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S. Davenport, C. Grimes and J. Davies

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Please address inquiries concerning this paper direct to the author*
Other queries to:

Monica Cartner
Research Co-ordinator
The Graduate School of Business and Government Management
The Victoria University of Wellington
PO Box 600 Telephone: 64-4-495 5085
Wellington Facsimile: 64-4-496 5435
New Zealand E-mail: Monica.Cartner@vuw.ac.nz

* Sally Davenport
Management Group
Victoria University of Wellington
Wellington
New Zealand

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COLLABORATION AND ORGANISATIONAL LEARNING: A STUDY OF A NEW ZEALAND COLLABORATIVE RESEARCH PROGRAMME

S. DAVENPORT, C. GRIMES AND J. DAVIES

Management Group
Victoria University of Wellington
PO Box 600, Wellington, New Zealand

ABSTRACT

Collaboration with a research partner is one strategy that small and medium sized enterprises (SMEs) can pursue to counter their size-imposed research and development (R&D) resource and capacity constraints and to enhance their learning. The Technology for Business Growth (TBG) programme supports collaborative R&D projects between New Zealand industry and research institutions. This research attempted to gauge the effects of participation in a collaborative project on broader aspects of organisational learning, on the industry managers' subsequent attitudes towards R&D, as well as managers' perceptions of success and failure factors for collaboration. The majority of managers stated that their attitude to R&D had not changed (it was already positive prior to the project). However, their organisation's attitude towards the management of R&D projects had often changed, with many companies adopting the practices of project evaluation and planning enforced by the TBG application process, thus providing considerable evidence that organisational learning had taken place. Objective measures of subsequent R&D activity, such as increased spending on, and number of, R&D projects and increased employment of technical staff provide further evidence that the companies' learning experiences with collaborative projects may have encouraged them to invest more readily in R&D.

Keywords: Collaboration, Organisational Learning, Research and Development Management, Technology for Business Growth, New Zealand.

1. INTRODUCTION

Strategic alliances, particularly regarding the development of technological core competencies, are increasingly common in the corporate world [1]. The fast pace, high cost and increasing complexity of technology investments naturally leads to the establishment of consortia, alliances and cooperative efforts [2,3,4]. The promotion of collaborative research also exists as a strategic element in the technology policies of many of the world's nations [5,6].

Collaboration between firms remains something of an anathema to theorists as it does not conform easily to classical economic models of competitive behaviour [7]. Traditional explanations of collaborations, networks and alliances are based on assumptions about responses to, for example, competitive pressures and external uncertainties. However, emerging explanations look more at behavioural traits of organisations, particularly focussing on the link between collaboration and learning, with the advantage that these approaches address the motive, process and outcome of technological collaborations [7].

Dodgson describes learning as the way *"firms build, supplement and organize knowledge and routines around their activities and within their cultures, and adapt and develop organisational efficiency by improving the use of the broad skills of their workforce"* [8].

The intangible process of higher level learning, or double-loop learning, in which firms reflect upon and inquire into previous episodes of learning, discover what facilitated or inhibited learning and change their behaviour accordingly, is the ideal but rare form of organisational learning [8,9]. In addition, it is external learning, typically derived from collaboration, that is necessary, Dodgson argues, for firms to be able to respond to the current rapid and radical technological and market changes [10].

"*Collaboration has the potential to encourage higher level learning. It provides the possibilities not only of learning about new technologies, but learning about methods of creating future technologies and of the ways those technologies might affect the existing business. It can teach companies new ways of doing things, and can conceivably alter the nature of the business.*" [7]

Dodgson argues that it is the indigenous capabilities within firms and nations that provides the basis for the future of technological collaborations and effective learning. In particular, he states that such indigenous capabilities are necessary to enhance the receptivity of firms, agencies and research institutions to external inputs; to prove attractive to potential partners and investors; and to provide nodes of excellence on which to base the diffusion and transfer of know-how and good practice throughout the economy [6].

In any collaboration, at least at some stage, there is likely to be a differential learning capacity between partners. Innovative small firms, for example, possess advantages over large firms, because they are often already adept at external learning. This is due to their "*dense and diverse external linkages both vertically and horizontally. These firms learn technologically not only through R&D but also through a variety of manufacturing and marketing linkages*" [7]. It has been argued [8] that individuals are the primary learning entity in firms, and that it *"is individuals which create organizational forms that enable learning in ways that facilitate organizational transformation"*. Cohen and Levinthal [11] also argue that absorptive (learning) capacity *"refers not only to the acquisition or assimilation of information but also to the organization's ability to exploit it"*. In addition, they state that an organisation's *"absorptive capacity is not, however, simply the sum of the absorptive capacities of its employees"*, and that the firm's absorptive capacity *"depends on the individuals who stand at the interface"*, in this context, of the collaboration. Hamel et al. [3] make a similar point. *"Learning begins at the top. Senior management must be committed to enhancing their companies' skills as well as to avoiding financial risk. But most learning takes place at the lower levels of an alliance. Operating employees not only represent the front lines of effective defense but also play a vital role in acquiring knowledge"*.

Small firms, therefore, may learn more effectively because of the very fact that they consist of small numbers of individuals. Small firms have few intervening structures, and therefore presumably good communication between senior management and interface individuals (and in some of New Zealand's very small high technology firms, they are the same individuals), thus facilitating organisational learning by being able to more rapidly initiate organisational transformation. As Rothwell and Dodgson [12] state, the innovatory advantages of small firms are mainly behavioural rather than material as in large firms. Small and medium-sized enterprises (SMEs) do, however, experience problems with collaboration [12,13], particularly when there is a mismatch of management and resources between partners. Studies of SME collaborations have shown the importantance of three attributes to linkage activity; in-house technical skills, complementarity between in-house and external know-how accumulation and the existence of technology strategy to guide the accumulation process.

Dodgson describes a framework developed by Doz and Schuen [14], which suggests three learning processes are involved in the collaboration: learning about the partner, learning about the tasks and learning about outcomes. Learning about the partner, they argue, involves acquiring tacit organisational knowledge. Following the onset of the collaboration, learning relates to the management of the task with clarification of objectives, partner's requirements, achievable outcomes and timing. Learning about the outcomes brings reality to the participants' expectations of the collaboration.

The assumptions about the potential synergies and beneficial features of collaborative research and development (R&D) are based upon the goals of learning, that is, useful outcomes [8]. The incentives to collaborate, advantages and expected benefits of R&D collaboration have been canvassed by numerous authors [6,13,15,16]. In essence, it is assumed that such a partnership will reduce the expense (for example by reducing duplication or the possibility of unproductive research), the time to results (as breadth and depth of knowledge are enhanced by integrating research efforts) and the risk (speculative investment is spread between partners) normally associated with R&D.

However, several authors have also identified the limitations of collaborative research [13,17,18,19] and the additional factors that appear to contribute to a successful research partnership [15,20,21,22]. Many are based around the concept that such interactions bring or even force cultural differences between the organisations to the fore, and how these differences are strategically managed appears to be crucial to the eventual outcomes of the collaboration [20]. In a study of suppliers of information technology, Bruce et al. [23] found that collaboration success factors fell into several clusters, of which the most important were choice of partner; establishing the ground rules for partnership (for example agreeing on objectives); the process of partnering (for example, communication, trust and honesty and ensuring equity in partnership); and the people involved in committing to, and championing the partnership. Many of the problems associated with R&D collaborations mirror image the success factors, that is, problems appear to arise when the success parameters of the collaboration are not actively addressed or managed.

During 1995, a survey of private sector organisations that had participated in a New Zealand government scheme, the Technology for Business Growth (TBG) programme that sponsors collaborative research, was performed. TBG was developed to address what is viewed as one of New Zealand's major impediments to continued economic growth [24], the very low levels of private sector R&D expenditure (about 0.3% of GDP) and, within that, the low participation rate (for example, 61% of the private sector R&D expenditure is performed by only seventy companies). The TBG scheme supports collaborative R&D in the hope that New Zealand's companies would undergo Dodgson's "higher level learning", and improve their technogical literacy and abilities. Integral to the learning process of collaborative research, is a change of attitude on the part of the company towards the benefits of undertaking R&D. While an aim of the research was to investigate New Zealand managers' attitudes to R&D, this paper will also focus on the results pertaining to expected benefits from collaborative research and the managers' perceptions of the success factors for collaborative research projects. Objective evidence that attitudes to R&D had changed and that learning had occurred was sought in terms

of increased spending on, and number of, R&D projects and increased employment of technical staff.

2. R&D IN NEW ZEALAND AND THE TBG PROGRAMME

The total R&D expenditure in New Zealand is over $670 million per year which represents about 0.9% of GDP. Of this amount, the business sector contributes about $227 million and the remaining $443 million is public investment [25] (including universities) which, despite recent increases in funding, is less than 0.6% of GDP. In comparison with other OECD countries, this appears to represent a severe under-investment in science and technology [26]. Many of the growing Asian economies (New Zealand's key trading partners) have, for example, targets for this decade of 2-5% of GDP for R&D investment. The New Zealand Government has committed to increase its part of the R&D expenditure towards a goal of 0.8% of GDP by 2010 which, although still small on an international scale, represents a significant increase in investment when the rising GDP environment is taken into account.

However, it is the private sector's low contribution to total R&D that is particularly evident when international comparisons are made. The ratio of private to public sector investment in New Zealand is close to 1:2, which is the inverse of the ratio of the average of OECD countries. In Asian economies, the ratio can be as high as 5:1. There are many possible causes for this inverted spending pattern, including the history of "free" public support of private sector R&D until the mid 1980's, and the high proportion of small firms in the New Zealand economy (in 1989, for example, about 90% of the 146,205 enterprises operating in New Zealand had fewer than 10 employees [27]) which do not have the resources or the capacity to either develop their own or contract out significant R&D projects. A study of New Zealand's leading R&D oriented firms [28] showed that there is a small group of committed export firms that are technologically innovative and invest in R&D at international levels. However, they are almost exclusively small firms with turnover generally below NZ$100m and constitute a minority of New Zealand business and industry.

In 1992, the public research laboratories were restructured into industry focused Crown Research Institutes (CRIs) which operate under a commercial business model with Boards of Directors and the Crown as shareholder. At about the same time, the public investment in research was reorganised into centralised funds (the largest being the Public Good Science Fund (PGSF)) administered on a contestable basis by the Foundation for Research, Science & Technology (FRST). The main aims of the reforms of the science sector were to improve the transparency and accountability of research funding, and to increase the likelihood of the successful application of science towards the government's economic, environmental and social goals.

The New Zealand Government is aware of the low private sector R&D investment, and the underlying problem of a generally low level of technological sophistication in New Zealand companies. In 1996 it appointed a taskforce to evaluate current approaches and recommend new initiatives to attack this issue. The TBG scheme is one of the very few government schemes that supports private sector technology development. Hence there is a great deal of interest in whether the scheme is helping to address the technological problems of industry, and of SMEs particularly, given that the private sector R&D investment is increasing, but at a significantly lower rate than many other countries.

2.1 The TBG Programme

TBG's central purpose is to provide financial and developmental assistance for organisations to undertake R&D projects, usually in collaboration with a research partner such as a CRI or equivalent. The intention is to develop technologies that will improve business performance and profit. The programme attempts to do this by improving the strategic management of technology in NZ's businesses, and to improve the linkages between the private sector and governmental research institutes. An important part of this process is changing the attitudes

towards R&D in the businesses and allowing NZ managers to gain experience and confidence in making research investment decisions.

TBG is not a venture capital fund. It does not take an equity position in projects, manage the commercialisation of new ventures, or finance business 'start-ups'. It was set up in 1990 as a business unit of FRST. TBG's initial funding of NZ$4 million, was substantially increased in the 1993/94 financial year to NZ$10.6 million.

Applications to the TBG programme consist of a project plan and business plan to provide a full description of the work to be carried out. Eligible projects must satisfy the following criteria; technological advancement, close working relationship between the business and the research institute, a good business opportunity and a commitment from the business. The business organisation and the research institution are held jointly responsible for compliance with the contract.

3. RESEARCH OBJECTIVES AND METHODOLOGY

This study was conceived as an attempt to gauge New Zealand managers' attitudes towards R&D after involvement in a collaborative R&D programme funded by TBG. More specifically we wanted to identify the managers' current attitudes towards R&D, to detemine R&D's place in the overall operating structure of the organisation, to ascertain managers' expectations (albeit during and after the event) of participating in collaborative research and, lastly, to evaluate the manager's perceptions of the effectiveness of the TBG programme at influencing R&D in New Zealand organisations.

An interview protocol of thirty general questions was developed from an extensive review of literature regarding issues in R&D management and particularly collaborative R&D [29]. Three types of question were asked, requiring either simple yes/no responses or ranking on a scale of importance (or some other appropriate descriptor), or open questions asking for comment.

The questions were grouped into four sections. One section asked about managers' attitudes towards R&D and perceptions of R&D success factors while another focused on actual R&D activity in the organisation, with questions in both sections aimed at particularly uncovering any changes made subsequent to the collaboration, as possible indicators of organisational learning. Another group of questions ascertained the original motivation for applying to the programme, any history of collaboration and whether the project would have occurred without TBG involvement.

The remaining set of questions investigated three aspects of collaboration; the expected and actual benefits of the collaboration as perceived by the manager, the managers' views of the importance of collaboration success factors identified in the literature and, based on the managers' experiences, what would cause a collaborative partnership to fail. It is the results of this series of questions tempered with the background information gained from questions in the other sections, that will be particularly explored in this paper.

The study targeted senior level managers because of their level of authority regarding R&D management in the organisation and, in most cases, they were the person that had applied to the TBG programme, or had been directly involved in the project. The structured interviews were 60 to 90 minutes long and were recorded.

Of the 219 potential TBG companies identified from FRST research reports, 73 could not be contacted because contact addresses could not be located or the organisation no longer existed. Of the 146 companies approached to participate in the study, 93 responded with 52 being prepared to be interviewed. Due to geographic and time constraints, interviews were eventually conducted with 40 senior managers only, representing 27% of the companies that had participated in the TBG programme that still appear to be in operation. The majority of the companies were small or medium sized firms using TBG's definition of size; 25 small

companies (<$NZ5 million turnover), 10 medium companies (<$NZ50 million turnover) and 5 large companies (>$NZ50 million turnover). However, given the small number of respondents, the results were not correlated with firm size, particularly as on an international scale, most of these firms would be regarded as SMEs.

4. THE INFLUENCE OF COLLABORATIVE RESEARCH ON MANAGERS' ATTITUDES TOWARDS R&D

The selection process for obtaining a TBG grant effectively guarantees that the majority of successful companies are likely to come from the small and select group of already technologically competent New Zealand companies [28]. This is reflected in the fact that the majority of the managers (95%) viewed their organisations to be very technologically innovative, although for two distinct reasons; either through clever application of existing technologies, or by competing at the forefront of technology. It was also evident in the near unanimous awareness of, for example, the importance of investment in technology and R&D to their company's competitiveness and market share, with many managers considering their organisations to be the leader in their field, not only in New Zealand but also internationally, because of their cutting edge technology.

Nearly half of the companies surveyed had engaged in collaborative research prior to their TBG projects, and three-quarters of these had been with their TBG partner. Similar results have been found in a European study of Eureka collaborative projects, with two-thirds of participants having had previous collaboration experience and many of these with their current Eureka partner [16]. The authors suggested that *"if previous collaborative experience tends to be something of a prerequisite for designing and proposing projects which are granted Eureka status, this puts SME leaders at a disadvantage to large firms"*, as SMEs were less likely to have previous collaborative experience. In the New Zealand context, where it is a select group of SMEs that have had the previous collaborative experience, this unintentional filter could have the effect of limiting the number of firms that would be able to successfully apply to TBG which, in turn, decreases the likelihood of TBG being able to influence those companies that are not already technologically competent.

About two-thirds of the managers stated that the project would have probably or definitely proceeded if it had not been funded by TBG, but that the research would have been conducted differently, for example, not to the same depth or with a narrower scope, or would have extended over a longer time period. It is interesting to note that in the Eureka study, a large number (about half) of the respondents also said that their project would have existed without Eureka. TBG is, therefore, not always supporting "new" projects and, in about a third of cases, TBG is not necessarily encouraging new partnerships, but is viewed as underwriting the costs for the company of access to the CRIs' skills and knowledge in the new funding environment.

However, even in these cases TBG is contributing to Doz and Schuen's "task learning" regarding the management of R&D. Given the nature of the companies and their experience with R&D, it is not surprising that the managers interviewed already had very positive attitudes towards R&D and that these attitudes had not diminished but had been made more positive, by the collaboration experience. Where their attitudes had changed, it was often regarding how to manage the R&D process. The organisations had adopted improved practices for the management of R&D, for example, by focussing on explicitly setting achievable goals and by targeting the most efficient use of resources. Such practices are management aspects of R&D that are highlighted and enforced in the TBG application procedure. Often the TBG project had provided the R&D manager with leverage to build a greater acceptance of R&D within the senior management of the organisation, with the subsequent success of projects further contributing to building the organisation's overall faith in the value of R&D.

Interestingly, the changes in R&D management that resulted from the TBG projects, are also reflected in the highest ranking factors that the managers regarded as being important for

successful R&D. The top six success factors that were rated as vital or very important by the majority of companies were: high quality technical personnel, senior management commitment, market and customer focus, adequate resources, clearly defined research goals and objectives, and effective project planning and management.

5. EXPECTED AND ACTUAL BENEFITS OF R&D COLLABORATION

Access to funding was the main motivation for most of the companies in applying to TBG, although other factors commonly cited included accessing expertise, gaining credibility (either from "passing" the TBG audit process or from association with the research partner), the integrity of the likely research results, sharing the risks of speculative research, and strengthening the relationship with the research institute.

Several of these latter motivations are consistent with some of the benefits that companies expected to gain from the collaboration (figure 1). The access to technologies and knowledge, and to complementary skills and equipment are very important to these companies given their small size and resource capacity. Most companies also felt that these expectations had been satisfied.

However, the other cited motivations for applying to TBG, regarding access to, and increased amount of, funding and reduction of risk, are not reflected in their rankings in the list of expected benefits of the collaboration. It may be inferred that the companies see the R&D collaboration as being distinct from the application to TBG. In other words, they rely on TBG to commit to supply the funds and reduce the risk (through TBG's thorough selection and audit procedures) prior to commencing the project. Increased funding and reduced risks are seen, in retrospect, as necessary conditions for the collaboration to proceed, but they are not recognised as motivators for or benefits of the actual collaboration. They are, therefore, comparable to the hygiene factors in Herzberg's Theory of Motivation [30]. This is confirmed by the managers' responses to a question about the impact of TBG's involvement in the project. Managers stated that TBG reduced the time and cost of the project (ie the risks), or "made it possible" by allowing access to the researchers, that is, TBG is seen as the enabler of the collaboration.

It is interesting to note that the improvement in competitive position that was expected by 95% of the companies, did not necessarily occur. In fact, many of the expectations related to competitive or market issues, such as ability to compete with foreign competitors or larger companies, access to larger markets and shorter time for product development, were all significantly unfulfilled. However, since TBG has only been operating since 1990, the reported failure to meet expectations probably reflects the fact that most of the projects are fairly recent and the results have not yet influenced competitive parameters. On the other hand, it could also indicate that the companies had overly optimistic expectations of the speed at which the results of the research collaboration could be implemented into products, and consequently affect their market position. This conclusion is consistent with Doz and Schuen's [14] learning about outcomes: *"partners initially start off with too rosy a picture of the expected outcomes. This over-expectation can result from the bargaining process, where each partner is encouraged to oversell its advantages and capabilities and undersell its weaknesses."*

The Eureka study provides similar evidence of raised expectations [16] with about half of the participants expecting to achieve marketable results within two to five years of commencing their project, but only twenty percent of projects had actually been completed five years after Eureka came into existence. Eureka is charged with supporting "near market" R&D [31], but this low completion rate led to the inference that it must be funding a high proportion of "pre-competitive" or generic research. Even though the TBG programme has a much higher completion rate, the unfulfilled expectations relating to implementable results appear to be similar, and are compatible with one of McHenry's myths of cooperative research, *"that industry can get finished technology from such cooperation"* [22].

The fact that the research collaboration did not necessarily enhance product development was also found in a study of suppliers of information technology [23] in which the respondents *"regarded collaboration as making product development more costly, complex and difficult to control and manage"*. However, in this latter study by Bruce et al, and in the TBG study, the unfulfilled expectation did not detract from the participants' enthusiasm for collaboration in general.

The Eureka study also asked about the perceived benefits for the participants (figure 1). The most highly valued benefit was the cross-fertilisation of ideas, while other frequently mentioned and highly ranked benefits concentrated on competitive issues such as, improvement of competitive position and access to larger competitive markets. The Eureka study also separated the responses for SMEs (using a definition of less than 500 employees [32]) from large companies. There are significant differences in the responses, with SME project leaders more highly valuing the ability of Eureka funding to enlarge projects and hasten project completion. Larger firms, on the other hand, appear to be primarily motivated by the ability to share the costs of expensive R&D projects.

The Eureka SME benefit ranking more closely resembles that of the TBG participants, although the New Zealand companies valued more highly, the access to skills and technologies. This probably reflects that fact that TBG supports collaboration specifically with a research institute, whereas Eureka mainly supports an eclectic mix of participants with collaborations involving variable numbers of partners, often with universities and research institutes as sub-contractors. The other major variation between the Eureka and TBG results is the higher ranking by the TBG respondents of the expected benefit to be able to compete with foreign competitors. This is not surprising given the trait mentioned previously, that the successful TBG companies are likely to be export-oriented and, if they are not doing so already, are planning to compete internationally with leading edge technology, whereas the Eureka participants are probably more focussed on "internal" competition within Europe.

6. COLLABORATIVE R&D SUCCESS FACTORS

Defining whether an R&D project is successful is problematic [7,23]. Those projects that do not meet their stated technical objectives, may still result in an increase in knowledge and contribute to future technically successful projects. There are also other intangible benefits to be gained from the learning involved in seemingly "unsuccessful" projects.

Nearly all of the managers surveyed considered their TBG projects to be successful; only one manager did not. Although emphatic, this strong result might reflect a non response bias, involving managers of unsuccessful projects who may not have wished to take part in the survey. It may also reflect a view that not all measures of success were technical or financial. For example, some managers defined success as involving "relationships built" and "knowledge gained", even though the project did not meet other stated objectives.

In contrast with the views of the importance of general R&D success factors, there was a far greater variability of response from the managers about the importance of individual success factors for collaborative R&D, which suggests that the collaboration success factors might be quite situation dependent. The managers would have less experience with collaborative R&D and are, therefore, less sure of the influences that might actually discriminate between success and failure. However, the five mostly highly ranked collaboration success factors were considered to be "vital" by more than 50% of the managers (figure 2). These factors are selecting the "right" collaborative partner, a clear understanding of each partners' responsibilities and tasks, common goals with no hidden agendas, mutual respect and trust amongst partners, and top managerial commitment from all parties. These factors are generally about establishing trust and good working relationships and correlate with the success factor clusters of Bruce et al [23], namely partner selection, establishing ground rules, the partnering process (communication,trust and honesty etc), partnership equality and people issues regarding commitment to partnership. Dodgson [17] also cites similar groupings of success

factors, namely partner selection (particularly involving "high trust"); communications and human resource issues (specifically project management and equity considerations).

There are, however, some apparent inconsistencies in the rankings of related success factors for the TBG study. Selecting the "right" partner was ranked very highly, yet having knowledge of the partner prior to the start of the collaboration (which one third of the companies did have) to presumably help assess if they were "right", was not perceived as being very important. Similarly, having a clear understanding of each partner's responsibilities and tasks, and having common goals with no hidden agendas, would presumably have involved resolving any areas of dispute in advance or agreeing on procedures for resolving problems, but the latter two factors were not considered to be important. Many managers commented that identifying problem areas prior to the relationship was not possible. However, this view may reflect the fact that the majority of managers considered their projects to be successful, and presumably did not encounter major areas of dispute.

7. PROBLEMS ENCOUNTERED IN R&D COLLABORATION

The preponderance of successful projects may also have tempered the managers' responses when asked about factors that might cause a collaboration to deteriorate. However, several clusters of problems were identified and, in general, the factors correlate with the equivalent high ranking success factors. It is perhaps understanding the causes of problems that has enabled the managers to clearly identify the most important success factors.

Managers identified the collaboration as deteriorating when respect and trust was breached, for example, by withholding results or not revealing problems, or by misleading the partner about abilities. A lack of active or long term committment was cited several times, as was concern about having selected the "wrong" partner as evidenced by personality or cultural clashes and conflicts, or with the emergence of hidden agendas. Cultural differences were manifest in problems such as "researchers telling management how to do their job" and vice versa, and with "misunderstandings" about the commercialisation process, target markets and time frames.

However, by far the most common cluster of problems was broadly linked to the lack of clear objectives and delineation of tasks, and with the resulting adverse impact on project management. Expectations not being met, lack of clear, common, achievable goals, inadequate performance (particularly when funds were "lost") and not meeting milestones, a lack of clear direction, a lack of clarification about "who is paying for what", are all symptoms of inadequate project planning, and underpinning that, a lack of communication between partners during the project. However, given that all but one of the managers considered their projects a success, these problems must have been transitory or have been resolved to some extent.

Many of the factors identified in the study by Bruce et al [23], as discriminating between successful and less successful collaborations, are similar in nature to those of the TBG study. Their most highly ranked negative factors included the failure of the collaborating partners to contribute as expected, a lack of frequent consultation between collaborating partners and little trust between the collaborating partners. It is interesting to note that the Eureka study [16] surfaced the same major problems in collaboration for SMEs as well as large firms, the main factors being different expectations among partners and delays in the project schedule.

8. LEARNING AND SUBSEQUENT R&D ACTIVITY

To investigate whether the TBG programme is effectively stimulating organisational learning, the study needed to surface objective evidence that collaboration not only modified attitudes to R&D and collaborative research, but had, for example, resulted in greater R&D activity and funding. Such evidence is outlined below.

Subsequent to completion of the TBG project, a majority of the companies had carried out further R&D projects (90%), and most were conducting R&D at the time of the survey (82.5%). Of the current R&D projects, a large number were collaborative R&D projects (70%).

Over three quarters of the companies had increased R&D funding since being involved in the TBG collaboration (77.5%), with a similar proportion having increased the number of R&D projects undertaken (72.5%). In fact, most firms had increased R&D funding and the number of R&D projects undertaken (70%). Two thirds of the companies had since employed more technical people (65%), which is significant given that the highest ranking general R&D success factor was cited as having high quality technical personnel/researchers.

Rothwell and Dodgson [12] have stated that the existence of a technology strategy is an important condition for SME collaboration to lead to learning (the know-how accumulation process). In this New Zealand study, conducted during 1995/96, nearly two-thirds of the companies possessed an explicit technology strategy (62.5%), of which, over half had been developed since the companies' involvement in TBG. This is a considerable increase over that found in a survey of technology strategy in New Zealand R&D spending firms carried out in 1991 [28,33], and suggests that TBG is stimulating more organisations to plan for their future learning needs.

Several managers commented that TBG had had "disciplinary effects" on the organisation beyond the boundaries of the project, which is evident in the subsequent uptake into general operations, of the planning and R&D management processes that TBG requires of participants. In turn, these new or improved skills and know-how are reflected in managers' perceptions of what are the most important general R&D success factors. To extend the organisational learning metaphor, this implies that TBG is fulfilling a "teaching" and "training" role in many organisations' development, as well as the collaboration guidance and facilitation roles.

All of the managers stated that they would enter into collaborative projects in the future, although not all would participate in another TBG project (85%). The remaining managers stated that they wanted to have more control of, or more flexibility within, the collaborative projects; which implies that these managers feel that the firm has "learnt" enough about the management of collaborative projects to be able to be independent of the security (risk and funding hygiene factors) that TBG provides.

9. CONCLUSION

This study indicates that TBG is definitely fulfilling its aims. Not only were the more obvious measures of increased technological capability, such as R&D activity and technical employee numbers, improved markedly subsequent to the TBG collaboration, but substantial evidence was found for more pervasive organisational higher level learning about technology management. This higher level learning in New Zealand's small innovative companies should have a significant impact on the companies' future, and ultimately on New Zealand's economy, if this ability to initiate organisational transformation based on the learning, is retained as the organisations grow.

However, the challenge for the TBG programme, and for New Zealand technology policy makers, is to extend this ability to stimulate organisational learning to the remainder of the New Zealand private sector, which currently would not meet TBG's exacting entry criteria. Softening these criteria is not the answer, as this study has shown that the TBG requirements are an integral part of the learning process, not least because they lead to reducing elements of risk, but also because they provide the platform for successful R&D collaborations. Part of the answer may be to isolate the learning disciplines that are "educational" elements of the programme, in order to raise other possible participants to a level that would enable them to proceed to a full TBG collaboration. TBG is already performing this "educational service" on a case by case basis with potential applicants in the preparation of the company's business plan,

but a more generic and far reaching programme may be needed to make any impact on New Zealand's low private sector R&D figures.

TBG has stimulated many New Zealand firms to become "nodes of excellence" in technological learning. The future of New Zealand's economy, and that of many other nations, will depend on the ability of its firms to engage in this higher level technological learning. Collaborative research programmes, such as TBG, must have an increasingly significant role in any nation's arsenal of technological learning fora.

10. REFERENCES AND NOTES

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Figure 1

Expected & Actual Benefits of Collaboration
Ranked by Percentage of Respondent Companies

Benefit	Expected Benefits		Actual Benefits		Eureka Project Ranks		
	Rank	%	Rank	%	All	SMEs	Large
Access to complementary skills/equipment	1=	95.0	1	90.0	-	-	-
Access to technologies/knowledge	1=	95.0	2=	82.5	5	6	4
Improvement of competitive position	1=	95.0	4	75.0	2	1	2
Cross fertilisation of ideas	4	92.5	2=	82.5	1	3	3
Better chance of project completion	5	87.5	5	75.0	6	2	5
Ability to compete with foreign competitors	6=	82.5	7=	65.0	16	15	16
Access to larger market	6=	82.5	10=	57.5	8	10	13
Shorter time for product development	6=	82.5	12	52.5	-	-	-
Risks reduced	9	80.0	9	62.5	9	7	9
Ability to compete with larger companies	10	72.5	10=	57.5	15	13	16
R&D costs reduced	11=	70.0	7=	65.0	3	4	1
Larger project/increased funds	11=	67.5	6	67.5	4	5	11
Influence on development of standards	13	55.0	13	42.5	11	12	8
Knowledge of partners' products/strategies	14	42.5	15	35.0	13	15	10
Elimination of duplicated R&D	15	40.0	14	40.0	12	11	7

Figure 2

Collaboration Success Factors for TBG participants

Ranked by Expressed Level of Importance

Collaboration Success Factors	% of Responses showing level of Importance					Mean Importance	Mean Distribution				
	Not Important 1	Minor Importance 2	Important 3	Very Important 4	Vital Importance 5		1	2	3	4	5
Mutual respect and trust amongst partners			15.0	25.0	60.0	4.45				x	
Top managerial commitment from all parties			12.5	32.5	55.0	4.43				x	
Clear understanding of each partners' responsibilities & tasks			12.5	35.0	52.5	4.40				x	
Selecting the 'right' collaborative R&D partner		2.5	10.0	37.5	50.0	4.35				x	
Common goals with no hidden agendas	2.5	2.5	10.0	32.5	52.5	4.30				x	
Good project management			15.0	45.0	40.0	4.25				x	
Good communication and regular contact between partners			10.0	62.5	27.5	4.18				x	
Clear and honest understanding of each others abilities			25.0	35.0	40.0	4.15				x	
Active participation on project team by both organisations		7.5	27.5	22.5	42.5	4.00				x	
Monitoring projects progress against agreed milestones	2.5		20.0	50.0	27.5	4.00				x	
One agreed project leader with required authority		10.0	37.5	15.0	37.5	3.80			x		
Agreed procedures for resolving problems	2.5	7.5	32.5	40.0	17.5	3.63			x		
Resolving any areas of dispute at the beginning of the project		12.5	37.5	27.5	22.5	3.60			x		
Long term perspective of partnership commitment	2.5	27.5	20.0	22.5	27.5	3.45			x		
Knowledge of partner prior to start of collaboration	2.5	17.5	35.0	25.0	20.0	3.43			x		
Comparable levels of management competency	2.5	12.5	40.0	35.0	10.0	3.38			x		

n=40, Modal responses are presented in shade.

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