may affect the commercialisation of their technologies within industry. These impediments are discussed in the next section.

[4] Rothwell (1984) illustrates the important role new technology-based firms play during the early phases of innovation, using the example of the US Semiconductor industry.

## 2.2 Impediments Faced by the Technology-Based, Small firm

Small firms can be disadvantaged by a number of factors that may prevent or affect the way they commercialise their technologies within industry. These factors include difficulties acquiring:

- intellectual property rights (ACOST, 1990; Rothwell & Zegveld, 1982; Smith, Dickson & Smith, 1991);
- scale economies along the vertical chain (ACOST, 1990; Rothwell and Zegveld, 1982; Moore & Garnsey, 1993);
- finance and infrastructure capital (Hall, 1989; Moore and Garnsey, 1993; Barber et al, 1989); and
- external communications (Oakey, Rothwell, Beesley & Cooper, 1987; Sheen, 1992).

Each of these impediments is discussed in the next section.

### 2.2.1 Intellectual Property Rights

Small firms are a major source of new leading-edge technologies. However, ACOST (1990, p.56) argued that the development and protection of such a distinctive capability is necessary for the comfortable exposure of technologies within the external environment. According to Rothwell & Zegveld (1982, p.201), however, small firms are often unable to cope with the implications of acquiring intellectual property rights, having neither the time or funds for patent litigation.

In their examination of 27 cases of collaborative partnerships, Smith et al, (1991, p.464) found that when intellectual property rights are not in place, the small firm becomes a target of unfair behaviour by rivals who lack the same technological competence. If returns from investments in new technologies are not justified, then the small firm will be less likely to invest in new technological activities because of the possible repercussions of this behaviour.

### 2.2.2 Economies of Scale

Small firm must design appropriate products out of their knowledge base, and have the skills to efficiently manufacture, market and distribute these products (ACOST, 1990, p.43). However, an inability to achieve scale economies in R&D, production and marketing and to offer a portfolio of product lines is a barrier faced by most technology-based, small firms in commercialisation (Rothwell & Zegveld, 1982, p.51).

When a level of efficiency lacks within these departments, the firm is unlikely to generate funds for investments in product diversification and market expansion (Moore & Garnsey, 1993, p.508). This may override the industrial potential of initially developed technologies, eroding potential competitive advantages to the firm.

### 2.2.3 Finance and Infrastructure Capital

Technology-based, small firms have significant potential to create competition within industrial sectors. Most private sector firms, however, are unwilling to invest in these technologies mainly because of the high element of risk involved. Hall (1989) who deals with the issue between the needs of small firms and the willingness of holders of finance/capital to meet these needs attributes this to a level of uncertainty within the private sector.

A reflection of this uncertainty is acknowledged by Moore & Garnsey (1993, p.508) who alleged that for external investors the problems of assessing the caliber of technologies is higher than for those in the R&D team. They further claimed that investors place as much weight on the firm's mass capabilities as on the viability of the development work being undertaken, which may sway private sector decisions away from the funding of small firm R&D projects.

These mass capabilities according to Barber et al (1989, p.11) may relate to the inability of small firms to present credible business plans and documentation to potential external investors. They thus argue that not all "capital market deficiencies" are a result of private sector unwillingness to invest in small firm technologies. The credibility of the small firm's search for finance and infrastructure capital may ultimately depend on its marketing efforts to emphasise the leading-edge nature of their technologies and to therefore influence private sector firms to invest.

### 2.2.4 External Communications

The generation of relevant scientific and technical knowledge is crucial for the development of new technologies by small high-technology firms (Oakey et al, 1987, p.155). In her examination of six pharmaceutical companies through in-depth interviews Sheen (1992), however, finds that the small firm often lacks the time, resources and skills to acquire such information. This inability to monitor technical trends may mean small firms are unlikely to acquire first to market advantages and therefore unlikely to attract the interests of industrial users who may invest in and commercialise their technologies. The root to this complacency with regard to the search for external technological information may be due to a lack of qualified technical specialists within the firm.

#### 2.2.4.1 Qualified Technical Specialists

The generation of external technical information by small firms is contingent on the employment of qualified scientists and engineers who may determine the acquisition of an "optimal" amount of necessary technical knowledge enabling small firms to run technologically advanced operations. This "optimal" amount of technical knowledge is heavily dependent upon the employment of "suitably" qualified specialists (Rothwell & Dodgson, 1991, p.131).

Freeman (1991, p.501) explains that there is often a tendency for "information overload", where technical employees may experience difficulties in matching information to the quality and volume needs of the firm. The implications of having unsuitable technical specialists, unable to acquire appropriate technical information, may mean that potential competitive advantages are lost because these specialists often overlook possible product development and market expansion opportunities.

According to Porter (1990a, p.205) the impediments related to intellectual property, economies of scale, finance and capital and external communications, leave the small firm "stuck" in a fragmented state (ie. the small firm has well-developed technologies but lacks the resources and skills to commercialise these technologies within industry).

Technology-based, small firms face most of the previously discussed impediments. However, these impediments are not necessarily binding constraints preventing the commercialisation of “all” small firm technologies. The commercialisation of small firm technologies will depend on the willingness and ability of small firms to exploit the availability of external resources and to take advantage of market opportunities, implying a more active role for marketing staff.

Ultimately the commercialisation of small firm technologies and the alleviation of these impediments lie in the interaction between the inherent motivation and capabilities of marketing employees and the external environment (McGee, 1989). The next section will evaluate the technology marketing strategies available for small firms to commercialise their technologies given their associated impediments.

## 2.3 Technology Marketing Strategies Available for the Technology-Based, Resource-Scarce, Small Firm

According to the researcher's knowledge, the marketing literature has not addressed strategies available for technology-based, resource-scarce, small firms to commercialise their technologies within industry. The business and industrial marketing literature has addressed marketing strategies for firms with an appropriate level of resources and skills, rather than the more realistic circumstances experienced by the small firm (Gross et al, 1993; Haas, 1986, 1992; Webster, 1984; Hutt and Speh, 1995; Morris, 1992; Romer and Van Doren, 1993; Eckles, 1990).

Similarly, the high-technology marketing literature assumes all firms are resource abundant and have the ability to adopt these strategies (Shanklin and Ryans, 1984, 1989; Link, 1987; Midgley, 1977; Rexroad, 1983). This is, however, not the case, especially with regards to the technology-based, small firm that lacks the resources and skills to commercialise their technologies, let alone have the resources and skills to adopt the strategies pronounced within the marketing literature.

There is, however, a marketing strategy particularly relevant to the technology-based, resource scarce, small firm within the industrial innovation literature (Saupin, 1997). The strategy known as 'user-producer interaction' accommodates the resource deficiencies of small firms by promoting the commercialisation of small firm technologies through interactions with industrial users. Close interactions with these industrial users enables small firms to assess the technological needs of these users and to develop technologies in accordance with these needs, enabling product-market fit and hence the commercialisation of their technologies within industry.

The commercial opportunities derived by the small firm increases when the small firm interacts with large industrial users who have the large-scale marketing resources and distribution channels for generating wide market appeal, ultimately creating opportunities for market expansion and product diversification. The following two sections discuss the strategy of user-producer interaction and the benefits of interacting with large industrial users.

## 2.4 User-Producer Interaction as a Marketing Strategy for the Technology-Based, Resource-Scarce, Small Firm

The rapid pace of technology change and the need for firms to sustain competitive advantages (Saxenian, 1991; Mowery, 1989; Watkins, 1991; Bertodo, 1990) have encouraged technology producers to move away from the traditional transaction approach to a more interactive approach with industrial customers (Larrson, 1993). Many studies have attributed interactions with industrial customers for technological and commercial success (Lundvall, 1985; Maidique and Zirger, 1984; Mueser, 1985; Beesley and Rothwell, 1987).

The most noted of these studies is project SAPPHO, and perhaps the most detailed empirical study of technological innovations. Measuring approximately one hundred characteristics of 40 pairs of innovations, one of the 12 characteristics that consistently distinguished between commercial success and failure were user-producer linkages and/or close interactions with industrial customers (Rothwell, 1972).

One of the first authors to acknowledge customers in the innovation process was Von Hippel (1976; 1977; 1978) who brought into effect the user-dominated/customer-active paradigm. His key finding in 1976 was that users rather than producers initiated approximately 80 percent of the 111 scientific instrument innovations studied. These users who were able to initiate new technologies through defining new requirements, formed a major source of technological know-how, tested prototypes, and reduced the risk of technical failure often associated with the development of new technologies (Gemunden and Heydebreck, 1995, p. 90-91).

In later years recognising the opportunity costs[5] of relying on present customer needs he introduced the concept of lead users (Von Hippel, 1986, 1989; Urban and Von Hippel, 1988) characterised with latent demand states. As a result these lead users enabled technology producers to pre-empt the development of leading edge technologies that acquired first to market advantages and a competitive market position for the firm. However, these advantages were only temporary since the construct remained essentially linear through technology development.

In order to sustain or expand their competitive positions, technology producers were required to closely integrate with lead users throughout technology development, bringing into effect what Hagedoorn and Schakenraad (1992) has termed the "strategic-based relationship".

Bar & Borrus (1992) brings this relationship into focus emphasising the need for a more dynamic problem-solving type relationship between users and producers. This relationship involves the continuous examination of user needs and the development of technologies in accordance with those needs so as to ensure continuous product-market fit and therefore the successful, as well as successive commercialisation of small firm technologies (Shaw, 1987).

[5] Von Hippel recognised that by focusing on customers with present needs he was foregoing the opportunity of focusing on customers with advanced technical needs who have already considered the needs of present customers.

These efforts between producers and users in technology development may be either near or distant interactions. In their empirical study of 848 manufacturing companies, Gemunden, Heydebreck & Herden (1992) finds close contacts between technology producers and industrial users during the development of new technologies are significant to commercial success. Cooke and Morgan (1994) also emphasised the importance of having close contacts with industrial users, arguing for the reduction in geographical boundaries through an environment encouraging local user-producer networks.

Gertler (1993) also supported the above views arguing that technology development difficulties arise when users and producers of advanced technologies are physically, organisationally and socially distant from one another. However, Gertler (1993, p.674) also justified circumstances for more distant interactions. He emphasised that "large" industrial users, independent of their location, will be served by distant producers because of the opportunity to access large scale resources within these firms – resources that may generate a wider market appeal for producer technologies. (These resources, known as "complementary assets", will be discussed in the next section.)

Examples of successful distant user-producer interactions have been emphasised by Sabel, Herrigel, Kazis & Deeg (1987) demonstrating that close relationships may be maintained between users and producers across different countries. Porter (1990b) also supported the success of international relationships between users and producers of technologies, referring to Japanese and Italian producers of advanced technologies.

Given the success of user-producer interactions and the potential these interactions have in developing and commercialising technologies, then the question remains as to what is the best way to initiate these interactions given the impediments of small firms.

The literature has argued for the creation of user linkages through an integrative approach by the marketing and R&D departments within the producer firm (Littler, 1994; Moenaert & Souder, 1990). In essence, an integration of the R&D and marketing departments will break down the barriers between producers and users, enabling the effective communication of technological opportunities and an understanding of the emerging technological needs of potential users (Sashittal & Wilemon, 1994).

While user-producer interactions are significant for the development and commercialisation of small firm technologies, not all users according to Rothwell (1994, p.636) are of equal value. He stresses that the extent to which technologies will be successfully developed and commercialised will depend on selecting industrial users that are technically proficient and with a credible history in the adoption and use of technologies developed by other producers.

Lovett (1992) on the other hand, emphasised that establishing a productive relationship requires effort and commitment from not only users, but also producers. To this extent Biemans (1992, p.112) argued that producers should make the technological adoption process easier and more enticing for potential industrial users through conveying the technology's characteristics into "quantified benefits".

However, Davidow (1986) highlighted that as advanced technologies are becoming harder to differentiate and simultaneously complex, the producer must learn to distinguish its technologies through a relationship based on trust and commitment with its industrial users. Ultimately this relationship will enable effective channels and codes of information to be developed, bringing efficient and successive technological exchanges (Lundvall, 1993, p.285). User-producer interactions must therefore be socially, as well as technologically oriented.

Lundvall (1988) argued that when relationships are strategic, passivity may force relationships to become inward looking, overlooking external opportunities. This was rejected by Rothwell & Gardiner (1990) and Rothwell (1986) who highlighted that user-producer interactions enable "re-innovations and re-designs" as a result of the continuous integrated efforts between the two parties in response to changing technological developments and industrial needs. These re-innovations and re-designs become more apparent when "design flexibility" is incorporated in original technologies, leaving room for potential product diversification opportunities (Rothwell and Gardiner, 1988a, 1988b).

The construct of user-producer interaction is a marketing strategy that technology-based, resource-scarce, small firms may adopt to successfully develop and commercialise their technologies within industry. Dyadic interactions with industrial users enable technology producers to develop technologies in accordance to the user's technical needs and requirements, simultaneously achieving product-market fit and hence the commercialisation of technologies.

User-producer interactions may be profitable for small producer firms through interactions with either small or large industrial users. However, it is argued that the level of this profitability, in terms of the scope of development and commercialisation of technologies, may be leveraged when small firms interact with large industrial users who have the resources to compete in large established markets.

This is supported by Rothwell and Zegveld (1982, p.44) who claim that though interactions with small firms may be profitable in highly segmented markets for specialist products, when small firms begin to compete within larger markets, high volumes of capital and large scale economies become a prerequisite for competition. Hence the ability for small firms to compete in large established markets is often coupled with the resources of the large firm.

Schumpeter had acknowledged the need for small producer firms to integrate with large industrial users within large established markets as early as 1939. He argued that the level of commercialisation and extent of influence small firm technologies will have on industrial developments will ultimately depend on the efforts of large firms who have the resources and market power to create market expansion and product diversification opportunities for these technologies. Successful and successive technological innovations result because of the "complementarities" between large and small firms.

The next section discusses how the commercial opportunities generated within user-producer interactions increase when technology-based, small firms interacts with large industrial users.

## 2.5 Interactions with Large Industrial Users as a Basis for User-Producer Interactions

It is the "complementary assets" of large industrial users that encourages small firms to interact with them. Complementary assets refers to "large-scale marketing and distribution channels, competitive manufacturing resources, after-sales support and specialist interconnected technologies" (Teece, 1986). Access to these resources enables the successful but more importantly successive commercialisation of small firm technologies through exposure to an array of product diversification and market expansion opportunities.

These "complementary assets" are also referred to by MacDonald (1992) as mutual complementarities and by Rothwell (1983, 1989a) as "dynamic complementarities" in his examination of large/small firm interactions within the semi-conductor, CAD and biotechnology sectors.

According to Rothwell and Dodgson (1991, p.128) these complementarities are revealed in the advantages and disadvantages of both large and small firms,[6] where the resources held by one party can alleviate the resource constraints experienced by the other party. For large firms, advantages tend to centre on large financial and marketing resources, while disadvantages concern a lack of technological expertise; for small firms this tends to be the opposite, where advantages relate to technological competencies, and where disadvantages include a lack of financial, distribution and marketing resources.

[6] The advantages of large firms include large financial and qualified manpower resources, extended external scientific and technical networks, large marketing resources, comprehensive range of management skills, etc. The advantages of small firms include management dynamism, organisational flexibility, rapid internal communication, high degree of adaptability, etc. (See Rothwell and Zegveld, 1982)

Pisano (1991, p.241) demonstrates these complementarities in his study of the development and commercialisation of technologies by small biotechnology firms. He emphasised that a combination of technological compatibilities and specialist expertise were reasons why large established firms acquire biotechnologies from new biotechnology firms. On the other hand, access to financial, capital and marketing resources formed reasons as to why small new biotechnology firms were willing to commercialise their technologies through large established firms.

The reasons identified by Pisano have also formed the basis of interactions between large industrial users and small technology producers examined by Von Hippel (1976) and Shaw (1988), Roberts and Berry (1985) and Maier (1988). There are many modes of large/small firm interactions,[7] which involve essentially technological exchanges driven by the complementarities of both firms. However, the reasons for large/small firm interactions often go beyond the interests of small firms to simply commercialise their technologies, and the interests of large firms to access new technologies.

Hagedoorn & Schakenraad (1990) reviewing developments in biotechnology, information technology and material technology found that in addition to technological complementarities, a reduction in lead times and market positioning were main stimulants to interaction between large and small firms. Analysing the development of new computer systems in Silicon Valley, Saxenian (1991) also supports these findings. Saxenian, further, argued that small firms which failed to interact with large industrial users were unable to remain

[7] Modes of large/small firm interactions include manufacturing subcontracting relationships; producer/customer relationships; licensing agreements; contract-out R&D; collaborative developments; large/small firm joint ventures; educational acquisitions; sponsored spin-outs, venture nurturing; independent spin-out assistance; and personnel secondment (Rothwell, 1989b).

competitive because of the first to market advantages achieved via those firms that were interacting.

Technology-based, small firms are also stimulated to interact with large industrial users because of the exposure these firms generate across industrial markets, creating a network of new contacts for the small firm (Katz and Martin, 1997, p.15). This commercial visibility ultimately attracts other industrial users for the small firm's technologies, increasing their potential for wider commercial applications through product diversification and market expansion opportunities.

The adoption of strategies promoting user-producer interaction with large industrial users is therefore argued to bring a myriad of commercial opportunities for the small firm. There are, however, several barriers the small firm may face in trying to pursue these interactions with "large" industrial users.

### 2.5.1 Barriers to Interactions with Large Industrial Users

The ability of small firms to compete is often constrained by conditions internal, as well as, external to the firm (Taylor and Thrift, 1983). In this sense, given that small firms can overcome their impediments through the adoption of user-producer methods of interaction with large industrial users, there are, however, external barriers that may prevent small firms pursuing a relationship with these large industrial users.

According to Hartley and Hutton (1989) these barriers relate to the high risk of procuring new technologies from unknown producers. Furthermore, they argue that since most small firms lack an established reputation, large industrial users have tended to rely on established producers with an established reputation to avoid certain technological risks.

Hennart (1988) and Teece (1987) also emphasised that this risk derives from the fact that potential users do not have as thorough an understanding of the information associated with the new technology as the producer does. Therefore, large industrial users prefer producers with which they have previous experience (Cunningham and White) cited in (Barber et al, 1989, p.113).

Small firms, as a result, are often faced with the cost of convincing potential large users of the credibility of their technologies and their potential within industry (Harley and Hutton, 1989). To this extent small firms perceive they are able to persuade approximately half of the decisions by which large firms select technology producers (Forrester &West, 1985, p.25).

Watkins (1991, p.92) argued that it is likely interactions between large users and small producers are more successful when the firms involved are compatible in "institutional culture and technical capabilities", and where there is opportunity for sustained interactions.

## 2.6 Summary

The chapter has emphasised the small firm's role in the development of leading edge technologies. It is shown that despite their technological capabilities they experience difficulties commercialising their technologies within industry. These difficulties spring from their impediments they face as a small firm.

These impediments include their inability to develop intellectual property rights, their incapacity to create economies of scale, and their incapability to attract potential investors for financial and capital leverage. The most debilitating of these impediments is their lack of external communications efforts, which reduces the opportunity for the development of technologies with potential competitive advantages and therefore reduces the opportunity to attract potential industrial users. This will, however, ultimately depend on the technical specialists employed by the firm responsible for the retrieval of appropriate external information.

According to the researcher's knowledge, the marketing literature reveals that there are currently no strategies available for technology-based, resource-scarce, small firms for the commercialisation of their technologies within industry. The innovation literature has addressed this issue through a marketing strategy termed 'user-producer interaction'.

User-producer interaction involves the dyadic interaction between technology producers and industrial users about technological opportunities and user needs that enables product-market fit and the commercialisation of small firm technologies. The extent of this commercialisation is argued to increase when technology-based, small firms interact with large industrial users able to create product diversification and market expansion opportunities via their large-scale marketing and distribution resources.

There are, however, barriers that the small firm may face in initiating user-producer interactions with large industrial users, which includes the risks in the adoption of new technologies from new technology-based firms.

| |
|---|
| The next chapter will discuss the methodology for this study. It presents the research design, research setting, subjects of examination, data collection methods, data analysis measures and ethical considerations. The theoretical pathway adopted by this study is also presented. |

# CHAPTER THREE

# METHODOLOGY

## 3.0 Introduction

This chapter sets out the methods and procedures used within the context of this study. It presents the research design, the research setting and the subjects of examination. The data collection methods and data analysis measures are also presented. The theoretical pathway adopted by this study is illustrated and the ethical considerations are noted.

## 3.1 Research Design

This study uses a multiple-holistic case study design that uses qualitative methodology involving a combination of secondary data and face-to-face interviews with the managers of firms that have received funding under the WAISS.

According to Yin (1981a, 1981b) quoted by Yin (1989, p.23) a case study is an empirical inquiry that:

- "Investigates a contemporary phenomenon within its real-life context;
- When the boundaries between phenomenon and context are not clearly evident; and in which
- Multiple sources of evidence are used."

This study fits in within the context of this definition. This study:

- Investigates user-producer interaction in the commercialisation of small firm technologies within industry;
- The boundaries between user-producer interaction and the commercialisation of small firm technologies are not clearly evident;
- Documentation, interviews and direct observations are employed by the research.

Miles and Huberman (1994) and Taylor and Bogdan (1984) have supported the use of case studies adopting a qualitative research methodology. Miles and Huberman (1984) have given emphasis to its provision for a chronological flow of events that extracts in-depth information from a close appraisal of the informant's experiences and perceptions.

The case study methodology in this study allows for a comprehensive chain of events provided by small firm managers who can account for:

- ♦ how their firm conceived their technological ideas;
- ♦ how they pursued the development of these technologies;
- ♦ the impediments they faced during technological development;
- ♦ their experiences with other technology-based firms during technological development;
- ♦ the interactions with industrial users that enabled the commercialisation of their technologies;
- ♦ the extent of commercial opportunities derived from interactions with large and/or small industrial users; and
- ♦ the barriers faced to interactions with large industrial users.

This provided the basis upon which the research questions for this study were answered. The research questions were:

1. How have grantee firms overcome their impediments?
2. How does the process of user-producer interaction facilitate the commercialisation of grantee firm technologies?
3. How does user-producer interaction facilitated with large industrial users affect the commercial extent of technologies as opposed to interactions with small industrial users?
4. How have entry barriers affected user-producer interactions with large industrial users?

Hamel (1993) also encourages the case study methodology through emphasising the exploration of the social experiences of informants. The case study methodology therefore allowed for the examination of the social, as well as the technological orientation of user-producer interactions. For example, the data revealed:

- the trust and commitment that was built with industrial users; and
- the strategic relationships that were formed.

These two aspects of social interaction formed the basis of what this study has called the social significance of user-producer interaction.

The innovation literature has supported the adoption of case study methodology in the evaluation of interactions between technology producers and industrial users, where Dodgson cited in Dodgson & Rothwell (1991, p.132), Rothwell (1984) and Saupin (1995) have all successfully adopted the approach. Dodgson and Rothwell further use the methodology to analyse the commercial extent derived from interactions between technology-based, small firms and large industrial users, which is a subject also examined by this study.

The support for case study methodology also comes with reservations. According to Yin (1989) and Edwards (1998, p.13) one concern is the rigour of case study research, where many perceive biased views to influence the direction of the research and ultimate conclusions. However, it can be argued that bias is also often entered in the conduct of experiments (Rosenthal, 1966) and in composing questionnaires for surveys (Sudman and Bradburn, 1982) quoted by Yin (1989, p.21).

Although quantitative methods have the advantage of allowing researchers to measure and control variables, providing rigour within a study; these quantitative methods cannot account for the unique characteristics of individual cases (Edwards, 1998, p.1).

Perhaps the most documented concern with regards to case studies is the ability of the results to become generalised across populations and universes (Guba and Lincoln, 1981). However, Yin (1989) argued that similar to experiments, case studies are generalisable to theoretical propositions, where these theoretical propositions become the vehicle for generalising future cases.

The theoretical propositions within this study are:

1. User-producer interaction facilitates the commercialisation of small firm technologies through a dyadic, problem-solving style approach through technology development.
2. The larger the industrial user, the greater the level of commercial opportunities experienced by the technology-based, small firm.
3. Firms with a lesser extent of commercial opportunities are more likely to face barriers to interactions with large industrial users.

In the process of rigorous theory testing of specific propositions, case studies are argued to be equally as reliable as experimental research since findings and generalisations may also be tested within future cases (Bromley, 1986; Mitchell, 1983).

This study attempts to reduce the concerns of case study research through the application of rigorous testing by adopting a series of measures outlined by Yin (1989) to conduct explicit case study research and to exemplify the relevant results in accordance to research objectives. The criteria for judging the quality of any research design include four relevant tests - the test for external validity, reliability, construct validity and internal validity. Each test is justified in this study through the employment of case study tactics supported by Yin (1989).

### 3.1.1 External Validity

External validity refers to the generalisability of research findings to real situations (Edwards, 1998, p.15).

External validity is strengthened when replication is warranted amongst multiple cases. Each case must be selected so that either *a literal replication* (predicts similar results) or a *theoretical replication* (produces contrary results but for predictable reasons) is derived (Yin 1989, p.53). Herson & Barlow (cited in Yin, 1989, p.53) argued that this replication logic is similar to that used within multiple experiments.

The firms within this study were selected on the basis that each demonstrated a high value for interactions both in R&D and commercial activities with other firms (the basis of user-producer interaction). In this study, a literal replication could be that user-producer interaction commercialised all small firm technologies as a result of a dyadic problem-solving style approach through technology development. This replication would substantially increase the external validity of the study.

A theoretical replication in this study could be that firms experienced different levels of commercialisation as a result of interactions with large and/or small industrial users.

### 3.1.2 Reliability

Kiddler (cited in Yin, 1989, p. 41) defines reliability as a test to demonstrate that the operations of a study may be repeated with the same results.

The test for reliability is strengthened through the adoption of a *case study protocol*. The main element of the case study protocol is a set of questions reflecting the actual inquiry (Yin, 1989, p.76). The questions for this study were based from the literature in chapter two. (See appendix three) These questions were also based on the theoretical pathway presented in figure 3.6, therefore making the pattern matching logic adopted by this study easier to substantiate and the overall analysis more systematic. (see internal validity)

### 3.1.3 Construct Validity

Kiddler (cited in Yin, 1989, p. 40) defines construct validity as using the correct set of measures to analyse the concepts being studied.

The test for construct validity is justified using *multiple sources of evidence*. There are generally six sources of evidence contingent within case studies which includes documentation, archival records, interviews, direct observation, participant observation and physical artifacts (Yin, 1989, p.85). Three of these sources were used including documentation, interviews and direct observations, which helped to address historical, attitudinal and observational issues.

The support for construct validity is also justified through *a chain of evidence* where the reader is able to follow the derived evidence from initial research questions to case study conclusions (Yin 1989, p102). This is justified through the theoretical pathway adopted by this study which was constructed from the literature, reflected in the evidence derived from the case studies, and incorporated within the conclusions of the study, where each phase within the theoretical pathway systematically addresses the research questions proposed within this study.

### 3.1.4 Internal Validity

Kiddler (cited in Yin, 1989, p.40) defines internal validity as a test where certain conditions demonstrate a causal relationship.

To meet the test for internal validity, a case study according to Yin (1989) must adopt one of three dominant analytical techniques, which includes pattern matching, explanation building or time-series analysis.

This study adopted the *pattern matching system* and is one of the most preferred analytical techniques of case study researchers. The pattern matching logic compares an empirically based pattern with a predicted one (Yin, 1989, p.109).

The data in this study is analysed in accordance to the theoretical pathway in figure 3.6 constructed from multiple sources within the literature, and from which the theoretical propositions outlined earlier in this chapter have been based. If the pattern of case evidence coincides with the pattern set out within the theoretical pathway, providing support for theoretical propositions, then the results will strengthen the case study's internal validity.

## 3.2 Research Setting

The study formed part of a larger study conducted by members of the ISTP at Murdoch University in 1998. Their study concerned the evaluation of the State Government funding scheme in support for the industrial R&D activities of Western Australian technology-based, small firms - (WAISS).

The evaluation served to address a range of issues concerning the achievement of the scheme's objectives, achievements of grantee firms and the resource impacts on applicants. The efficiency and effectiveness of program administration, new investment within the State, extent of strategic networks between researchers and industry, and the level of technology transfer to the State's industry among the sample group of applicants, were also reviewed (Marinova et al, 1998, p.10).

Both firm and administrative interviews were conducted for the evaluation through open-ended questionnaires. This combined number totalled 100 interviews. The firm interviews involved three groups of applicants. These included successful/grantee applicants, unsuccessful applicants, and non-applicants.

Grantee applicants comprised a total of 48 companies; unsuccessful applicants made up a total of 24, which were chosen, at random from the Department of Commerce and Trade's database using a ratio of 1:12. A sample of non-applicants was chosen at random from the DCT's R&D Directory database. The administrative interviews focused on personnel responsible for the administration of the scheme. Ten interviews were conducted.

It is the group of successful/grantee applicants that was of interest to this study due to their reflected commitment to industrial R&D through the reception of funds from the State Government's largest industrial R&D funding scheme.

As has been already mentioned within the opening paragraphs of the first chapter, the evaluators of the WAISS found the overall scheme to be successful, with their main finding signifying increased investments in industrial R&D by WAISS grantees and a high rate of commercialisation for their technologies. Since it is widely accepted that direct investments in industrial R&D do not have direct affects on the commercialisation of technologies (Hall, 1984, p.268), *the main objective of this study set out to analyse how grantee firms have commercialised their technologies.* From arguments based within the literature the following objectives flowed:

- To examine how grantee firms have overcome their impediments to commercialisation;
- To examine how the process of user-producer interaction has enabled grantee firms to commercialise their technologies;
- To examine the process of user-producer interaction with large and/or small industrial users, and the subsequent benefits derived;
- To examine the entry barriers faced by grantee firms in forming interactions with large industrial users.

Out of the 48 firms that received the WAISS grant, those firms that signified a high value for interactions with other firms in both R&D and commercial activities (the basis of user-producer interaction) were selected for the research. The selection was based on the information derived from the questionnaire for the WAISS evaluation. (See appendix two, question 4) This consisted of 8 out of the 48 firms. During the progress of the research this was finally reduced to 5 firms due the absence of managers overseas, and a misinterpretation by one of the firms on the original WAISS questionnaire.

### 3.3 Subjects of the Study

The study conducted face-to-face interviews with the managers of the five technology-based, small firms who were responsible for overall operations and therefore with the ability to provide an overall account of the conception, development and commercialisation of technologies.

### 3.4 Data Collection Methods

The study used three sources of evidence: documentation, interviews and direct observation.

### 3.4.1 Documentation

Background information for each of the five firms was reviewed and documented at Murdoch University's ISTP before initiating contact with the selected firms. This information was derived from the questionnaire administered to these firms for the WAISS evaluation. See appendix two.

The managers of each of the five firms were then sent a letter thanking them for their consent and provided the main details of the interview.

### 3.4.2 Interviews

This study used in-depth interviews. The background information derived during earlier research stages was taken advantage of to build a rapport with the informants, as well as to demonstrate an understanding of their operations and technologies. During this time the subjects were informed of the objectives of the study and the study's overall significance to the technology marketing practices of technology-based, resource-scarce, small firms.

The interviews ranged from 45 to 90 minutes following a set of questions. See appendix three. The questions were based around the main themes within the literature and framed by the theoretical pathway adopted by this study, examining:

- their commitment in industrial R&D;
- impediments faced;
- user-producer interactions;
- the context of these interactions with large and or small industrial users; and

- the barriers faced in their interactions with large user firms.

Follow-up interviews were made to clarify information acquired within the original interviews. These interviews approximated 30 minutes.

All interviews were handwritten and not tape recorded as this was thought to put the informant at greater ease and therefore more comfortable in answering questions. During each interview, observations were also noted. All interviews were typed and filed.

### 3.4.3 <u>Direct Observation</u>

Field observations were demonstrated in this study through witnessing the tangible technologies that were developed by the firm, and in four out of the five cases the firm's production facilities. This gave the researcher an understanding of the technology as well as the opportunity to probe for further comments by the informant of the operational activities of the firm.

## 3.5 Data Analysis Measures

The study adopted the pattern matching logic for data analysis guided by the theoretical pathway.

The analysis involved two stages, which is supported by Yin (1989, p.56).

1. Each case was analysed independently under major themes derived from the theoretical pathway.

2. The cases were then combined and a cross-case analysis conducted. The analysis was framed by the theoretical pathway and compared and contrasted from the literature presented in chapter two.

## 3.6 The Theoretical Pathway

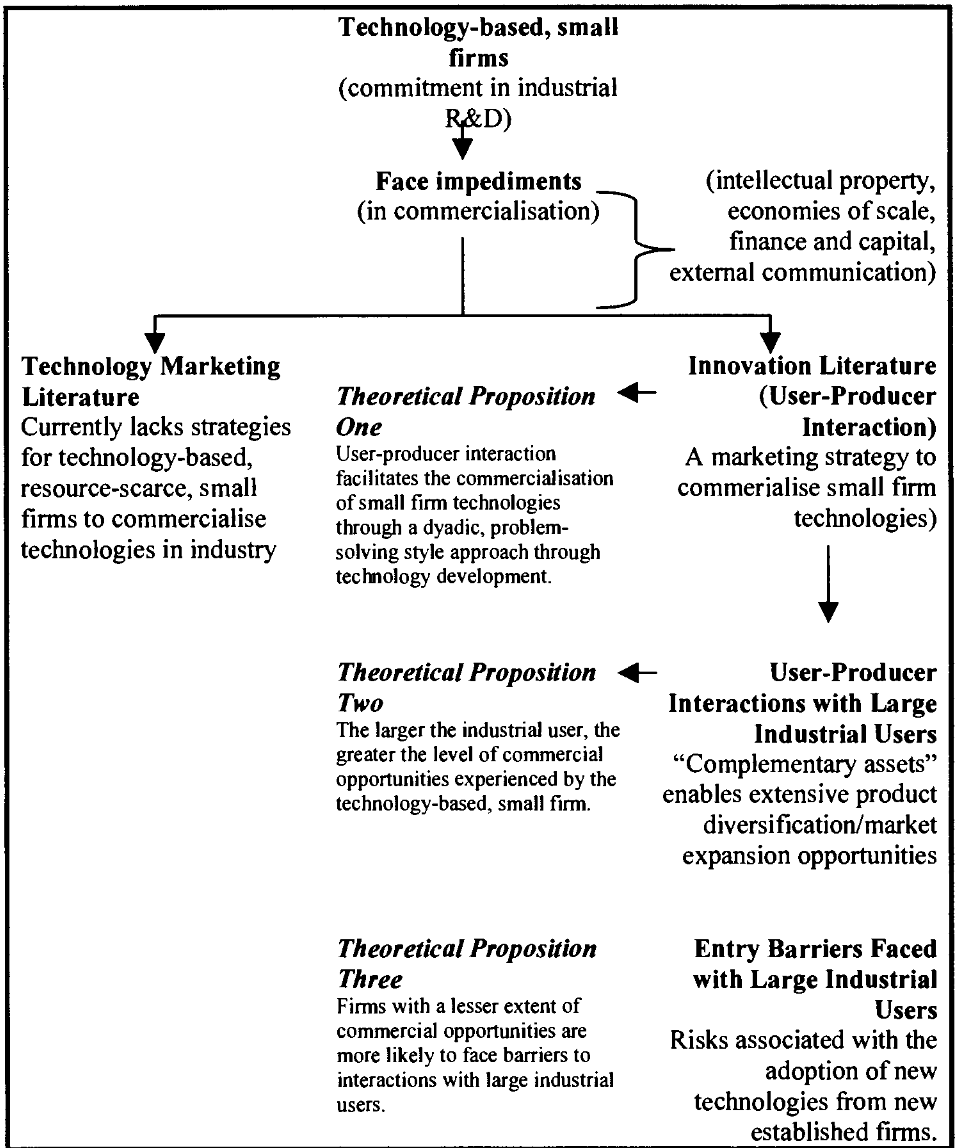


**Figure 3.6 Theoretical Pathway**[8]

[8] Based on arguments presented by Haas (1986); Shanklin & Ryans (1984); Rothwell (1972); Lundavll (1985); Maidique & Zirger; 1984; Teece (1986); Hartley and Hutton (1989) and others – see literature review.

### 3.7 Ethical Considerations

- Permission to undertake the research was granted by the Ethics Committee at Edith Cowan University in February 1998.
- Informed consent was obtained from respondents prior to the commencement of each interview; and confidentiality and anonymity were granted.
- The evaluation upon which this research was based is yet to be published. Until publication of this evaluation, this thesis remains **CONFIDENTIAL** and is not publicly available until otherwise advised by the authors of the evaluation.
- The latter does not apply to the ISTP at Murdoch University, the Department of Commerce and Trade, and the examiners of this thesis.

| |
|---|
| The next chapter forms the case studies administered for the research. The theoretical pathway presented within this chapter guides a comprehensive analysis of each case. |

# CHAPTER FOUR

# THE CASE STUDIES

## 4.0 Introduction

The following chapter examines five cases of technology-based, resource-scarce, Western Australian small firms that are significant in interacting with other firms in R&D and commercial activities. The chapter analyses each case based on the theoretical pathway presented in chapter three by examining:

- The firm's commitment in industrial R&D;
- Their impediments faced;
- The process of user-producer interaction that has commercialised their technologies;
- The commercial extent derived from their interactions with large and/or small industrial users; and
- The entry barriers they faced in forming interactions with large industrial users.

## 4.1 Case A

### 4.1.1 Commitment in Industrial R&D

"A" is a small Western Australian firm specialising in the development of weigh-bridge and video-image processing technologies for the railway and mining industries. The firm was incorporated in 1993 with two staff and in the first year of operation produced a net turnover of approximately A$100,000. One hundred percent of this turnover was allocated towards further R&D activities. By 1997/98, "A" employed seven full-time R&D staff skilled in engineering and computing. The chief engineer inclusive within this R&D team was also responsible for the marketing activities of the firm. During that year they experienced a net annual turnover of A$800,000 where seventy percent of this turnover was allocated towards further R&D.

Throughout this period they have received a WAISS grant for the development of an automatic car identification system using optical character recognition (OCR), forming part of their video-image processing technologies. They have also won an R&D Start grant worth around A$1 million to develop a video imaging system for the North American railway market.

***The idea for weigh-bridge and video-image processing technologies***

"A" has come along way since its inception in 1993. Prior to incorporation of the firm, its chief engineer worked for BHPIO Iron Ore (BHPIO) as a senior research engineer from 1986 to 1990. His wife, "A's" executive officer, also worked for BHPIO as a financial analyst from 1986 to 1989.

It was during this time with BHPIO that the chief engineer realised the potential for technological advancements within railway engineering and was where his initial ideas on weigh-bridge and video-image processing technologies were conceived. His ambition to pursue these ideas and to take on a more autonomous role encouraged him to leave BHPIO and form a partnership with his wife to specialise in the development of these technologies. “A” was a continuation of this partnership.

### 4.1.2 Impediments Faced

Operating as a partnership from 1990 both the chief engineer and the executive officer conducted R&D activities from their home in Sorrento. While the chief engineer worked on technical developments, the executive officer concentrated on the more administrative details of the partnership. Like most small firms they experienced difficulties with regards to finance and infrastructure capital available for R&D tasks. They were unable to attract the interests of external investors, as they were a new firm with leading-edge technologies that evidently posed a substantial risk. To enable them to continue their efforts in R&D they took a second mortgage on their house.

During this time the chief engineer developed several prototypes of PC based in-motion-weighing systems, the first of its kind. He also made major breakthroughs developing a wheel-rail interaction monitoring system using video-image processing technology. Uncommon within most small firms, intellectual property rights were acquired for each technology, as the chief engineer was sufficiently skilled in this area through his experience with BHPIO. The chief engineer’s expertise also enabled the firm to keep up-to-date with the latest industrial and technical trends therefore minimising the external communication difficulties usually experienced by most small firms.

However, an inability to effectively market these technologies prevented the firm from attracting potential industrial users and therefore from acquiring subsequent scale economies. The chief engineer, who was determined his technologies were leading-edge with the potential to bring significant advantages within the railway industry approached BHPIO with his technologies.

Fortunately, the chief engineer had managed to maintain informal relations with BHPIO even after leaving the firm. In fact, the chief engineer's technical skills were so highly valued by BHPIO that they were unable to find an employee with the same technical expertise. Subsequent meetings led BHPIO to realise the potential of the chief engineer's technologies within their operations and the very real possibility of reaping first to market advantages within the railway industry.

This initial motivation to interact with BHPIO has led to the commercialisation of the firm's technologies and a number of product diversification and market expansion opportunities. The basis of this interaction and the opportunities derived are discussed in the following section.

### 4.1.3 User-Producer Interaction with Large Industrial Users

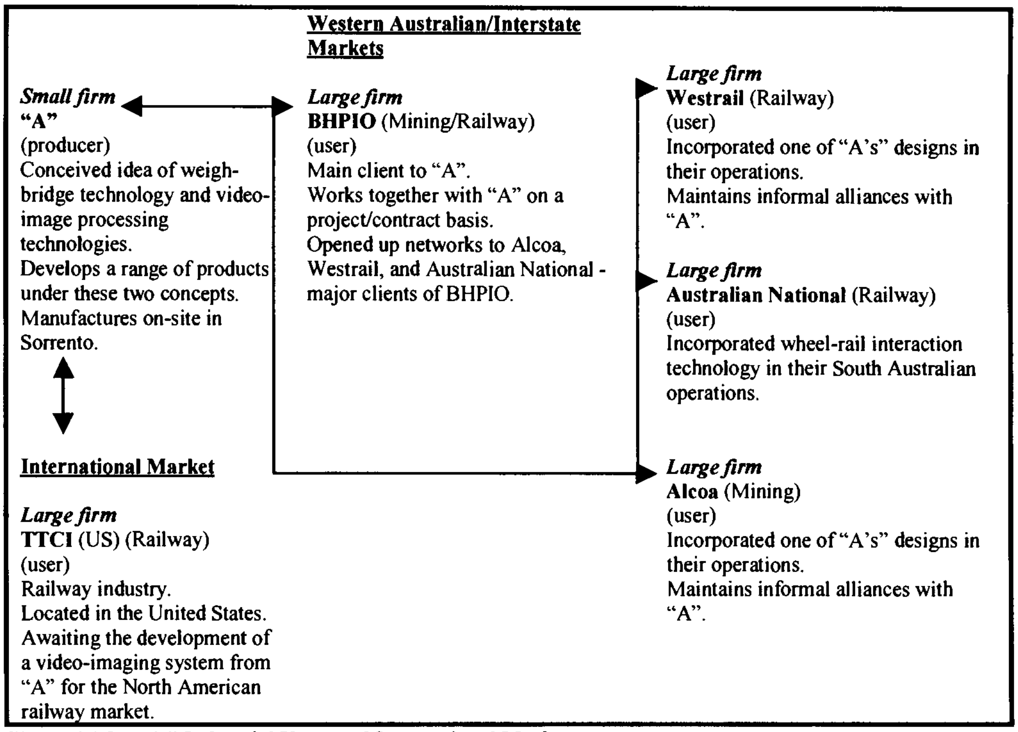

**Figure 4.1.3 "A's" Industrial Users and International Markets**

BHPIO was the firm's first industrial user. (see figure 4.1.3) Close user-producer interactions with BHPIO through a problem-solving type relationship enabled the firm to acquire product-market fit, simultaneously commercialising their technologies within the railway industry. More significantly, it was the "complementary assets" of BHPIO in terms of their large-scale marketing resources and distribution channels that created a number of product diversification and market expansion opportunities for the firm, consequently generating the attraction of other industrial users. (see figure 4.1.3)

This section examines the user-producer interactions with BHPIO, the subsequent interactions with Westrail, Australian National, Alcoa of Australia Ltd (Alcoa) and the Transport Technology Centre Incorporated (TTCI), and the product diversification and market expansion opportunities that were derived.

Realising the potential of the chief engineer's advanced software capabilities after initial meetings, BHPIO asked him to develop a technology that would automate their freight trains. The project, which involved close user-producer interactions with BHPIO, took approximately two years. Within the project the chief engineer was required to assess the reliability of transferring a control signal to the locomotive cabin, interface real-time systems through various communication links, program micro-controllers, and to develop the necessary hardware for BHPIO. "A" and BHPIO conducted trials on a number of train tests before installing the technology on BHPIO track. The success of the system within BHPIO operations enabled the technology to achieve "World's Best Practice " in 1992.

During these initial user-producer interactions with BHPIO, "A" realised the value of adopting a social, as well as technological orientation with their users. This meant that a relationship of trust and commitment was built with industrial users in conjunction with the communication of information about technological opportunities and user needs. This was the subsequent strategy promoted by the firm to commercialise their technologies. Following references to "user-producer interaction" assumes this social orientation.

In that same year, the chief engineer came up with one of his most major achievements to date. He carried out a study for BHPIO to assess the feasibility of using video-image processing for the analysis of 'wheel-rail interaction' in their ore car fleet. User-producer interactions with BHPIO throughout the development of the system enabled The chief engineer to produce a world first prototype software algorithm for the assessment of wheel-rail interaction using video-image processing technology. The technology was used by BHPIO for the detection of excessive wheel wear rates, wheel-rail stresses and unhealthy track conditions on their Western Australian tracks.

The developed software was also installed on the Australian National track in South Australia after user-producer interactions with the firm enabled “A” to assess the excessive wear conditions present in their rolling stock. Australian National came to learn of the chief engineer's technologies through interactions with BHPIO, which demonstrates the expanded market opportunities created via user-producer interactions with a large resource-based firm.

Following the successful development and incorporation of the 'wheel-rail interaction' technology within BHPIO’s operations, the chief engineer was asked to conduct several feasibility studies for BHPIO to see which other parts of a moving train could be monitored using similar technology. This stimulated ideas for a train health monitoring system – an extension of the original wheel-rail interaction project.

The need for a higher level of R&D funding at this stage encouraged the incorporation of “A”, essentially to take advantage of the funding schemes that were available for small firms conducting R&D.

Subsequently “A” applied for and won a WAISS grant for the development of an automatic car identification system, forming part of their train health monitoring system. It was during this time a wider technical base was also required because of the larger workload involved to develop the system. Technical staff were supplied by BHPIO and recruited externally by the firm.

With a source of R&D funds and an integrated technical team, “A” began development of their "automated train health monitoring system" for BHPIO. Close user-producer interactions with BHPIO enabled “A” to develop a world first video-image and acoustic signal processing system able to process images from 22 cameras continuously during the passage of a train. This enabled the system to conduct all train measurements automatically, able to identify factors associated with premature component failure. Trials of the technology with BHPIO proved successful and the system was installed by BHPIO in their Pilbara operations.

During this time there were also demands by BHPIO for more efficient weigh-bridge systems within their operations. Having already witnessed “A’s” developments in video-image processing technologies and learning of their headway in weigh-bridge developments through regular interactions with the firm, they approached “A” to build a weigh-bridge at their Yarrie mine site, South East of Port Hedland.

After several feasibility studies via user-producer interactions with BHPIO, “A” developed a "load-out facility weigh-bridge" based on a PC dynamic weighing system - the first of its kind. The weighing system installed at a load-out facility weighs the car wagon in-motion during the loading process. This was beneficial to BHPIO because the system helped lower the costs of transporting bulk materials, and substantially reduced the risk of derailment.

Recognising the potential of these in-motion-weighing systems through interactions with BHPIO, Westrail - one of BHPIO’s major clients, approached “A” for the development of a "high-speed in-motion weigh-bridge" to be installed at their Kalgoorlie operations in WA. Close user-producer interactions with Westrail during the development of the system enabled “A” to build a weigh-bridge operating with an accuracy of +/-0.2% at train speeds of up to 75 kph. This was successfully installed within Westrail’s Kalgoorlie operations.

“A’s” weigh-bridge technologies were further diversified within BHPIO’s operations where they developed a "front-end loader system"

(CATWEIGH) for efficiency within BHPIO's iron ore loading plants. Close user-producer interactions with BHPIO through development of the system enabled "A" to develop and install a weigh-bridge that enabled uniform amounts of iron ore to be loaded automatically in-motion within BHPIO's iron ore operations.

"A's" interactions with BHPIO in the development of weigh-bridge technologies also attracted the interests of Alcoa, another major client of BHPIO. Like Westrial and Australian National, Alcoa also came learn of "A's" technologies via the distribution and marketing channels of BHPIO. After witnessing demonstrations of "A's" technologies within BHPIO, Alcoa approached "A" to develop a weigh-bridge that would enable more efficiency within their bauxite operations. Close user-producer interactions with Alcoa enabled "A" to successfully develop an "empty wagon detector", a weigh-bridge that ensured no bauxite was left in a wagon during dumping operations. This was subsequently installed within Alcoa's operations.

Currently "A" continues to develop weigh-bridge and video-image processing technologies for BHPIO and has developed a strategic relationship with the firm. They also continue to supply Westrail, Australian National and Alcoa with railway technologies, keeping them up-to-date on current technological developments and proactively identifying new technical needs and/or requirements of these firms.

Though efforts to expose "A's" technologies within international markets has been dependent upon the marketing capabilities of "A's" chief engineer, the professional and technical visibility of "A's" technologies have derived more from their interactions within major Western Australian/interstate industrial users who are recognised within international markets. After the chief engineer's attendance at conferences in Montreal communicating the potential of in-motion weighing systems and video-image processing technologies for the railway and mining industries, it was at this stage that "A's" domestic focus turned international.

The calibre of "A's" technologies coupled with the association of major Western Australian/interstate industrial users, attracted the interests of a major railway research body from North America – TTCI. The TTCI is a Government research centre that has access to all major railroads in the US. After initial meetings and evaluating the feasibility of several demonstrations of "A's" technologies, they asked "A" to conduct R&D for a video-imaging system that was suitable for North American market conditions (high-speed trains, a variety of rolling stock, severe weather conditions, etc).

Developments are currently under-way and "A" is now working on the system maintaining close user-producer interactions with the TTCI, where the TTCI has accordingly funded "A" for the chief engineer to travel to the US to keep them up-to-date on the technical developments of the project. Since the costs involved for R&D of the system was beyond "A's" financial base, "A" applied for an R&D Start grant for the development of the video-imaging system. They won the grant worth A$1 million, which will be used over the next three years.

Once the system has been developed, the potential for "A's" technology to acquire first to market advantages and possible competitive advantages within North America is high, given the "complementary assets" held by the TTCI in terms of their extensive marketing resources and distribution networks. The exposure for "A's" technologies generated through the channels of the TTCI may derive further opportunities for product diversification and market expansion through the attraction of other potential industrial users.

### 4.1.4 Barriers to Interactions with Large Industrial Users

"A" did not face entry barriers in their interactions with BHPIO, Westrail, Australian National, Alcoa, or the TTCI.

There were a number of factors that were responsible for the relative ease of market entry. Since the chief engineer was familiar with BHPIO as a former employee, a level of trust was already established between both parties. The chief engineer's recognised technical expertise brought more credibility for "A's" technologies. As a result, this reduced the technological risks associated with the adoption of "small firm" technologies by BHPIO. These risks were also reduced for Westrail, Australian National and Alcoa, as a result of the professional and commercial visibility created for "A's" technologies via interactions with BHPIO.

However, overall it has been the technological and social orientation of user-producer interactions by "A" that has sustained their relationship with BHPIO, and secured the interests of Westrail, Australian National, Alcoa and the TTCI.

### 4.1.5 Case Summary

"A's" interactions with BHPIO, Westrail, Australian National, and Alcoa have enabled them to successfully develop and commercialise their technologies within the mining and railway industries. "A" has adopted strategies promoting user-producer interaction, cohesively working with these industrial users through the development and trials of technologies. Dyadic interactions with these industrial users through the exchange of technological opportunities and user needs has enabled "A" to acquire product-market fit and the subsequent commercialisation of their technologies.

"A's" interactions with "large" industrial users have brought a number of product diversification and market expansion opportunities to the firm. Their original weigh-bridge technology has diversified into four major designs with applications in both the railway and mining industry. Similarly their original wheel-rail interactive design has evolved into a complete train health monitoring system.

These opportunities have been created from the "complementary assets" held by these large industrial users in terms of their interconnected technologies and large-scale marketing resources and distribution channels. In addition to the ability of these industrial users to create product diversification and market expansion opportunities for "A" through their own operations, the networks of these industrial users have generated the appeal of other industrial users for "A's" technologies. For example, "A's" interactions with BHPIO raised the interests of Westrail, Australian National and Alcoa for their technologies.

The benefits of interacting with major industrial users have also extended “A’s” efforts internationally. For example, the interests expressed by the TTCI for “A’s” technologies were based on “A’s” former/current projects with major WA/interstate industrial users, as well as the technical capabilities of the firm.

Market entry has been relatively easy for “A” because of their previous experience with BHPIO who in turn exposed the firm to other large industrial users. However, it has also been the social and technological orientation of user-producer interactions that have overcome the entry barriers associated with large firm interactions.

Overall, the social, as well as technological orientation of “A’s” strategies promoting user-producer interaction has commercialised their technologies, sustained relationships with initial industrial users and secured the interests of “other” (introduced) industrial users, through reducing the risks associated with the adoption of new technologies.

“A” continues to work with BHPIO in the development of new weigh-bridge and video-image processing technologies at the same time monitoring the progress of existing technologies used by the firm. “A’s” ability to actively search for new product opportunities and to advance existing technologies developing a basis of trust and commitment, has enabled them to create a strategic relationship with BHPIO and to create sound relations with its other industrial users.

## Commitment in Industrial R&D

***Core Technology***: Weigh-bridge and video-image processing systems.

***Industry***: Railway and mining.

***Ratio of Technical/Commercial Staff:***

- Technical Staff: 6.5
- Commercial Staff: 0.5

***Government Grants Received:***

- WAISS grant; R&D Start Grant

***Funds for R&D as a % of 1998 turnover:***

- Turnover: $800,000
- % to R&D: 70 %
- Funds to R&D: $560,000

## Impediments faced

- Economies of scale, finance and infrastructure capital.

## User-Producer Interaction

- Social and technological orientation.
- Dyadic problem-solving style approach through technological development.
- Achieved product-market fit.
- Commercialised technologies.

## User-Producer Interactions with Large Industrial Users

***Industrial Users:*** BHPIO, Westrail, Australian National, Alcoa, TTCI (pending).

***Product Diversification:*** Load-out facility weigh-bridge, high speed weigh-bridge system, empty wagon detector, front-end loader weighing system, train health monitoring system.

***Market Expansion:*** Railway to Mining Industry

***International Market:*** North America (pending)

## Barriers to Interactions with Large Industrial Users

- No barriers faced.
- The barriers associated with risks in the adoption of new technologies were avoided because of "A's" former relationships with BHPIO who subsequently introduced Westrail, Australian National and Alcoa to the firm. These entry barriers were also avoided with the TTCI via the credibility of the firm's interactions with established Western Australian/interstate industrial users.
- Overall, it has been the social and technological oriented efforts of user-producer interaction by the firm that has secured the interests of, and promoted a strategic relationship with, industrial users.

## Case B

### 4.2.1 Commitment in Industrial R&D

"B" is a small foreign owned (United Kingdom) firm specialising in the development of lightweight seats and accessories for the fast ferry industry. They were established in 1955 in Fremantle specialising in motor transport and trimming for the marine industry. During this time, ordinary seats were imported from Singapore and Norway.

In 1993 they opened up an office in Henderson to develop marine transport seating specifically for the fast ferry industry. Commencing operations in Henderson with 10 staff and one full-time engineer (FTE), within the first year of operations they produceda net turnover of A$1.1 million. Two percent of this turnover was allocated towards further R&D. By 1997/98 "B's" employee base expanded to 45 staff including 5 FTE's, 4 R&D consultants, 3 Australian and 5 overseas marketing consultants. Within this year they experienced a net annual turnover of A$6 million where eight percent was allocated towards further R&D.

Throughout this period they have received a 125% tax concession for the development of their initial light weight seat technology, and a WAISS grant for the development of a computer simulation system that was to enhance the design and component optimisation of their light weight seats.

*The idea for lightweight seats*

In 1988 as the fast ferry industry began to emerge within Australia, technical staff within "B's" operations in Fremantle pre-empted the idea of a lightweight seat. Since there was no lightweight seat manufacturer in Australia at this time they realised a potential market opportunity. Working from within their Fremantle manufacturing division, initial work consisted of plywood seats with steel bases. They re-modelled and re-designed the seat for a number of years without complete satisfaction until 1993. It was at this stage that the direction of their R&D changed.

In 1993 through interactions with their European offices they learnt that the UK marine industry had implemented a High Speed Safety Craft Code. The code concerned passenger safety, specifying the importance of seat safety design and deck attachment methods in accordance with the level of G forces generated in a high-speed collision. Recognising possible latent demand states within the growing Australian marine industry as a result of this policy, and the very real possibility of acquiring first to market advantages, "B" incorporated the aspect of safety in their seating design and came up with an aluminium-based lightweight seat. It was at this stage that "B" established their new production facility in Henderson.

### 4.2.2 Impediments faced

The firm commenced operations with one full-time engineer and ten production staff who worked on the design and development of the aluminium seat. To be expected initial progress was slow, primarily because they lacked sufficient technicians to carry out development of the technology.

This need for a wider technical base was overcome through their relationship with Orbital Engine Corporation Ltd (Orbital Engines) in WA who were competent in assessing the feasibility of design and the overall engineering of the seat. During this time "B" also formed a relationship with engineers from Crash Laboratories Ltd (Crash Lab), a testing facility in Sydney where "B's" seats were tested under different collision scenarios. (see figure 4.2.3)

"B's" extensive experience within the marine industry did, however, enable them to keep up-to-date with the latest industrial/technical trends. Moreover, as a well-established firm their finances were also sound, where approximately $100,000 was delegated to R&D activities. (They do, however, stress that finance for R&D is their greatest impediment) This was the same for infrastructure capital, where production equipment from their Fremantle operations was transferred to Henderson. The accumulated skills and experiences of "B's" FTE within industry also helped in acquiring intellectual property rights for the technology.

Also uncommon within most small firms, "B" had a market for their technologies, with potential industrial users. Their operation in the maritime industry for a number of years had consequently led them to develop strategic relationships with two of Australia's major ship builders – Austal Ships Pty Ltd (Austal Ships) and In-Cat Pty Ltd (In-Cat).

Throughout these years they have also learnt to engage in close user-producer interactions with these industrial users to develop and trial their technologies, and were strategies adopted when introducing their lightweight seats to these firms. The generation of demand for "B's" technology through close user-producer interactions with these firms brought subsequent economies of scale in the development, manufacture and marketing of their lightweight seat designs.

The user-producer interaction that generated this demand and the product diversification and market expansion opportunities that were derived are examined in the next section.

### 4.2.3 User-Producer Interaction with Large Industrial Users

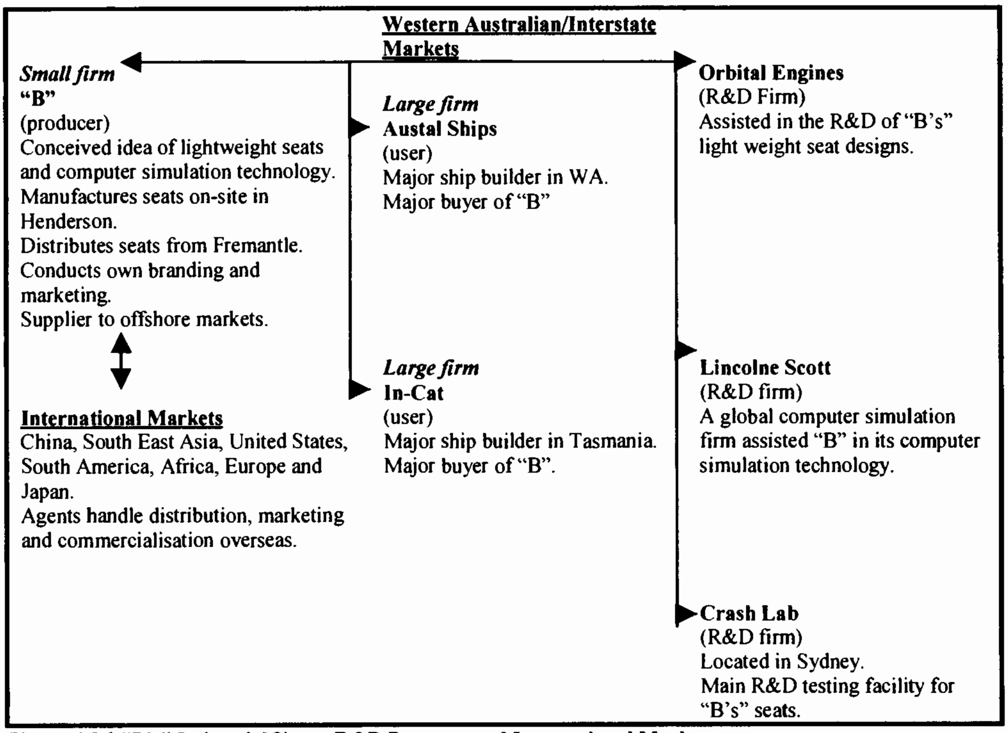

**Figure 4.2.3 "B's" Industrial Users, R&D Partners and International Markets**

"B's" adoption of strategies promoting close user-producer interaction through a problem-solving style approach with their industrial users has enabled them to commercialise their technologies within industry. The success of these user-producer interactions has derived from their socially, as well as technologically oriented efforts which has led them to sustain their relationships with WA/interstate industrial users, and to create relationships with industrial users internationally.

These socially oriented efforts refer to the trust and commitment built with industrial users in conjunction with the exchange of technological opportunities and user needs. Following references to "user-producer interaction" will assume this social orientation.

"B's" first industrial user for their lightweight seats was Austal Ships - WA's's largest ship builder. (see figure 4.2.3) Since Austal Ships had acquired a significant rapport with "B" throughout their long experience with them, they were eager to see new technologies by the firm. Initial meetings enabled Austal Ships to realise the competitive advancements these lightweight seats would bring to their operations. Subsequent close user-producer interactions with Austal Ships enabled "B" to acquire product-market fit and the commercialisation of their technology.

"B's" other major industrial user was In-Cat, located in Tasmania. (see figure 4.2.3) In a similar case to Austal Ships, In-Cat raised immediate interests for "B's" new technology inspired by the leading-edge design and competitive potential of the technology within their markets. Subsequently, close user-producer interactions with In-Cat enabled "B" to achieve product-market fit and commercialisation of their technology.

As "large" industrial users with "complementary assets", both Austal Ships and In-Cat have brought a number of product diversification and product expansion opportunities for "B". As a result, "B's" original light weight seat now has 25 different designs with a number of accessories including reclining back, armrests, fold-away table in armrest, food tray (back of seat), sound system, antimacassor, document holder, alloy bin, life jacket bag, footrests and custom widths.

The "complementary assets" of these large firms in terms of their large-scale marketing resources and distribution channels have also generated an international appeal, attracting the interests of major industrial users in China, South East Asia, United States, South America, Africa, Europe and Japan.[9] This international recognition consequently made the efforts of "B's" overseas marketing agents an easier task, managing to attract and secure the interests of international ship building organisations.

Close user-producer interactions with these industrial users through "B's" commercial staff have enabled "B" to develop seating in accordance with their specifications for safety, strength and light weight structure, enabling product-market fit and the sequential international commercialisation of "B's" technologies. These large international users were also responsible for product diversification and product expansion where "B" now exports to these users on a regular basis.

Encouraged by the domestic and international success of their lightweight seats but more importantly by the need to increase the efficiency of their development operations, "B" progressed a step further in the design safety of its seats. In 1997 "B" conceived the idea of a world-first computer simulation system to test seat designs and deck attachment devices under different collision and stress scenarios.

At the time current tests were conducted by Crash Lab in Sydney which incurred significant costs in terms of both time and money. For example, if a seat did not meet safety standards it would have to be sent back to "B" to be re-designed and then re-sent to Sydney for

[9] The names of these industrial users were confidential and not dispersed by "B" during the interview.

further testing. With a high domestic and international demand for their technologies, the need for efficiency was paramount.

It was at this time they applied for the WAISS grant, as well as allocating approximately A$480,000 from their R&D budget to the project. A lack of expertise in computer technology encouraged them to conduct R&D with Lincolne Scott Australia Pty Ltd (Lincolne Scott), a computer simulation firm. The system required details of all of "B's" seat designs, specifying the weight, height, width, and depth of each seat. The input of this data combined with the engineering of the system enabled "B" to design and produce seats in compliance with current strength and safety standards. This substantially increased the efficiency and productivity of the firms operations increasing economies of scale within development and manufacture.

"B's" commercial prospects are forecasted to expand as they face market expansion opportunities as a result of their close user-producer interactions and technological coverage in international markets. For example, they are currently conceiving the possibility of developing lightweight seats and accessories for large cruise ships, where there is a potential demand. They are also concentrating their efforts to break into the North American market where market research by the firm shows a potential demand for their lightweight seats.

"B" has become a world leader in the development of lightweight seat designs and accessories in the fast ferry industry. They continue to maintain close user-producer interactions with their industrial users, both domestically and internationally, keeping them informed on the technical developments of the firm, and consistently searching for new opportunities that may widen "B's" product and market base.

### 4.2.4 Barriers to Interactions with Large Industrial Users

"B" has not experienced barriers to interactions with their large industrial users. It is important to note that the technological risks characteristic with the adoption of small firm technologies by large industrial users were substantially reduced because of "B's" strategic relationships with their Australian/interstate industrial users.

Overall, it has been the social and technological orientation of strategies promoting user-producer interaction by "B" that has enabled them to sustain relationships with their WA/interstate industrial users and to secure the interests of industrial users internationally.

### 4.2.5 Case Summary

"B's" adoption of strategies promoting user-producer interaction with two of Australia's largest ship builders - Austal Ships and In-Cat have enabled them to successfully develop and commercialise their technologies within the Australian fast ferry industry. Dyadic technological interactions between "B" and its industrial users through the exchange of technological opportunities and user needs have enabled them to develop technologies that have achieved product-market fit.

“B’s” promotion of user-producer interaction with these “large” industrial users have brought a number of product diversification/expansion opportunities to the firm where the firm’s original seating technology has diversified to over 25 different seating designs with extensive accessories.

These commercial opportunities have derived from the “complementary assets” held by Austal Ships and In-Cat in terms of their large-scale marketing resources and distribution channels, which has consequently created a high demand for “B’s” technology.

The benefits of interacting with these “large” industrial users has also extended “B’s” opportunities internationally attracting the interests of major industrial users in China, South East Asia, United States, South America, Africa, Europe and Japan. Therefore it is the networking capabilities of these “large” users as well as their ability to commercialise “B’s” technologies that has substantial benefits for the technology-based, resource scarce, small firm.

As a market leader in the development of lightweight seats in Australia, “B” did not face any major barriers in their interactions with large industrial users. “B’s” circumstances were unique in that they had established a relationship with these users throughout their years of operation within the maritime industry. This, therefore, substantially reduced the high level of risk usually associated with the adoption of small firm technologies by large industrial users.

Overall, however, it was the social and technological orientation of strategies promoting user-producer interaction that have enabled "B" to sustain their relationships with their WA/interstate industrial users and to secure the interests of international industrial users.

Close user-producer interactions with Austal Ships and In-Cat, and their international industrial users via their overseas marketing agents continue to create commercial opportunities for the firm. These commercial opportunities also continue to increase as "B" internally expands and proactively searches for new product and market applications.

Although "B" was not as resource-scarce as the typical small firm, the case does show the application of user-producer interaction to acquire product-market fit and to commercialise small firm technologies, and the opportunities derived through interactions with large industrial users.

## Commitment in Industrial R&D

***Core Technology:*** Lightweight seats

***Industry:*** Marine/Fast ferry

***Ratio of Technical/Commercial Staff:***

- Technical Staff: 9
- Commercial Staff: 8

***Government Grants Received:***

- 125% tax concession; WAISS grant.

***Funds for R&D as a % of 1998 turnover:***

- Turnover: A$ 6 million
- % to R&D: 8%
- Funds to R&D: A$480,000

## Impediments faced

- Finance

## User-Producer Interaction

- Social and technological orientation
- Dyadic problem-solving style approach through technological development.
- Achieved product-market fit.
- Commercialised technologies.

## User-Producer Interactions with Large Industrial Users

***Industrial Users:*** Austal Ships and In-Cat

***Product Diversification/Expansion:*** Original lightweight seat diversified into 25 different designs with extensive accessories.

***Market Expansion:*** Cruise Liners (pending)

***International Market:*** China, South East Asia, United States, South America, Africa, Europe and Japan. (North America – pending)

## Barriers to Interactions with Large Industrial Users

- No barriers faced.
- Strategic relationship has been developed with Austal Ships and In-Cat over their 45 years in operation. This has enabled them to avoid the entry barriers typical amongst interactions with large industrial users.
- They have been able to sustain these relationships and create new relationships through the promotion of socially and technologically oriented strategies of user-producer interaction.

## 4.3 Case C

### 4.3.1 Commitment in Industrial R&D

"C" is a small Western Australian firm specialising in the development of ceramic and polyurathane products for the laboratory, brick and mining industries. The firm commenced operations in 1991 through its head engineer. "C" did not produce a turnover within the first year of operation, as they were still involved in product design activities.

By 1992, however, "C's" employee base grew to eight staff and produced a net turnover of A$500,000 of which five percent was allocated towards further R&D. By 1997/98 "C" employed 15 staff comprising of 4 full-time R&D staff. The head engineer who was included in this R&D team was also responsible for the commercial activities of the firm. They experienced a net annual turnover of A$2million where twelve percent of this turnover was attributed to further R&D.

Throughout this period "C" has been successful in acquiring a number of government grants to assist them in their R&D activities. Early in the firm's history they received an NIES grant to assist them in business development activities. Neville Stanley Scholarship students have also been taken on board to conduct specific R&D projects for the firm.

"C" has also received two WAISS grants. The first WAISS grant related to the development of a pressure casting system to complement their existing slip casting technology. This was successfully completed and has opened up new product lines for the firm. Their second WAISS grant assisted in the development of high purity magnesium oxide based ceramics, which have been commercialised within the laboratory industry.

“C” has also won a Category 2 WAAIRDS grant to the value of $25,000 to assist the firm in applying for a larger national grant to design a modular system for high wear ceramic design. “C”, however, suspended this project due to a change in technological focus. The funds are now being used to apply for an R&D Start grant for approximately A$1 million to assist “C” in the area of non-oxide based ceramics, the firm’s latest technological direction.

### 4.3.2 Impediments faced

The firm began as a one-person operation through its head engineer. With a background in engineering ceramics he endeavoured to specialise in the area and to develop related technologies. Most of his time was spent in the research laboratory designing a number of brick extrusion cores and simple crucible shapes.

He was, however, unable to commence production due to a lack of finance and appropriate manufacturing resources (infrastructure capital), a problem usually experienced by most small firms. Having contacts within Curtin University he approached their Applied Chemistry department to see if he could gain access to laboratory equipment required for the development of his technologies. Invariably he did not have sufficient funds to pay for this equipment. However, his academic qualifications enabled him to supervise a few of Curtin's Applied Chemistry PhD students as substitute payment.

He soon began developing prototypes of his designs. Progress was slow initially, but the help of a former colleague from UWA who had a background in the area managed to speed up product development activities. Though there was still a significant need for a wider technical base that could retrieve relevant external technical information, attracting skilled labour was difficult due to the specialist expertise of the firm.

These external communication difficulties were reduced after the head engineer recognised the technical potential of some of his PhD students. These students soon formed part of "C's" R&D team bringing greater efficiency in development and production. All technologies were patented through the efforts of "C's" chief engineer.

Though "C's" first technologies appeared robust with significant industrial potential, they were unable to generate economies of scale within their operations due to the lack of a formal marketing strategy which consequently prevented the firm from capturing the attention of potential industrial users.

However, the motivation of "C's" head engineer encouraged him to further "C's" relationship with Curtin by approaching them with the firm's developed technologies. This led to the commercialisation of "C's" technologies and their initial break within the laboratory industry.

The user-producer interactions attributing to this commercialisation and the product diversification and market expansion opportunities that were derived through the subsequent adoption of this interactive strategy, is discussed in the next section.

### 4.3.3 User-Producer Interaction with Large Industrial Users

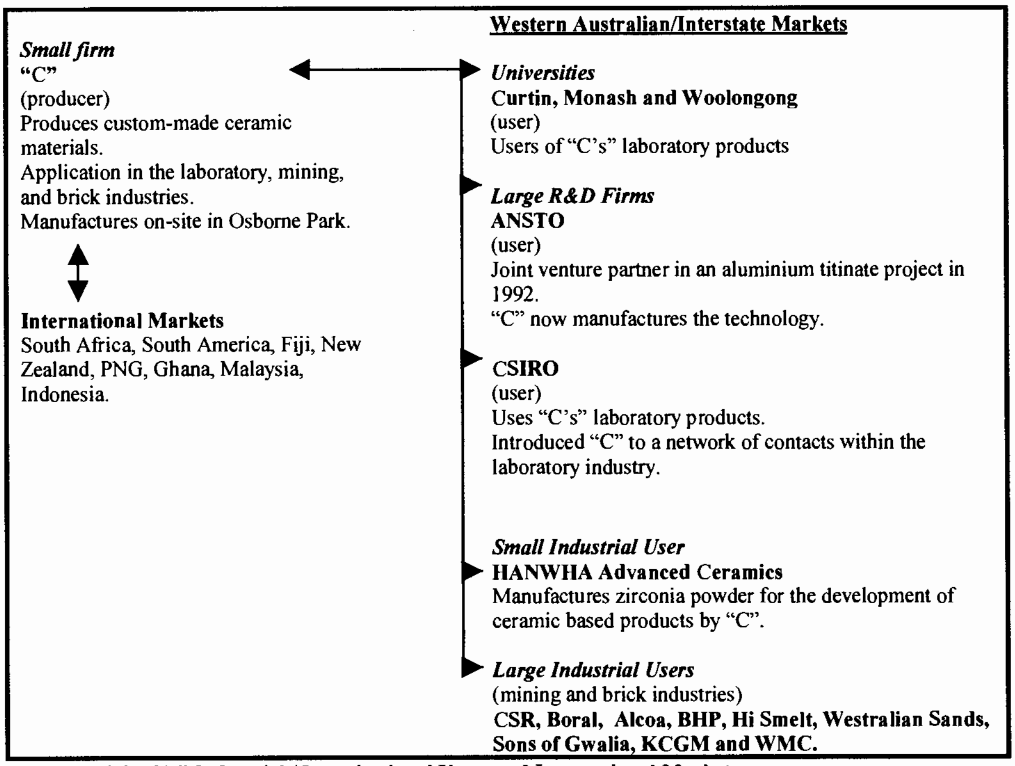


**Figure 4.3.3 "C's" Industrial /Organisational Users and International Markets**

"C" has interacted with a number of industrial users since its incorporation. (This is illustrated in Figure 4.3.3) Close user-producer interactions through a problem-solving style approach with these industrial users have enabled "C" to acquire product-market fit and the commercialisation of their technologies. "C's" interactions with 'large users', in particular, have enabled them to extend their commercial scope via a number of product diversification opportunities as a result of the "complementary assets" held by these users. Examples examining the basis of these user-producer interactions and the opportunities that have been generated are now discussed.

Since the firm's incorporation in 1991 "C" has managed to maintain close links with Curtin. Consequently, they were "C's" initial industrial user. At first "C" supplied Curtin with simple crucible shapes for their laboratories. Subsequent close user-producer interactions with Curtin revealed more specialised needs which enabled the diversification of crucibles into trays, dishes, tubes and other custom made shapes made from alumina and magnesia.

These close user-producer interactions incorporating a social, as well as technological orientation formed a marketing strategy that they continued to use with other industrial users. The social orientation of these efforts refers to the trust and commitment that was built with industrial users in conjunction with the exchange of technological opportunities and user needs. Following references to "user-producer interaction" incorporates this social orientation.

During this time "C" also made efforts to contact the Commonwealth Scientific and Industrial Research Organisation (CSIRO), conveying the potential application of their technologies within the laboratory industry. "C's" specialised skills in the development of ceramic materials enabled "C" to establish a close relationship with the CSIRO. Through close user-producer interactions with the CSIRO, "C" developed custom-made crucibles in accordance to their needs and specifications.

In addition to the commercialisation of "C's" technologies, interactions with the CSIRO also led to the introduction of other industrial users, research organisations, and universities, as a result of the large-scale distribution and marketing networks of the CSIRO. (see figure 4.3.3) These users included Australian Nuclear Science and Technology Organisation (ANSTO), HANWHA Advanced Ceramics Australia Pty Ltd (HANWHA), and Monash and Woolongong universities.

Subsequently, ANSTO approached "C" in 1992 for a joint venture concerning the production of aluminium titinate based ceramic products. (see figure 4.3.3) Realising the possibility for further product diversification opportunities, "C" agreed to the formation. Close user-producer interactions with ANSTO enabled the successful development of the aluminium titinate based products. The products are now developed by "C" and supplied to ANSTO on a regular basis.

During this time, interactions with the CSIRO in Melbourne led "C" to the discovery that they were buying magnesium oxide (MgO) based crucibles from Japan that incurred long delivery times and high transportation costs. Close user-producer interactions enabled "C" to successfully develop MgO based crucibles for their operations with shorter delivery times and lower transportation costs.

The development of these crucibles attracted the interests of Monash and Woolongong Universities who were in need of similar MgO based products. Again close user-producer interactions with these universities enabled "C" to acquire product-market fit and to develop the appropriate products.

"C's" technical exposure within the laboratory industry also encouraged HANWHA, a ceramic engineering and production firm to approach "C". (see figure 4.3.3) Recognising "C's" potential to convert raw materials into ceramic products they asked "C" to convert manufactured zirconia power into ceramic products. Close user-producer interactions with HANWHA enabled "C" to develop products that were suitable for their operations. ("C" now supplies these products to HANWHA on a weekly basis) In addition to the commercial benefits that were derived for "C" from interactions, HANWHA now supplies zirconia powder to "C" for the development of ceramic products for other industrial users.

While developments within the laboratory industry surged, "C's" initial design of brick extrusion cores also diversified as "C" initiated contact with major industrial users within the heavy clay industry. These users included Boral Ltd (Boral) and the CSR Ltd (CSR) and a number of other industrial users in brick and tile manufacturing.[10] (see figure 4.3.3)

Close user-producer interactions with these industrial users enabled "C" to diversify their original extrusion cores into extrusion sleeves, die box liners, die base liners, burner nozzles, and arris wheels. These products continue to expand as these industrial users continue to approach "C" with specific technological problems, and as "C" proactively monitors the market for new industrial users and new product applications.

"C's" dedication to consistently develop new technologies and to monitor the market for new product applications and growth opportunities has expanded "C's" coverage towards the mining industry. They have created links with Broken Hill Proprietary Pty Ltd (BHP), Hismelt Corporation Pty Ltd (Hismelt), Alcoa of Australia Ltd (Alcoa), Westralian Sands Ltd (Westralian Sands), Sons of Gwalia Pty Ltd (Sons of Gwalia), Kalgoorlie Consolidated Gold Mines Pty Ltd (KCMG), and WMC Resources Ltd (WMC). (see figure 4.3.3)

Close user-producer interactions with these industrial users through the analysis of their technological needs for better wear and corrosion resistant materials and products have enabled "C" to develop a range of ceramic and polyurethane products spanning many applications. These applications include hydro-cyclone components, chute and duct linings, spray nozzles, conveyor belt cleaning systems, valves, pipe sections, thermocouple sheaths and a range of epoxy/ceramic trowlable systems.

---

[10] Some clients remained confidential and were not dispersed within the interview.

In addition to the commercial extent that interactions with these large domestic users have brought to "C's" operations via their marketing and distribution channels, these large users have also extended a professional and commercial visibility for "C's" technologies within international markets.

As a result, international firms from South America, South Africa, Fiji, New Zealand, PNG, Ghana, Malaysia, and Indonesia have contacted "C" for the application of their specialist product design expertise within their operations.[11] Close user-producer interactions with these users have enabled "C" to perform design work identifying appropriate materials and design solutions for specific wear, corrosion and thermal problems.

"C's" current market focus lies in the development of non-oxide based ceramics. They are currently applying for an R&D Start grant worth A$1 million to commence R&D in the area. This will enable "C" to expand its product base creating further opportunities for domestic and possible international market expansion.

### 4.3.4 Barriers to Interactions with Large Industrial Users

"C" has not experienced any major barriers in their interactions with large industrial users. "C" has avoided the confrontation of risks associated with most technological adoption processes through their affiliations with Curtin, who brought them the credibility to interact with the CSIRO, and who in turn exposed the firm to a network of industrial users.

[11] The names of these industrial users were confidential and not dispersed by "C" during the interview.

Overall, it has been the social and technological orientation of strategies promoting user-producer interaction that has enabled "C" to sustain their relationships with industrial users within the laboratory industry, to establish links with industrial users across the brick and mining industries, and to secure the interests of industrial users internationally.

### 4.3.5 Case Summary

"C's" adoption of strategies promoting user-producer interaction with their industrial users have enabled them to successfully develop and commercialise their technologies. The basis of these interactions have involved dyadic technological interactions through a problem-solving style approach between "C" and its users, involving the exchange of technological opportunities and user needs, which has consequently achieved product-market fit and subsequent commercialisation of their technologies.

Their interactions with "large" industrial/organisational users have brought a number of benefits to the firm in terms of the product diversification and market expansion opportunities that have been derived. "C" now has an extensive line of ceramic and polyurathane products with application across the laboratory, brick and mining industries.

It is the "complementary assets" of these large users, in terms of their large-scale marketing resources and distribution channels, that has created these commercial opportunities for "C". The benefits of interacting with these "large" users have also made "C's" efforts to attract potential international industrial users an easier task, where "C" now develops and designs products for industrial users in South

America, South Africa, Fiji, New Zealand, PNG, Ghana, Malaysia, and Indonesia.

"C" is one of a number firms specialising in the development of ceramic based technologies. Although some of these firms form their industrial users, they are also competitors to "C" (eg ANSTO, CSIRO, HANWHA) who incorporate the ability to develop similar technologies.

"C" has managed to keep ahead of their competition through their consistent efforts to internally innovate and to seek the market for new ideas and technological opportunities. More importantly, it is their ability to maintain a close relationship with their industrial users through monitoring their needs, and the progress of adopted technologies, that has built relationships based on trust and commitment.

"C" have not experienced major entry barriers in their interactions with large industrial users. Market entry was relatively easy through their affiliation with Curtin who brought them the credibility to interact with the CSIRO who in turn exposed the firm to a network of contacts within the laboratory industry. However, it is their ability to persist with socially, as well as technologically oriented user-producer interactions that have substantially reduced the risks associated with the adoption of new technologies by large industrial users within the laboratory industry, as well as the brick and mining industries.

Overall, the case of "C" has shown how the social and technological orientation of user-producer interactions has enabled them to commercialise their technologies; to sustain relationships with their industrial users; and to secure the interests of potential industrial users, through reducing the high risks involved in the adoption of new technologies by large industrial firms.

## Commitment in Industrial R&D

***Core Technology:*** Ceramic and polyurethane products.

***Industry:*** Laboratory, Brick and Mining.

***Ratio of Technical/Commercial Staff:***

- Technical Staff: 3.5
- Commercial Staff: 0.5

***Government Grants Received:***

- NIES grant, Neville Stanley Scholarship, two WAISS grants, WAAIRDS grant (category 2), R&D Start grant (pending).

***Funds for R&D as a % of 1998 turnover:***

- Turnover: A$ 2 million
- % to R&D: 12%
- Funds to R&D: A$ 240,000

## Impediments faced

- Economies of scale, finance, infrastructure capital, external communications.

## User-Producer Interaction

- Social and technological orientation.
- Dyadic problem-solving style approach through technological development.
- Achieved product-market fit.
- Commercialised technologies.

## User-Producer Interactions with Large Industrial Users

***Industrial Users:*** CSIRO, ANSTO, HANWHA, Curtin, Monash and Woolongong universities, BHP, Hi Smelt, Alcoa, Westralian Sands, Sons of Gwalia, KCGM, WMC, Boral and CSR.
***Product Diversification:*** Simple crucible shapes and brick extrusion cores diversified into a myriad of ceramic and polyurethane based products.
***Market Expansion:*** Laboratory/brick/mining industries.
***International Markets:*** South Africa, South America, Fiji, New Zealand, PNG, Ghana, Malaysia and Indonesia.

## Barriers to Interactions with Large Industrial Users

- No barriers faced.
- Entry barriers were reduced through "C's" affiliation with Curtin who brought them the credibility to interact with the CSIRO who in turn exposed the firm to a network of contacts.
- The social and technological persistence of user-producer strategies by "C" enabled them to sustain the above relationships, and to create new links with industrial users across the mining and brick industries.

## 4.4 Case D

### 4.4.1 Commitment in Industrial R&D

"D" is a small Western Australian firm specialising in the development of mooring equipment for the maritime industry. They were formed by the principals of Ocean Industries Pty Ltd (Ocean Industries) and Diver I and Diver II Corporation (Diver I and Diver II) in 1994, commencing operations with two full-time engineers (FTEs). "D" devoted the first four years of operations to R&D of an advanced mooring concept – the Easy Rider Mooring System (Easy Rider).

Commercialisation of the technology in 1998 produced a net turnover of A$30,000, which was a disappointing result for the firm given the resources and time allocated to R&D of the technology. However, the returns for the Easy Rider are expected to rise as "D" plan to increase their marketing efforts through the exposure of their technology within trade shows. To date, "D" employs one FTE and with the current development of a new mooring concept called the Screw Lock Anchor System (Screw Lock) – an extension of the original Easy Rider technology, they forecast a turnover of A$500,000 within the next five years.

Since incorporation "D" has received two WAISS grants. Their first grant was for the development of the Easy Rider, a design enveloping efficiency and environmental sensitivity over more conventional mooring systems. Their second grant was for the development of the Screw Lock, an extension of the Easy Rider concept with the addition of anchor technology. "D" has also relied on R&D funds from their principals, where A$140,000 was allocated to R&D of the Easy Rider, and A$131,000 was allocated to R&D of the Screw Lock.

### *The Idea for the Easy Rider Mooring System*

The idea for the Easy Rider was conceived prior to the incorporation of "D" between Ocean Industries and Diver I and Diver II. At this time both Ocean Industries and Diver I and Diver II had a close supplier-user relationship where Ocean Industries provided engineering and manufacturing of under water design housings and equipment for Diver I and Diver II to supply to individual buyers (end users) within the maritime industry.

Exchanges of technical and industrial knowledge enabled them to conceive a new mooring concept - the Easy Rider, which was environmentally friendly unlike the more conventional mooring systems. At the time, conventional systems were responsible for destroying vast areas of sea grass meadows and coral reef throughout Australia. This consequently revealed a potential opportunity for both Ocean Industries and Diver I and Diver II to pursue possible first to market advantages within the maritime industry.

However, they were unable to transform their ideas into a tangible technology because of an insufficient amount of capital to commence development. Realising the opportunities of government grants to assist the R&D efforts of technology-based, small firms, it was then that they formed "D" to commence development.

### 4.4.2 Impediments faced

The technical managers that conceived the idea of the Easy Rider technology commenced operations under "D". Characteristic amongst most technology-based, small firms they faced financial constraints, which was overcome through the provision of a WAISS grant and through funding from "D's" principals who allocated $140,000 over the five years through development of the system. They did not, however, face infrastructure capital constraints since they operated from the premises of Ocean Industries where they had access to production and manufacturing equipment.

In 1996, recognising the need for a wider technical base they applied for a Neville Stanley Scholarship where they took on-board a student specialising in environmental science/engineering from Murdoch Univerisity. During his time with "D", the student has progressed from an environmental scientist to the main administrator of "D's" R&D activities, and is now the full-time and sole employee of "D".

The former employees of "D" although resuming their positions within the principal firms still maintained close relations with "D" through technological development, as well as keeping them informed of technical and industrial trends within the maritime industry. This reduced the external communication difficulties experienced by "D". Both Ocean Industries and Diver I and Diver II also assisted "D" in establishing intellectual property rights for the technology, which alleviated another impediment usually faced by the technology-based, small firm.

User-producer interactions remained between "D" and its principals. However, "D's" principals were small firms with limited marketing and distribution resources. This meant that the demand for "D's" technologies and the opportunities for product diversification and market expansion were limited. Therefore “D” was unable to achieve scale economies within their operations.

The next section examines the user-producer interactions responsible for the commercialisation of “D’s” technologies and the commercial opportunities derived.

### 4.4.3 User-Producer Interaction with Small Industrial Users

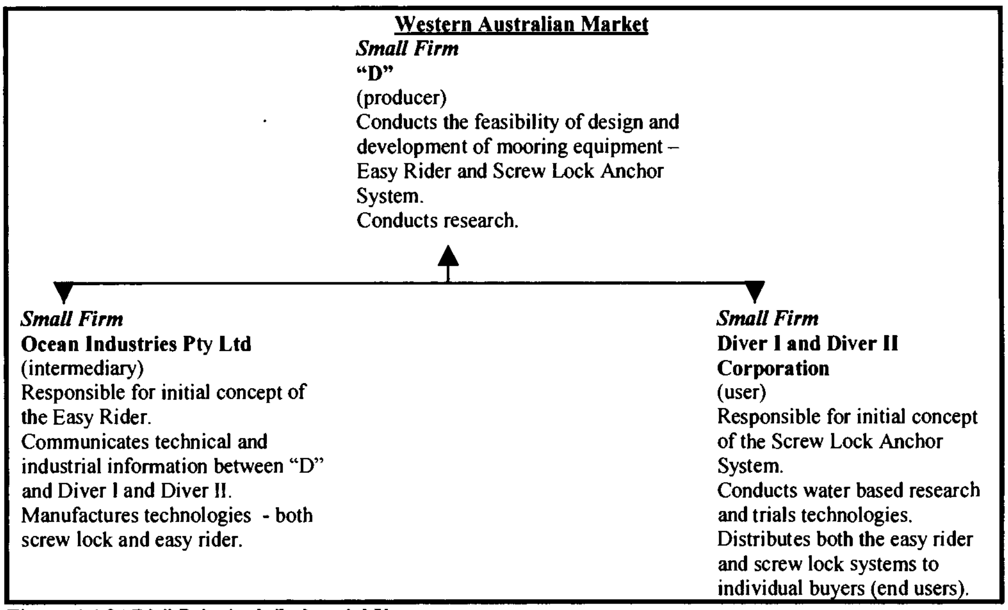


**Figure 4.4.3 “D’s” Principals/Industrial Users**

Both Ocean Industries and Diver and Diver II Co have maintained close technological relationships with “D” since its incorporation. Diver I and Diver II are “D’s” sole industrial users and Ocean Industries have taken the role of an intermediary, responsible for the communication of technical and industrial information between “D” and Diver I and Diver II. They are also responsible for the manufacture of technologies. (see Figure 4.4.3)

Since Ocean Industries were the main conceivers of the Easy Rider technology the development of the Easy Rider mainly involved the efforts of both "D" and Ocean Industries. Close technological exchanges between the two firms involving the design capabilities of "D" and the engineering and development expertise of Ocean Industries through a problem-solving style approach, enabled the successful development of the Easy Rider. This proceeded with extensive field-testing and tank testing by Diver I and Diver II before incorporation and commercialisation of the technology within their operations.

These interactions involved a social, as well as a technological orientation amongst the firms, which was second nature as a result of their previous links in industry. The following references to "user-producer interaction" incorporates this social orientation.

The extent of commercialisation was, however, limited as a result of the small-scale operations of Diver I and Diver II. Therefore similar to that of "D" and most small firms, Diver I and Diver II faced resource constraints in terms of marketing and distribution resources being only able to supply "D's" technology to a few individual buyers within the maritime industry.

During this time "D" did, however, manage to expand the original design of the Easy Rider technology. Interactions between Diver I and Diver II and their individual buyers (end users) stimulated ideas within Diver I and Diver II to install a displacement buoy within the original Easy Rider to hold vessels of larger capacities. (See figure 3.4.3)

Close user-producer interactions with Diver I and Diver II through Ocean Industries enabled "D" to research and develop the Screw Lock Anchor System, which was formed via the attachment of a number of helix plates at the bottom of the Easy Rider. The Screw Lock incorporated the flexibility to be lengthened via an extension shaft, which was able to increase the diameter or number of helix plates in accordance to the size of the vessel.

The developed system is currently undergoing trials within Diver I and Diver II where commercialisation of the technology is forecasted within the next few months pending the success of these trials.

The projected minimal coverage of the technology through Diver I and Diver II has encouraged "D" to plan to promote their Screw Lock, as well as the Easy Rider within the Perth, Melbourne and Sydney boat shows to attract the interests of potential industrial users who may generate wider commercial opportunities for their technologies.

Research by "D" has revealed that diversification of the Screw Lock may enable the application of their technology on land, including anchoring pipelines, overhead power lines and other structures. However, this remains prospective as "D" have yet to interact with industrial users within these areas of industry.

### 4.3.4 Barriers to Interactions with Large Industrial Users

"D" have experienced difficulties in attracting large industrial users to their technologies. This is attributed to the fact that they have not used methods of user-producer interaction to cooperate with these large industrial users.

If user-producer methods of interaction that has been demonstrated by "D" with their principals are also used to promote a social, as well as a technological orientation with potential large industrial users, the risks associated with the procurement of new technologies by these users may be reduced.

### 4.3.5 Case Summary

"D" has interacted with its principal firms, Ocean Industries and Diver I and Diver II to develop and commercialise its technology in the maritime industry. Diver I and Diver II has formed "D's" sole industrial user and Ocean Industries has operated as an intermediary through which both "D" and Diver I and Diver II have exchanged technical and industrial knowledge.

"D" has adopted strategies promoting close user-producer interaction with Diver I and Diver II through the intermediary efforts of Ocean Industries in the development of the Easy Rider Mooring System. Dyadic technological interactions through the development have enabled "D" to achieve product-market fit and the subsequent commercialisation of their technology.

However, though "D" developed a leading-edge technology with potential application within the large maritime market, their extent of commercialisation was restrained as a result of their interactions with a "small" industrial user. The resource constraints of Diver I and Diver II in terms of their limited marketing resources and distribution channels have substantially reduced their ability to attract other industrial users who may further product diversification or create market expansion opportunities. This is because, unlike large industrial users, Diver I and Diver II do not have the "complementary assets" able to stimulate or create such opportunities.

"D" has been unsuccessful in its attempts to attract large industrial users to its technology. They have experienced barriers typical to the technology-based, resource-scarce, small firm, unable to convince potential large industrial users of their technological capabilities and expertise, and the benefits of their technologies against the risks associated with adoption.

Successful attempts to interact with large industrial users may come with the social, as well as the technological persistence of user-producer interactions.

## Commitment in Industrial R&D

*Core Technology:* Mooring equipment

*Industry:* Maritime industry

***Ratio of Technical/Commercial Staff:***

- Technical Staff: 1
- Commercial Staff: 0

***Government Grants Received:***

- Two WAISS grants

***Funds for R&D as a % of 1998 turnover:***

- Turnover: A$30,000
- % to R&D: 0
- Funds to R&D: A$131,000 (from principals)

## Impediments faced

- Economies of scale, finance and external communications.

## User-Producer Interaction

- Social and technological orientation.
- Dyadic problem-solving style approach through technological development.
- Achieved product-market fit.
- Commercialised technologies.

## User-Producer Interactions with Small Industrial Users

***Industrial User:*** Diver I and Diver II.

***Product Diversification:*** Easy Rider Mooring System to Screw Lock Anchor System

## Barriers to interactions with Large Industrial Users

- Barriers faced.
- Unable to attract the interests of potential large industrial users to adopt their technologies.
- Plans to promote their technologies within the Perth, Melbourne and Sydney boat shows to attract potential industrial users.
- A social, as well as technological persistence of user-producer interaction with potential large industrial users may entice the adoption of their technologies.

## 4.5 Case E

### 4.5.1 Commitment in Industrial R&D

"E" is a small Western Australian firm specialising in the development of bacterial water filters for the aquarium industry and was formed by the principals of QED Australia Pty Ltd (QED) and Underwater World International Pty Ltd (UWI). The firm commenced operations in 1996 with 5 employees including 4 scientists and engineers, and a marketing manager.

To date these employee levels have remained the same. Since the firm is still involved in R&D trials, they are as yet to generate a turnover. They, however, plan to enter commercialisation in the next 18 months, forecasting a A$3 million turnover within the next five years. Since incorporation, "E" have received a tax concession, funding from Fisheries WA and a WAISS grant for their R&D activities. They also rely on funds from their principals to conduct R&D activities.

***The idea of bacterial water filters***

The idea of bacterial water filters originated from a project conducted by QED and UWI prior to the incorporation of "E". In 1995 their involvement in the aquarium industry led them to the development of a new biological bacteria to assist in the biological filtration of artificial seawater in landlocked areas in Nanjing, China. Initial results of the application of the bacteria revealed that the quality of water in aquariums could be maintained for extensive periods of time without regular water changes.

This led to the realisation of widespread applications in controlling the parameters of seawater and it was at this stage that they conceived the idea of bacterial water filters. QED and UWI were, however, unable to commence development due to an insufficient capital/finance base. It was at this stage that "E" was formed to take advantage of the government schemes available to assist technology-based, small firms.

### 4.5.2 Impediments faced

Employees from QED were forwarded to "E" to begin development of the bacterial water filter. Like most small firms, "E" faced a number of capital constraints to develop and trial their technology. They, however, overcame these impediments through interactions with CSIRO Marine Laboratories (CSIRO) who provided them with holding facilities, water analysis equipment and water and air pumps, required for development and trials.

Interactions with the CSIRO also enabled "E" to keep up-to-date with the latest technical and industrial trends, which is usually a constraint faced by most small firms. "E" was also kept informed of these trends through their principal QED, who have been specialists in waste water management for a number of years. The expertise and skills of QED also assisted "E" in acquiring intellectual property rights for their technology, which is again a usually difficult task for new small firms.

"E" also faced financial constraints. Though "E" were part of an alliance with QED and UWI, these firms were also "small", facing similar resource constraints to "E", and therefore unable to fund "E's" research on an appreciable scale. As a result, "E" applied for government assistance securing a tax concession, Fisheries WA funding and a WAISS grant.

With resources and funding in hand they were able to develop their bacterial filter. Though "E" commercialised their technology within UWI, the demand was not significant enough to generate scale economies for the firm.

The next section examines the user-producer interaction that was responsible for the commercialisation of "E's" technology within UWI, and the extent of commercial opportunities derived as a result of this interaction. The next section also demonstrates the user-producer interactions with Kailis M.G. Exports Pty Ltd (Kailis) whom which "E" are currently engaged in trials.

### 4.5.3 User-Producer Interaction with both Large and Small Industrial Users

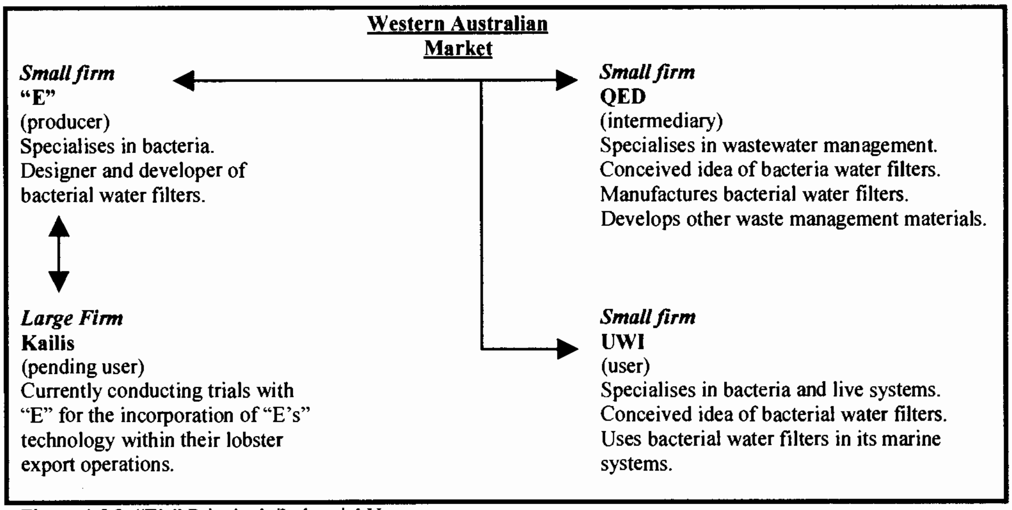


Figure 4.5.3 "E's" Principals/Industrial Users

QED and UWI have worked cohesively with "E" since the firm's incorporation. QED has formed an intermediary through whom UWI and "E" have communicated technical information, and who have also been the basis of "E's" technical developments. UWI has been the main user of "E's" bacterial water filters, incorporating and commercialising the technology through their operations. (See figure 4.5.3)

Close user-producer interactions with their principals through a problem-solving style approach, enabled them to acquire product-market fit. This was combined with a social orientation between the firms, which was second nature due to their former experiences together. This social, as well as technological orientation of user-producer interaction formed the basis of their interactions with Kailis. This 'social orientation' refers to the trust and commitment built with industrial users in combination with the informational exchanges of technological opportunities and user needs. The following references to "user-producer interaction" will assume this social orientation.

As has already been mentioned, close user-producer interactions with QED and UWI enabled "E" to develop the bacterial filter within the first few months of operation. This was trialed and successfully incorporated within UWI's marine systems. Though product-market fit was achieved through user-producer interactions, commercialisation was limited. This was because QED and UWI were also "small" firms facing similar constraints to "E", and where UWI lacked the "complementary assets" for large-scale commercialisation.

As a result, "E" turned their focus towards the fishing industry, which had a larger market potential for their technology. They planned to apply their bacterial water filters within seawater containers to maintain the condition of live seafood transported by ship to export markets.

"E" conducted initial trials on two different species of marine fish that were exposed to the bacteria water filters. Results, however, indicated that more comprehensive research was required on specific species to determine their environmental needs/parameters for transport.

The focus of their research quickly turned to the crayfish market as a result of the growing demand for Western Australian crayfish from China. At the time there were no current methods of transportation that could export crayfish to overseas markets in good condition. This created a major opportunity for the application of "E's" technology and subsequently led to their current interaction with Kailis.

Recognising the commercial potential of interacting with large industrial users and realising the potential application of "E's" technology for crayfish export, "E" approached Kailis with their technology. Initial meetings with Kailis discussing the potential application of "E's" bacterial water filter for use in their crayfish export operations encouraged them to agree to initial trials.

Kailis provided "E" with 20 lobsters for initial experimentation and promised a further 200 lobsters for a full-size experiment if initial results were successful. Initial results, were successful. "E" was able to keep 20 lobsters in optimum water parameters with their bacterial water filters live for 26 days without the loss of condition. This convinced Kailis to provide 200 lobsters for the full-size experiment. During this time, "E" found that most of the lobsters within the original experiment were still live 18 weeks later. This extended the credibility for "E's" technology since most shipments would be delivered well within 5 weeks.

With a clear set of water parameters to maintain crayfish at optimum conditions, "E" engineers are currently designing the sea container for the full-size experiment. The completion of this trial will lead into "E's" final phase of trials which will involve the supply of 6000 lobsters by Kailis to load ship containers for export. If this final phase is successful and product-market fit is acquired, Kailis will formally adopt "E's" technology within their export operations, hence commercialising "E's" technology.

Close user-producer interactions with Kailis have brought product expansion opportunities for "E", where they are currently developing a holding system, which will prepare lobsters for transportation at Kailis' Dongara lobster processing plant. If Kailis formally adopts "E's" technology within their crayfish export operations there will be other product diversification/expansion opportunities for "E" through Kailis. For example, the incorporation of "E's" bacterial water filters within their live holding facilities and within their exports of other major seafoods.

Close user-producer interactions with Kailis have also generated a number of other potential product diversification/expansion opportunities external to Kailis. This has been a result of Kailis' large-scale marketing resources and distribution channels within the fishing industry. For example, interests have been expressed to incorporate "E's" bacterial water filters into live fish holding facilities, and to assist fisherman with their on-board live holding tanks (eg. coral trout fisherman) in Northern Queensland to improve the quality of fish delivered from their boats to their on-shore holding facilities. The Coral Trout industry has also stimulated interests with regard to the potential of "E's" technology in delivering coral trout to their Asian markets.

Currently these opportunities are pending on the success of "E's" last phase of lobster trials with Kailis. Once results have proven to be successful, "E" will begin to pursue these opportunities. Until then, "E" are currently planning to move into the aquarium industry to maintain a sufficient cash flow to continue their trials with Kailis.

### 4.5.4 Barriers to Interactions with Large Industrial Users

"E" did not experience barriers in their interactions with Kailis. This has been attributed to the social and technological orientation of their strategies promoting user-producer interaction.

They have, however, experienced barriers convincing other 'preferred' industrial users of the potential application of their technology. For example, they have been unable to convince Fremantle Fisherman Cooperative and Geraldton Fisherman Cooperative to trial their technology.

This is typical of the market entry problems experienced by most small firms, where large industrial users perceive a level of uncertainty and technological risk in the adoption of technologies from new small producers who have little proof of successful application. Though the social and technological persistence of user-producer strategies may be adopted to build a relationship of trust with these users, the perceptions of these industrial users and the efforts to convince them may change if final trials with Kailis are successful.

### 4.5.5 Case Summary

"E's" strategies promoting close user-producer interactions with their principals - QED and UWI, has enabled them to develop and commercialise their technology within the aquarium industry. Dyadic technological informational exchanges through the intermediary efforts of QED have enabled "E" to acquire product-market fit and subsequent commercialisation of their bacterial water filters within UWI's marine systems.

However, since UWI were "E's" end user, as well as industrial user, and were a principal to the firm, no commercial returns were derived for the technology. This was also because UWI was a "small" user, lacking the "complementary assets" (large-scale marketing resources and distribution channels) able to commercialise "E's" technologies on an appreciable scale.

"E" have been unsuccessful on several attempts to attract potential large industrial users to their technology, unable to reduce the risks involved in the adoption of new technologies by these firms. This has been attributed to "E's" lack of resources and skills which is characteristic of most technology-based, small firms.

Through the social and technological persistence of user-producer interactions, "E" have, however, been able to secure the interests of Kailis, a large industrial user with the "complementary assets" able to extend the commercialisation of "E's" technologies on a larger scale. Dyadic user-producer interactions through the exchange of technological opportunities and user needs enabled Kailis to trial their technology, where "E" are currently nearing their last stage of trials with the firm.

If the succession of these user-producer interactive efforts achieves product-market fit, this will create a number of product diversification/expansion opportunities through the operations of Kailis. Moreover, the market coverage that will be achieved will secure the interests of those "preferred" industrial users, and of those potential industrial users who have expressed interests for "E's" technology during their trials with Kailis, ultimately bringing a stream of commercial opportunities to the firm.

Although "E" have yet to formally commercialise their technology with Kailis, the case does show how socially and technologically oriented strategies promoting user-producer interaction during trials with Kailis has acquired pending product-market fit and the potential large-scale commercialisation of their technology.

## Commitment in Industrial R&D

***Core Technology:*** Bacterial water filters

***Industry:*** Aquarium, fishing (pending)

***Ratio of Technical/Commercial Staff:***

- Technical Staff: 4
- Commercial Staff: 1

***Government Grants Received:***

- 125 % tax concession, Fisheries WA, WAISS grant.

***Funds for R&D as a % of 1998 turnover:***

- Turnover: A$0
- % to R&D: 0
- Funds to R&D: A$50,000 (from principals)

## Impediments faced

- Economies of scale, finance, infrastructure capital, and external communications.

## User-Producer Interaction

- Social and technological orientation.
- Dyadic problem-solving style approach through technological development.
- Achieved product-market fit.
- Commercialised technologies.

## User-Producer Interactions with Large and Small Industrial Users

***Industrial Users:*** UWI, Kailis (pending)

***Product Diversification:*** Bacterial water filters to the development of a live holding tank.

***Market Expansion:*** Aquarium to fishing industry pending trials with Kailis.

## Barriers to Interactions with Large Industrial Users

- Barriers faced.
- Unable to convince Fremantle Fisherman Cooperative and Geraldton Fisherman Cooperative to adopt their technologies.
- Risks associated with the adoption of "E's" technology may be reduced when trials with Kailis have been completed and have proven to be successful, and or through the social and technological persistence of user-producer interactions.

| |
|---|
| The next chapter presents a cross-case analysis of the cases within this chapter, providing a comprehensive analysis framed by the theoretical pathway and arguments presented within the literature. |

# CHAPTER FIVE

# CROSS-CASE ANALYSIS

## 5.0 Introduction

This chapter presents a cross-case examination of case results and their similarities and differences to the literature. The support for theoretical propositions is emphasised and the additional findings of the research are stipulated. The examination provides the basis of implications for the technology marketing practices of technology-based, resource-scarce, small firms presented in the concluding chapter.

## 5.1 The Results

The case results were framed by the theoretical pathway set out in chapter three and were analysed on the basis of comparisons against the literature presented in chapter two.

## 5.1.1 Commitment in Industrial R&D

**Table: 5.1.1 Commitment in Industrial R&D by Case Firms[12]**

| Case | Technical Staff/Commercial Staff | Government Grants Received | Funds for R&D as a % of 1997/98 turnover | Core Technology | Compete in large industrial sectors |
|---|---|---|---|---|---|
| "A" | Technical staff :6.5<br>Commercial staff :0.5 | WAISS grant; R&D Start Grant | Turnover: $800,000<br>% to R&D: 70%<br>Funds for R&D: $560,000 | Weigh-bridge and Video-image Processing Technologies | Railway and mining industry. |
| "B" | Technical staff :9<br>Commercial staff: 8 | 125% tax concession; WAISS grant | Turnover: $6 million<br>% to R&D: 8%<br>Funds for R&D: $480,000 | Lightweight Seats | Fast Ferry/Marine Industry |
| "C" | Technical Staff: 3.5<br>Commercial Staff: 0.5 | NIES grant; Neville Stanley Scholarship; Two WAISS grants; WAIIRDS grant (Category 2); R&D Start Grant (pending) | Turnover: $2 million<br>% to R&D: 12%<br>Funds for R&D: $240,000 | Ceramic and Polyurethane Products | Mining, Brick, and Laboratory industries. |
| "D" | Technical Staff: 1<br>Commercial Staff: 0 | Two WAISS grants | Turnover: $30,000<br>% to R&D: 0%<br>Funds for R&D: $131,000 (from principal firms) | Mooring Equipment | Maritime Industry |
| "E" | Technical Staff: 4<br>Commercial Staff: 1 | 125 %Tax Concession; Fisheries WA; WAISS grant | Turnover: $0<br>% to R&D: 0%<br>Funds for R&D: $50,000 (from principal firms) | Bacterial Water Filters | Fishing Industry (pending) |

The cases have demonstrated a significant commitment in industrial R&D activities. (See Table 5.1.1)

[12] The characteristics that have been chosen to represent the firms' commitments in industrial R&D have been selected by the researcher to reflect the closest representation of an individual firm's efforts in industrial R&D activities. See ACOST (1990, p.20) who argued that it is difficult to quantify the R&D activities of the small firm due to their informal structure.

All firms have a higher proportion of technical staff compared to commercial staff reflecting a scientific orientation typical amongst most technology-based firms. Their lack of commercial staff may explain the difficulties experienced by small firms in general to attract potential industrial users, and may explain the general inability of small firms to commercialise their technologies in industry.

All firms have received government grants at some stage since their incorporation. The reception of these government grants reflects their commitment to industrial R&D activities and their role in stimulating industrial competition, which supports the comments by Rothwell and Zegveld, 1981).

The case firms' commitment to technological activities has also been reflected in their internal investments to industrial R&D. "A", "B" and "C" have all derived funds from their annual turnovers to invest in further R&D activities. Both "D" and "E" have, however, relied on further investments in R&D via funding from their principal firms, as they have yet to generate a significant turnover to cover investments in industrial R&D.

The core technologies of the case firms supports Rothwell (1983) and Ettlie and Rubenstein's (1987) representation of basic technologies that are external to existing market structures, and therefore reflect technologies that are advanced and leading-edge.

Finally, four out of the five firms have shown the ability of their technologies to compete in major Western Australian industrial sectors (mining, railway, building, and marine)[13] which supports the argument

[13] Recognised major Western Australian industrial sectors by the Department of Commerce and Trade.

outlined by ACOST (1990) with regards to the capability of small firms to create competition within large industrial markets.

### 5.1.2 Impediments Faced by the Technology-Based, Small Firm

**Table 5.1.2 Impediments Faced by Case Firms**

| Case | Intellectual Property Rights | Economies of Scale | Finance | Capital (Infrastructure) | External Communication |
|---|---|---|---|---|---|
| "A" | ✗ | ✓ | ✓ | ✓ | ✗ |
| "B" | ✗ | ✗ | ✓ | ✗ | ✗ |
| "C" | ✗ | ✓ | ✓ | ✓ | ✓ |
| "D" | ✗ | ✓ | ✓ | ✗ | ✓ |
| "E" | ✗ | ✓ | ✓ | ✓ | ✓ |

**Key:**

✓ **Faced impediment**

✗ **Did not face impediment**

All firms experienced impediments characteristic amongst technology-based, small firms when developing and commercialising their technologies. (See Table 5.1.2)

***Intellectual Property Rights***

In contrast to the arguments put forth by Rothwell & Zegveld (1982) none of the case studies experienced difficulties in acquiring intellectual property rights for their technologies. In both "D's" and "E's" case, the skills to acquire such rights and the funds to obtain them, came from their principals who have operated in their relevant industrial sectors for a number of years and who realised the importance in protecting developed technologies.

Similarly, the experience of managers also enabled "A", "B" and "C" to acquire intellectual property rights for their technology. For example, “A’s” manager came from a research background within the railway and mining industries, “B’s” manager had adopted a strong technical background through the firm’s extensive experience within the fast ferry industry, and “C’s” manager had a background in ceramic engineering with industrial experience in the UK and South Africa.

***Economies of Scale***

“A” and “C” have experienced difficulties in acquiring economies of scale because of the lack of a vertically integrated structure (see Rothwell and Zegveld, 1982). However, “A’s” contacts with BHPIO enabled them to acquire a break within the railway and mining industries that consequently generated a high demand for their technologies. Similarly, “C’s” contacts with Curtin gave the firm an initial break within the laboratory industry, which led to a network of contacts and subsequent high demand for their technologies.

In “C’s” case, however, it was also the efforts of its manager to proactively scan the market for technological and commercial opportunities, which led to their break within the mining and brick industries.

“B” did not experience impediments in achieving economies of scale within their operations because of their already established distribution networks as a result of their 45 - year operational span within the marine industry. “B’s” established reputation within the marine industry and links with two of Australia’s major ship builders created an instant market for “B’s” technologies.

“D” and “E” had a market for their technologies through a semi-integrated structure. However, their industrial users were small firms unable to generate the level of demand to create scale economies for the firm. Consistent with the argument put forth by Moore and Garnsey (1990, p.508) this subsequently affected their ability to further invest in R&D activities.

### *Finance*

All cases experienced financial difficulties. Though "D" and "E" did acquire funds from their principals, and "B", from their internal budget, this was often not enough to cover the costs of R&D. Since all cases were unable to attract external funding from private sector firms, a common impediment experienced amongst most technology-based, small firms (see Hall, 1989), all firms received government grants to assist them in this area.

### *Infrastructure Capital*

"A", "C" and "E" faced impediments with regards to infrastructure capital to commence initial developments. (See Hall, 1989) "A" overcame this impediment through a second mortgage on the manager's house; "C" previous relationships with Curtin enabled them to acquire laboratory equipment from the university in exchange for the supervision of PhD students; and "E" acquired equipment from Fisheries WA and CSIRO Marine Laboratories.

Both "B" and "D" did not experience any impediments in this regard as capital was provided internally in the former case, and through principal firms in the latter case.

*External Communications*

Contrary to the argument by Sheen (1992) external communication difficulties were overcome by “A” and “B” due to their familiarity and experience within Western Australian industry.

“C”, “E” and “D” did, however, face such constraints. In “C’s” case, this was overcome through the employment of Neville Stanley/PhD students who formed part of “C’s” research team. In “E’s” case, this was overcome through links with Fisheries WA and CSIRO Marine Laboratories, as well as the knowledge of principal managers. “D” overcame these constraints through the efforts of their principal firms. Therefore the help of qualified technical specialists enabled them to overcome these external communication impediments. (See Rothwell & Dodgson, 1991, p.131)

Whilst user-producer interaction was clearly the most important stimulus to commercialisation, it is evident that other factors such as the assistance of principal firms, other R&D firms, the State Government, and the experience of firm managers, also helped to accelerate this process.

### 5.1.3 User-Producer Interaction to Commercialise Technologies

**Table 5.1.3 User-producer Interactions by the Case Firms and the Commercialisation of Technologies**

| Case | Demonstrated Strategies of User-Producer Interaction | Commercialised Technologies |
|---|---|---|
| "A" | ✓ | ✓ |
| "B" | ✓ | ✓ |
| "C" | ✓ | ✓ |
| "D" | ✓ | ✓ |
| "E" | ✓ | ✓ |

**Key:**

✓ yes

✗ no

All firms commercialised their technologies through the adoption of strategies promoting user-producer interaction. (See Table 5.1.3) Dyadic technical interactions, involving a problem-solving style approach through the exchange of technological opportunities and user needs, enabled firms to develop technologies for industrial users that acquired product-market fit. This resulted in the commercialisation of their technologies, and supports the arguments put forth by Lundvall (1993, p.285); Bar and Borrus (1992) and Shaw (1987).

All firms demonstrated close user-producer interactions with their Western Australian based industrial users, which enabled the successful development of technologies, supporting the findings by Germunden (1992). However, they also experienced successful user-producer interactions with distant industrial users, which supports the findings by Gertler (1993).

For example, "B" demonstrated successful interactions with In-Cat in Tasmania and "C" had demonstrated successful interactions with firms in the Eastern States. There is also evidence to suggest successful user-producer interactions with industrial users internationally. This, however, was beyond the scope of this study and was not analysed in any great depth. This does, however, support the arguments put forth by Sabel et al (1987) and Porter (1990).

In contrast to the findings by Littler (1994) and Moenaert and Souder (1990) user-producer interactions were initiated by technical, rather than commercial staff amongst the case firms. This is because as resource-scarce, small firms they lacked a formal marketing department to commercialise their technologies. For example, in all cases the managers of the firms conducted commercial activities, as well as heading technical developments.

Though Rothwell (1994, p.636) has extended concerns with regards to the value of industrial users, all firms have been successful in their initial interactions to commercialise their new technologies. In each case this was because the firms either knew the industrial users or were principals to the firm.

For example, "A's" manager had informal ties with BHPIO as a former employee of the firm. Similarly "C" had former ties with Curtin which enabled them to pursue successful interactions. In the case of both "E" and "D", the principals to the firm formed their industrial users (UWI was an industrial user to "E", and Diver I and Diver II was an industrial user to "D"). In the case of "B", cooperation from industrial users was substantially easier to attain as a result of their many former experiences with these firms over their 45 years within industry.

A major finding within the present study is that all firms have been able to sustain their efforts with these industrial users through the ***social,*** as well as technological orientation of user-producer interactions. (See Davidow, 1986; Lundvall, 1993, p.285)

The relationships demonstrated by "A", "C", "B" and "D" do not support the argument put forth by Lundvall (1988) that when relationships are strategic, passivity may force relationships to become inward looking, overlooking external opportunities. Each case has shown product diversification as a result of their integrated efforts with initial industrial users, consequently supporting the arguments by Rothwell (1986) and Rothwell and Gardiner (1990). These product diversification opportunities were more extensive for those firms who interacted with large industrial users. The influence that large industrial users had over product diversification and market expansion opportunities is now examined.

### 5.1.4 User-Producer Interaction with Large and Small Industrial Users

**Table 5.1.4 Product Diversification and Market Expansion Opportunities Experienced by the Case Firms**

| Case | Industrial Users | Commercial Opportunities Derived |
|---|---|---|
| "A" | **Large Firms:**<br>BHPIO; Westrail, Australian National; Alcoa; and TTCI. | **Product Diversification:**<br>Four weigh-bridge designs<br>-Loadout facility weighing<br>-High speed weigh-bridge system<br>-Empty wagon detector<br>-Front end loader weighing system<br>Wheel/rail interaction system diversified into a train health monitoring system<br>**Market Expansion:**<br>Railway to mining<br>**International Market:**<br>North America |
| "B" | **Large Firms:**<br>Austal Ships and In-Cat. | **Product Diversification:**<br>Lightweight seats diversified into 25 designs with extensive accessories.<br>**Market Expansion:** Cruise Liners (pending)<br>**International Markets:**<br>China, South East Asia, United States, South America, Africa, Europe and Japan.<br>North America (pending) |
| "C" | **Large Firms:**<br>CSIRO; ANSTO; HANWHA; Curtin, Monash and Woolongong Universities; BHP; Hismelt; Alcoa; Westralian Sands; Sons of Gwalia; KCGM; WMC; Boral and CSR. | **Product Diversification:**<br>Simple crucible shapes and brick extrusion cores diversified into a myriad of ceramic and polyurethane based products<br>**Market Expansion:**<br>Laboratory to brick, mining industries and foundaries.<br>**International Markets:**<br>South America, South Africa, Fiji, New Zealand, PNG, Ghana, Malaysia and Indonesia. |
| "D" | **Small Firm:**<br>Diver I and Diver II. | **Product diversification:**<br>Easy Rider to Screw Lock System |
| "E" | **Small Firm:**<br>UWI | |
| | **Large Firm:**<br>Kailis | **Product Diversification:**<br>Bacterial water filters to live holding tank.<br>**Market Expansion:**<br>Aquarium to fishing industry pending trials with MG Kailis |

Those firms that interacted with large industrial users ("A", "B", and "C") were able to commercialise their technologies, as well as extend their scope of commercial opportunities through the "complementary assets" held by these firms (see Teece, 1986). (See Table 5.1.4)

In addition to the product diversification and market expansion opportunities achieved through interactions with these large industrial users, it was clear that the large-scale marketing and distribution resources of these industrial users also enabled the case firms to attract *other potential* industrial users (both domestic and international) to the firms technologies. This consequently enabled further product diversification and market expansion opportunities for the firms. (See Katz and Martin, 1997, p.15)

A major finding within this study is that all firms have been able to secure the interests of *'other potential'* industrial users through the ***social***, as well as technological orientation of user-producer interactions. (See Davidow, 1986; Lundvall, 1993, p.285)

For example, "A's" initial interactions with BHPIO enabled them to diversify their technologies, as well as acquire relationships with Westrail, Australian National, and Alcoa, which consequently brought further commercial openings for the firm. Furthermore, the credibility of interacting with these industrial users coupled with their extensive market coverage encouraged interactions with the TTCI in North America.

In the case of "B", interactions with Austal Ships and In-Cat have brought extensive product expansion opportunities, as well as the attraction of major users internationally. "C's" interactions with Curtin brought a number of product diversification opportunities, while their links with the CSIRO led to the attraction of other major industrial users and product diversification within the laboratory industry.

However, it was the efforts of "C's" manager that extended the firm's market expansion opportunities where he interacted with potential large industrial users across the mining and brick industries. The social and technological orientation of user-producer interactions within these industries created a network of contacts for "C", explaining their large client base.

In contrast, those firms ("D", "E") that interacted with small industrial users experienced minimal or no product diversification and market expansion opportunities because of the "small firm" characteristics of their users. Similar to "D" and "E", these small industrial users also faced constraints with regards to the availability of marketing resources and distribution channels, and were therefore unable to attract the interests of industrial users within large-scale markets.

"E" has, however, attempted to overcome these constraints through interactions with Kailis, whom which they are currently conducting trials of their technology. If trials are successful, this will bring a number of commercial opportunities for "E" as a result of Kailis's "complementary assets".

It is clear that the 'dynamic complementarities' (see Rothwell, 1983; 1989a) existing between the case firms and their large industrial users formed the basic stimulant to interaction. Three of the cases showed interactions to be also based on competitive factors, which supports the findings by Hagedoorn and Schakenraad (1990) and Saxenian (1991).

For example, in the case of "A" and "B", interactions with large industrial users enabled their technologies to accomplish a first to market advantage as a result of these users' extensive marketing and distribution resources. "E's" intent to interact with Kailis also arose for competitive reasons.

Overall, the cases demonstrated that interactions with large industrial users brought more product diversification and market expansion opportunities than interactions with small industrial users.

### 5.1.5 Barriers to Interactions with Large Industrial Users

**Table 5.1.5 Barriers to Interactions with Large Industrial Users Faced by the Case Firms**

| Case | Interactions with Large Industrial users | Interactions with Small Industrial Users | Barriers to Interactions with Large Industrial Users |
|---|---|---|---|
| "A" | ✓ | ✗ | ✗ |
| "B" | ✓ | ✗ | ✗ |
| "C" | ✓ | ✗ | ✗ |
| "D" | ✗ | ✓ | ✓ |
| "E" | ✓ | ✓ | ✓ |

**Key:**

✓ **Yes**

✗ **No**

Both "D" and "E" have experienced entry barriers that are typical amongst small firms when trying to find large industrial users for their technologies (see Hartley and Hutton, 1989). (See Table 5.1.5) They have been unable to attract the interests of these users as a result of the high risk factors associated with the newness of their technologies and their credibility as a newly established firm. Given these impediments, "E" has, however, managed to attract the interests of Kailis through the social and technological persistence of user-producer strategies of interaction. This has consequently led to their current trials with Kailis.

Contrary to the argument put forth by Forrester and West (1985, p.25), "A", "B" and "C" have been able to influence the decisions of large industrial users to adopt their technologies through strategies promoting user-producer interaction.

It must be noted that those firms that did interact with large industrial users experienced 'easier market entry' and exposure to a network of industrial users than would most technology-based, small firms. For example, "A" and "C" had former contacts within industry, and "B's" industrial users were users whom which they have had many past experiences, which substantially reduced the technological risks usually associated with the adoption of small firm technologies by large industrial users.

This study has found that in a majority of cases it has been the persistence of ***social*** and technological orientation of user-producer interactions that has enabled them to reduce the risks experienced by large industrial users in the adoption of new technologies from technology-based, small firms.

## 5.2 Support for Theoretical Propositions and Additional Findings

### 5.2.1 Support for Theoretical Propositions

Theoretical Proposition One

***User-producer interaction facilitates the commercialisation of small firm technologies through a dyadic, problem-solving style approach through technology development.***

The cases have demonstrated that the adoption of strategies promoting user-producer interaction through a dyadic problem-solving style approach with industrial users enables small firms to commercialise their technologies in industry.

Theoretical Proposition Two

***The larger the industrial user, the greater the level of commercial opportunities experienced by the technology-based, small firm.***

The cases have found that small firms interacting with large industrial users have experienced extensive product diversification and market expansion opportunities as opposed to those firms interacting with small industrial users.

Theoretical Proposition Three

***Firms with a lesser extent of commercial opportunities are more likely to face barriers to interactions with large industrial users.***

The study has found that those firms that have experienced a lesser extent of commercial opportunities faced barriers to interactions with large industrial users.

### 5.2.2 Additional Findings

The study has found that the commercialisation of small firm technologies, the commercial extent derived for these technologies, and the overcoming of barriers faced by the small firm, was dependent on the social orientation of user-producer interaction in conjunction with the dyadic information exchanges of technological opportunities and user needs.

This social orientation included:

- the trust and commitment that was built with industrial users; and
- the strategic relationships that were formed.

The findings of the present study forms an original contribution to the way technology-based, resource scarce, small firms may commercialise their technologies.

The original pathway upon which the analysis of case studies was based is up-dated to incorporate these new findings.

### 5.2.3 The Up-dated Theoretical Pathway

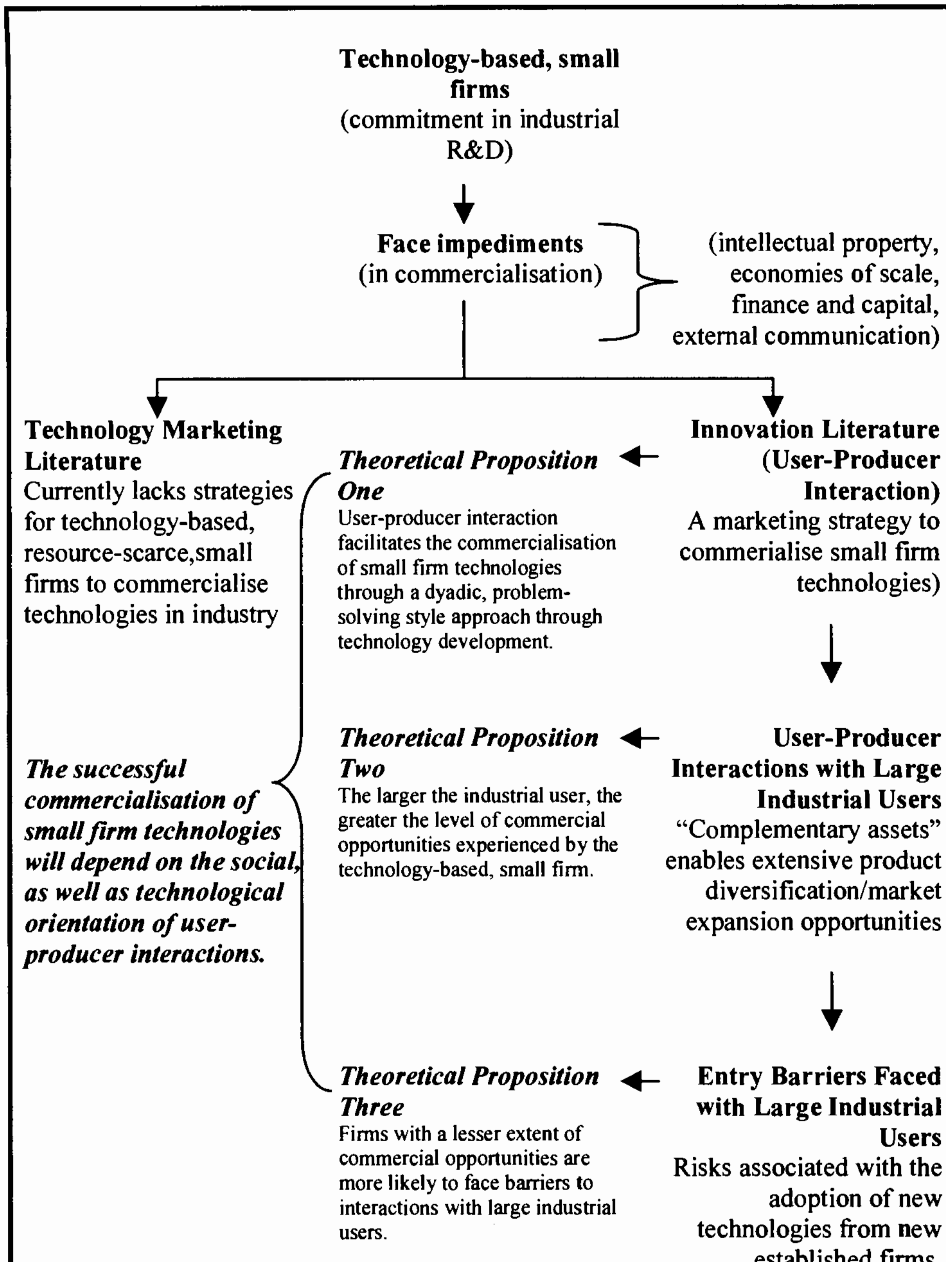


**Figure 5.2.3 Up-dated theoretical pathway**

The next chapter forms the conclusions to this study. It presents an overview of the study, a summary of main findings, the limitations and further areas of research. The chapter concludes with implications for the technology marketing practices of technology-based, resource-scarce, small firms.

# CHAPTER SIX

# CONCLUSION

The conclusion provides an overview of the study and the findings to the research questions posed at the beginning of this study. The limitations of the study are highlighted and further areas of research are proposed. This chapter concludes with implications for the technology marketing practices of resource-scarce, small firms.

## 6.0 Overview of the Study

Chapter one has presented the background to the study, the scope of the study, the objectives and the research questions. The significance of the research, a definition of terms, and the organisation of the overall study were also presented.

Chapter two has examined the literature related to the role of technology-based, small firms in the development and commercialisation of new technologies. The chapter was the basis upon which the theoretical pathway within this study was constructed.

Chapter three has discussed the methodology. The study adopted a multiple, holistic case study design that used qualitative methodology involving a combination of secondary data and face-to-face interviews with the managers of firms that have received WAISS funding, and that have signified a high value for interactions with other firms in R&D and commercial activities.

Chapter four has presented the case studies on five technology-based, small firms who were recipients of the WAISS and who had a high value for interactions in R&D and commercial activities. The theoretical pathway guided the composition and interpretation of each case.

Chapter five has provided a cross-case analysis of the five cases, framed by the theoretical pathway and analysed through comparisons with arguments presented within the literature. The theoretical propositions emphasised within this study were supported and an original contribution to the way resource scarce, small firms may commercialise their technologies was made. This was up-dated within the theoretical pathway upon which the cross-case analysis was based.

### 6.1 Summary of Main Findings

**<u>Research Question One</u>: How have grantee firms overcome their impediments?**

Whilst user-producer interaction was clearly the most important stimulus to commercialisation, other factors such as the assistance of principal firms, other R&D firms, the State Government, and the experience of firm managers, also helped to accelerate this process.

**Research Question Two: How does the process of user-producer interaction facilitate the commercialisation of grantee firm technologies?**

Dyadic technological interactions, involving a problem-solving style approach, have enabled firms to develop technologies for industrial users that achieved product-market fit and the simultaneous commercialisation of their technologies.

The study found that it was the ***social***, as well as technological orientation of user-producer interaction that has enabled firms to commercialise their technologies. This 'social orientation' referred to the trust and commitment that was built with industrial users in conjunction with information exchanges of technological opportunities and user needs.

**Research Question Three: How does user-producer interaction with large industrial users affect the commercial extent of technologies as opposed to interactions with small industrial users?**

Three of the five firms that interacted with large industrial users were able to commercialise their technologies, as well as extend their scope of commercial opportunities as a result of the "complementary assets" held by these users.

In addition to the product diversification and market expansion opportunities acquired through interactions with these large industrial users, it was clear that the large-scale marketing and distribution resources of these industrial users also enabled the three firms to attract other industrial users, both domestically and internationally. This ultimately led to further product diversification and market expansion opportunities.

The two firms that interacted with small industrial users experienced either minimal or no product diversification and market expansion opportunities because of the 'small firm' characteristics of these users. This meant that as 'small firms' these industrial users also faced constraints with regards to the availability of marketing resources and distribution channels, and were therefore unable to attract the interests of industrial users within large-scale markets.

The study found that it was the ***social***, as well as the technological efforts of user-producer interaction that enabled three of the five firms to sustain strategic relationships with their large industrial users, as well as secure the interests of other potential large industrial users both domestically and internationally.

**Research Question Four: How have entry barriers affected user-producer interactions with large industrial users?**

The two firms that experienced either minimal or no product diversification and market expansion opportunities have faced entry barriers typical to the small firm when trying to find large industrial users for their technologies. For example, the high risk factors associated with the newness of their technologies and their credibility as a newly established firm, formed barriers to their interactions with large industrial users. However, the two cases did reveal that though they have demonstrated user-producer interaction with their principal firms, they have not applied the principles of this interaction when attempting to form relationships with large external industrial users.

The three firms that have experienced extensive market opportunities for their technologies have been able to commercialise their technologies with large industrial users through the adoption of socially and technologically oriented efforts of user-producer interaction.

The study therefore found that it was the ***social***, as well as the technological efforts of user-producer interaction that enabled the three firms to overcome entry barriers in their interactions with large industrial users by reducing the technological risks often associated with the adoption of new technologies from new technology-based firms.

**<u>Research Question Five</u>: Given that all firms demonstrate user-producer interaction to commercialise their technologies, why are some firms more successful than others?**

The study found that it was the trust and commitment that was built with industrial users in conjunction with the exchange of technological opportunities and user needs that enabled some cases to not only commercialise their technologies but, also to:

- sustain their relationships with large industrial users;
- secure the interests of other potential large industrial users, both domestically and internationally; and
- more importantly reduce the risks often associated with the adoption of new technologies by large industrial firms.

## 6.2 Study Limitations and Further Areas of Research

The study is representative of a sample of Western Australian technology-based, small firms. Further legitimacy to the use of user-producer interaction:

- in the commercialisation of small firm technologies;
- in the benefits derived through interactions with large industrial users;
- in reducing the entry barriers faced in forming interactions with large industrial users; and
- in a social, as well as technological context;

may be examined through studies of similar firms across Australia and internationally.

This study was restricted from conducting an in-depth analysis of other grantee firms who did not adopt strategies promoting user-producer interaction but had nevertheless commercialised their technologies. Further research may be conducted on these firms by examining the processes through which they have commercialised their technologies.

The commercial efforts by unsuccessful and non-applicants of the WAISS were also not examined. Further areas of research could involve a combination of quantitative and qualitative methods of analysis to examine whether, and how these firms have commercialised their technologies.

The research has examined user-producer interactions from the experiences of the small producer. Further research could explore the experiences of large industrial users, their interactions with small technology producers, and their perspective on the development and commercialisation of technologies.

## 6.3 Implications for the Technology Marketing Practices of Resource-Scarce, Small Firms

This study has found support for a strategy available for technology-based, small firms who face a number of impediments commercialising their technologies within industry. The strategy known as "user-producer interaction" involves the dyadic exchange of technological opportunities and user needs between technology producers and industrial users through technological development, where product-market fit is achieved and technologies are simultaneously commercialised.

The study has also found that the commercial extent of these interactions increase when technology-based, small firms interact with large industrial users who have the large-scale "complementary assets" able to generate product diversification and market expansion opportunities. A major finding within this study was that these firms were able to sustain their relationships with large industrial users and secure the interests of other potential large industrial users through the social, as well as the technological orientation of user-producer interaction.

The study also highlighted the entry barriers faced by technology-based, small firms in their interactions with large industrial users. The study has found that user-producer interaction on a social, as well as a technological basis, may reduce the risks often associated with the adoption of new technologies from new technology-based firms by large industrial users.

In addition to the support of the theoretical propositions upon which this study was based, this research has found that the social, as well as technological orientation of user-producer interaction have enabled technology-based, small firms to:

- commercialise their technologies;
- sustain their relationships with large industrial users;
- secure the interests of other potential large industrial users, both domestically and internationally, but
- more importantly reduce the risks associated with the adoption of new technologies by large industrial firms.

*In essence the social, as well as the technological orientation of user-producer interaction demonstrated by these small technology producers is a solid basis upon which other technology-based, small firms may commercialise their technologies in large industrial markets.*

### 6.4 Implications for the WAISS

At the beginning of this study it was acknowledged that direct investments in industrial R&D do not always have a direct affect on commercialisation (Hall, 1984, p.268). This study has substantiated this argument by emphasising the crucial role user-producer interaction plays in the commercialisation of small firm technologies. This implies that in order for the WAISS to realise the commercial effects of industrial R&D funding, the scheme must either promote or encourage the context of user-producer interaction in the technological development activities of small firms.

### 6.5 Final Comments

This study built on the marketing literature with respect to the strategies available for resource-scarce, small firms to commercialise their technologies. The study contributes insight on several crucial issues. First, the findings provide information helpful in anticipating whether user-producer interaction is effective in commercialising small firm technologies. Second, the study contributes an important finding relating to the social and technological context of user-producer interaction in the commercialisation of small firm technologies. Third, the study supports theoretical propositions based on arguments from within the industrial innovation literature, but with direct application to the marketing literature, with respect to the commercialisation of small firm technologies.

Future research on the use of user-producer interaction will not only contribute to an important area of the marketing literature but, as is clear from this present study, to developing practical marketing strategies for the managers of technology-based, resource scarce, small firms.

# REFERENCES

# REFERENCES


ACOST (1990). The enterprise challenge: Overcoming barriers to growth in small firms. London: HMSO.

Bar, F., & Borrus, M. (1992). Information networks and competitive advantage: Issues for government policy and corporate strategy. Int. J. Technology Management, Special Issue on the Strategic Management of Information and Telecommunication Technology, 7(6/7/8), 398-408.

Barber, J., Metcalfe, J.S., and Porteous, M. (1989). Barriers to growth: The ACARD study. In J. Barber et al (eds.), Barriers to growth in small firms (pp.1-19). London & New York: Routledge.

Barclay, I., & Benson, M.H. (1987). Improving the chances of new product success. In R.Rothwell and J. Bessant (eds.), Innovation: Adaptation and growth (pp.103-112). Amsterdam: Elsevier Science Publishers.

Beesley, M.N., & Rothwell, R. (1987). Small firm linkages in the United Kingdom. In R.Rothwell and J. Bessant (eds.), Innovation: Adaptation and growth (pp.189-200). Amsterdam: Elsevier Science Publishers.

Bertodo, R.G. (1990). The strategic alliance: Automotive paradigm for the 1990s. Int. J. Technology Management, 5(4), 375-388.

Biemans, W.G. (1992). Managing innovation within networks. London: Routledge.

Bromley, D.B. (1986). The case-study method in psychology and related disciplines. Chichester: Wiley.

Chakrabarti, A.K. (1991). Industry characteristics influencing the technical output: A case of small and medium size firms in the US. R&D Management, 21(2), 139-152.

Commerce and Trade (1996). Directory of research and development in Western Australia, 2nd ed., Perth: DCT.

Cooke, P., & Morgan, M. (1994). The creative milieu: A regional perspective on innovation. In M. Dodgson and R.Rothwell (eds.), The handbook of industrial innovation (pp.25-32). London: Edward Elgar Publishing.

Davidow, W.H. (1986). Marketing high technology: An insider's view. New York: The Free Press.

Dodgson, M. (1987). High-growth technology-based small and medium-sized firms in Europe. In R.Rothwell and J. Bessant (eds.), Innovation: Adaptation and growth (pp.247-254). Amsterdam: Elsevier Science Publishers.

Eckles, R.W. (1990). Business marketing management: Marketing of business products and services. New Jersey: Prentice Hall.

Edwards, D.J.A. (1998). Types of case study work: A conceptual framework for case-based research [on-line]. Available WWW: http://proquest.umi.com/pqdweb?TS=9T750...id=000000034995541&Deli=1&RQT=309&Dtp=1

Ettlie, J.E., and Rubenstein, A.H. (1987). Firm size and product innovation. Journal of Product Innovation Management, 4, 89-108.

Forrester, J., and West. T. (1985). Defence sector procurement: Opportunities for high technology small firms. London: Small Business Research Trust.

Freeman, C., Clark, J., & Soete. L. (1982). Unemployment and technical innovation. London: Frances Pinter Publishers Ltd.

Freeman, C. (1991). Networks of innovators: A synthesis of research issues. Research Policy, 20, 499-514.

Gemunden, H.G. and Heydebreck, P. (1995). The external links and networks of small firms – their role and nature. In D.P. O'Doherty (ed.), Globalisation, networking and small firm innovation (pp.87-100). London: Graham & Trotman Ltd.

Gemunden, H.G., Heydebreck, P., & Herden, R. (1992). Technological interweavement: A means of achieving innovation success. R&D Management, 22(4), 359-376.

Gertler, M. S. (1993). Implementing advanced manufacturing technologies in mature industrial regions: Towards a social model of technology production. Regional Studies, 27 (7), 665-680.

Gross, A.C., Banting, P.M., Meredith, L.N., and Ford, I.D. (1993). Business marketing. Boston & Torronto: Houghton Mifflin Company.

Guba, E.G., and Lincoln, Y.S. (1981). Effective evaluation. San Francisco: Jossey-Bass.

Haas, R.W. (1986). Industrial marketing management, 3rd ed., Massachusetts: Kent Publishing Co.

Haas, R.W. (1992). Business marketing management: An organisational approach: Text and cases, 5th ed., Massachusetts: PWS-Kent Publishing Co.

Hagedoorn, J., & Schakenraad, J. (1990). Strategic partnering and technological cooperation. In C. Freeman and L. Soete (eds.), New explorations in the economics of technical change (ch.1). London: Pinter Publishers.

Hagedoorn, J., & Schakenraad, J. (1992). Leading companies and networks of strategic alliances in information technologies. Research Policy, 21, 163-190.

Hall, P.H. (1984). The theory and practice of innovation policy: An overview. Greek Economic Review, 6 (3), 253-286.

Hall, G. (1989). Lack of finance as a constraint on the expansion of innovatory small firms. In J. Barber et al (eds.), Barriers to growth in small firms (pp.39-57). London & New York: Routledge.

Hamel, J. ( 1993). Case study methods. London: Sage Publications

Hartley, K., and Hutton, J. (1989). Large purchasers. In J. Barber et al (eds.), Barriers to growth in small firms (pp.105-127). London & New York: Routledge.

Hennaart, J.F. (1988). A transaction cost theory of equity joint ventures. Strategic Management Journal, 9, 361-374.

Hutt, M.D., and Speh, T.W., (1995). Business marketing management, 5th ed., Chicago: Dryden Press.

Katz, J.S., & Martin, B.R. (1997). What is research collaboration? Research Policy, 26, 1-18.

Larsson, S. (1993). New dimensions in organizing industrial networks. International Journal of Technology Management, 8(1/2), 39-58.

Link, P. (1987). Marketing of technology: An Australian perspective. Melbourne: Nelson Wadsworth.

Littler, D. (1994). Marketing and innovation. In M. Dodgson and R.Rothwell (eds.), The handbook of industrial innovation (pp.293-300). London: Edward Elgar Publishing.

Lovett, J.R. (1992). Doing the right things right, all the time. Research and Technology Management, Sept-Oct, 35-38.

Lundvall, B.A. (1985). Product innovation and user-producer interaction. Aalborg: Aalborg University Press.

Lundvall, B.A. (1988). Innovation as an interactive process: from user-producer interaction to the national system of innovation. In Dosi et al (eds.), Technical change and economic theory (pp.349-369). London: Pinter Publishers.

Lundvall, B.A. (1993). User-producer relationships, national systems of innovation and internationalization. In D. Foray & C. Freeman (eds.), Technology and the wealth of nations (pp.277-300). London & New York: Pinter Publishers.

MacDonald, S. (1992). Formal collaboration and informal information flow. Int. J. Technology Management, Special issue on strengthening corporate and national competitiveness through technology, 7(1/2/3), 49-60.

Maidique, M.A., and Zirger, B.I. (1984). The new product learning cycle. Research Policy, 14, 299-313.

Maier, H. (1989). Partnership between small and large firms. Proceedings of the conference held in Brussels, 13 & 14 June 1988. London & Boston: Graham & Trotman.

Marinova, D., Phillimore, J., and Saupin. M.G. (1998). Evaluation of the Western Australian Innovation Support Scheme (WAISS). Perth, Western Australia: Murdoch University, Institute for Science and Technology Policy.

McGee, J. (1989). Barriers to growth: The effects of market structure. In J. Barber et al (eds.), Barriers to growth in small firms (pp.173-195). London & New York: Routledge.

Midgley, D.F. (1977). Innovation and new product marketing. London: Croom Helm.

Miles, M.B., & Huberman, A.M. (1984). Qualitative data analysis. California: Sage Publications.

Miles, M.B., & Huberman, A.M. (1994). Qualitative data analysis: An expanded source book, 2nd ed., California: Sage Publications.

Mitchell, J.C. (1983). Case and situation analysis. Sociological Review, 31(2), 187-211.

Moenaert, R.K., & Souder, W.E. (1990). An information transfer model for integrating marketing and r&d personnel in new product development projects. Journal of Product Innovation Management, 7, 91-107.

Moore, I., & Garnsey, E. (1993). Funding for innovation in small firms: The role of government. Research Policy, 22, 507-519.

Morris, M.H. (1992). Industrial and organisational marketing, 2nd ed., New York: Mac Millan Publishing Co.

Mowery, D.C. (1989). Collaborative ventures between US and foreign manufacturing firms. Research Policy, 18(1), 19-33.

Mueser, R. (1985). Identifying technical innovations. IEEE Transactions in Engineering Management, 32(4), 158-176.

National SBIR Conferences (1998). Let us help you win some of the $2 billion available for small firms in federal r&d funding this year [on-line]. Available WWW: http://infoserv.rttonet.psu.edu/sbir-con.htm

Oakey, R.P., Rothwell, R., Beesley, M., & Cooper, S.Y. (1987). Research and development and competitive performance in British and American high technology small firms. In R.Rothwell and J. Bessant (eds.), Innovation: Adaptation and growth (pp.155-188). Amsterdam: Elsevier Science Publishers.

Pisano, G.P. (1991). The governance of innovation: Vertical integration and collaborative arrangements in the biotechnology industry. Research Policy, 20, 237-249.

Porter, M.E. (1990a). Competitive strategy: Techniques for analyzing industries and competitors. New York: The Free Press.

Porter, M.E. (1990b). The competitive advantage of nations. Harvard Business Review, 68, 73-93.

Rexroad, R.A. (1983). High technology marketing management. New York: Wiley.

Roberts, E.B. (1989). Managing technological innovation in the medical devices industry. Research Technology Management, July-August, 34-41.

Roberts, E., and Berry. (1985). Entering new business: Strategies for success. Sloan Management Review, Spring.

Romer, K., and Van Doren, D.C., (1993). Implementing marketing in a high-tech business. Industrial marketing management, August.

Rothwell, R., et al. (1972). SAPPHO updated. Research Policy, 3(3), 259-291.

Rothwell, R. (1983). Innovation and firm size: a case for dynamic complementarity; or, is small really so beautiful? Journal of General Management, 8(3), 5-25.

Rothwell, (1984). The role of small firms in the emergence of new technologies. OMEGA The International Journal of Management Science, 12(1), 19-29.

Rothwell, R. (1986). Innovation and re-innovation: A role for the user. Journal of Marketing Management, 2(2).

Rothwell, R. (1989a). Small firms, innovation and industrial change. Small Business Economics, 1 (1).

Rothwell, R. (1989b). SME's, inter firm relationships and technological change. Entrepreneurship and Regional Development, 1, 275-291.

Rothwell, R. (1994). Issues in user-producer relations in the innovation process: the role of government. International Journal of Technology Management, 9(5/6/7), 629-649.

Rothwell, R., and Dodgson, M. (1991). External linkages and innovation in small and medium-sized enterprises. R&D Management, 21(2), 125-137.

Rothwell, R., and Dodgson, M. (1994). Innovation and size of firm. In M.Dodgson and R.Rothwell (eds.), The handbook of industrial innovation (pp. 310-324). London: Edward Elgar Publishing.

Rothwell, R. and Gardiner, P. (1988a). The strategic management of re-innovation. R&D Management, 18(2).

Rothwell, R. and Gardiner, P. (1988b). Re-innovation and robust designs: producer and user benefits. Journal of Marketing Management, 3(3), 372-387.

Rothwell, R., & Gardiner, P. (1990). Re-Innovation and robust designs: Producer and user benefits. In C. Freeman (ed), The economics of innovation (pp.218-233). London: Edward Elgar Publishing.

Rothwell, R., and Zegveld, W. (1981). Industrial innovation and public policy. Connecticut: Greenwood Press.

Rothwell, R., & Zegveld, W. (1982). Innovation and the small and medium sized firm. London: Frances Pinter Publishers.

Sabel, C.F., Herrigel, G., Kazis, R., and Deeg, R. (1987). How to keep mature industries innovative. Technology Review, April, 27-35.

Sashittal, H.C., & Wilemon, D. (1994). Integrating technology and marketing: implications for improving customer responsiveness. International Journal of Technology Management, 9(5/6/7), 691-708.

Saupin, M.G. (1995). Regional appropriability: The case of the WARD program in Western Australia. Dissertation Abstracts International, Murdoch University, Perth: Western Australia.

Saupin, M.G. (1997). User-producer interaction and technology marketing: The case of Transcom International Group. Paper presented at the Australian New Zealand Marketing Educators Conference, Melbourne.

Saxenian, A.L. (1991). The origins and dynamics of production networks in silicon valley. Research Policy, 20, 423-437.

Schumpeter, J.A. (1939). Business cycles. New York & London: McGraw-Hill.

Shanklin, W.L., and Ryans, J.K. (1984). Marketing high technology. Massachusetts: Lexington

Shanklin, W.L., and Ryans, J.K., (1989). Essentials of marketing high technology. Massachusetts: Lexington.

Shaw, B. (1987). Strategies for user-producer interactions. In R.Rothwell and J. Bessant (eds.), Innovation: Adaptation and growth (pp.255-266). Amsterdam: Elsevier Science Publishers.

Shaw, B. (1988). Gaining value added from centres of excellence in the UK medical industry. R&D Management, 18(2).

Sheen, M.R. (1992). Barriers to scientific and technical knowledge acquisition in industrial r&d. R&D Management, 22(2), 135-143.

Smith, H.L., Dickson, K., & Smith, S.L. (1991). "There are two sides to every story": Innovation and collaboration within networks of large and small firms. Research Policy, 20, 457-468.

Storey, D.J. (1982). Entrepreneurship and the small firm. London: Croom & Helm.

Taylor, S.J., & Bogdan, R. (1984). Introduction to qualitative research methods: The search for meanings, 2nd ed., New York: John Wiley.

Taylor, M.J., and Thrift, N. (1983). Business organisation, segmentation and location. Regional Studies. 17, 445-465.

Teece, D. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. Research Policy, 15, 285-305.

Teece, D.J. (1987). Capturing value from technological innovation: Integration, strategic partnering, and licensing decisions. In B.R. Guile and H. Brooks (eds.), Technology and global industry: Companies and nations in the world economy. Washington: National Academy Press.

Tether, B.S., Smith, I.J., & Thwaites, A.T. (1997). Smaller enterprises and innovation in the UK: The SPRU innovations database revisited. Research Policy, 26, 19-32.

Urban, G. L., & Von Hippel, E. (1988). Lead user analyses for the development of new industrial products. Management Science, 34(5), 569-582.

Von Hippel, E. (1976). The dominant role of users in the scientific instrument innovation process. Research Policy, 5, 212-239.

Von Hippel, E. (1977). The dominant role of the user in semiconductor and electronic subassembly process innovation. IEEE Transactions on Engineering Management, 24(2), 60-71.

Von Hippel, E. (1978). A customer active paradigm for industrial product idea generation. Research Policy, 7, 240-266.

Von Hippel, E. (1986). Lead users: A source of novel product concepts. Management Science, 32(7), 791-805.

Von Hippel, E. (1989). New product ideas from lead users. Research Technology Management, May/June, 24-27.

Watkins, T.A. (1991). A technological communications costs model of r&d consortia as public policy. Research Policy, 20, 87-107.

Webster, F.E. (1984). Industrial marketing strategy, 3rd ed., Canada: John Wiley & Sons.

Yin, R.K. (1989). Case study research: Designs and methods. Calafornia: Sage Publication

# APPENDICES

# APPENDIX ONE

## Background of Western Australian State Government Support for Industrial R&D

| Year | Programme | Funds Allocated to Industrial R&D |
|---|---|---|
| 1988-1991 | Western Australian Research and Development (WARD) programme introduced by the Technology Industry Development Authority (TIDA) | A$1.4 million allocated across 16 projects |
| 1991-1992 | Programme Review | |
| 1992 | WARD programme replaced by the WA Advantage Industrial Research and Development Scheme (WAIIRDS). | A$200,000 allocated over four projects |
| 1993 | WAAIRDS suspended | |
| 1994 | Western Australian Innovation Support Scheme (WAISS) introduced – current programme by the Department of Commerce and Trade. | Approximately A$3 million granted to industrial R&D so far. |
| | **Total Support for Industrial R&D since 1988** | **A$4.6 million** |

**Source: Marinova, Phillimore and Saupin (1998).**

# APPENDIX TWO

## WAISS Questionnaire for Successful Applicants

## Source: Marinova et al (1998)

QUESTIONS FOR SUCCESSFUL COMPANIES

## PART 1: BUSINESS AND INNOVATION INFORMATION

**1. Your company:**

- name:..........................................................................................................
- date of establishment/years in operation:.................................................
- location:......................................................................................................
- core products/technologies/business activities: ......................................

..........................................................................................................................

..........................................................................................................................

- stock exchange listing...............................................................................
- parent company:..........................................................................................
- ownership/% foreign owned:.......................................................................
- name and position of the interviewee:........................................................

..........................................................................................................................

2. Describe your company now, five years ago and in five years time:

| | 1993 | 1998 | 2003 |
|---|---|---|---|
| Industry | ............................ | ............................ | ........................ |
| Production range | | | |
| -total number | ............................ | ............................ | ........................ |
| -new products | ............................ | ............................ | ........................ |
| Employees (excl. mergers and acquisitions) | ............................ | ............................ | ........................ |
| Staff profile | | | |
| -R&D staff | ............................ | ............................ | ........................ |
| -scientists and engineers in production | ............................ | ............................ | ........................ |
| -commercial/marketing | ............................ | ............................ | ........................ |
| -contractors | ............................ | ............................ | ........................ |
| Annual turnover | ............................ | ............................ | ........................ |
| % sales related to the project [where applicable] | ............................ | ............................ | ........................ |
| R&D budget | | | |
| -as % of sales | ............................ | ............................ | ........................ |
| -in-house R&D as % of total R&D | ............................ | ............................ | ........................ |

Comments:
..............................................................................................................................
..............................................................................................................................
..............................................................................................................................
..............................................................................................................................
..............................................................................................................................
..............................................................................................................................

3. If you manufacture, where are your facilities located? If you do not manufacture in WA, do you intend to do so?

**4. If you are involved in collaboration, joint ventures or alliances, what is their importance to your business and company?**

1 - low importance, 2 - medium importance, 3 - high importance

| | No | Yes | W A | Aust ralia | overseas | Importance 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|
| In R&D with: | | | | | | | | |
| -research organisations (eg universities, CRCs) | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |
| -other companies | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |

Comments: ......................................................................................................
..............................................................................................................................
..............................................................................................................................
..............................................................................................................................

| | No | Yes | W A | Aust ralia | overseas | 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|
| In commercialisation (eg venture capital, innovation management companies) | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |

Comments: ......................................................................................................
..............................................................................................................................
..............................................................................................................................

| | No | Yes | W A | Aust ralia | overseas | 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|
| In production | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |

Comments: ......................................................................................................
..............................................................................................................................
..............................................................................................................................

| | No | Yes | W A | Aust ralia | overseas | 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|
| In marketing/branding | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |

Comments: ......................................................................................................
..............................................................................................................................
..............................................................................................................................

| | No | Yes | W A | Aust ralia | overseas | 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|
| In distribution | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |

Comments: ......................................................................................................
..............................................................................................................................
..............................................................................................................................

| | No | Yes | W A | Aust ralia | overseas | 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|
| In post-sales services | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |

Comments: ......................................................................................................
..............................................................................................................................
..............................................................................................................................

**5. To what extent is your innovation performance influenced by suppliers and clients (eg as sources of information, innovative ideas, awareness of competition, quality standards)?**

1 - low importance, 2 - medium importance, 3 - high importance

| | Importance 1 | 2 | 3 | Comments |
|---|---|---|---|---|
| Suppliers: | | | | |
| -WA-based | ❑ | ❑ | ❑ | .............................................. |
| -Australia-based | ❑ | ❑ | ❑ | .............................................. |
| -overseas-based | ❑ | ❑ | ❑ | .............................................. |
| Clients: | | | | |
| -WA-based | ❑ | ❑ | ❑ | .............................................. |
| -Australia-based | ❑ | ❑ | ❑ | .............................................. |
| -overseas-based | ❑ | ❑ | ❑ | .............................................. |

**6. Do you have a formal strategic business plan? If so, please describe.**

No ❑ Yes ❑ Comments:..........................................................................
..........................................................................................
..........................................................................................

**7. Do you have a formal R&D program? If so, please describe.**

No ❑ Yes ❑ Comments:..........................................................................
..........................................................................................
..........................................................................................

## PART 2: INFORMATION ABOUT THE PROJECT(S) FUNDED FROM THE WAISS/WAAIRDS GRANT(S)

8. Describe why you applied for the grant.

9. Why did you choose this particular project?

10. If you attended the briefing session(s) prior to receiving the grant, what opinion do you have of these sessions?

1 - low value, 2 - medium value, 3 - high value

| | | Value | | | |
|---|---|---|---|---|---|
| No | Yes | 1 | 2 | 3 | Comments |
| ❑ | ❑ | ❑ | ❑ | ❑ | ................................................................ |

11. Did you experience any difficulties in applying for the grant? Please explain.

12. Comment on the assistance provided by DCT during the process of application.

1 - low value, 2 - medium value, 3 - high value

| | Value | | |
|---|---|---|---|
| 1 | 2 | 3 | Comments |
| ❑ | ❑ | ❑ | ................................................................................ |

13. Did you receive any benefits from the process of applying for the grant? For example, did you learn more about your product, marketing, finances, R&D and associated risks during the process of applying for the grant? Please explain.

14. How much time and funds did you allocate for the proposal?

15. How much, and from which sources, did you allocate funds for the project?

16. Did you experience any problems (eg delays in processing, reporting requirements, timing, changes in the project or matching funds) in receiving the grant money? Please describe.

17. Did you experience any problems in using the grant? Please describe.

18. How has the grant affected your R&D performance? Please describe.

19. Has your investment in R&D changed after receiving the grant? Please explain.

20. Is the outcome of your project commercialised? If not, how close is it to commercialisation?

Yes ❑ No ❑ Estimated commercialisation date:..............................
Comments:..........................................................................
..........................................................................................
..........................................................................................

21. Has the grant speeded up the rate of commercialisation?

22. Has the grant helped collaboration with any university, CRC, CSIRO or any other organisations? If yes, please explain the nature of this collaboration.

23. What have been the effects of the grant on employment and skill levels in your company?

24. How has the project affected your company's performance, eg investments, turnover, profits, sales?

25. What would have happened with your project without the grant?

| | | Comments |
|---|---|---|
| continued with in-house funding | ❑ | ........................................................ |
| continued if outside funding was found | ❑ | ........................................................ |
| modified | ❑ | ........................................................ |
| stopped | ❑ | ........................................................ |
| other ........................................................... | ❑ | ........................................................ |

26. Have there been any spin-offs from the project? If so, please describe.

Please, tick as many as necessary.

No ❑

| | | | | Comments |
|---|---|---|---|---|
| Yes | ❑ | new projects | ❑ | .................................................................. |
| | | new knowledge | ❑ | .................................................................. |
| | | new markets | ❑ | .................................................................. |
| | | new networks | ❑ | .................................................................. |
| | | other .............................. | ❑ | .................................................................. |
| | | .............................. | ❑ | .................................................................. |
| | | .............................. | ❑ | .................................................................. |

27. Has there been any movement of personnel (eg from university to industry or vice-versa) in relation to the project? If yes, please describe.

28. Have you applied for funds from other organisations since receiving the grant? Please explain.

| No | Yes | Comments (including success) |
|---|---|---|
| ❑ | ❑ | .................................................................................................... |
| | | .................................................................................................... |
| | | .................................................................................................... |

## PART 3: USE OF VARIOUS SOURCES FOR FINANCING INNOVATION

**29. Which of the following sources for funding R&D and innovation have you found valuable?**

Please tick as many boxes as necessary.
1 - low value, 2 - medium value, 3 - high value

| Source | Aware of it | Have used | Intend to use | Value 1 | Value 2 | Value 3 | Comments (incl. eligibility) |
|---|---|---|---|---|---|---|---|
| 150/125% R&D tax concession | Y/N | Y/N | Y/N | ❑ | ❑ | ❑ | ................................ |
| WAISS, WAAIRDS | Y/N | Y/N | Y/N | ❑ | ❑ | ❑ | ................................ |
| Other state support (eg NIES, MERIWA, Dpt of agriculture) | Y/N | Y/N | Y/N | ❑ | ❑ | ❑ | ................................ |
| Specific industry R&D programs (eg ERDC, PIIP NHMRC, RIRF) | Y/N | Y/N | Y/N | ❑ | ❑ | ❑ | ................................ |
| Federal grants for industrial R&D and innovation (eg GIRD, R&D Start, ARC, CRC, CTI, SBIF) | Y/N | Y/N | Y/N | ❑ | ❑ | ❑ | ................................ |
| Student support (eg APA(I), Neville Stanley scholarships) | Y/N | Y/N | Y/N | ❑ | ❑ | ❑ | ................................ |
| In-house R&D funding | Y/N | Y/N | Y/N | ❑ | ❑ | ❑ | ................................ |
| Debt finance (eg bank loans) | Y/N | Y/N | Y/N | ❑ | ❑ | ❑ | ................................ |
| Equity finance (eg venture capital) | Y/N | Y/N | Y/N | ❑ | ❑ | ❑ | ................................ |
| Syndicated R&D | Y/N | Y/N | | ❑ | ❑ | ❑ | ................................ |
| Others | | | | | | | |
| ................................... | Y/N | Y/N | Y/N | ❑ | ❑ | ❑ | ................................ |
| ................................... | Y/N | Y/N | Y/N | ❑ | ❑ | ❑ | ................................ |
| ................................... | Y/N | Y/N | Y/N | ❑ | ❑ | ❑ | ................................ |

## PART 4: COMMENTS ON WAISS

30. How did you learn about WAISS?

| | Yes | No | Comments |
|---|---|---|---|
| media advertising | ❑ | ❑ | ........................................................ |
| direct correspondence from DCT | ❑ | ❑ | ........................................................ |
| word of mouth | ❑ | ❑ | ........................................................ |
| other ................................................ | ❑ | ❑ | ........................................................ |

31. Which aspects of the scheme are attractive or positive for you?

32. What do you see as any weaknesses in the scheme?

33. Please give specific comments on:

- the size of the grants (currently up to $50,000)

- eligibility of companies (currently less than 100 employees and less than $20 mln turnover)

- leveraging (currently on a $ per $ basis)

- application time and timing (currently two rounds per year)

- compliance costs (ie administrative load on the company)

- handling of applications

- handling of grants

- any interactions with DCT staff (eg company visits, telephone discussions, written communications)

- objectives of the scheme (issues such as start-up *vs* established companies, R&D *vs* trial&demonstration projects, particular sectors, grants for individual inventors)

- any other improvements/suggestions for the scheme

34. Please comment on the possible intangible benefits of the scheme and their importance for your business and company.

1 - low importance, 2 - medium importance, 3 - high importance

| | Importance 1 | 2 | 3 | Comments |
|---|---|---|---|---|
| Credibility | ❑ | ❑ | ❑ | ................................................ |
| Image | ❑ | ❑ | ❑ | ................................................ |
| Enthusiasm for R&D and innovation | ❑ | ❑ | ❑ | ................................................ |
| Company morale | ❑ | ❑ | ❑ | ................................................ |
| Capability to attract funds | ❑ | ❑ | ❑ | ................................................ |
| Other | | | | |
| ........................................ | ❑ | ❑ | ❑ | ................................................ |
| ........................................ | ❑ | ❑ | ❑ | ................................................ |
| ........................................ | ❑ | ❑ | ❑ | ................................................ |

35. What role do you see for the scheme in the future?

for firms like you

for your firm in particular

## PART 5: OTHER COMMENTS OR RECOMMENDATIONS FOR THE STUDY

36. Do you have any other comments or recommendations for the study?

37. If need be, can we contact you again?

Yes ❑ No ❑

# APPENDIX THREE

## Questions for Case Studies

**A) Background of the firm and Commitment in Industrial R&D**

1. When/How was the firm established?
2. Growth in staff. (Technical/Commercial Staff)
3. Core Technology.
4. Where did the idea for your technology originate?
5. How was this idea transformed into a developed technology?
6. Has the technology been commercialised?
7. Net Annual Turnover for 1998 (% to R&D activities)
8. What government grants have you received for the development of technologies?
9. In which industries are your technologies applied?
10. Where is the firm's R&D activities concentrated today? (new technologies)
11. Describe your production/marketing/distribution networks?

**B) Impediments faced as a small firm**

1. Did the firm experience difficulties acquiring intellectual property rights for the new technology? (Intellectual Property) Explain.
2. Does the demand for your technologies exceed your production costs? (Economies of Scale) Explain.
3. Do you experience constraints in acquiring finance/infrastructure capital? (finance/capital) Explain.
4. Do you experience difficulties keeping up-to-date with technical trends/ industry needs. (External Communications) Explain.

**C) User-Producer Interaction**

1. What is the basis of your interaction with industrial users? (eg. Problem-solving, needs analysis, users involved in product development)
2. Does the basis of this interaction change when you interact with local as opposed to international users? (near/distant interactions)
3. Who from within your firm initiates interactions with potential industrial users? (R&D or marketing)

**D)Large/Small Firm Interactions**

***Interactions with Large Industrial Users***

1. Interactions with large industrial users. Who? Provide examples.
2. Benefits of this interaction? ("Complementary Assets")
3. What opportunities have been generated through interactions with these large industrial users - product diversification/market expansion opportunities? Provide examples.
4. Have other industrial users been introduced through interactions with these industrial users? Provide examples

***Interactions with Small Industrial Users***

1. Interactions with small industrial users. Who? Provide examples.
2. Benefits of this interaction?
3. What opportunities have been generated through interactions with these small industrial users - product diversification/market expansion opportunities? Provide examples.
4. Have other industrial users been introduced through interactions with these industrial users? Provide examples?

**E) Barriers to Interactions with Large Industrial Users**

1. Have there been any problems associated with these interactions? Provide examples.
2. How have you dealt with these problems?

**Justification of questions**

**The questions were based on the theoretical pathway constructed from the literature.**

Section A examines the firm's commitment in industrial R&D.
Section B examines the impediments faced in terms of intellectual property, economies of scale, finance/capital, and external communications.
Section C examines the process of user-producer interaction between the case firms and their industrial users.
Section D examines the level of commercial opportunities derived with large and/or small industrial users.
Section E examines the entry barriers faced in forming interactions with large industrial users.

## List of persons interviewed for the case study analysis

| Name and Address of Firm | Person Interviewed | Contact Details |
|---|---|---|
| **Advanced Technical Research Organisation Pty Ltd** ("A")<br><br>6 Bonito Way<br>SORRENTO<br>WA | Mr. The chief engineer Dudek | Tel: 9448 5640<br>Fax: 9448 0373 |
| **"B" Australia Pty Ltd** ("B")<br><br>20 Egmont Road<br>HENDERSON<br>WA 6166 | Mr. Neil Howe | Tel: 9410 1688<br>Fax: 9410 2474 |
| **"C" Advanced Ceramics Pty Ltd** ("C")<br><br>Unit 2, 87 Hector Street<br>OSBORNE PARK<br>WA | Mr. Head engineer | Tel: 9244 4844<br>Fax: 9244 4846 |
| **Advanced Mooring Technology Pty Ltd** ("D")<br><br>8 Sparks Road<br>HENDERSON<br>WA 6166 | Mr. Brett Phillips | Tel: 9437 3447<br>Fax: 9437 3448 |
| **"E" Industries Pty Ltd** ("E")<br><br>11 Henderson Drive<br>KALLAROO<br>WA 6025 | Mr. Jason Pugh | Tel: 9401 1299<br>Fax: 9401 1588 |