

## ENTREPRENEURSHIP, HOLISM AND TECHNOLOGICAL INNOVATION: THEORY CONFLICTS IN LESSONS FROM SPIN-OFF COMPANIES

*John Yencken: Swinburne University Of Technology, Hawthorn, Vic, Australia*  
*Murray Gillin: Australian Graduate School Of Entrepreneurship, Hawthorn, Australia*

~

**Contact:** John Yencken, Swinburne University of Technology, Australian Graduate School of Entrepreneurship, PO Box 218, 3122 Hawthorn, VIC, Australia, (T) 613 9214 5870, (F) 613 9214 8381, Email: [jyencken@groupwise.swin.edu.au](mailto:jyencken@groupwise.swin.edu.au)

### Abstract

Entrepreneurship scholars have described entrepreneurship as a holistic process. This has presented conceptual difficulties in the analysis of technological innovation, particularly the development process of new high-tech small firms, such as spin-offs from public research agencies. The paper first discusses the concept of holism and reviews the analytical and dialectical philosophy literature to establish possible tests for holism, and next reviews the constructs of entrepreneurial orientation and entrepreneurial capacity with the extension of Penrose growth theory to entrepreneurial ventures. Data from case studies of companies spun-off by universities and other public agencies have been used to explore the relevance of holism and the other constructs as defined to the study of new technology - based firms (NTBF). The implications of these findings for the generation of new high-growth companies were also explored.

*Key words:* Entrepreneurship, commercialisation, holism, innovation.

### Introduction

Harvard philosopher W.V. Quine's seminal contribution was to throw into doubt the very idea of a distinction between purely linguistic or conceptual questions and purely factual questions. According to Quine, the philosopher differs from the scientist only in that the former tends to focus on the most abstract questions belonging to domains of inquiry that are ultimately the province of both. Thus, the epistemologist and the cognitive psychologist, the philosopher of language and the linguist, the metaphysician and the physicist, are partners who investigate common domains of inquiry. It follows from this general picture that the findings of empirical science are of direct relevance to philosophical inquiry; there is no distinctive sphere of "philosophical questions" that is the exclusive preserve of the philosopher (Kelly, 2002).

The purpose of this paper has been to review and clarify the various definitions associated with the entrepreneur and entrepreneurship. This was necessary to resolve some conceptual problems in the relationship between technological innovation and entrepreneurship. These conceptual problems started from the need to reconcile entrepreneurship scholars' arguments that entrepreneurship was a holistic process (Bygrave 1991) and Drucker's concept of entrepreneurship being 'the engine of innovation' (Drucker, 1989) with the processes that lead to technological innovation in a new technology-based spin-off company (NTBSF). This has led first to exploration of how this description of entrepreneurship as a holistic purpose arose and what was its meaning.

The PhD research topic that was the origin of this paper has been the role of spin-off companies in the commercialisation of research outcomes from universities and other public research agencies. This has involved the analysis of data from qualitative research case studies of the early phases of some 20 such spin-offs in Australia and two in Scotland. The literature review and research supporting this analysis has identified a theoretical dilemma in the reconciliation of technological innovation, as seen in these spin-off ventures, with entrepreneurship scholars' views in the literature of entrepreneurship as a holistic process. This aspect of the research started from Bygrave's (1991) comment that there was "...in

general, a lack of preciseness starting at the very root of the paradigm, the definition of an entrepreneur”. Bygrave and Hofer (1991:2) gave working definitions of various aspects of entrepreneurship indicating a clear separation of Entrepreneurial Event and Entrepreneurial Process:

An *Entrepreneurial Event* involves the creation of a new organisation to pursue an opportunity

The *Entrepreneurial Process* involves all of the functions, activities, and actions associated with perceiving of opportunities and the creation of organizations to pursue them.

An *Entrepreneur* is someone who perceives an opportunity and creates an organization to pursue it.

This paper later explores the relevance of these statements to new technology start-ups where it has been difficult to establish who or where was the entrepreneur at different phases of the venture’s development.

Bygrave and Hofer (1991:14.) and Hofer and Bygrave, (1992:99) in both papers have made statements that a unique characteristic of the entrepreneurial (Bygrave and Hofer p.2) or entrepreneurship (Hofer and Bygrave p. 99) process was that it “is a holistic dynamic process that is both unique and involves numerous antecedent variables”. In both papers these statements are made without any supporting argument. It was therefore necessary to explore other, including earlier, studies, firstly to be clear about the meaning of the word holistic and secondly to explore its application as a descriptor of the entrepreneurial process. The review started with Bygrave’s earlier 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. Bygrave saw entrepreneurship research on the other hand as requiring 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: 20).

The end objective of the analysis in this paper has been to build an integrated and hopefully predictive model—as opposed to just a framework—for the analysis of the case study data. To do this, it has been necessary to reconcile the various constructs involved—*viz.* technological innovation, entrepreneurship, entrepreneurial orientation and entrepreneurial capacity—with new entry performance by such spin-off ventures. The keys to the development of this model came from recent work on the extension of Penrose’s resource based theory of the firm (Kor and Mahoney,2000; Peteraf, 1993; Rugman and Verbecke,2002; Rumelt, 1984) to entrepreneurship (Alvarez and Barney, 2000; Alvarez and Busenitz, 2001) and the consideration of entrepreneurial capacity as a *set* of knowledge resources essential to the development of such new technology-based small firms (NTBSFs).

An earlier version of this paper was presented at the High Technology Small Firms (HTSF) Conference at the University of Twente at Enschede in the Netherlands in May 2003.

### **Holism and holistic**

To my knowledge the term “holism” goes back to Smuts (1926) where it was introduced in a biological context (Esfeld 1998:373).

As against the atomistic and absolutized separations of reductionism, holists counterpose the unity of the world. That is, they align themselves at the "oneness" end of a spectrum from isolated to "One." They look for some organizing principle behind the wholeness, some "harmony" or "balance" or purpose which gives the wholes their unity and persistence...

Dialectical "wholes" are not defined by some organizing principle such as harmony or balance or maximization of efficiency. In my view, a system is characterized by its structured set of contradictory processes that gives meaning to its elements, maintains the temporary coherence of the whole and also eventually transforms it into something else, dissolves it into another system, or leads to its disintegration (Levins, 1998).

Already there are two different views of holism in terms of "some organizing principle". The Shorter Oxford Dictionary defines *holism* as "the tendency in nature to produce wholes from the ordered grouping of units". The term *holistic* refers to a philosophical position (Hansen 1995, quoted by Campbell 2002) which claims that:

- Wholes cannot be taken apart.
- Every apparent whole can be understood only in the context of the larger whole containing it.
- A whole is more than the sum of its parts.

Esfeld (1998) has explored the relationship of holism to analytical philosophy. He used the example of quantum physics where holism was based on what is known as the entanglement of quantum systems. "It can be argued that entanglement is ubiquitous at the level of quantum systems and that it is not a causal relation" (p.373).

...our intuitions suggest that holism is opposed to reductionism. If there are holistic properties at some level of complex systems in nature, the description of these properties cannot be reduced to a description of non-relational properties at a lower level plus a description of a suitable arrangement of objects at the lower level in question.

In his analysis, he argued that "the characteristic feature of a holistic system is a certain sort of dependence among its constituent parts".

...Holistic properties are relational properties. A relational property is holistic if and only if it satisfies the following two conditions: (1) It belongs to a family of properties which make something a constituent of an S [*system*] in case there is a suitable arrangement. (2). Nothing can instantiate this property unless there actually are other things together with which this thing is arranged in such a way that there is a system (p.371).

Ontology is "the science or study of being" and ontological means "pertaining to or of the nature of being" (Shorter Oxford Dictionary). Esfeld (p.369) has argued that the test for holism was whether there are ontological relationships between the parts of a holistic system. He suggests three requirements:

1. There is an issue of substantial philosophical argument as to whether holism applies in specific areas.
2. Holism needs to be construed as an ontological claim; that is, "a thesis about the structure of certain systems".
3. A holistic system is characterized by "a certain sort of mutual dependence on its parts".

Sawyer (2002) has discussed holism in the context of emergence theory in psychology and sociology and more generally non-reductionist science:

Holism, in my usage, is the position that the science of the lower level is largely irrelevant to the higher level science, that the higher level has explanatory primacy, and that the behaviour of the components can only be examined in terms of their relationship within the entire system (p.14).

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.

Rubernik and Mulej went on to define holism as a system. Their use of the word *viewpoint* in this context implies viewpoints as the elements of a possibly holistic system.

The definition of holism reads as the following system (not a set!) of attributes:

- The systemic attributes cover attributes which the whole system has, but parts do not. They can be found by examination of the entire whole as a whole.
- The systematic attributes cover attributes which the individual components of the entire whole have, but not the entire whole.
- The interdependence between individual parts causes their mutual impacts, relations, sometimes expressed as feedback. It leads to synergistic, emerging attributes. They make the entire whole different from its individual parts as separate, smaller wholes. The attributes can be found by examination of mutual interplay (feedback, etc.) of the parts as well as their backgrounds.
- The realism of considering the entire whole, its parts, and their relations as well as their environment(s) and its or their mutual relations with the parts and the entire whole prevents exaggeration in both over-simplification and total holism. This is a pre-condition for the outcomes to make sense and to be close enough to life “out there”.

Applying these concepts to entrepreneurship, Rebernik and Mulej started from the resource-based theory of the firm (Penrose 1958, 1985).

Resources matter because they enable the entrepreneur to exploit an opportunity... (Rebernik and Mulej 2000 p.1170).

A quite holistic view of the entrepreneurship process is requisite, not every resource is appropriate to every business opportunity...every opportunity has a certain lifetime: a window of opportunity”. (p. 1131).

Wilber (1995,2000) has written extensively in his chapter on the Web of life on related questions. He has analysed the concept of *holons*:

Reality is not composed of things or processes; it is not composed of atoms or quarks nor does it have any parts. Rather it is composed of whole/parts, or holons (p.41).

He quoted Koestler who noted that all such hierarchies are composed of holons, or increasing orders of wholeness and pointed that the correct word for “hierarchy” is actually *holarchy* (Wilber op. cit. p. 29). These concepts bear comparison with Rebernik and Mulej’s concepts of requisite holism

### **Entrepreneurship, entrepreneurial orientation, entrepreneurial capacity and technological innovation**

In this section of the paper, consideration has been given to the core constructs surrounding entrepreneurship—entrepreneurship itself, entrepreneurial orientation, entrepreneurial capacity—that are involved in any analysis of successful technological innovation.

Definitions of these constructs have been reviewed against the various tests for holistic and requisite holistic systems discussed earlier.

In an earlier paper, Olson (1985:27) identified the different tasks involved in the development of a new venture. The 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 the customers”. He suggested that these second phase activities were often known as *innovation*. However, he recognized that “creative work also requires left-hemispheric, rational information processing”.

...intuitive thinking generates the early insight or awareness that focuses entrepreneurs and prepares them for more concentrated, rational follow up activities. Then to reach the prototype stage, logical, sequential thinking is needed to develop the detail (p.29).

Rebernik and Mulej (2000) also clearly identified the need for separate and sequential entrepreneurial and management functions:

When an opportunity is spotted, resources gathered and organised, the entrepreneurial function offers its place to the managerial function; the managers take charge of running the business (p.1131).

Gartner (1988) had a similar view:

*Entrepreneurship is the creation of new organisations...Entrepreneurship ends when the creation stage of the organisation ends.*

In contrast, more recent analysis of technological innovation as opposed to entrepreneurship, (Hindle 2002; Hindle and Yencken 2003), would include all phases from idea to commercial application and successful wealth creation as the scope of BIG-I technological innovation (Figure 1). The question is where and how do the various entrepreneurship related constructs fit into this total innovation process.

Bygrave (1989:9) developed a model or framework—he prefers the word *framework* as it is explanatory rather than predictive—of the entrepreneurial process based on Moore’s (1986) earlier analysis. This has been shown as Figure 2 and has been used to analyse the application of the word *holistic* to entrepreneurship. Under the Hindle and Yencken (2003) definition, this is a model of the innovation process rather than just entrepreneurship and raises the question of whether entrepreneurship extends beyond the act of new entry or enterprise creation.

The model contained four sub-systems—Innovation, Triggering Event, Implementation, Growth. As sub-systems, they appeared to satisfy the condition of ontological dependence, even if growth was subsequently contained by management and market performance. Clearly Bygrave here has used the word *innovation* in its *small-i* connotation—that is, invention or newness as opposed to its BIG-I connotation that includes the commercial exploitation of the new knowledge (Hindle, 2002).

Definitions of the three key constructs involving entrepreneurship—entrepreneurship, entrepreneurial orientation, and entrepreneurial capacity—have next been reviewed against the various criteria for the description of *holistic* discussed earlier. This has provided the basis for the model of technological innovation through new start-up spin-off ventures that has been used in the analysis of the case study data for the sample of such companies described in the Introduction (Hindle and Yencken, 2004;Yencken, 2005).

### Entrepreneurship and entrepreneurial orientation

The literature (Wiklund 1999, Shane, 2005) has provided evidence that entrepreneurial orientation contributes to “both growth and financial performance, suggesting that it has double payoff” for small firms: at least over the two-year period involved with Wiklund’s reported research. Lumpkin and Dess (1996) have sought to define better the entrepreneurship orientation (EO) construct, particularly in relation to corporate entrepreneurship in existing companies. The issues discussed however have also been relevant for the study of new technology-based companies. They first focussed on entrepreneurship as being about the *act of new entry*:

The essential act of entrepreneurship is new entry. New entry is the act of launching a new venture either by a start-up firm, through an existing firm or via internal corporate venturing. New entry is thus the central idea underlying the concept of entrepreneurship (p.136).

When these characteristics of entrepreneurship as the act of new entry were tested against Bygrave’s framework of entrepreneurial process (Figure 1), entrepreneurship as the act of new entry might satisfy the criteria for a holistic viewpoint. Its elements suggested ontological dependence. They would also appear to satisfy Sawyer’s (2002) condition of holism for the entrepreneurship system involved. The *science* of the higher level—in this case the generation of the new venture—is largely irrelevant to the lower level *science*—that is, that is the science of those “viewpoints” that relate to the various environments to which the entrepreneur is subject in generating a new entry event. Research into such *new entry* thus can require a holistic and non-reductionist approach.

The holistic nature of each of the sub-systems—since as presented the elements consist of a mixture of people and properties—was more questionable. The presentation above (Figure 2) of the elements of entrepreneurship has also shown the relevance of Rubernik and Mulej’s (2000) concept of requisite holism “as a system of all essential, but only essential viewpoints”. Not all the “viewpoints” shown in the figure will be relevant in all entrepreneurship systems. As discussed earlier, they use the word *viewpoints* to describe the elements of a system that may show some level of requisite holism.

Lumpkin and Dess (1996) distinguished between entrepreneurship primarily involving “new entry” as a firm level phenomenon and entrepreneurial orientation (EO) (of the firm) as the process that determines new entry performance, that is, how successfully the new entry was undertaken (processes, functions, decision making activity). Their analysis concluded that the important factors (not just traits of an individual) affecting new entry performance of firms in this EO process were autonomy, innovativeness, risk taking, proactiveness leading to vision and imagination, and competitive aggressiveness.

#### *Autonomy*

...refers to the independent action of an individual or a team in bringing forth an idea or a vision and carrying it through to conversion.

#### *Innovativeness*

...reflects a firm’s tendency to engage in and support new ideas, novelty, experimentation and creative processes that result in new products, services and technological processes.

#### *Risk taking*

Presently there is a well-accepted and widely used scale based on Miller’s (1983) approach to EO which measures risk taking at the firm level.

#### *Proactiveness*

...refers to processes aimed at anticipation and acting on future needs by “seeking new opportunities which may or may not be related to the present line of operations” (Venkataraman, 1989).

*Competitive aggressiveness*

... refers to a firm's propensity to actively and aggressively challenge its competitors.

These “salient dimensions” are most relevant to existing firms. However for entrepreneurial new ventures, individual entrepreneurs in the team will drive the new venture. Lumpkin and Dess's hypothesis was that these “salient dimensions of EO may vary independently of each other in a given context”. They argued that “any attempt to limit entrepreneurial behaviour to only those cases in which all levels of all EO dimensions are evident falls short of explaining many types of entrepreneurship” (p.150) They also identified qualifying factors (p. 152) such as environmental variables and mediating factors such as organisational variables that also affected performance.

Lumpkin and Dess' (1996:129) analysis of entrepreneurial orientation as a process shows how the different factors that determine performance can vary and come together in varying strengths in different situations. Some may not be evident at all. EO cannot therefore, against the tests described earlier, be considered as a holistic process. Lumpkin and Dess did not show entrepreneurial orientation as an “ordered grouping of units” and showed that it could be taken apart. These findings equally breach Sawyer's test of the validity of the *science of the lower levels*—Lumpkin and Dess' salient dimensions and qualifying and mediating factors—to the *science of the higher level*, the act of new entry, since all of these dimensions and factors will have their own *science* and may be present at differing levels for different acts of entrepreneurship, that is new venture entry.

**Hypotheses and research findings**

Specific hypotheses have been formulated to test the issues raised in the preceding examination of various key entrepreneurship-related constructs. Data from qualitative research case studies of twenty two new spin-off companies from universities and other public research agencies in Australia and Scotland—conducted as part of a doctoral thesis by one of the present authors (Yencken, 2005: 123-136)—have been used to test these hypotheses: Preliminary exploration of the case study data had suggested that an appropriate segmentation would be one based on the level of selectivity, planning and resource inputs before the venture started to operate as an independent incorporated entity (Bhidé, 2000; Degroof and Roberts, 2003). The case studies were rearranged into four groups (Table 1) based on Bhidé's (2000) classification that related 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, as well as a separate Group O for the three companies that were not found to be spin-offs from research provider parents. In summary, the groups were:

- Group O. Companies that were not found to have university or other public research providers as parents
- Group A: Opportunity driven entrepreneurial ventures
- Group B: Venture capital driven ventures
- Group C: Corporate style spin-off ventures.

The hypotheses have essentially been derived from the null hypothesis that all spin-off companies show the same attributes as opportunity driven entrepreneurial new ventures as shown in the entrepreneurship literature and the constructs defined and discussed in that section of the literature review.

*H(1) Entrepreneurship as the act of new venture creation is a dynamic holistic process and is not suited to a reductionist research strategy (Bygrave and Hofer, 1991)*

The analysis (Table 1) showed that for the three Group O companies, where there was no research provider parent, the act of new venture creation clearly required holistic analysis: the new ventures could not be usefully researched separately from the entrepreneur(s). Three of the Group A companies, opportunity driven entrepreneurial ventures appeared to satisfy the tests for holism. The other three in this group were better matched to the Rebernik and Mulej concept of requisite holism, as “a dialectic system as a system of all essential, but only essential, viewpoints”. The two Group B. venture capital

driven companies, both appeared to satisfy the tests for requisite holism as a distributed variable rather than holism as a dichotomous variable. Of the companies in Group C, the corporate spin-offs, that had been well planned and resourced initially by their parents, two out of the six appeared to satisfy tests for requisite but not dichotomous holism. The others appeared better suited to reductionist analytical strategies.

*H(2) The conceptual process of venture creation is non-linear and iterative (Bhavé, 1994).*

The case study analyses suggested that linearity and non-linearity as defined by Campbell (2004) have been less clear and less useful constructs than the concept of holism and the need for holistic rather than reductionist research strategies.

*H(3): In any study of new technology small firm (NTSF) creation, the entrepreneur can always be clearly identified.*

In all the cases in Groups O and A, the opportunity driven entrepreneurial ventures, the entrepreneur was clearly and easily identified. He or she had a lead role throughout the development of the venture. For the Group B cases, venture capital driven spin-offs, the person in the driving product champion role was in both cases an employee of the university parent's technology transfer office. The description in both cases probably best fitted the Lockett et al. (2003) concept of the surrogate entrepreneur. For the Group C cases, corporate spin-offs, the situations were more complicated. In two cases entrepreneurs could be clearly identified, in three there were researcher technology champions who quite quickly handed over to externally recruited CEOs, Lockett's surrogate entrepreneurs. In the sixth case, there was a succession of managers, neither of whom easily fitted the description of entrepreneur.

*Holism, linearity and entrepreneur identity*

Table 2 has summarised the findings under these three headings. There is support for the need for a holistic analysis strategy where an entrepreneur could be identified, but there was a less consistent relationship between the construct of linearity, or more relevantly non-linearity, and the construct of holism in this context.

## **Conclusion**

The theoretical dilemma between the more traditional views of entrepreneurship as a holistic process and the sequential processes of technological innovation in new technology spin-offs from universities and other public research providers has been identified and explored. In the process, the analytical philosophers' interpretation and meaning for *holism* and the adjective *holistic* have been studied. The next step was to clarify the meaning of the various constructs involved—innovation, entrepreneurship, entrepreneurial orientation and entrepreneurial capacity—and to apply the philosophers' tests for holism and the related issue of *requisite holism*, that is "as a system of all essential, but only essential, viewpoints". The analysis led to the conclusion following Lumpkin and Dess (1996) that entrepreneurship was the potentially holistic act of new entry. Entrepreneurial orientation was the process whose attributes determined performance in relation to new entry, that is entrepreneurship. Entrepreneurial capacity was the *set* of disparate and different knowledge resources that need to be contributed during the process of technological innovation by individual players during various phases in the new venture's development to achieve commercial success and wealth creation. For entrepreneurial orientation and entrepreneurial capacity, reductionist as well as requisite holistic research strategies were valid.

The cases were sampled to cover a wide range of technologies on the one hand and research providers on the other. There was no sampling bias to include or exclude individual companies that did or did not fit with a particular entrepreneurship related construct. The qualitative and comparative data analysis for this sample strongly supported the Rebernik and Mulej (2000) concept of requisite holism as a distributed rather than a dichotomous variable as the basis for determining a research or data analysis strategy for a particular new venture. Within the sample, there were examples of non-linearity and holistic integration of the entrepreneur and his new entrepreneurial venture; there were, at the other end of the spectrum, examples of corporate type, well planned and resourced new ventures that did not

appear to satisfy tests for either dichotomous or requisite holism. In between there were many cases where requisite rather than dichotomous tests for holism were best satisfied.

### Acknowledgements

The authors would like to acknowledge the wise and critical comments and suggestions from Professor Kevin Hindle that led to significant improvements in the earlier drafts of this paper.

### References

- Alvarez, S. and Barney, J. (2000) Entrepreneurial Capabilities: A Resource-Based View. Entrepreneurship as Strategy: Competing on the Entrepreneurial Edge. In: Meyer, G. and Heppard, K.A., (Eds.) *Entrepreneurship Strategy: Competing on the Entrepreneurial Edge*, pp. 63-82. Thousand Oaks, CA: Sage]
- Alvarez, S. and Busenitz, L. (2001) The entrepreneurship of resource based theory. *Journal of Management* **27**, 655-676.
- Bhave, M.P. (1994) A process model of entrepreneurial venture creation. *Journal of Business Venturing* **9**, 223-242.
- Bhide, A.F. (2000) *The Origin and Evolution of New Businesses*, edn. Oxford: Oxford University Press.
- Bygrave, W. D. and Hofer, C. W.. (1991) Theorizing About Entrepreneurship. . *Entrepreneurship Theory and Practice* **6**, 13-22.
- Bygrave, W.D. (1989) The entrepreneurship Paradigm (I): a philosophical look at its research methodologies. *Entrepreneurship: Theory and Practice* **14**, 20
- Campbell, A. (2003) Melbourne: PhD dissertation Australian Graduate School of Entrepreneurship, Swinburne University of Technology.
- Degroof Jean-Jacques and Roberts, E.B. (2003) Spinning off new ventures from academic institutions in areas with weak entrepreneurial infrastructure: Insight on the impact of spin-off processes on the growth-orientation of ventures. Working Paper 4311-03 edn, Boston: MIT Sloan School of Management.
- Drucker P. (2002). *The discipline of innovation*. Harvard University Press.
- Eisenhardt, K.M. and Martin, J.A. (2000) Dynamic capabilities: what are they? *Strategic Management Journal* **21**, 1105-1121.
- Esfeld, M. (1998) Holism and analytic philosophy. *Mind* **107**, 365-380.
- Gartner, W.B. (1988) Who is an entrepreneur? *American Journal of Small Business* **13**, 11-32.
- Hansen, B.G. (1995) *General Systems Theory: Beginning with Wholes*, , edn. Washington D.C.: Taylor & Francis.
- Hindle, K. (2002) How entrepreneurial capacity transforms 'small-i' into 'Big-I' innovation: implications for national policy. *Telecommunications Journal of Australia* **52**, 51
- Hindle, K. and Yencken, J. (2003) Public Research Commercialisation, Entrepreneurship and New Technology Based Firms: An Integrated Model. *Technovation* (Forthcoming).
- Hofer, C.W. and Bygrave, W.D. (1992) Researching Entrepreneurship. *Entrepreneurship: Theory and Practice* **17**, 91

- Kelly, T. (2002) "Invariances: the Structure of the Objective World", by Robert Nozick. A review. *The Review of Politics* **64**, 761-763.
- Kor, Y.Y. and Mahoney, J.T. (2000) Penrose's Resource Based Theory: The Process and Product of Research Creativity. *Journal of Management Studies* **37**, 109-140.
- Levins, R. (1998) Dialectics and Systems Theory. *Science and Society* **62**, 375-399.
- Lockett, A., Wright, M. and Franklin, S., (Eds.) Technology Transfer and Universities' Spin-out Strategies. edn. Babson College, Wellesley, Mass.: Babson Kauffman Foundation. (2003)
- Lumpkin, G.T. and Dess, G.G. (1996) Clarifying the Entrepreneurial Orientation Construct and Linking to Performance. *Academy of Management Review* **21**, 135-172.
- Miller, D. (1983) The correlates of entrepreneurship in three types of firm. *Management Science* **29**, 770-791.
- Moore, C. F.(1986) Understanding entrepreneurial behaviour. In Pearce, J.A. and Robinson Jr., R.B., (Eds.) *Understanding entrepreneurial behaviour*. Academy of Management Best Papers Proceedings. Forty-sixth Annual Meeting of The Academy of Mangement.edn. Chicago: Academy of Management.
- Olson, P.D. (1985) Entrepreneurship: Process and Abilities. *American Journal of Small Business* **10**, 25-32.
- Penrose, F. (1995-1999) *The Theory of the Growth of the Firm. First edition*. edn. Oxford: Basil Blackwell and New York: John Wiley & Sons. Second edition, 1980, Oxford: Basil Blackwell
- Peteraf, M.A. (1993) The Cornerstones of Competitive Advantage: A Resource-based View . *Strategic Management Journal* **14**, 179-191.
- Quine, W.v.O. (1951) Two Dogmas of Empiricism. *Philosophical Review* **60**, 20-43.
- Rebernik, M. and Mulej, M. (2000) Requisite Holism, Isolating Mechanisms and Entrepreneurship. *Kybernetes* **29**, 1126-1140.
- Rugman, A.M. and Verbeke, A. (2002) Edith Penrose's Contribution to the Resource Based View of Strategic Management. *Strategic Management Journal* **23**, 769-781.
- Rumelt, R.P. (1984) Towards a strategy theory of the firm. In: Lamb, R., (Ed.) *Competitive Strategic Management*, Eaglewood Cliffs. NJ.: Prentice-Hall]
- Sawyer, K. (2002) Emergence in Psychology: Lessons from the history of non-reductionist science. *Human development* **45**, 2-28.
- Shane S. (2005). *iEconomic Development through Entrepreneurship*. Cheltenham, UK. Edward Elgar.
- Venkataraman, N. (1989) Strategic orientation of business enterprises: The construct dimensional personality. *Management Science* **35**, 942-962.
- Wilber (2005). *A brief history of everything*. Boston. Shambahla.
- Wiklund, J. (1999) The sustainability of the entrepreneurial orientation -- performance relationship. *Entrepreneurship: Theory and Practice* **24**,
- Yencken, J. ( 2005) The role of spin-off companies in the commercialisation of university and other public agency research outcomes. Melbourne: Swinburne University of Technology.

**Table 1 Tests for holism**

*Group O. Companies with no research provider parent*

Case No.	Product /activity	Tests for holism
3	Customer relations management software	This case was included as an example of a classic opportunity driven act of entrepreneurship. This act was holistic in the sense that the entrepreneur and his new venture needed to be explored and analysed in a holistic rather than a reductionist mode.
4	Asset location hardware and software	The early development of Oztrak was all about an entrepreneur who saw opportunities that others did not see and then found the resources to exploit these opportunities. In the end the entrepreneur was too closely tied to the company, even when it had reached a stage of rapid growth that needed planning and managerial skills rather opportunity finding. In these early stages the entrepreneur and the venture had to be analysed holistically as one unit.
8	Specialised light alloy billets	The entrepreneurship event could only be analysed holistically with the entrepreneur in this case.

*Group A. Opportunity driven entrepreneurial ventures*

Case No.	Product / activity	Tests for holism
6	Glaucoma detection instrument	Entrepreneurship as the event of creating a new venture was evident. In this event, the behaviour of the components cannot only be examined in terms of their relationship within the entire system, thus failing the Sawyer (2002) test for holism. The entrepreneurial orientation that contributed to this came primarily from a Director of the Institute working in a business development role and also from the inventor scientist. The process failed tests for holism and was best suited to a reductionist analysis strategy.
10	Robotic seabed drill	The involvement of the inventor/entrepreneur could not be analysed except in the context of the new venture. This case satisfied the description of requisite holism (Rebernik and Mulej, 2000), a “dialectic system as a system of all essential, but only essential, viewpoints”. The essential viewpoints are those of the geologist and engineer inventors in this case.
19	Egg white based fat replacer	The process of new venture creation for this research provider of a spin-off venture followed closely the process involved in entrepreneurship, that was the creation of a new opportunity driven business. The idea behind Nandi was creative and innovative, but the process of development followed a planned linear series of activities that well satisfy Campbell’s (2004) criteria for linearity.
22	Monitoring rotating machinery	The new venture creation involved here had the characteristics of entrepreneurship with an entrepreneur identifying the opportunity but with other parties involved in finding the resources needed to develop the opportunity. Esfeld (1998) described the characteristic feature of a holistic system as a certain sort of dependence among its constituent parts. This did not appear to apply to all the parts in this case. It fits better with the Rebernik and Mulej (2000) description of requisite holism where “not every resource is appropriate to every business opportunity”.
27	Waste water filtration	In this case the entrepreneur and the company were one and the same (Bygrave, 1989). The tests for holism were well satisfied.
28	Minituarised reflux pH probe	As for Baleen filters from the same University, the analysis showed an entrepreneur who analytically could not be researched separately from the new venture that he had created. He identified the opportunity, found the resources and put them together synergistically.

*Group B. Venture capital driven spin-offs*

<i>Case No.</i>	<i>Product / activity</i>	<i>Tests for holism</i>
11	Nasal filter and particle measure	The early history in this case started with a licensing strategy that failed because of the withdrawal of the potential licensee. The role of the inventor entrepreneur could not be studied separately from the eventual new venture. There was a need for an analysis strategy that satisfied tests for requisite holism, at the minimum, if not totally holistic
13	Blood clotting factor	The formation of Kinacia by two clinician researchers and a university technology company executive satisfies the tests for requisite holism, but could not be approached adequately as a uniquely holistic event where the actions of the founder entrepreneurs could not be analysed separately from the new venture.

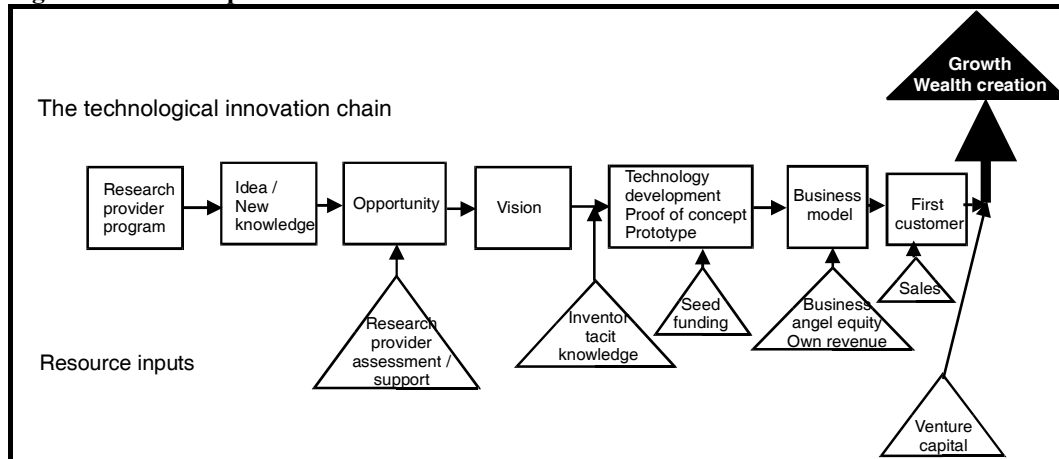
*Group C. Corporate spin-offs*

<i>Case no.</i>	<i>Product / activity</i>	<i>Test for holism</i>
1	Java encryption software	The initial algorithm invention was quite separate from the later parties involved. Each played a part. Its description matches better the Rebernik and Mulej (2000) concept of requisite holism as a system of all essential, but only essential viewpoints.
2	Polymer adhesion	There was no entrepreneur driving this company's formation and development. Problems were identified that were suited to a research investment. The tests for a holistic view of entrepreneur and entrepreneurship event were not satisfied.
5	Pain killer drugs	The critical prior knowledge leading to the formation of Xenome was of reptile and cone shell venoms and of the bioactivity of the compounds involved. The decision to set up a new venture and its development involved different people at different stages. This process closely matched Bhidé's (2000) model of a spin-off venture from a large established company which has been well planned and resourced before being set free by its parent.. Developments of new ventures of this type do not satisfy tests for a holistic process.
7	Stem cell therapy	It started life with a technology champion/founder, who has since left, a CEO and a COO. The initiation of the company came from the lead scientist and technology champion and he was also heavily involved in bringing in investors already known to him. He identified the opportunity and brought together the scientist resources needed. As such he was the technological entrepreneur, but management responsibility was quickly handed over and by the time of the interviews he had severed all connections with the Company. The early stages can be seen as a holistic event where it was difficult to study the new venture separately from the serial technological entrepreneur involved.
9	X-ray imaging	The trigger came from outside and the key person involved became its first CEO. The inception showed a degree of requisite holism in the integral role of the CEO entrepreneur with the company itself
24	Pig growth improvement	A new company was established, an entrepreneurship event, but it was part of the ongoing development of an established company, a CRC spin-off, in a logical rationalisation of the parent company's activities. This case does not fit that description, not even that of requisite holism.

**Table 2 Comparisons between holism, linearity and entrepreneur identity**

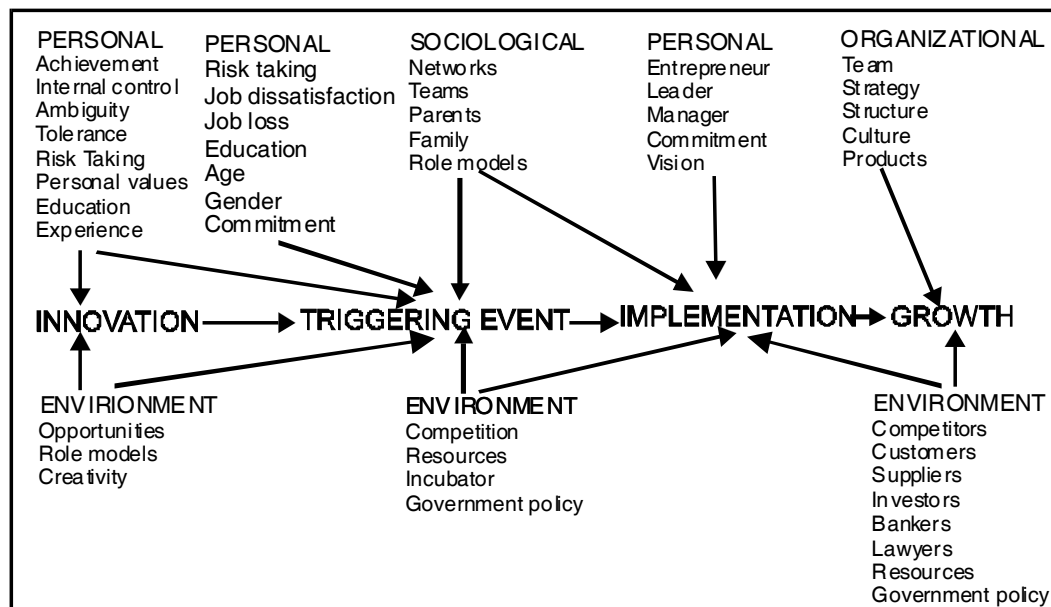
<i>Group</i>	<i>Holistic research strategy</i>	<i>Linearity</i>	<i>Entrepreneur identification</i>
O. No research provider parent	Holistic	Two non-linear and one linear	Yes, clear
A. Opportunity driven entrepreneurial ventures	Mostly requisite holistic	All linear except one.	Yes, clear
B. Venture capital driven spin-offs	Requisite holism	Both linear	TTO employees as surrogate entrepreneurs in both cases
C. Corporate spin-offs	Two requisite holistic, the rest reductionist	Two linear and four non-linear	Both entrepreneurs (but only in early stage) and technology champions succeeded by externally recruited CEOs.

**Figure 1 The total process of BIG-I innovation**



Source: Present authors.

**Figure 2 A model of the entrepreneurial process**



Source: Bygrave (1989) embellishment of Moore (1986) model.