



High-tech Entrepreneurship

Managing innovation,
variety and uncertainty

Edited by
Michel Bernasconi
Simon Harris
and Mette Moensted

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High-tech entrepreneurship is one of the most important driving forces behind innovative change in our world. It occurs in large, small and new organizations, in firms that are private, public and state owned, and has great political and economical attention. The uncertainty intrinsic to innovative and advanced technology environments makes the use of conventional economic planning models redundant. For high-tech entrepreneurship to thrive, those managing and influencing it need to understand the special management skills required, which are much more responsive to risk, uncertainty and evaluation of the unknowable.

High-tech Entrepreneurship focuses on the mix of theory and practice needed to inform students on advanced entrepreneurship courses who have an interest in the high-tech environment. The book's expert contributors highlight the variety and uncertainty within this world as an opportunity for entrepreneurship, and explore some of the many ways in which managers pursue their shared interest, innovation. In doing this, this book is a valuable companion to many courses on this ever-more important aspect of business education, contributing to the understanding of entrepreneurship in the broad sense, and to conditions for innovation in firms and society.

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 **Routledge**
Taylor & Francis Group
LONDON AND NEW YORK

First published 2006
by Routledge
2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN

Simultaneously published in the USA and Canada
by Routledge
270 Madison Ave, New York, NY 10016

Routledge is an imprint of the Taylor & Francis Group, an informa business

Transferred to Digital Printing 2006

© 2006 Michel Bernasconi, Simon Harris and Mette Moensted for editorial selection
and material; individual contributors, their own contributions

Typeset in Perpetua and Bell Gothic by
HWA Text and Data Management, Tunbridge Wells

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British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication Data
High-tech entrepreneurship : managing innovation, variety and uncertainty / edited by
Michel Bernasconi, Simon Harris, and Mette Moensted.

p. cm.

Includes bibliographical references and index.

1. High technology industries—Management. 2. Technological innovations—Management.

I. Bernasconi, Michel. II. Harris, Simon. III. Moensted, Mette.

HD62.37.H535 2006

658.4'21—dc22

2006011813

ISBN10: 0-415-38058-8 (hbk) ISBN13: 978-0-415-38058-4 (hbk)

ISBN10: 0-415-38059-6 (pbk) ISBN13: 978-0-415-38059-1 (pbk)

Publisher's Note

The publisher has gone to great lengths to ensure the quality of this reprint
but points out that some imperfections in the original may be apparent



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Preface

One impetus for this volume is an explosion of interest in high-tech entrepreneurship, reflected amongst other things in a burgeoning in the number of courses on the subject offered around the world at undergraduate, postgraduate and post experience level. The other is a dissatisfaction with existing texts which tend to fall into one of two camps. Some present a 'top-down' description of the phenomenon of high-tech entrepreneurship, with little insight into the managerial issues involved.

Others often present clear and comprehensible models of the managerial issues, but these invariably ignore the deep complexities involved, complexities that arise from the variety of forms of high-technology entrepreneurship and from the extraordinary uncertainties which pervade the world of high-technology entrepreneurship. Our focus in this book is on the management of high-tech entrepreneurship, and our central themes are the variety and the uncertainty within the process of doing it.

Our desire, then, was to assemble a team that would rise to this challenging task, and contribute to a research-led book that reflected not only deep scholarship on the subject, but deep experience as well. We have been extraordinarily fortunate. The different chapters are contributed by leading people in the field throughout Europe. Nearly all the authors have some strong connection with Sophia Antipolis, Europe's largest high-tech business park near Nice in the South of France. Their backgrounds, however, like the subject that is examined, are varied, some being internationally acknowledged on grounds of their scholarship, and others similarly acknowledged on grounds of their experience in the process of high-technology entrepreneurship.

The outcome is a book that deals with the subject with different voices, and from different perspectives, from the academically rigorous born of scholarship and careful examination of real cases, to the direct voice of the experienced practitioner richly enriched with real examples. All are valued, and all contribute, with examples

PREFACE

throughout, to a rich and complex tapestry that begins to describe a rich and complex, but immensely important, phenomenon.

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Sophia Antipolis, June 2005

High-tech entrepreneurship

Managing innovation in a world of variety and uncertainty

Michel Bernasconi, Simon Harris and Mette Moensted

For economies to achieve growth in an increasingly technologically advanced and borderless world, the creative talents of its residents need to be marshalled into successful businesses. This has ever been so. It has been witnessed in Europe, for example, from the times of the Roman Empire, through the age of the Holy Roman Empire, when some countries and regions achieved phenomenal economic success through the entrepreneurial activities of individuals and groups who translated technological and merchant opportunity into the creation of wealth. In this book, we call this process high-tech entrepreneurship.

We are, once again, entering a period of global economic liberation, running in parallel with significant technological advance. This is, inevitably, leading to questions from policy makers with local, regional, national and supranational economic concern as to how this process can be fostered. Managers of firms, whether in their own businesses or professional managers of larger firms, ask how it may be managed. Individuals with innovative intentions ask how they may be able to achieve their dreams: the dreams upon which the future economic welfare of us all, and of future generations, will depend.

So many types of people share an interest in the subject of this book, but do so from different standpoints. Technicians with innovations in their heads and in their hearts seek to understand the process of developing ideas into businesses. Entrepreneurs look to see how they can increase the impact of their innovations, financially or in other ways. Owners and managers of established firms from the small to the very large are seeking ways that they can gain or regain the innovative and entrepreneurial dynamism that characterizes the growth business. Managers and administrators of that environment, from the managers of business incubators, to local support and advice agencies, to the managers of venture capital bodies, wish to learn how they can make a constructive difference, in part by understanding how others do so. Political interests are concerned with how government policies can improve the environment they set for the high-tech entrepreneurship process, and

how the environment can impair that process. And students of management, who may be in, or may develop into, one of these roles benefit from an understanding of the processes involved. From in-house executive programmes to specialist MBA and masters programmes, for science and for business specialists, at postgraduate and at undergraduate level, the number of courses offered in the area of high-tech entrepreneurship has exploded.

One outcome of this interest has been a plethora of books that purport to show how it is done; the 'how-to' books. Typically, these give models of the high-tech entrepreneurship process that are clear and logical and, usually, on the face of it at least, reasonably complete. They appear to give us what we want. They make it look straightforward. They present us with certainty. Follow their linear template, they suggest, and we can also do it. As we shall see, this is not a realistic proposition: high-tech entrepreneurship, like life, is more difficult than that.

A WORLD OF VARIETY AND UNCERTAINTY

First, let us define what we mean. Following Jolly and Thérin (1996), we define technology to be any original and protected combination of scientific knowledge, technical knowledge and know-how, mastered by a firm (or firms), and incorporated into a product, service, production process, information system or management method, for an economic purpose. Taking the marketing standpoint that Paul Millier presents in Chapter 12, we regard a high-tech product to be a product or service which is a breakthrough in upsetting its market to a point where the market can no longer be considered in the same way.

High-tech entrepreneurship is the creation of value from technical innovation through success in business. It is not a person, nor is it an idea; rather, it is a process. It is a process of building new companies based on technologies. It is not the only way to innovate, and is not necessary best way to innovate, but as Ludovic Dibiaggio argues in Chapter 3, it is a way that is well adapted to complex situations.

The first thing that we know – this is a research-led text – as Mette Moensted presents in Chapter 2, is that the world of and the process of high-tech entrepreneurship is highly complex. This book will attempt to embrace the complexity that we know to be involved, in two aspects. First, the contexts in which managers are 'doing' high-tech entrepreneurship are highly diverse, and the ways in which they do it vary greatly. Second, they are also doing all this in environments of extreme uncertainty.

Variety in high-technology entrepreneurship

The context within which high-technology entrepreneurship takes place is varied. First, it is geographically varied. The relationship between high-tech firms and the national or regional context is an important theme, since we must remain aware

that 'it is not the same everywhere'. Second, the institutional setting for high-tech entrepreneurship is also varied. It can involve young start-ups led by technologically advanced individuals, but it is also commonly practised by existing companies, big or small, research and development centres, universities, private inventors and government departments and agencies.

Technological innovation comes mainly from scientists and technologists, but it is not only the realization of the work and dreams of individuals. As Valérie-Inès de La Ville shows us in Chapter 5, it is also a collective creation, and one that develops over time. The transformation of these people into entrepreneurs, the process examined by Alain Fayolle in Chapter 4, is complex to define, culturally grounded, and the result of personal trajectories. High-tech entrepreneurship requires many different skills that are not available in one person, and as Céline Druilhe and Elizabeth Garnsey show us in Chapter 10, and Michel Bernasconi shows in Chapter 11, entrepreneurial teams are, of necessity, made up of people who complement the founders. All the individuals involved are embedded in social networks, and as Michel Bernasconi and his colleagues show us in Chapter 6, these are not only essential for the success of the entrepreneurial process, but are a key element of the environment in which the firms are created. Such networks are, as Mette Moensted shows us in Chapter 16, an essential element of the innovation process to create access to diversity, but as Simon Harris cautions in Chapter 7, we cannot simply dictate our networks, since they are highly dependent on the cultural heritage.

This all leads us to see each high-tech entrepreneurial context to be at least highly varied, and often infinitely varied. All these factors do not only create complexity, but complexity that itself differs from manager to manager and from management situation to management situation.

Uncertainty in high-technology entrepreneurship

Management in high-technology entrepreneurial contexts has, however, one other dominant trait: uncertainty. This includes risk, differences between contexts, and evaluation of the unknowable. Uncertainty and complexity, innovation and advanced technology is what makes it difficult to use the usual linear business economic models and planning, and makes it necessary to reflect on how to cope with management under these entrepreneurial conditions.

Our analysis of uncertainty in high-tech entrepreneurship, however, is made difficult by there having been so many efforts to define the concept of uncertainty, some including various related concepts, such as opportunity, risk, ignorance, bias or ambiguity, and some discriminating it from these concepts. We are helped by Van de Ven and Grazman's definitions of uncertainty and ambiguity, which by seeing innovation more as a journey than as a well planned and scheduled programmed process, matches our 'process' vision of high-tech entrepreneurship:

Much of an innovation journey involves an adaptive learning process to deal with conditions of ambiguity (i.e. where it is not clear what specific preferences or objectives should be pursued to reach a vague super ordinate goal) and uncertainty (i.e. where it is not clear what means of actions will achieve desired outcome goals)

(Van de Ven and Grazman 1997: 279)

Julien and Marchesnay (1996) identify uncertainty as a condition for entrepreneurship: an uncertain context is open for new interpretations and for new actions, creating opportunities through innovation. Innovation and entrepreneurship are based on creating new ideas and new knowledge. But a number of aspects of high-tech contexts make the issue of uncertainty even greater than in other entrepreneurial environments.

First, we are faced with intrinsic characteristics of the context. Technologies, especially in early phases, are not yet proven, and the ability of the technology to deliver its promise, and the time this will take, is also uncertain. New markets, especially in radical innovation areas, tend to be novel as well, and do not just fit into an existing market. The time scales for these future developments of technology and markets are unknowable.

Second, lack of control is an important dimension of the uncertainty involved. In high-tech environments there is a greater dependence on skills and other resources which are outside the control of the managers themselves. This creates great demands on communication and learning on the part of those in control of those other resources. In high-tech environments, this is a difficulty. Much of this communication may well be with culturally different people. Some of the lack of communication between high-tech entrepreneurs and financial investors, for example, may be associated with them knowing too little about each other, which is exacerbated by the intrinsic uncertainty of the projects noted before. Others in the support system can see aspects like the uncertainties embedded in an innovation, the opportunities involved and the risks in very different ways.

Third, in high-tech entrepreneurship, stories do not repeat themselves, and even if analysis of earlier experience is important for some creation of meaning, it does not predict the future. This challenges the conceptualizations and strategic models that are typically based on projection of patterns observed earlier and elsewhere. When exploring new ideas, and when developing ideas into innovations, our perspectives on what we know, and our understanding of the models of stable development need to change as well.

So in high-tech entrepreneurship, it is the norm rather than the exception for factors to be unpredictable, and is it the norm rather than the exception for most important factors also to be outside managerial control. Nevertheless, important decisions have to be made, but as we must now recognize, this will be without

the possibility of straightforward and clear analysis based on established models of development. That is what we mean by uncertainty.

VARIETY AND COMPLEXITY IN THIS BOOK

We can now begin to see why it is necessary for us to disappoint those who might have wanted us to present a simple, new and all-encompassing 'model' of high-tech entrepreneurship. Whenever faced with contexts of uncertainty and complexity, we can expect calls for solutions, strategies or 'saviour-recipes' (Stacey 1996), as managers in a human way seek meaning and linear causality. The purpose of these is to create 'a sense of certainty', but one that we would now recognize to be an illusion. Such an exercise, therefore, would be both foolish and dangerous.

First, the implicit decision-making structures do not address environments that are either different from those implicit structures, or which are intrinsically diverse. The models which implicitly assume the structure of a Silicon Valley start-up may be irrelevant for a German university spin-out, or for a Swedish government department, even though all may be doing high-tech entrepreneurship.

Second, these business models are embedded with implicit certainties. The simple models, simply, will not do. For example, models based on earlier experience with sectors can overlook new opportunities, and only allow understanding of 'me-too' technologies, not real innovations.

Third, these simplistic models do not show the interacting and organizing conditions of the high-tech entrepreneurial firms. The organization of resources to combine skills for developing technology and markets, which requires communication and negotiation to persuade other firms and agents, is critical. The environmental conditions allow entrepreneurs to recruit supporters such as partners, subcontractors, customers, and investors. Those based on personal traits, for example, overlook the interactive setting, and negotiated influence to form an innovative context. In the simple models this complexity is not transformed into simple indicators but is lost.

The evidence of research into what managers actually do is that in this environment these simple business models do not work. Managers do not use them, and the approaches that they do adopt are highly diverse. The special features of technological innovation, uncertainty in particular, make high-tech entrepreneurship a non-linear process. In this book we will see a diversity and variety of approach: there is not a universalistic 'one way' to manage in this environment. So we have a strong case for recognizing diversity in the high-tech entrepreneurship process, and to begin the process of understanding it by seeing it in many different ways. That is what we do in this book, and Table 1.1(below) shows how we do it.

This book cannot hope to describe all the variety and uncertainty that pervades the high-tech entrepreneurial firm, but it does cover a lot. Part I takes a holistic approach to the issue, and the chapters present a range of different perspectives to

Table 1.1 *Variety and uncertainty in the contributions to this volume*

<i>Chapter</i>	<i>Variety in:</i>	<i>Uncertainty in or from:</i>
PART I: UNDERSTANDING INNOVATION AND ENTREPRENEURSHIP		
2: Mette Moensted High-tech, uncertainty and innovation	Levels of uncertainty; how trust is used in innovation and entrepreneurship	From the environment, from technological changes, and from the market
3: Ludovic Dibiaggio Small is beautiful for high-tech firms	The dynamics of learning and knowledge creation; organizational structures	In firms' innovation processes; from the complexity of the environment and dynamic problems
4: Alain Fayolle Engineers as high-tech entrepreneurs	Within and between countries in the entrepreneurial orientation and the career paths of engineers	In who become entrepreneurs; from their own as well as others' expectations
5: Valérie-Inès de La Ville Collective learning in high-tech firms	The ways in which people interact with one another; a necessary element of innovation	In the processes of interaction between people in innovation, and from the necessity of improvisation
PART II: DIFFERENT ENTREPRENEURIAL WAYS OF FACING UNCERTAINTY		
6: Michel Bernasconi, Ludovic Dibiaggio, and Michel Ferrary High-tech clusters	The characteristics of the local milieu; in the communities of practice and social networks	The presence and effectiveness of communities of practice, and the levels of interaction between them
7: Simon Harris Network relationships in different cultures	The national and institutional cultural assumptions underlying business activity and network relationships	The behaviour and wishes of others in network relationships
8: Philippe Albert and Lynda Gaynor Technology business incubation management	The stakeholders, objectives, profiles and practices of technology business incubators	The interaction between incubators stakeholders, management, and the technology firms
9: Franck Moreau Strategy development processes	In the dynamics and models of high-tech start-up development	The unknowables in and interactions between development aspects
10: Céline Druilhe and Elizabeth Garnsey University spin-out firms	How university scientific/technical capabilities and developments can be commercially exploited	The necessary technical and managerial capabilities available and required
11: Michel Bernasconi Creation processes as evolving projects	The industries, the entrepreneur(s) and the local milieu involved; in all the elements of the projects	In the technologies involved, the market acceptance, and the economic model
PART III: MANAGING INNOVATIVE HIGH-TECH FIRMS		
12: Paul Millier Marketing technological innovations	The specific innovation mechanisms and the former industrial experiences	In customers, markets, competitors and regulatory environments
13: Gil Ayache Creating competitive intelligence	The sources and nature of information; in organizational skills	In markets, technologies and competitors
14: Dominique Jolly Evaluating technology development projects	External technological factors and companies' internal technological resources (skills and competences)	In the markets, the competitors, the technologies and the standards that are demanded
15: Mette Moensted Networking for innovation	Resources and people; how projects are created across boundaries	Know-who to get access to know-why

show different angles on this variety and uncertainty. Part II uses empirical research on different types of high-tech entrepreneurs to show the very different approaches adopted by different types of entrepreneurs. Part III looks at the different managerial functions of high-tech firms, and outlines different approaches to these functions.

ANALOGIES OF HIGH-TECH ENTREPRENEURSHIP

So we are not going to give a standard model. Such standard solutions may be good in stable conditions, but uncertainty and turbulence may call for other methods and tools that are related to this kind of context. The need for sense making, however, remains; we are only human after all. In these circumstances, some kind of structure is needed, or failing that, a narrative with dialogues and narratives that can create images and metaphors as analogies for action (Steyaert 1995). We will now conclude this introduction by drawing on the various contributions in this book to look at this complex world through two analogies.

The world of high-tech as a field of icebergs

We can envisage the environment of the high-tech firm as a field of icebergs in an inhospitable and dangerous sea. What are these icebergs? The first is the high-tech entrepreneur himself. Above the surface we see the expression of an idea, possibly a business plan. But it is what is below the surface that matters: not only the entrepreneur's skills, but character, drive, network of friends, and abilities in the face of uncertainty, setback or potential disaster.

Then we can consider the innovation, and the technology involved. Above the surface we might see an apparently coherent and definable technology. High-tech entrepreneurs, however, rarely succeed on the technology they start with: they nearly always have to change, adapt and augment their technological base. Once again, it is what is below the surface of the technology that really matters: for example, the availability of complementary technologies, and of suppliers of them, and the ability of the entrepreneurial team to combine different technologies into a value creating proposition.

Then we might think of the incubator. The incubator is one important element of the environment (or milieu) for high-tech entrepreneurship. Above the surface we have an office, perhaps some buildings, and some facilities. These may well be of value, but it is what lies below the surface that really matters: for example, the skills and experience of those involved, their networks, and their understanding of the complexities involved. We can also consider the financier. Above the surface we see an individual with access to finance, but below the surface we see a rich array of abilities and relationships that can be the difference between success and failure for the high-tech entrepreneur.

In each 'iceberg' we are dealing with things that we can see, and therefore, it is easy to think that we know. But in each case, we are only seeing the surface, the top, that which reveals itself to the travellers on the sea. There is more, much, much more, below the surface, which is difficult to see. So we are dealing with a situation of asymmetric information. Those in each 'iceberg' know that their own operation – and 'iceberg' – is full of complexities, subtle nuances, and dynamic changes that they find difficult enough to manage themselves. Each iceberg has agendas, cultures and perspectives or 'ways of thinking' that are very different to one another.

What of our environment, our sea is the environment of high-tech entrepreneurship, our 'milieu'. It can be benign, or it can be hostile. A benign environment is a clear sea, so that you can see the depth of the icebergs, and the different parties involved are able to see what they are dealing with and can make better decisions on that basis. They all need to be able to gain knowledge and understanding of the different parties involved, and the different factors involved.

From outside the 'icebergs', it is very difficult to see those agendas, and even if one is told them, to understand them because they may well be embedded within cultures, perspectives, and 'ways of thinking' that are very different to one's own. This lack of understanding, this difficulty of comprehension, generates the massive uncertainty which we emphasize in this book. The consequence of this is that there is a tremendous risk of proceeding on courses of action that will not work out, because that course of action is predicated on assumptions born of observations of the top of the 'icebergs' and without an understanding of the vast complexities that lie beneath the surface.

The world of high-tech as a tropical forest

We can also see the world of high-tech as a tropical forest. Why should we do that? It is because there are a number of features of a tropical forest that seem to hold parallels with the world that we are examining in this book; by using that analogy, we can draw some important lessons. Looked from the sky, a tropical forest can seem to be a flat green carpet; a simple world. On the face of it, the world that we are examining can also be so simple. Expressions such as 'it's just a matter of putting the money together with the idea', and 'market research will establish the demand' seem to reflect this apparent simplicity.

We do not, however, have the luxury of floating about above the forest. We have to land. Having penetrated the canopy, we find a strange, dense, dark, complex, exiting, dangerous world that is rich in variety and complexity. Each business situation differs – the people involved, how they interact, and the dynamics of the technologies.

So what kind of guide might we need to understand such a world? Would it be a picture from the sky, of a green carpet? Such a 'top-down' overview might take you to the forest by air, but will be of no help within it. Will the guide have a picture of

a mahogany tree, as a single idealized type of forest tree? It is possible that we may find a mahogany tree, but there are hundreds of other types of tree as well. Even mahogany trees grow in different ways. What of the land that the trees grow in, the hills and the earth, the climate and the rainfall that feeds in? And what also of the animals that live in the trees, that both feed off them and which pollinate them and allow them to breed and spread? And what of the trees that die, that decompose and feed both different types and of animals and ultimately future generations of trees?

Like the tropical forest, the world of high-tech entrepreneurship is a rich, vibrant and exiting world full of variety and uncertainty. A simple guide will not only not do, it will mislead. Instead, we need a rich feeling for our world, and the diverse contributions within this book will begin to give just that.

Uncertainty and innovation in entrepreneurship

Mette Moensted

The first section of this book is concerned with uncertainty as the basis for entrepreneurship, innovation and advanced high-tech. Innovation processes, and how innovation is organized under conditions both of environmental uncertainty and high complexity, is analysed with an organization and competence perspective. The starting point is that if there were certainty, the market mechanism would leave no opportunities for entrepreneurship to exploit. The fluidity and uncertainty of innovation processes pose special problems. These include methodological problems, for example in measuring fluid and chaotic processes. They also include communication problems, between the entrepreneurs on the one hand, and the experts, customers, and investors who are likely to be outside the narrow field of expertise of the high-tech firm's advanced technology on the other hand.

Most economic development and marketing models are based on the evaluation of known factors and the stochastic evaluation of risks. Radical innovations may question these basic conditions that underlie most business development models. For firms that thrive in and on chaos or uncertainty, new ways of iterative decision processes in project management are needed. Experts in large stable customer firms or in venture capital organizations think in terms of the classical models of business development, which is linearly, and which relies on experience. The problem, however, is that in radical innovations, we cannot expect history to repeat itself. Chapters 2, 3 and 5 discuss these conditions for high-tech entrepreneurial processes.

Understanding high-tech entrepreneurs in complex and uncertain environments is quite fundamental for communicating with and persuading customers and investors. This chapter tries to get closer to the radical innovation and early technological development that is an embedded part of the innovation process.

In Chapter 2 Mette Moensted analyses the uncertainty concept as an embedded part of innovation. The search for new knowledge at the boundaries of the organization may be the foundation for creativity, but it also creates vulnerability

and risk in entrepreneurial young high-tech firms. The whole process of innovation opens new fields unknown before, intrinsic aspects of radical innovation and of new advanced high-technologies. Creating and enacting a new industry happens before we have knowledge, not after. Young high-tech firms without an established record have to develop projects beyond the resources of their own firm, and they have to create mechanisms to act and decide.

The rhetoric and communication within the scientific communities of practice can form platforms of understanding the differences that matter. The difficulty is in effectively communicating the entrepreneurial growth potential to other groups outside those scientific or technological communities of practice, to groups of experts, customers and investors who are likely to have different mindsets. One of the issues then is how entrepreneurs can create credibility and trust among those outside their own communities of practice, and how at least some of those outside those communities of practice are able to understand the innovation process sufficiently to allow high-tech firms to be created.

In Chapter 3 Ludovic Dibiaggio discusses why Schumpeter's statement of 'small is beautiful' is still valid, but only for high-tech firms in complex environments. The innovation is not considered a homogeneous and uniform process, but is based on various dynamics of learning and knowledge creation. The size and organizational structure of firms has a strong effect on the efficiency of the firm's innovation process.

In environments of radical uncertainty, normal cause and effect relationships do not work. Here, because complex uncertain situations do not succumb to standardization, the standardization procedures that large firms rely on for competitive advantage do not work either. Large firms have lots of other advantages in terms of resources, capacities, and control, but they have less autonomy for flexibility and radical change. Small firms show greater abilities in creating new organizations of more variety of form, within networks, and may do this in very flexible ways, as they are unencumbered by there being established organizations which need to be turned-around first. So here is a niche capability in which small entrepreneurial firms can excel, for handling dynamic, complex, and unpredictable problems, through new forms of absorptive capacity, also examined further in Chapter 5. A case study illustrates some of these features in an illuminating way.

In Chapter 4 Alain Fayolle raises interesting issues as to whether engineers are really high-tech entrepreneurs. As high-tech innovation demands insight in advanced technology by scientists and engineers, these are potentially the high-tech entrepreneurs and interesting partners in the field, and their career patterns are important for recruitment of high-tech entrepreneurs.

The French engineer-entrepreneurs are engineers who follow a special career path. French engineers are graduating from elite institutes of higher learning, and seem to identify with the technical culture. Very few become entrepreneurs. They are compared with German and Dutch engineers, showing different patterns and

other identities in management. These engineers should be the foremost basis for recruitment for high-tech entrepreneurs, as they have the technical expertise and the ideas for high-tech innovation. The analysis of the identity of engineers both before and after the creation of these firms shows interesting surprising patterns through a longitudinal study of their careers.

In Chapter 5, Valérie-Inès de La Ville analyses innovation as a collective learning process. The barriers and resistance to radical innovation is analysed within a longitudinal case study of a software company. Innovation is analysed as a social process, which develops in an unplannable and unknowable way, as it is based on both uncertainty and high level of complexity. By looking at dramatic and radical innovation as a collective process of interaction and sense making, technological innovation is seen to be related to the skills and competence of the firm. The social processes involved show the dependency on sharing the ways of understanding between those involved, for improvisation to occur. The interaction between people builds up a fragile dynamic capability that is related to the organization and to the competing tasks of the developers.

A continual process of improvisation is an essential element of technological innovation, and of entrepreneurship. It is akin to the perception of the process of development as a journey, discussed in Chapter 2. To understand the improvisation that lies at the heart of high-tech entrepreneurship, it is necessary to identify the specific social characteristics within the technological 'field' involved, and also to distinguish the 'technique' from the 'technological development' that is required. Here, Alain Fayolle's engineering identity in Chapter 4, and his distinction of 'technique', is particularly relevant.

The first part of this book creates a framework for understanding the specific nature of high-tech entrepreneurship, in its organization, its innovation processes, its skills and its people. Opening up the uncertainty and complexity develops a foundation for understanding the processes of building high-tech firms.

High-tech, uncertainty and innovation

The opportunity for high- tech entrepreneurship

Mette Moensted

Reasonable men adapt themselves to their environment; unreasonable men try to adapt their environment to themselves. Thus, all progress is the result of the efforts of unreasonable men.

(George Bernard Shaw)

Why should we look at uncertainty as a framework for understanding high-tech entrepreneurs and innovation? If there was transparency and certainty, the market mechanism would be perfect and no opportunities would be left un-exploited. Uncertainty is a basis for new ideas, allowing new knowledge to be generated, but also combats and controls in the process of establishing and driving innovation. This in itself is a paradox, but some of uncertainty's characteristics are tied to different understandings of the concept of uncertainty.

Innovation and high-tech are both based on new ideas and new technology, which in the early stages are characterized by opportunities to be developed and by knowledge 'not-yet-known'. Specifically, high-tech and innovation in small firms could be characterized as exploring and exploiting opportunities under a high level of uncertainty. The innovation perspective is tied to what will knowledge be and how markets will develop in the future. The further ahead in the future, the higher the level of uncertainty, as we cannot foresee the future. Managers' ability to handle uncertainty and manage the process of innovation in an uncertain environment is the basis for creating and developing growth potential.

Creativity and entrepreneurship are tied to action and exploitation of opportunities, and a perspective of embedded uncertainty creates a framework for understanding the concepts. Malecki (1991) takes the argument beyond the firm to the region, arguing that the instability and uncertainty that together improve entrepreneurship are created by unexpected events and inter-firm rivalry, as well as by fluidity and diversification. This may easily be transferred to a regional ability to create new organizations, products and firms, depending on high-tech

entrepreneurs' ability to handle and thrive on uncertainty (Leonard and Sensiper 1998).

Innovation processes are not only based on uncertainty; they also create uncertainty. Leavitt (1986) develops his ideas of pathfinders in the organization as a perspective of understanding some of the paradoxes of managing innovations. The need for the pathfinder to be creative disturbs balances and creates uncertainty in the organization, and can threaten current efficiency. But if innovations are necessary in the long run, then this process is important, and others in organizations have to manage the implementations of the projects that result.

UNCERTAINTY AS A BASIS FOR INNOVATION

It is tempting to distinguish risk from uncertainty. The distinction could actually go further, to perceive uncertainty as a contextual condition that is part of chance and opportunity on the one hand, and risks involving estimable probabilities of failures in the operation on the other hand. In economic considerations it is often assumed that maximization of efficiency cannot be achieved under a high level of uncertainty, i.e. when 'agents cannot anticipate the outcome of a decision and cannot assign probabilities to the outcome' (Beckert 1996: 804). Making this distinction between risk and uncertainty is not new; Knight (1921) distinguished between changes in the economy to which probabilities can be assigned and situations where the individual has no information on which to base calculation of probabilities. The first type Knight calls 'situations of risk', and the latter, 'uncertainty' (Beckert 1996: 807).

Many researchers' concern is for uncertainty as the condition for entrepreneurship and innovation. Julien and Marchesnay (1996) interestingly distinguish between uncertainty as conditions for entrepreneurship, and various kinds of risks as the improbable or unlikely. Like Knight, they tie the concept of risk to variables with low probabilities, a perception also shared by Perrow in *Normal Accidents* (1984). In Perrow's interpretation, high-tech in the chemical and nuclear industries works with an evaluation of risk and probabilities of a combination of errors, within a framework of limiting the probabilities of risk.

Daft and Lengel (1992) change the concept, and distinguish uncertainty from equivocality. Uncertainty refers to clearly formulated questions with right or wrong answers, and equivocality refers to situations where not only the answers are missing, but the questions themselves are unclear. Equivocality thus becomes more like the ambiguity and the embedded uncertainty of innovation tied to communication media and communication richness, discussed extensively here. Daft and Lengel (1992) claim that written communication may reduce uncertainty, but only face-to-face communication, with the richness that it implies, may be used to reduce equivocality (ibid). The complexity, and thus the dependency, of communicating in dialogue rather than in serial monologue communication – such as in writing, including in emails – creates a dependency on local networks or communities of

practice where signs and forms of tacit knowledge may be shared to some extent. ICT people, for example, do not only use electronic connections, but also use face-to-face communications and local networks (Jensen *et al.* 2004).

In order to understand entrepreneurial action and the perception of opportunity, the concepts of uncertainty, persuasion, and the creation of trust will have to be linked to other concepts of influence and dependency. A 'quantitatively' high level of uncertainty and low inertia seems to change not only the qualitative conditions for action, but also changes the decision structures, communication and organizational forms. As a manager in a firm working with artificial intelligence declared:

This firm may disappear from one day to another, as it is based on trust and references. There is no inertia as in production firms.

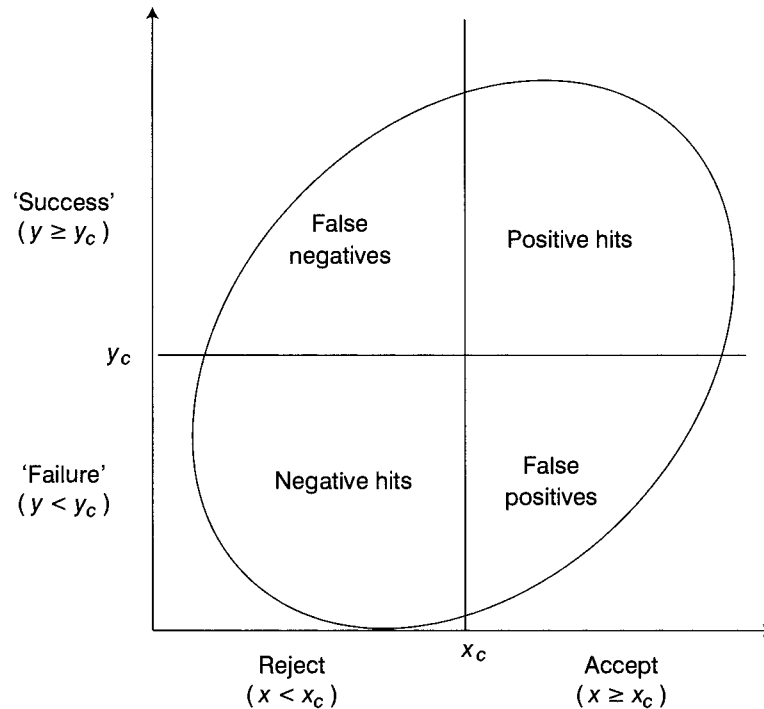
This is one of the specific characteristics of high-tech entrepreneurship, here seen especially in ICT, and is one of the reasons for questioning the limitations of models of development taken from firms in more stable environments.

These arguments do not imply that everything is based on serendipity, and that we have to wait for opportunities to show up by chance. Atherton (1997) links uncertainty directly and indirectly to the context of entrepreneurs, and to possibilities of manoeuvring and influencing through a variety of channels and mechanisms. Entrepreneurship is action, and the exploring and exploiting of opportunities. The next step for the entrepreneur is to persuade others, and uncertainty has to be communicated as opportunity with low uncertainty – in itself, a paradox.

One small Danish firm had problems persuading a large customer that they had an exceptional innovation, and that, though small, they had solved a problem that large American companies could not. One condition for establishing expectations and confidence is the number of inventors and charlatans promising 'rose gardens'. These promise-making 'crazy inventors' raise suspicion and make it difficult for serious small innovative firms to be heard. They are reminiscent of fourteenth century alchemists, where the hope of finding gold caused royal investors – the 'venture capitalists' of those days – to continue their investments for a long time. The alchemist's image maintained promise for some time, but their lack of results eventually replaced earlier expectations with a loss of credibility: in the long run, trust cannot be maintained without results. The balance between trust and documentation is a problem faced by most innovative units in the early stages. The question is, how long will customers and investors wait for results?

INNOVATION MANAGEMENT AND UNCERTAINTY

The innovation literature mostly examines large organizations and projects that have proven successful (Teece *et al.* 1987; Kanter 1983; Dosi and Fagiolo 1997). They reveal a method, well-known in most growth models, which is a kind of

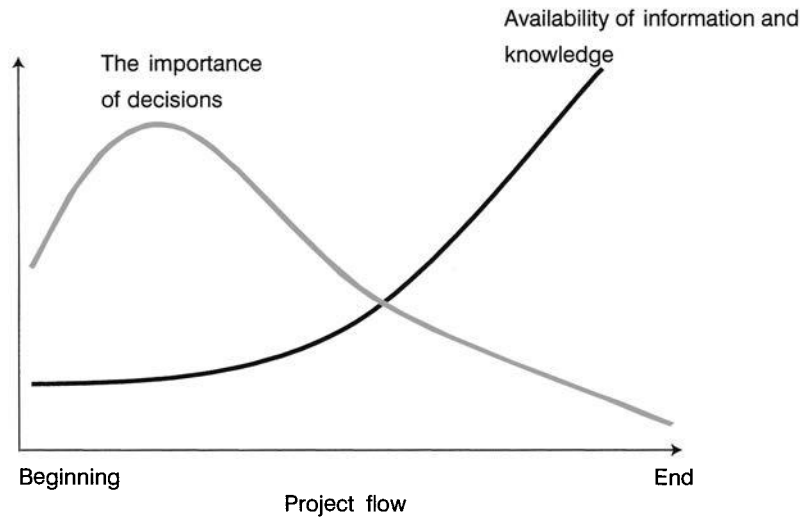


■ **Figure 2.1** Project selection, decision and outcomes

Source: Garud et al. (1997), p. 25.

're-engineering of the successes' (e.g. Greiner 1972). The re-engineering perspective presume predictability, and a 'pick-the-winner' strategy, assuming an ability to define clear criteria based on experience, even though expecting history to repeat itself in conditions of radical innovation would be a paradox. The embedded uncertainty of innovation questions the usual cause and effect relationships; innovations are neither re-engineered nor imitations. Uncertainty implies that decisions often have to be taken without what could be considered a rational analytical basis. A normal problem for managers is to decide on potential innovation growth projects at an early stage of development. Here, they often face pressure both to avoid failures of investments in 'false positives' – type I errors – and also projects later proven successful in other contexts, i.e. 'false negatives' or type II errors (Garud et al. 1997: 25). This is shown in Figure 2.1.

The general idea of sorting negatives from positives is fundamental to the whole study of innovation and the management of knowledge. It is tied to decisions of managers, and to decision of investors, both trying to find recognisable clues to development. The high level of uncertainty means many errors, and 'war-stories' of both failures and successes are abundant in ex-post interpretations.



■ **Figure 2.2** *The importance of decisions and the knowledge basis for decisions*

Source: Mikkelsen and Riis (1998), p. 62

The serendipity element is based on the fact that decisions are taken before we have knowledge and not after. This presumes that empirical experience from development projects is the basis for visions and strategy models, reacting as if information is more predictable (Stacey 1992). Ex-post fallacies may create the assumption that we could have predicted and found the knowledge. In most of these innovations, however, there is no chance of finding the unknowable except after the event.

Figure 2.2 shows a model is built on the experience that the most important decisions, with the greatest implications, are made in the early stages, before relevant knowledge is available. Early decisions are based on a high level of uncertainty, but still have to be taken and cannot wait for the necessary knowledge to be generated. The timing of decisions in innovation projects is a challenging and stressful factor for innovation management. The task is to create meaning and to enact a platform for decisions that is based on the not-yet-known, or on some kind of intuition.

Most innovations are not radical, but represent small increments of ‘normal change’ that refine and improve projects. These are easier to understand and to invest in, since they do not make large changes, and usually allow for a proper technology and market analysis to be undertaken. In some cases, though, it may generate real innovative processes, in what Raghu Garud, based on a study in 3M, calls ‘mindful replications’ (Garud 2004).

In the early stages of development, high level of uncertainty makes the distinction between ‘facts’ and ‘virtual facts’ very difficult. It is very unclear what the ‘real’ facts are, which arguments are based on facts or tests, and which are based on ‘daydreams’

or 'virtual facts'. Fundamental innovations are set in motion in a sequence of events that can change the need for competences; 'these innovations have a transilient ... capacity to transform established systems of technology as well as markets' (Van de Ven and Garud, 1989: 196). In microelectronics, for example, instruments for testing have to be developed while the products themselves are developed (Larsen 2001). The secrecy necessary at an early stage makes it even more difficult to create credible scientific arguments for legitimacy and, in these circumstances, it is difficult also to find experts to legitimize them. This is part of a fundamental paradox that sets the scene for most innovation decisions.

The anxiety arising from the high level of uncertainty within radical innovations has been found in a number of other studies (Oakey *et al.* 1990; Herlau and Tetzschner 1999; Elfring and Foss 1997). A tendency towards a preference for small incremental adaptations is further supported by impatience in evaluation, and the need for predictability on the part of investors and managers. The evaluation systems and economic rationality used may use efficiency criteria from another context based on 'weapons from the last war'. This creates a barrier against experimentation, which limits long-run effectiveness. A tendency towards incremental changes arises from the constraints on and the fear of the exploration of fundamental innovations.

The problem is how to perceive radical innovations? Some are like a series of actions where a number of incremental innovations together gradually constitute a radical change, rather than a planned breakthrough. In an analysis of biotech firms in Europe, Rip and Velde (1997) provide a narrative depicting the early innovation processes as 'a journey', where new product experiences and changes in perception arise on the journey. It is not a linear, programmed process to find specified solutions to a very specific problem. Instead, problems, questions and solutions appear during the journey, which may easily end up going somewhere other than originally intended. This perspective is akin to the 'garbage can' model (March and Olsen 1976), focusing on a competent expert team working in a promising innovative field, which assumes that the team has the competence to create innovative solutions.

The whole question of what is high-tech or biotech is not always clear. Oakey *et al.* (1990) characterize biotechnology production 'with high levels of research and intellectual inputs to value added and high value per unit of weight' (Oakey *et al.* 1990: 69). This feature covers both the innovation, the growth potential and the intellectual input and forms the basis of the kind of relationships that the biotech people develop within the industry and with universities. Arie Rip and Robbin te Velde (1997), in their analysis of biotechnological innovation projects, perceive 'product creation processes as innovation journeys with several setbacks along the road'. This means that 'innovation success might be more usefully viewed as "by-products along the journey" than as end results' (Rip and Velde 1997: 12). See Table 2.1.