ENTREPRENEURIAL CAPACITY AND KNOWLEDGE RESOURCES FOR THE NEW TECHNOLOGY SMALL FIRM

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ABSTRACT

The processes of technological innovation through new spin-off ventures from universities and other research providers have been studied to explore the nature, relevance and positioning in these processes of the various entrepreneurship related constructs — entrepreneurship, entrepreneurial orientation, entrepreneurial capacity and entrepreneurial cognition. This started from an examination of the set of resources that constituted entrepreneurial capacity and has led to investigation of the linearity and requisite holistic nature of the events and the processes involved.

INTRODUCTION

The research presented here has been part of doctoral research on the role of new technology-based Small Firms (NTSF) as spin-off ventures for the commercialization of research outcomes from universities and other public research providers. The research has been limited to a sample of new venture spin-offs where there has been a continuing link to the parent research provider (Direct Research Spin-offs, as defined by Yencken and Gillin, 2002) arising from either or both of the parent research provider’s continuing ownership of the new intellectual property and/or from temporary secondment or permanent transfer of research provider staff to work with the new venture. The sample excluded new ventures generated by staff or students, where there was no ongoing intellectual property relationship with the parent research provider.

The scope of the research has involved qualitative case studies and other comparative survey data collection on twenty-five spin-off companies from universities and other public research providers, twenty-three in Australia and two in Scotland, involving a range of research providers and a range of technologies. The Australian research provider parents included universities, CSIRO (See www.csiro.au), Australia’s large public research agency and Cooperative Research Centers (CRC), joint ventures involving public research providers and research users with competitively bid Commonwealth Government funding (See www.crc.gov.au). Sixteen of these spin-off companies (See Tables 1-3 later in this paper), for which there were adequate interview data to ensure triangulation, have been the subject of detailed case studies of their initiation and development up to the point where was a first equity investor or other outside revenue stream. The population of spin-off companies was progressively and theoretically sampled to ensure coverage by type of research provider parent and by technology.

This paper has sought to address two issues. The first issue was to explore the nature of the processes of new venture formation and particularly the extent to which these processes were
determined by the parent research provider planning and other resource and inputs in the period immediately prior to the new venture’s formation, either before or after incorporation. This analysis was then used to test for individual ventures the relevance of statements that “entrepreneurship is the engine of innovation” (Drucker, 2002) and that “entrepreneurship is a dynamic, holistic and non-linear process” (Bygrave and Hofer, 1991 p.2) that cannot be studied in a reductionism mode separately from the entrepreneur. The study will show that in this particular context a key question is who in fact is the entrepreneur. A key finding has been that the processes of technological innovation through the genesis of new spin-off ventures can differ quite substantially from the processes described in the literature for a classical opportunity driven entrepreneurial new venture (that may or may not involve new technology). Many of the cases in this study appear similar to those described by Bhidé’ (2000) as the class of corporate spin-off ventures both in the linearity of the development process and the level of planning and other resource inputs before the release of the new venture.

DEFINITIONS AND LITERATURE REVIEW

As a start it was necessary to clarify the meaning of the relevant constructs, including innovation, entrepreneurship, entrepreneurial orientation, entrepreneurial capacity and entrepreneurial cognition. The many definitions of entrepreneurship and innovation have been explored in a recent paper by Hindle and Yencken (2003). The definitions of the related constructs have been further explored in recent conference presentations (Yencken and Gillin, 2003a, 2003b) and have been reviewed below. This discussion is followed by the discussion of the inter-relationships between entrepreneurship and innovation, particularly technological innovation. This issue has paralleled the lead author’s dilemma as a research student involved in research on technological innovation in a graduate school of entrepreneurship.

Entrepreneurship, the entrepreneur and entrepreneurial orientation

The literature contains many definitions of the various entrepreneurship constructs. This present review started with Bygrave’s paper (1989) that involved “a philosophical look at entrepreneurship research methodologies”. It started with the statement that “entrepreneurship begins with a disjointed, discontinuous, non-linear (and usually unique event) that cannot be studied successfully with methods developed for examining smooth, continuous, linear (and often repeatable) processes”. He identified as an important aspect of scientific research that “physicists examine nature by remorselessly isolating the parts from the whole”; it was reductionist in nature. “Entrepreneurship research on the other hand requires a non-reductionist approach”.

And I am certain that we cannot separate entrepreneurs from their actions. After all in a start-up company, the entrepreneur and the company are one and the same…We should avoid reductionism in entrepreneurship research. Instead we should look at the whole (Bygrave, 1989 p. 20).

The need to define the concept holistic and to develop tests for holism has been reviewed in a recent conference paper by the present authors (Yencken and Gillin 2003a). Rebernik and Mulej (2000) have explored the concept of requisite holism:

A brief summary of the law of requisite holism may thus read as follows: In consideration of complex features and processes, the exaggeration of false holism, which is caused by limiting consideration to a single viewpoint, and the exaggeration
of total holism, which is caused by the absence of any limitation on the selection of a system of viewpoints, must be avoided. A requisite system is introduced by a “dialectic system” as a system of all-essential, but only essential, viewpoints.

The concept of requisite holism addresses the question of whether holism is a dichotomous variable—that is, there is a particular class of systems that are holistic and the rest are not. Requisite holism suggests that holism may be a continuous variable that may be applied to all systems that may be holistic to various degrees in terms of the previous definition of requisite holism.

The implications for research strategies in NTSF case studies is whether reductionist research approaches, as used in the sciences, are acceptable or should all such research take a holistic viewpoint. The relevance of this requisite holism concept has been tested in the authors’ discussion of their case study research findings.

**Entrepreneurial capacity as a resource**

Attention has also to be given to the definition and role of entrepreneurial capacity in the process of development of spin-off ventures. Hindle (2002) in exploring the differences between small-I and BIG-I innovation has pointed to the importance of entrepreneurial capacity.

The upshot of all this is that in the absence of entrepreneurial capacity the achievable value to a firm of any new knowledge will always be zero, irrespective of its inherent value or the scale of the productive opportunity it generates... Entrepreneurial capacity is the resource that is essential for discovery to lead to a realised commercial opportunity. Alvarez and Busenitz (2001) have argued that in this context entrepreneurial capacity is a set of knowledge resources. This leads to consideration of knowledge as a resource and the relation between entrepreneurship and resource based theory of the firm.

The next step was to explore the relevance of resource based theory (RBT) as applied to entrepreneurial new ventures. Resource based theory derives from Penrose’s (1980, 1995, 1999) theory of the firm.

It is the firm’s unique bundle of resources that is different from competitor firms that are potentially valuable and contribute to a firm’s competitive advantage (Alvarez and Busenitz 2001).


We use RBT to show entrepreneurship generally involves the entrepreneur’s unique awareness of opportunities, the ability to acquire the resources needed, and the organizational ability to recombine homogeneous inputs into heterogeneous outputs (p.771)...As a result of taking an entrepreneurial perspective, one contribution to RBT is that we are now able to identify resources such as entrepreneurial alertness, insight, entrepreneurial knowledge, and the ability to coordinate resources, as resources in their own right (p.772).

They identified three specific knowledge resources that the entrepreneur brings to new venture development: “viz. the founder’s unique awareness of opportunities, ability to acquire
the resources needed to exploit the opportunity, and organizational ability to recombine homogeneous inputs into heterogeneous outputs”. For high-tech start-ups involved in the process of technological innovation, the knowledge resource and skills of the technology champion in managing technology development—together with access to market and particularly competitor intelligence coming from the surrogate entrepreneur and often from the first investor—can also be critically important. Alvarez and Busenitz’s use of the word entrepreneur as a singular word is confusing. In the integrated model (Figure 3 later) developed by Hindle and Yencken (2003) for analyzing the development of NTSFs, the knowledge resources that constitute entrepreneurial capacity have been shown to be generally contributed by more than one individual and to differ between individuals and between phases of development of the venture (Figure 2 later).

Cognition and discovery

In the Discovery or Opportunity recognition phase, it will be the founder(s)’ unique awareness of opportunities that will be the important resource. Venkataraman (1997) has argued that people recognize those opportunities related to information that they already possess. Scott Shane (2000) explored how such prior knowledge led different individuals to find different opportunities arising out of the one piece of new technology. He identified “three major dimensions of prior knowledge important to the process of entrepreneurial discovery: of markets, of ways to serve markets, of customer problems” (Shane op.cit.p.7). Fiet (2000) has shown experimentally that training potential entrepreneurs to know where to look and what to look for did not generate more new commercially viable ideas in total but did generate more ideas that survived initial scrutiny and merited further development. Mitchell (2002) has defined entrepreneurial cognition as relating to and describing the entrepreneur’s interaction with his environment.

The relationship between entrepreneurship and innovation

In the perception of many people, including many in government in Australia, innovation equates with invention or newness. Hindle (2002) has called this small-i innovation in contrast to BIG-I innovation, which extends to the commercial exploitation of this new knowledge.

In an earlier paper, Olson (1985, p.27) identified the different tasks involved in the development of a new venture. His first stage involved “the perception of awareness of a new idea”. He saw this as involving mainly the “right hemisphere (of the brain), which provides intuitive, synthetic and simultaneous processing”. “Processing information of this kind in a synthetic, holistic manner typically generates the impressions and feelings (the hunches) that focus entrepreneurs on an opportunity and excite them to action”. In contrast he suggested that the left hemisphere of the brain which operates in a rational, analytic, and linear thinking mode as dominating the second phase “where attention has to be given to the detailed plans necessary to produce and distribute the refined product to customers”. He suggested that these second phase activities were often known as innovation. Bygrave and Hofer (1991) on the other hand saw the whole process as entrepreneurship. In contrast, the definitions set out earlier are based on entrepreneurship being an event, the event involved in the creation of a new (usually business and commercial) venture. That event is part of the process that results in technological innovation that hopefully in turn leads to wealth creation. More recent approaches as quoted earlier (Hindle, 2002; Hindle and Yencken, 2003) would include all phases from initial idea to commercial application as the scope of BIG-I technological innovation.
The various NTSF development frameworks

The word *framework* has been used in preference to *model*, as these frameworks (unlike models) do not have any predictive capacity.

The first framework shown (
Figure 1) represents the process involved in a typical new opportunity-oriented entrepreneurial new venture. It follows Olson’s (1985) concept of two differing stages, the first being the creation of the new venture and the second the ongoing planning, resource management and execution. It also reflects, in the new venture discovery phase, Alvarez and Busenitz’s (2000) entrepreneurial capacity as a set of three knowledge resources: the founder’s unique awareness of opportunities, ability to acquire the resources needed to exploit the opportunity, and organizational ability to recombine homogeneous inputs into heterogeneous outputs. In this framework the act of new venture creation can be essentially both holistic and non-linear.

A second framework (Figure 2) has been developed by Vohora et al. (2002) out of their study of university spin-off companies in the United Kingdom. In this context, they developed a five-phase model focusing on the critical junctures between the various overlapping phases was preferred to the simpler three-stage framework developed by Bhavé (1994). As indicated earlier, the focus of the research reported here has been on the Research, Opportunity and Pre-organization phases and the critical conjunctures between them.

The third framework, based on further development of that originally presented by Hindle and Yencken (2003), has followed a similar pattern to the Vohora et al. framework but has been focused on the identification of the various knowledge resource inputs (that are the components of entrepreneurial capacity) into the new venture development process. These as shown are different both in terms of development phase and in terms of the source of the knowledge input. The set of knowledge resources has been illustrated in Figure 3.

The process, as illustrated in this third and last framework, (Figure 3) is generally linear and fails the tests for holism (Yencken and Gillin, 2003c), but may have a degree of requisite holism, suggesting the need for a reductionist rather than a holistic investigative approach.

Degroof and Roberts (2003 p. 51) in their analysis of academic spin-off processes used a framework with three phases. This framework assists in the analysis of the impact parent research provider environment on the early stage development of a spin-off company, but is of less direct relevance to the specific study of entrepreneurial capacity being undertaken here.

METHODOLOGY

The data on which these analyses were based included comparative survey and qualitative interview and other data for twenty-five case studies in Australia and Scotland of new start-up spin-off ventures from universities and other public research agencies in their early phases of development—from idea and opportunity recognition to first equity investor. Sixteen of these were selected for analysis based on quantitative survey data, interviews and data from public sources (company public records, Web sites etc.). For the remainder it had not been possible to obtain a sufficient number of interviews to ensure effective triangulation in the data analysis. All interviews were tape-recorded. Written verbatim transcripts were prepared for all interviews. NVivo text analysis software was used in a grounded theory analysis strategy.

Hypotheses

The first step was to test what essentially was the null hypothesis:

**H(0) The process of new venture creation for research provider spin-off ventures follows closely the process involved in entrepreneurship, that is the creation of new opportunity driven businesses.**
This hypothesis assumes that the spin-off development process satisfies tests for both holism and linearity and requires a holistic rather than a reductionist approach to its investigation. The framework, shown in
Figure 1, illustrates the holistic and non-linear nature of entrepreneurship as the act of new venture creation.

**H(1):** In any study of new technology small firm (NTSF) creation, the entrepreneur can always be clearly identified.

The literature stresses the importance of the entrepreneur both in the opportunity discovery and in the finding and combining of the resources needed to exploit that opportunity. The testing of this hypothesis seeks answers to the question who is the entrepreneur in the process of technological innovation through NTSF creation.

**H(2) Entrepreneurial capacity is a set of knowledge resources best studied in a holistic rather than a reductionist mode**

Hindle (2003) has drawn attention to the role of entrepreneurial capacity:

> The upshot of all this is that in the absence of entrepreneurial capacity the achievable value to a firm of any new knowledge will always be zero, irrespective of its inherent value or the scale of the productive opportunity it generates…Entrepreneurial capacity – not the quality of new knowledge – is the critical determinant of ultimate economic value (Hindle, 2002 p.55).

The differing knowledge resource inputs that may be involved in NTSF creation have been illustrated in Figure 1.

**RESEARCH FINDINGS**

The sixteen case studies have been separated into three groups (Tables 1, 2 and 3) based on Bhidé’s classification that relates to the increasing level of planning and other resource inputs by the research provider parent from negligible in Group A to significant in Group C.:  

- Group A: Opportunity driven entrepreneurial ventures  
- Group B: Venture capital driven ventures  
- Group C: Corporate spin-off ventures.

**Opportunity driven entrepreneurial ventures**

Nine of the selected sixteen cases belonged in this group (Table 3). The group included as a reference point a software company developed by an entrepreneur and still managed at the time of data collection by that entrepreneur. The group also included two new ventures where the research providers (university and a CRC respectively) were contract suppliers of technology inputs and support. They were not in fact spin-off companies. In both these cases, the entrepreneurs who identified the initial opportunity continued with the venture as CEOs. For the other six companies in this group, the entrepreneur who had first identified the opportunity continued to be the driving force, even if in several cases not formally the CEO.

These ventures were well described by the first framework (
Figure 1). They identified the opportunity, found the necessary resources to develop the opportunity and combined these resources and “the ability to coordinate these resources within their own right” (Alvarez and Busenitz, 2000).

**Venture capital driven spin-off ventures**

There were only two companies in the sample that belonged to this group
Table 2. Both were developing aspects of medical technology. Both required considerable venture capital over a relatively long period. One was technology asset companies that would probably market and license intellectual property rather than produce a product or provide a service. The other was looking to market both fine particle aerial monitoring equipment and nasal filters to protect people with respiratory problems from reactions to such fine particles.

For both these companies, a CEO was recruited from outside soon after the company’s formation and the scientist inventors continued in an advisory capacity.

The second (Vohora et al., 2002) and third (Figure 2) development frameworks best describe the process of development of these ventures. This process was essentially linear. The clear stages or phases in this development process over time make it difficult to pass the tests for being holistic, even if there is a degree of requisite holism involved.

**Corporate spin-off ventures**

There were five companies in this group. All the companies in the larger group of twenty-six whose parents were CRCs or CSIRO were in this category, but only two from (large research profile) universities. Other research into spin-offs from Cooperative Research Centres (CRCA, 2003) has suggested similar findings for other CRCs.

The parents of these companies had well-developed IP competencies and the ability to develop effective business models before a decision was taken to establish a new spin-off venture. In all cases, an experienced manager was appointed or externally recruited to be the first CEO. In two of the cases, there was no external equity (other than from the original research provider and research funding agencies).

The second (Vohora et al., 2002) and third (Figure 2) development frameworks best describe the process of development of these ventures. This process was essentially linear and appeared to fail the tests for holism.

**Entrepreneurial capacity as a set of knowledge resources**

In this section, answers are first explored to the question, “Who and where is the entrepreneur?” The discussion has then led to consideration of the entrepreneurial capacity, that is the set of knowledge resources, available to the new venture (Figure 3). The data in Tables 1 to 3 illustrate this set of knowledge sources and resources, that is the entrepreneurial capacity as defined earlier, that was available to the new spin-off and other ventures in the sample. To simplify the presentation, the data have been limited to knowledge resources made available at five phases in the development of the venture:

- Opportunity discovery
- Technology development
- Market/competitor intelligence and business model development
- Management
- First external equity investor.

The companies included in Table 1 as discussed in the previous section generally conform to the framework (Figure 1) for opportunity driven entrepreneurial ventures. For these companies the entrepreneur could be clearly identified and maintained his central role in the venture up to and including the entry of the first investor. This first investor was in many of the cases previously known to the entrepreneur.
On the other hand, for the companies listed in Table 3, which conform to Bhidé’s corporate model, there has been no clearly defined entrepreneur. The effective leadership role has progressively shifted from the inventor to a technology champion (frequently the inventor or his superior) to a CEO recruited externally, the surrogate entrepreneur (Vohora et al., 2002). Similarly for these companies a much wider range of knowledge sources was available with the source varying from one phase to another.
Table 2, which are both medical technology asset companies, there was still no clearly identified entrepreneur and there were a variety of knowledge resources. These companies tended to be driven by the venture capitalist investor with control of the board and the appointment of the CEO. As technology asset companies in the medical sector, their revenue will come from licensing their technology or new drugs to established companies rather than marketing a product or service itself.
<table>
<thead>
<tr>
<th>No.</th>
<th>Product or activity</th>
<th>Knowledge sources and resources</th>
<th>Opportunity discovery</th>
<th>Technology</th>
<th>Market / competition</th>
<th>Management</th>
<th>First investor</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Customer relations management software</td>
<td>Entrepreneur from previous consultancy</td>
<td>Entrepreneur plus recruited partner</td>
<td>Previous IT industry experience</td>
<td>Entrepreneur</td>
<td>First investor business and economic understanding</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Asset location hardware and software</td>
<td>Entrepreneur</td>
<td>University engineers</td>
<td>Entrepreneur</td>
<td>Entrepreneur</td>
<td>Local friend of entrepreneur</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Specialised light alloy billets</td>
<td>Entrepreneur from technical advice and marketing</td>
<td>Entrepreneur + CRC</td>
<td>Entrepreneur from previous industry experience</td>
<td>Entrepreneur</td>
<td>Company failed before investment</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Glaucoma detection instrument</td>
<td>Inventor a clinical ophthalmologist</td>
<td>Inventor’s friends, applied mathematics, computer science + university research unit</td>
<td>Inventor and university business liaison office</td>
<td>Recruited CEO with medical service industry experience</td>
<td>Venture capitalist as Board chair.</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Robotic seabed drill</td>
<td>Academic marine scientist with interest in seabed drilling</td>
<td>Engineering development firm with robotic design competence found by inventor</td>
<td>Inventor and technology developer contacts with academic and oil exploration industry users</td>
<td>Partner in equipment development as initial CEO, succeeded by professional manager</td>
<td>Venture capitalists, involved on Board.</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Egg white based fat replacer</td>
<td>Previous industry experience of academic researcher entrepreneur.</td>
<td>Research by academic entrepreneur.</td>
<td>Industry experience of academic researcher entrepreneur + mentor.</td>
<td>Entrepreneur supported by experienced mentor / technology manager in CEO role</td>
<td>Angel who provided early funding support holds 20 per cent of equity.</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Product or activity</td>
<td>Knowledge sources and resources</td>
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<tr>
<td></td>
<td>Opportunity discovery</td>
<td>Technology</td>
<td>Market / competition</td>
<td>Management</td>
<td>First investor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Monitoring rotating machinery</td>
<td>Entrepreneur during PhD studies saw opportunity to use ultrasound to monitor machinery.</td>
<td>Technology developed by the inventor entrepreneur.</td>
<td>Academic entrepreneur supported by CEO part time from company in similar market.</td>
<td>Entrepreneur as technology champion with CEO from equity investor part time.</td>
<td>Established company operating in the same market.</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Waste water filtration</td>
<td>Entrepreneur during his PhD studies saw the need for improved filtration of wastewaters.</td>
<td>New wastewater filtration system designed by academic entrepreneur within the university.</td>
<td>Entrepreneur developed business model with university TT office.</td>
<td>Entrepreneur as CEO.</td>
<td>Initial angel funding, then two tranches of venture capital.</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Minituarised reflux pH probe</td>
<td>Academic pathologist saw opportunity for minituarised reflux pH monitor.</td>
<td>Technology developed by entrepreneur with university support up to. Small-scale manufacture.</td>
<td>Pathology background led to understandin g market opportunity.</td>
<td>Entrepreneur with support from his professor and first investor friends.</td>
<td>First investors were university friends who also provided professional support.</td>
<td></td>
</tr>
</tbody>
</table>

Table 2 Entrepreneurial capacity as a set of knowledge resources: Group B venture capital driven

<table>
<thead>
<tr>
<th>No.</th>
<th>Product or activity</th>
<th>Knowledge resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Nasal filter and particle measure</td>
<td>Opportunity discovery: Academic asthma medical specialist saw need for monitoring small particles as potential asthma triggers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Research initially funded by large pharma which then withdrew.</td>
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<tr>
<td></td>
<td></td>
<td>Equipment development could not meet performance criteria. This lead to switch to marketing nasal filters.</td>
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<tr>
<td></td>
<td></td>
<td>Management: External CEO recruited when company formed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Financial resources: Venture capitalist but concerns about ability of company to meet development timelines and also at change in product focus</td>
</tr>
<tr>
<td>13</td>
<td>Blood clotting factor</td>
<td>Opportunity discovery: Academic haematologist and PhD student identified new blood factor with anti clotting potential.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Initial research in university. Now major program with full and part-time research team.</td>
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<td></td>
<td></td>
<td>Recruitment of CEO with pharmaceutical industry experience in this field.</td>
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<tr>
<td></td>
<td></td>
<td>Management: First CEO came from university TT office. Succeeded by an externally recruited CEO with relevant industry, but no small firm experience.</td>
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<tr>
<td></td>
<td></td>
<td>Financial resources: Venture capitalist closely involved at Board meetings and in between</td>
</tr>
</tbody>
</table>

Table 3  Entrepreneurial capacity as knowledge resources: Group C Corporate

<table>
<thead>
<tr>
<th>No.</th>
<th>Product or activity</th>
<th>Knowledge resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Java encryption software</td>
<td>Opportunity discovery: Web site interest of IT majors in radically new Java encryption algorithm. Technology: Initial development by CRC researcher. And elsewhere within the CRC. Market / competition: Initially the application involved consultancies and customising the algorithm for a client. Company was established to package and market encryption products. Management: Initially there was an internal technology champion. He was succeeded by an external CEO with Silicon Valley start-up experience. Finance: Venture capitalist with personal IT background in weekly and sometimes daily interaction with management.</td>
</tr>
<tr>
<td>2</td>
<td>Polymer adhesion</td>
<td>Opportunity discovery: Researcher developed surface modification treatment to improve adhesion to polymers. Technology: All technology development and funding within Parent, CSIRO. Market / competition: Systematic development of relationships with major users of coated polymers, ie cars, building products. Management: Appointment internally of CEO with many years of marketing management in large organisations. Finance: All equity still held by CSIRO parent. Board has experienced managers and venture capitalists.</td>
</tr>
<tr>
<td>5</td>
<td>Pain killer drugs</td>
<td>Opportunity discovery: Pain killing compounds developed from basic research on venoms. Technology: Initial compound developed in university and licensed. Company was formed when further research identified a family of potential bioactive compounds. Market / competition: Initial technology champion, a senior professor with long experience in the commercialisation of pharmaceutical products. The initial licence was with an Australian company. It continued as Initial technology champion was succeeded by an externally recruited CEO from the pharmaceutical industry. Management: Initial technology champion was succeeded by an externally recruited CEO from the pharmaceutical industry. Finance: Venture capital fund, specialising in this area of technology.</td>
</tr>
<tr>
<td>No.</td>
<td>Product or activity</td>
<td>Knowledge resources</td>
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</tr>
<tr>
<td></td>
<td>Opportunity discovery</td>
<td>Technology</td>
</tr>
<tr>
<td>7</td>
<td>Stem cell therapy</td>
<td>Cell therapy options from human stem cells</td>
</tr>
<tr>
<td>24</td>
<td>Pig growth improvement</td>
<td>Identification of effective growth factors in pigs</td>
</tr>
</tbody>
</table>


**Results and findings**

The discussion of findings in relation to the three hypotheses stated earlier has followed.

**H(0)** The process of new venture creation for research provider spin-off ventures follows closely the process involved in entrepreneurship, that is the creation of new opportunity driven businesses.

The degree of linearity and the holistic nature of the new venture creation events (entrepreneurship as an event in the definitions used in this paper) and development processes (entrepreneurial cognition, orientation and capacity) ranged widely with the varying origins and phases of the development processes for these new technology small firms, suggesting particularly that in the context of entrepreneurship non-linearity cannot be assumed and that holism (as requisite holism) is a continuous rather than a dichotomous variable. The entrepreneurship event could be characterized as non-linear and holistic for the market opportunity driven spin-off opportunities, as found usually in opportunity driven new entrepreneurial ventures generally, whether or not they started as a spin-off from a public sector research provider. However, for the cases, which were, in Bhidé’s characterization, technology and venture capital driven, and for others closer to his corporate class in their planning and early stage resource availability—as opposed to opportunity driven
entrepreneurs—the early stage development phases appeared to be generally linear. For all the cases, the access to entrepreneurial capacity came from a set of knowledge resources that differed between phases and between the people involved in these phases. They were better described in terms of Penrose’s “bundle of resources” that define the strategic performance of a firm.

This hypothesis was not supported.

\[ H(1): \text{In any study of new technology small firm (NTSF) creation, the entrepreneur can always be clearly identified.} \]

Many of the new ventures in the sample conformed closely to the traditional entrepreneurship framework (Figure 1). For these companies, there was a clearly identified entrepreneur who often continued as CEO beyond the first external equity investment. However for the other companies, described as venture capital driven or corporate spin-off ventures, there was no one person who could be identified as the entrepreneur throughout the early phases of the venture’s development. Vohora et al (2002) have described the externally recruited CEOs as surrogate entrepreneurs.

This hypothesis is not supported.

\[ H(2): \text{Entrepreneurial capacity is a set of knowledge resources best studied in a holistic rather than a reductionist mode} \]

The analysis of various knowledge sources and resources that constitute entrepreneurial capacity showed how these differed between the different development phases of new technology small firm (NTSF) ventures. This has been illustrated both in Tables 1-3 and in the framework illustrated in Figure 3. The data presented have suggested the need for disparate and reductionist investigative strategies for the various elements of entrepreneurial capacity, that is the various knowledge resources. The analytical strategies that might be most effective for each identified group of new ventures will vary. The application of the concept of requisite holism suggests an approach closer to holistic for the more traditional opportunity driven new ventures (Table 1 and Figure 1), but preference for a reductionist approach for the companies that fell into the venture capital driven (Table 2) and corporate groups (Table 3 and Figure 2).

This hypothesis is not supported

CONCLUSIONS

The analysis has shown that the entrepreneurship related constructs in the literature and the concept of entrepreneurship as requiring holistic rather than reductionist investigative strategies apply in a high proportion of but not in all spin-off ventures.

The second main conclusion relates to entrepreneurial capacity as a set of knowledge resources. The analysis has shown how these resources differ between phases and between different participants in the phases, suggesting the need for reductionist as well as holistic approaches to the investigations. This has illustrated the application of Rebernik and Mulej’s (2000) concept of requisite holism. The more traditional opportunity driven entrepreneurial ventures should benefit from a more holistic approach than the well planned and resourced corporate spin-off where there is no clearly identified single entrepreneur.
REFERENCES


Scott Kemmis, D., 2003 Seeing Machines Case Study. The National Graduate School of Management Commercialisation of Research and Development. Canberra Australian National University.


Figure 1  A Framework for an entrepreneurial opportunity driven new venture
Figure 2  A linear framework for a well planned and resourced spin-off

Figure 3  Entrepreneurial capacity as knowledge resources

Source: Yencken and Gillin (2003c)