# Valuation Models for Australian Biotechnology Companies

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# Valuation Models for Australian Biotechnology Companies

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# DECLARATION

I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program; and, any editorial work, paid or unpaid, carried out by a third party is acknowledged.

Paul Justin Jens

20 March 2007

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# ACKNOWLEDGEMENTS

I don't believe many PhD's would commence without an aspect of naive optimism. Whilst I was certainly naïve, the support I received from my supervisors, wife and family went far beyond what I could have optimistically hoped for.

My PhD journey is one that would not have ended in submission without the support and guidance of my three supervisors Roslyn Russell, Gina Nicoletti and Robert Brooks. To you all I am more grateful than I can express, so often through the process your counsel would convert a seemingly unsurmountable mountain into a mere speed hump. I was so fortunate to have a supervision team with such an extensive skill base and able to work together so seamlessly.

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Finally, to the study participants, thank you for making time in your busy lives to give the study richness and for illustrating the strength of the Australian biotechnology industry.

# ABSTRACT

Biotechnology generated solutions have been hailed as potential cures to many of the problems facing the world today. New therapeutics will eradicate disease, new agricultural products will solve food shortages, and industrial application will improve productivity with reduced environmental impact.

Despite the much anticipated benefits of biotechnology, the industry faces significant challenges that must be overcome in the coming decades. Biotechnology is an inherently complex field with a high degree of uncertainty and associated risks. In addition to the risk associated with project development and delivery, businesses looking to extract an economic return from the provision of biotechnology products and services face significant financial risk. This is exacerbated by the long lead times in biotechnology product development and the expensive nature of research and development.

This thesis looks investigates the multi faceted problem of biotechnology valuation in Australia using a multi method approach designed to provide greater insight into the valuation challenges facing the industry and identify key value drivers. The approach incorporates a broad qualitative investigation, complimented by more focused quantitative studies into specific valuation issues surrounding IPO and project valuation.

Australian biotechnology firms face a significant challenge to raise sufficient capital in order to remain internationally competitive. The current industry structure and funding mechanisms encourage creation of small firms with narrow pipelines, exacerbating the risk of company failure and acting as an impediment to sustainability and, therefore, investment in the sector. Despite the challenges facing the Australian biotechnology industry, the nation possesses a competitive advantage in the strength of local science which, if fully leveraged, should see the development of an internationally competitive industry. Through improved funding mechanisms which encourage the creation of sustainable business models, increased investor participation in the industry should see

a greater portion of the value generated through biotechnology retained by local participants.

An IPO is likely the largest single capital raising in a company's history. A quantitative investigation into the factors influencing the amount of underpricing and money left on the table for Australian biotechnology IPOs found that the amount of money left on the table was more critical than the level of underpricing. Additionally the impact of market sentiment on biotechnology IPOs was investigated and increased media coverage in the lead up to IPO was found to be positively related to the amount of money left on the table.

Using project valuation models, the drivers of value over the life of a typical biotechnology project were identified. Value in biotechnology firms is driven by the commercial viability of the products under development. Managers and investors should be continuously focused on the likely commercial outcomes from the products in development. Development costs and times are also key drivers of value and the ability of management to control these elements is crucial.

Analysis of project valuations using a traditional DCF model found value estimates exhibited a greater level of uncertainty than those calculated using the more contemporary methods of decision tree analysis (eDCF and binomial real options) and binomial lattices. Additionally, incorporation of management flexibility into valuation assessment using real options techniques increased the perceived value of biotechnology projects. The value of management flexibility was found to be most relevant for early stage projects where the option to abandon was found to greatly influence values.

# CHAPTER 1 INTRODUCTION

## 1.1 THESIS MOTIVATION

Broadly speaking, biotechnology is the term used to describe the application of technology to biological processes. Whilst this broad definition includes such practices as the ancient art of brewing beer, modern application of the term is used more specifically to describe the use of modern technology for biological application. This thesis focuses on the area of biotechnology within the development of new human therapeutics, within which around 50% of all Australian biotechnology firms operate.

Biotechnology generated solutions have been hailed as potential cures to many of the problems facing the world today. New therapeutics will eradicate disease, new agricultural products will solve food shortages, and industrial application will improve productivity with reduced environmental impact.

Despite the much lauded benefits of biotechnology, the industry faces significant challenges that must be overcome in the coming decades. Biotechnology is an inherently complex field with a high degree of uncertainty and associated risks. In addition to the risk associated with project development and delivery, business looking to extract an economic return from the provision of biotechnology products and services face significant financial risk. This is exacerbated by the long lead times in biotechnology product development and the expensive nature of research and development (R&D).

Many biotechnology firms have difficulty in raising sufficient capital to adequately fund their R&D programs often forced into effective sale of a portion of their intellectual property (IP) in order to finance development through to completion. The resulting loss of ownership reduces the return to the initial biotechnology firm, acting as a disincentive to further investment. If investment risk in biotechnology ventures could be reduced, the improved risk profile would encourage additional investment in the industry.

For Australia, biotechnology will form an increasingly important component of our financial, environment and social wellbeing. With limited natural resources and uncompetitive unskilled labour costs relative to our Asian neighbours, the ability to leverage off our competitive advantages such as the strength of our academic and research skill base is axiomatic to continued economic prosperity.

> *Australia's industrial competitiveness, and hence our standard of living, will be strongly influenced by whether we can grasp the opportunities presented by biotechnology, and underpinned by the knowledge and skills of our researchers (Australian Government 2000, p. 9)*

The Australian biotechnology industry is faced with particular challenges and opportunities. The relative scale of the domestic market in comparison with the larger international competitors in what is a global market creates particular difficulties in raising sufficient investment capital to be internationally competitive. Greater insight into the value drivers for Australian biotechnology investments will help reduce investment uncertainty in the industry, facilitating increased capital flows to the sector and improving the long term prospects of the sector and hence the Australian economy.

## 1.2 RESEARCH AIMS AND QUESTIONS

The ultimate aim of this research is to investigate the Australian biotechnology sector and its ability to compete internationally given the country's tangible and intellectual resources. This thesis fulfils this aim through the investigation of the following primary research question:

- What are the key drivers of value for Australian biotechnology firms?

In addressing the primary question, the following secondary questions are also addressed:

- What are the challenges and opportunities for Australian biotechnology firms?
- What factors endogenous and exogenous to the firm affect the amount of capital raised by Australian biotechnology companies through IPOs?
- How can Australian biotechnology firms signal their fair value to the investing community?

- What is the appropriate methodology for valuation of biotechnology investments?

## 1.3 SIGNIFICANCE AND INNOVATION

The primary contribution of this thesis is in providing a greater understanding of the unique characteristics of the Australian biotechnology industry and the valuation challenges therein. The research is a multi-method design which provides insight into the multidimensional problem regarding the challenges facing the biotechnology industry. In the face of investment uncertainty, Australian companies have particular difficulties raising sufficient capital to be competitive in an international market. This thesis examines the impact on the Australian industry of the funding scarcity then goes on to investigate the key value drivers of Australian biotechnology investments.

The multi-method approach utilises three discreet research methodologies which synergistically combine to provide greater insight. The initial phase consisted of interviews of senior management[1] from eight publicly listed Australian biotechnology firms. This component of the research provided context for subsequent stages and provided data in support of the literature.

A particularly poignant issue is the industry-wide challenge in raising sufficient capital to develop proprietary intellectual property and remain competitive in an international market. Additionally, the high degree of uncertainty regarding the valuation of biotechnology intellectual property, both from a capital budgeting and investment assessment perspective, is a significant barrier to capital raising within the industry.

One of the symptoms of the lack of development funding available to Australian biotechnology companies is the relative immaturity at which Australian firms choose to raise capital from the public markets via an initial public offering (IPO). As a result the sub-sector of publicly listed Australian biotechnology companies are typified by their narrow and immature product pipelines with small market capitalisations relative to equivalent international markets, particularly the world leading US market. As a result of the lack of venture capital investment in the Australian biotechnology market, the

[1] Participants were spread between chief executive officers, chief financial officers and chief scientific officers.

public markets have acted as a proxy venture capital provider. An IPO is one of the most significant capital raisings in a company's life and for an Australian biotechnology firm this is particularly so as the long lead times and large cost of biotechnology product development place firms at risk of failure due to capital constraints.

Underpricing is the term used to describe the consistently observed phenomenon whereby the shares of a newly issued firm close at a price higher than the issue price at the end of the first day of trading. This premium between market valuation and issue price is valuable capital which the issuing firm forgoes and is effectively money "left on the table" to the benefit of investors in the offer. The capital constraints of the Australian biotechnology industry imply that the issue of underpricing is of critical importance to the sector. This thesis provides one of the first examinations of underpricing of Australian biotechnology IPOs and the relationship between prospectus information, market sentiment, underpricing and money left on the table.

Greater uncertainty surrounding firm valuation has been shown to be associated with greater degrees of underpricing. Biotechnology investment is inherently uncertain due to the long lead times, large costs and high risks associated with product development. Additionally the global nature of competition within the sector, technological risk and commercial uncertainties render investments in biotechnology related projects particularly uncertain. If greater insight into the valuation of biotechnology projects were available, investment uncertainty could be reduced. An improvement in the risk profile of the Australian industry would encourage increased investment in the sector improving international competitiveness. Furthermore, additional capital would provide funds for firms to develop more mature product development portfolios prior to listing. A more mature product portfolio combined with reduced valuation uncertainty would serve to decrease investor uncertainty surrounding biotechnology IPOs, enabling the issuing firm to raise more capital at IPO, with reduced underpricing.

The final research component examines traditional and contemporary valuation models and their application to biotechnology assessment. These models provide an understanding of the value drivers for biotechnology investment and provide a nexus between the first two components of the research design through the examination of endogenous project factors on valuation and uncertainty. Managers of biotechnology

projects can apply this information to optimise the value increments from project investment and, similarly, investors can reduce investment uncertainty through the application of the developed models.

## 1.4 STRUCTURE OF THIS THESIS

This thesis consists of seven chapters including this introduction.

Chapter 2 provides a summary of the relevant literature and is comprised of three components. The first section provides an overview of the Australian biotechnology sector and a comparison with the major international competitors. Australia possesses a competitive advantage in the strength of our research however this is not fully exploited due to the funding challenge. The second section reviews the literature relating to IPO underpricing, commencing with a general discussion of the phenomenon before moving to Australian and biotechnology specific observations. The final component explores the relative strengths and weaknesses of traditional and contemporary valuation tools.

Chapter 3 details the research methodology outlining the multi-method approach. This chapter describes the research design and illustrates the sequential link between the initial broad qualitative study into the challenges and opportunities facing the industry and subsequent more focused quantitative analysis of IPO underpricing and valuation issues.

Chapter 4 is the first of three results and discussion chapters. This chapter presents the results and discussion from the qualitative investigation into the challenges and opportunities facing the Australian biotechnology industry. This chapter is presented as a summary discussion of the semi-structured interviews conducted with senior management from eight listed Australian biotechnology companies. The discussion highlights key points from the interviews including the common themes which emerged as well as contrasting viewpoints. The discussion is linked back to the literature and concludes with some recommendations on the way forward for the domestic industry.

Chapter 5 presents the results and discussion from the quantitative analysis examining underpricing and money left on the table in Australian biotechnology IPOs. The analysis is segmented into two components. Initially a broad model was built based on

the existing literature to examine the relationship between factors endogenous and exogenous to the firm on underpricing and money left on the table. The cross sectional econometric model was analysed in an OLS framework and provided the base for the second component. The second component extends the initial model to provide an additional econometric analysis examining in greater detail the influence of sentiment on underpricing and money left on the table.

Chapter 6 provides the final results and discussion chapter and details four valuation models for a typical biotechnology project. This chapter details the construction method for each model and describes the application of Monte Carlo scenario testing across all models to measure the relative influence of the input variables and the differences in valuation uncertainty. The chapter discusses the valuation drivers for biotechnology projects and the implications for management and investors in the industry.

Chapter 7 is the final chapter of this thesis and provides concluding remarks. This chapter provides a discussion which highlights the nexus between the three discrete research components and the implications of this piece of research. To finish, areas for future research are proposed.

# CHAPTER 2 LITERATURE REVIEW

## 2.1 INTRODUCTION

This chapter provides background and context to this study and is divided into three key areas pertaining to the Australian biotechnology industry. The first provides information regarding the evolution and performance of the industry in a global environment, the second examines the issue of capital raising through an IPO and the factors that influence the success of the capital raising, and the third reviews the literature relating to valuation and capital budgeting with a particular focus on assessment of research and development. The chapter finishes with some concluding remarks.

The first component of this chapter provides an overview of the Australian biotechnology sector which provides context for the remainder of the study. This discussion identifies the opportunities and challenges facing the Australian biotechnology industry and provides focus for the remaining components of the chapter.

One of the primary challenges facing the local industry is a lack of private capital for early stage commercialisation funds available to the sector. As a result of the lack of private funds many Australian biotechnology firms are forced to raise capital via an IPO at an early stage in their product and business development cycle. Given the expensive nature of biotechnology R&D, a successful IPO is a critical contributor to the success of a listed biotechnology company. The second stage of this chapter investigates factors contributing to the success of Australian biotechnology IPOs and provides insight into the key value drivers for this important capital raising.

The third component of this literature review extends on the IPO valuation investigation. Valuation assessments assist in demystifying the uncertainty surrounding investment decisions. Through more appropriate valuation tools the uncertainty of biotechnology investment can be reduced in turn encouraging greater investment in the sector. The literature relating to capital budgeting and valuation is reviewed with emphasis on the assessment of (R&D).

## 2.2 THE AUSTRALIAN BIOTECHNOLOGY SECTOR

The term "biotechnology" is derived through the combination of the words "biology" and "technology" thus broadly speaking the term biotechnology can apply to any application of technology to biological processes. Many formal definitions for biotechnology exist. The United Nations convention on Biological Diversity offers the broad definition:

> *"Biotechnology means any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use." (Convention on Biological Diversity 1992)*

In the report titled "Global Partners: Australian Biotechnology 2004" (Department of Industry Tourism and Resources, Advance Consulting & Evaluation and Aoris Nova 2004) the Australian government adopted the OECD definition:

> *"The application of science and technology to living organisms as well as parts, products and models thereof, to alter living or non-living materials for the production of goods and services." (OECD 2005)*

More recently the Australian government makes a broader definition, expanding the inference on technology to include all industrial processes:

> *"Biotechnology ... describes the use of biology in industrial processes such as agriculture, brewing and drug development." (Biotechnology Australia 2006)*

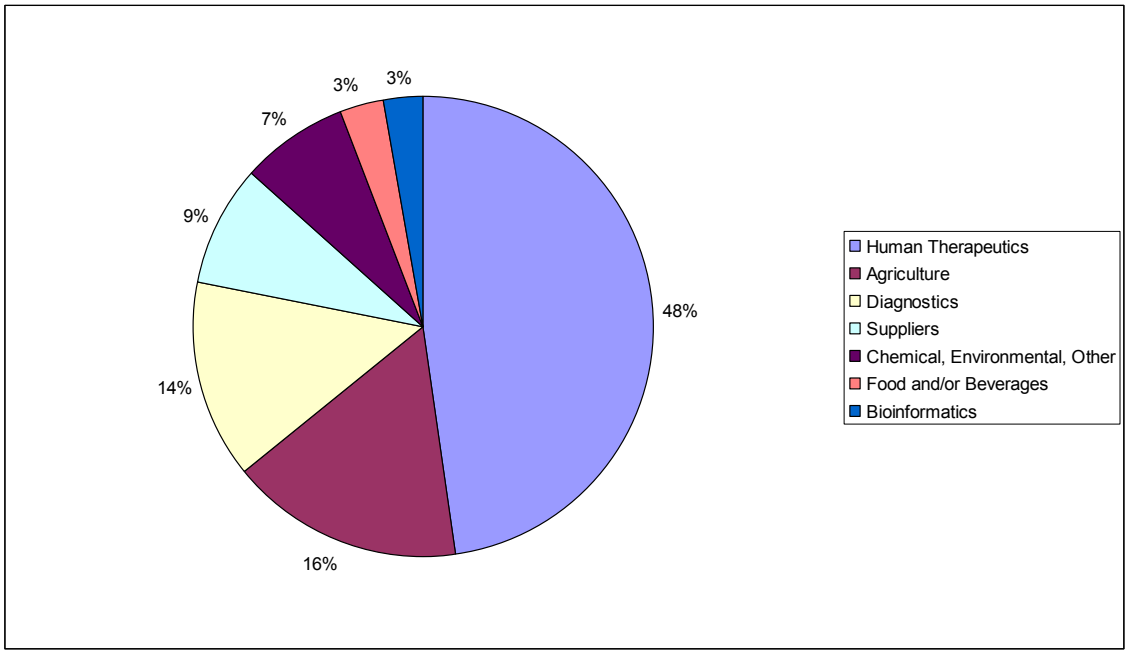
These broad biotechnology definitions capture the diversity of the Australian biotechnology sector which is made up of entities operating across different fields, all presenting unique challenges and opportunities. The complexity and diversity of sub-sectors in the biotechnology industry has created a number of differing segmentations and associated definitions. Table 2-1 shows seven sub-sectors of biotechnology as adopted by Hopper and Thorburn (2006).

**Table 2-1 Biotechnology Sub-Sector Definitions**

| Biotechnology Sub-sector | Definition |
|---|---|
| Human Therapeutics | Development of biotech-derived drugs to treat or prevent disease, and in vitro fertilisation |
| Agriculture | Development and delivery of products and services aimed at the agricultural sector. This may include promoting plant and animal growth, disease identification and prevention, or breeding programs |
| Diagnostics | Development of products and tests aimed at identifying and diagnosing human disease. Biotechnology-based diagnostics include nucleic acid and monoclonal antibody-based tests, and may also include hybridisation and amplification of the target sequence. Methods in use include enzyme-linked immunoassays (ELISA), polymerase chain reaction (PCR), Random Amplification of Polymorphic DNA (RAPD), microarrays and amplified fragment-length polymorphism (AFLP). These may be supplemented by other technologies including fluorescence, nanotechnologies, filter techniques, automation and fluid flow management |
| Suppliers | Suppliers of molecular biologicals, such as monoclonal antibodies, diagnostic reagents and gene chips |
| Chemical, Environmental, Other | Use of biotech in mining (bioleaching), chemical development (including molecular farming) and environment (including pesticide development and bioremediation). |
| Food and or Beverage | development of new foods (including functional foods) and food additives |
| Bioinformatics | Application of sciences and information technologies to the organisation, management, mining and use of life-science information. |

Figure 2-1 shows the proportion of firms within the Australian biotechnology sector operating within each of the identified sub-sectors.

**Figure 2-1 Australian Biotechnology Companies by Sub-sector (Hopper and Thorburn 2006)**



The biotechnology sector is dominated by firms whose research focuses on human health challenges[2] comprising just under two thirds of all biotechnology companies in Australia (Hopper and Thorburn 2006). The "human therapeutics" sub-sector makes up around half of all biotechnology companies in Australia and operates under unique regulatory governance. The diversity in challenges and regulatory requirements between firms in different biotechnology sub-sectors means that business models and value drivers vary greatly from sub-sector to sub-sector. This thesis focuses on valuations within the human health sub-sector. This sub-sector was chosen as the majority of biotechnology firms fall within this category and these firms have a unique discovery process and regulatory environment which allows particular application of contemporary valuation methodologies.

A description of each of the stages in the development process for human therapeutics is shown in Table 2-2. The manner in which the process is comprised of a series of discrete components allows a biotechnology project to be modelled as a series of decision gates, facilitating the application of contemporary financial option valuation theory to assess project value.

[2] Human health research includes both disease identification through diagnostics and disease treatment though human therapeutics.

**Table 2-2 Drug Development Process Description (Allergan; US Food and Drug Administration)**

| Development Stage | Description |
|---|---|
| Discovery | Comprehensive study of all publicly available data relating to the chemical entity or target therapeutic area. This review includes review of chemical and biological data and patent coverage. |
| Pre-Clinical Research | Initial studies to show that the drug is reasonably safe for the purposes of clinical trials. Data in this stage is generated through *in vitro* and *in vivo* laboratory animal testing. |
| IND | Investigational New Drug application filed with the regulator (the FDA in the US). Regulatory approval allows the commencement of clinical trials in humans. |
| Clinical Trials – Phase 1 | Small scale testing on around twenty to eighty (usually) healthy humans to determine the toxicity and the method of action. |
| Clinical Trials – Phase 2 | Small scale testing on around two hundred humans afflicted with the target disease to gain preliminary data regarding efficacy and further data regarding toxicity and side effects. |
| Clinical Trials – Phase 3 | Larger scale trials on humans to gather more data on efficacy and side effects to build a risk benefit profile for the drug. |
| NDA & Regulatory Review | New Drug Application (NDA) to the regulator for assessment. All relevant data gathered during clinical and pre-clinical trials are submitted to the regulator for approval. |
| Product Launch & Phase 4 Trials | Once approved the drug can be launched on the market. For some medicines the FDA may require additional data to monitor the long term effects of the drug. |

### 2.2.1 Evolution of a Sector

Evolution of the modern international biotechnology market is lead by the US which is home to the most mature and successful biotechnology market in the world. The US industry has benefited as a result of its early adoption of biotechnology and the amount of capital available to the industry[3].

#### *2.2.1.1 International Biotechnology*

The international biotechnology market is dominated by the USA when measured by any number of metrics. In their annual biotechnology report, Ernst and Young (2006) claim that over three quarters of all biotechnology investment occurs in the US along with the contribution of a similar portion of global revenues from biotechnology

[3] Whilst the availability of funds to US based biotechnology companies is high by global standards, the causal relationship with industry success is not immediately apparent. The success of the industry may be a result of the funding availability or conversely the funding availability may be a response by the providers of funds to industry success.

products. Over one third of the world's biotechnology companies are based in the US and around one half of all publicly listed biotechnology companies are similarly located.

**Figure 2-2 International Biotechnology Industry Comparison (Burrill 2006; Ernst & Young 2006)**

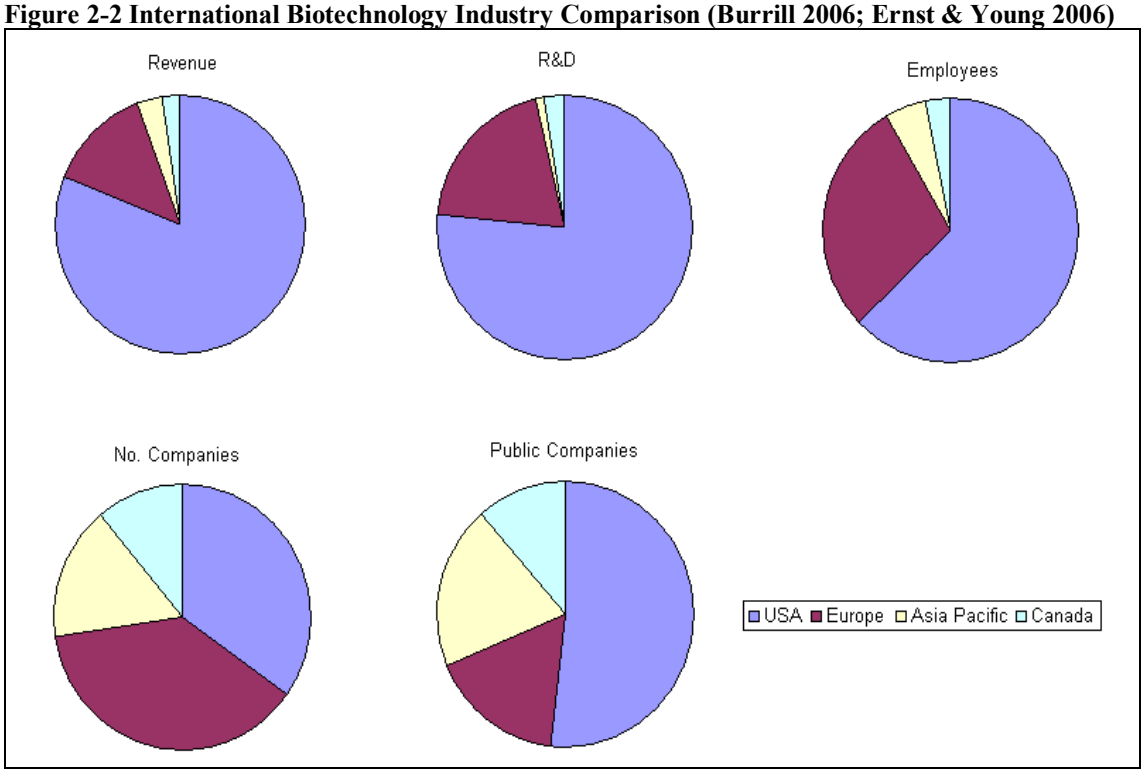



Figure 2-2 provides a graphical representation showing the extent to which the US biotechnology market dominates the global market. The US generates over 80% of global biotechnology revenues despite only 35% of the worlds companies being based in the US. The majority of biotechnology employees work in the US and three quarters of global research and development expenditure occurs in the US. Cross comparison of the pie charts reveals that the US has more employees per company than the rest of the world and spends more on research and development per employee. By contrast, the Asia-Pacific region has fewer employees per company and spends much less on research and development, a symptom of funding scarcity and the lower cost bases within which they operate.

The pie charts indicate that the Asia-Pacific region is well represented according to the portion of the metric measuring the total number of biotechnology companies worldwide however companies within this region are relatively small with significantly small research and development expenditures. Canadian based biotechnology companies display similar characteristics to those in the Asia Pacific region with a good

representation of companies with relatively few employees, however research and development expenditure per company is not as low.

**Figure 2-3 International Comparison of Biotechnology Market Capitalisations (Ernst & Young 2006)**

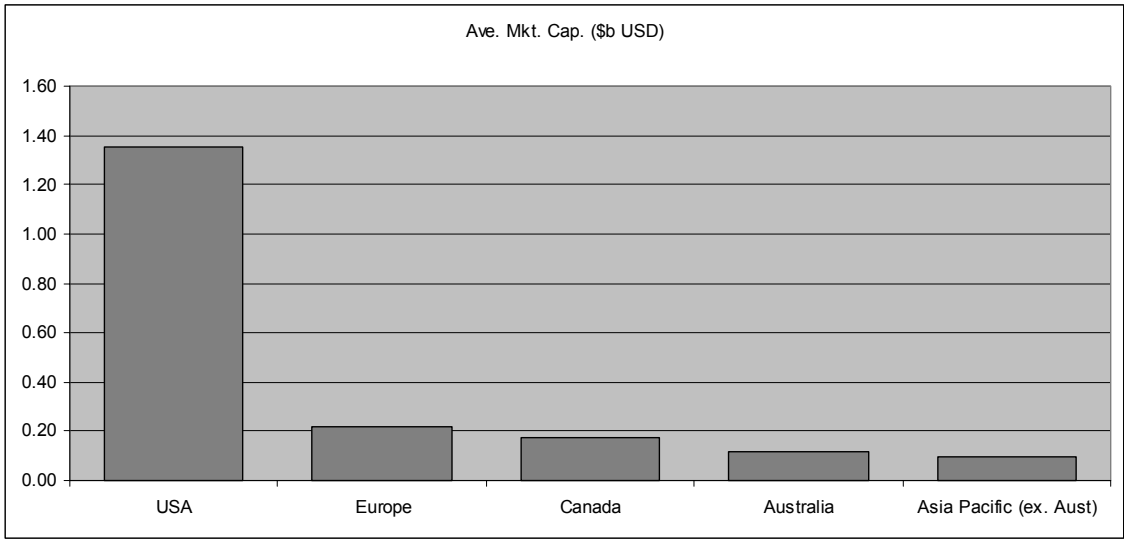



Figure 2-3 provides a comparison of the average market capitalisation of biotechnology companies located around the world. Firms listed in the US have easily the largest market value. In the US, biotechnology companies have access to greater levels of private funding allowing them to develop their product portfolios to a more mature state compared with competing firms around the world. As a result, firms listing in the US have more mature product pipelines enabling them to raise more capital at IPO.

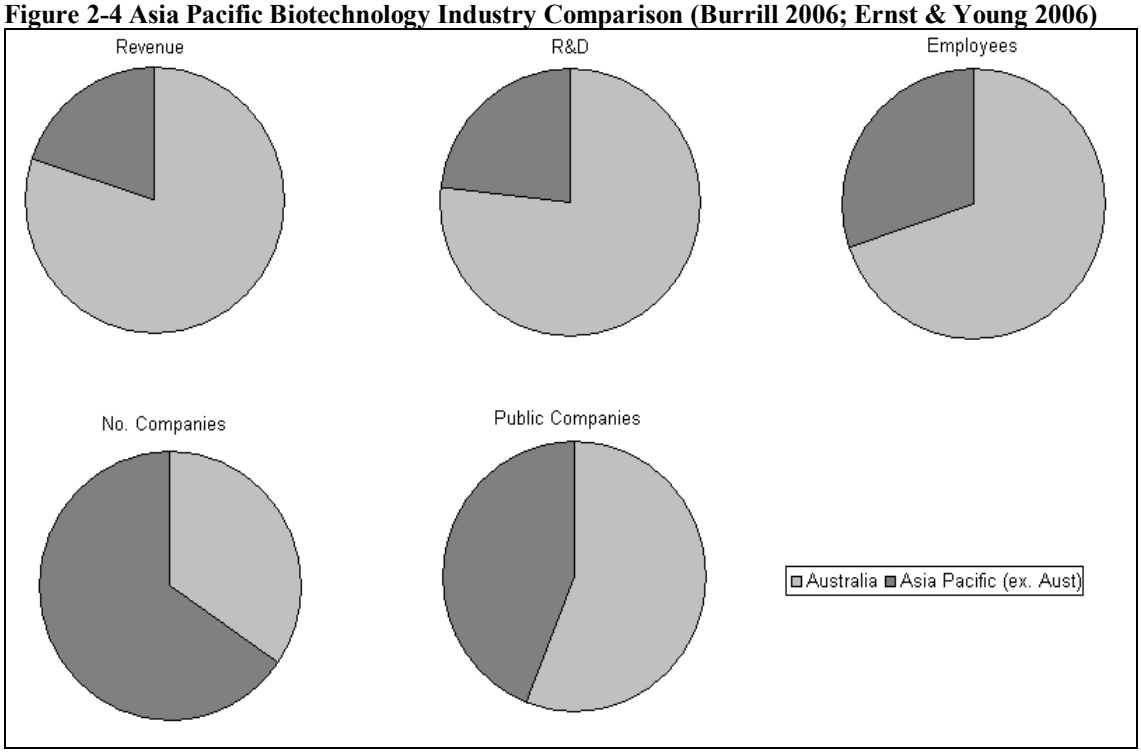
Australian biotechnology firms are often forced to raise capital through a public listing due to a lack of alternative funding sources (Herpin, Karuso and Foley 2005; Vitale and Sparling 2003). As a result, many Australian biotechnology firms raising capital via an IPO have narrower pipelines with products further from market launch compared to their international competitors. A company with a narrow pipeline and early stage products is a more risky investment proposition, which reduces the amount of capital that can be raised.

#### *2.2.1.2 Australian Biotechnology*

Australia has a proven history of quality research from academic and research institutions focused on health and medical research (Australian Government 2004). With many biotechnology companies spawned from academic research discoveries, it is

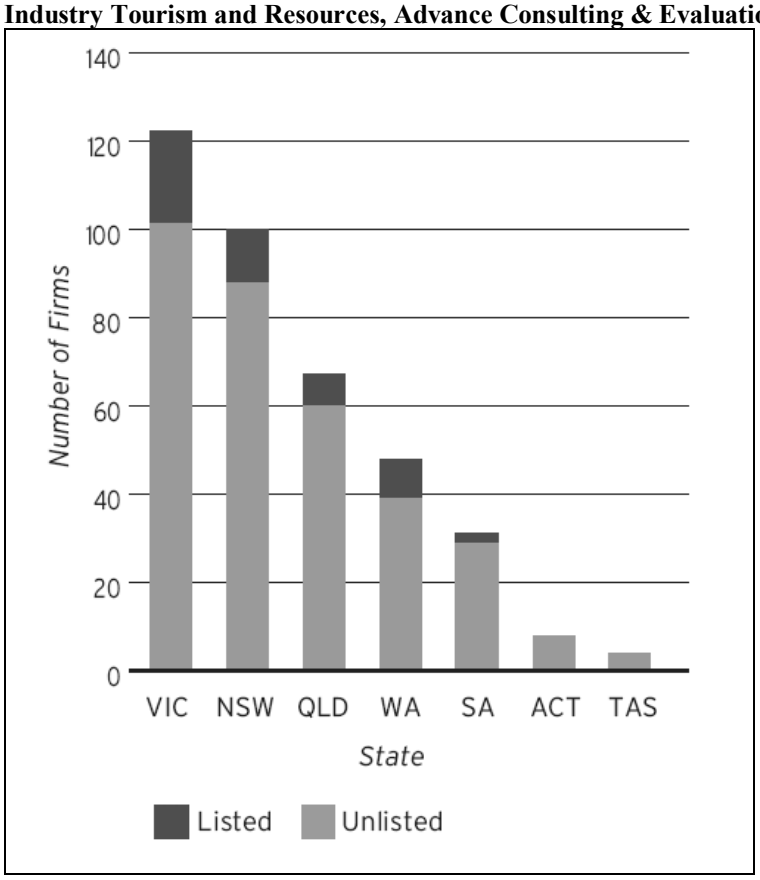
clear that our education system has helped fuel the local biotechnology industry. Whilst Australia is a small player in the global market, it produces 3.0% of OECD life science publications from only 0.3% of the world's population (Economist Intelligence Unit 2005). Even though Australia is a small player in the international market Figure 2-4 shows that Australia is the dominant player in the Asian region biotechnology sector. The majority of Asian biotechnology research and development investment expenditure, revenues, employees and public companies come out of Australia.

**Figure 2-4 Asia Pacific Biotechnology Industry Comparison (Burrill 2006; Ernst & Young 2006)**




Within Australia, biotechnology head offices are concentrated in locations within the capital cities of the eastern states, particularly Victoria and NSW as shown in Figure 2-5. Around 15% of Australian biotechnology firms were located in Queensland in 2004 and since then the state has experienced growth in biotechnology start ups at a rate greater than the national average (Innovation Dynamics 2006).

**Figure 2-5 Number of Publicly Listed and Unlisted Biotechnology Firms by State (Department of Industry Tourism and Resources, Advance Consulting & Evaluation and Aoris Nova 2004, p. 14)**




i Victoria

Victorian biotechnology is geographically concentrated around biotechnology precincts. Victoria is home to the largest number of biotechnology firms, hosting around one third of the nations firms within six high profile biotechnology precincts and around half of all Australian biotechnology employees (Department of Industry Tourism and Resources, Advance Consulting & Evaluation and Aoris Nova 2004). The six Victorian biotechnology precincts are located in Melbourne and are described in Table 2-3.

**Table 2-3 Victoria's Biotechnology Precincts (Department of Industry Tourism and Resources, Advance Consulting & Evaluation and Aoris Nova 2004).**

| Precinct | Summary |
|---|---|
| Bio21 | Research transfer unit and business incubator to facilitate business development and technology commercialisation for 15 Melbourne academic institutions. |
| Monash Science Technology Research and Innovation Precinct | Linked to Monash University and CSIRO and home to the National Stem Centre. This precinct is also located near the Australian Synchrotron Project. |
| Alfred Medical Research and Education Precinct | Based on the Alfred hospital campus, this is a biomedical and educational precinct. |
| Werribee Technology Precinct | Collaborative research and industry hub focusing on veterinary biotechnology |
| Grains Innovation Park | Collaborative research and industry hub focusing on agricultural biotechnology |
| LaTrobe R&D Park | Technology park located adjacent the Bundoora campus of LaTrobe University |

ii NSW

Biotechnology firms in NSW are less geographically clustered than those in Victoria. Research activity tends to be clustered around the campuses of teaching hospitals which also house many of the university clinical schools (NSW Government 2004). Sydney is home to forty international pharmaceutical companies (Department of Industry Tourism and Resources, Advance Consulting & Evaluation and Aoris Nova 2004) which can be a valuable source of funding for Australian biotechnology companies.

**Table 2-4 NSW Biotechnology Precincts (Department of Industry Tourism and Resources, Advance Consulting & Evaluation and Aoris Nova 2004).**

| Precinct | Summary |
|---|---|
| Australian Technology Park | Research centre focusing on human health and medical sciences. |
| St Vincent Biotechnology Precinct | Draws together University NSW, St Vincent's Hospital, the Garvan Institute and the Victor Chang Cardiac Research Unit |
| Macquarie University | Home to the Australian Proteome Analysis Facility and located amongst five biotechnology firms who have evolved as spin-offs from the university and the local CSIRO laboratories. |

iii Queensland

The Queensland state government has dedicated substantial investment to development of the local biotechnology industry through the Queensland Biotechnology Strategic Plan 2005-2015 (Queensland Government 2005). The Queensland biotechnology industry is growing faster than the national average with 31% of all new Australian biotechnology companies established between 2001 and 2005 based in Queensland

(Innovation Dynamics 2006). The Queensland biotechnology industry has a lower proportionate representation of human therapeutic companies and higher representation of agricultural biotechnology firms (42% and 25% respectively), compared to the national averages of 16% and 48% (Innovation Dynamics 2006).

In addition to the precincts detailed below, the government has identified investment in necessary infrastructure as a major focus of their 2005-2015 strategic plan for the industry (Queensland Government 2005). Part of this investment will facilitate development of two new precincts in Brisbane, one dedicated to health and food sciences and the other a national ecosciences precinct.

**Table 2-5 Queensland Biotechnology Precincts (Department of Industry Tourism and Resources, Advance Consulting & Evaluation and Aoris Nova 2004).**

| Precinct | Summary |
|---|---|
| Biosciences Precinct | Based at the University of Queensland this precinct connects over 1200 scientists from the Institute for Molecular Bioscience, the Australian Institute for Bioengineering & Nanotechnology, the Queensland Brain Institute, the Australian Genome Research Facility, the CSIRO and the Queensland Department of Primary Industries and Fisheries. |
| Kelvin Grove | Facilitates linkages around the Royal Brisbane and Women's Hospital and includes the Queensland Institute for Medical Research and the Queensland University of Technology Institute of Health and Bioscience Innovation. |
| Griffith University | A bioscience cluster at the university forms the basis for natural products discovery program bringing together the university, Astra Zeneca, the Eskitis Institute for Cellular and Molecular Therapies. |
| Brisbane Technology Park | Home to over 45 technology firms including multinational pharmaceutical companies. Combined revenue for park residents is in excess of A$160 million with more than A$5 million annually invested in research and development. |

iv Western Australia

Western Australia's biotechnology sector is based in Perth and focuses on biomedicine, agriculture and the environment. Technology Park, located near Curtain University in Perth has been established for more than twenty years and is the state's largest technology precinct. The precinct is home to a number of listed biotechnology companies, publicly funded research agencies and international pharmaceutical company bases.

v South Australia

The South Australian government's contribution to the local biotechnology industry is managed through BioInnovation SA, which was established in 2001 to implement the state's bioscience strategy and assist with policy development. The state has five major biotechnology precincts which are described in Table 2-6.

**Table 2-6 South Australian Biotechnology Precincts (BioInnovation SA 2006; Department of Industry Tourism and Resources, Advance Consulting & Evaluation and Aoris Nova 2004).**

| Precinct | Summary |
|---|---|
| Thebarton Bioscience Precinct | Adjacent to University of Adelaide's Research Park, this precinct is one of the largest biomedical clusters in Australia. |
| Waite Precinct | The Waite campus of the University of Adelaide hosts many research and development organisations with a focus on agricultural research including plant, veterinary and environmental science |
| Florey Precinct | Cluster focused on life and medical science research with collaboration between CSIRO, research institutes, the state's universities and the Women's and Children's Hospital. |
| Mawson Precinct | Research and teaching hub focused on defence, biomaterials and information communications technology. |
| Flinders Precinct | Biotechnology and marine related research with collaboration between Flinders University, Flinders Medical Centre and Flinders Science Park. |

vi Australian Capital Territory

The ACT is home to the third largest research and development cluster in Australia (Department of Industry Tourism and Resources, Advance Consulting & Evaluation and Aoris Nova 2004). A number of biotechnology firms have emerged clustered around The Australian National University's Innovation Centre. Whilst the ACT has more biotechnology companies per capita than the national average, none of the companies are currently publicly listed on the ASX.

vii Tasmania

Tasmanian biotechnology is focused on research and lacks the mechanisms and skills base required to effectively commercialise its research output (Tasmanian Government and AusBiotech 2005). Research strengths in agriculture and marine biotechnology are not supported by commercialisation funding (Tasmanian Government and AusBiotech 2005). With poor commercialisation opportunities, Tasmania has only four biotechnology companies, which is less than 1% of the national total (Hopper and Thorburn 2006).

### 2.2.2 Funding

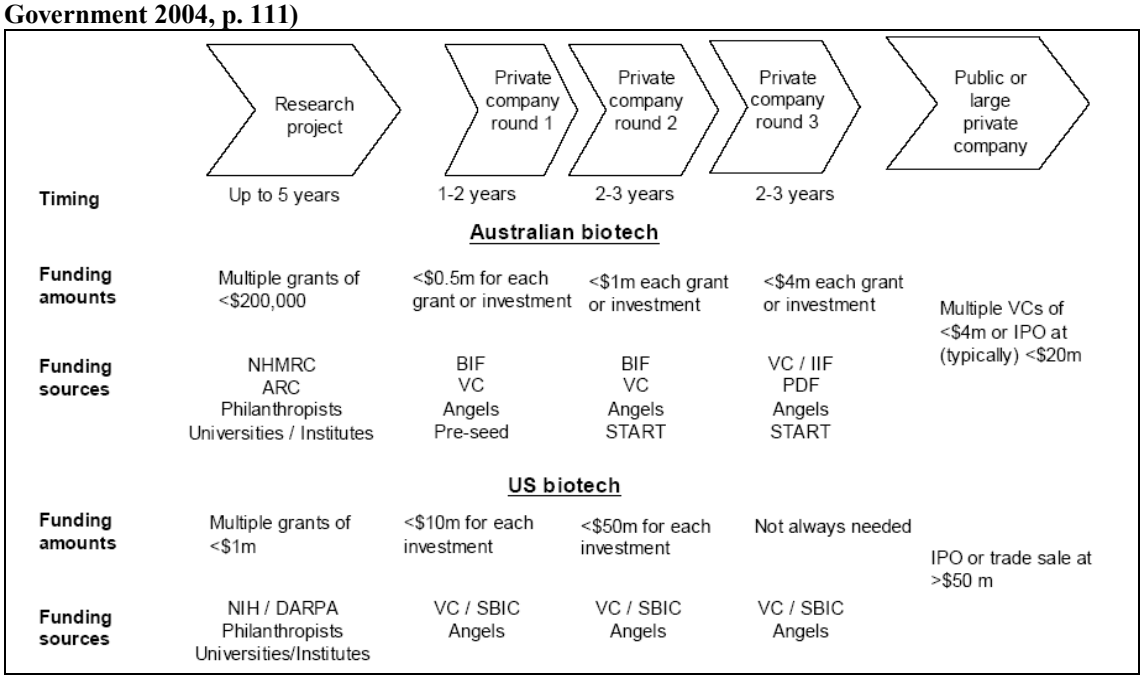
The Australian biotechnology industry is dominated by small companies with products in the early stages of development. A few mature firms do exist in the sector with diverse product portfolios and positive cash flows, however, these are a minority. The skewness in the distribution of biotechnology companies towards those with few products in development is in part a result of the funding mechanisms available to biotechnology research and development (Herpin, Karuso and Foley 2005).

The majority of biotechnology intellectual property (IP) is generated within a public research institution (Vitale 2004a). Unfortunately, whilst Government programs provide assistance for commercialisation of biotechnology discoveries, funding is not of the same magnitude or lengthy timeframe as other countries with biotechnology industries (Sparling 2003). Once validated, new ideas are usually spun-out into a private company, a strategy which is now encouraged by the performance assessment criteria for research institutions and an abundance of early stage funding (Herpin, Karuso and Foley 2005).

Once a validated idea has been spun-out, the private company faces fierce competition for scarce development funding from the multitude of small biotechnology companies. Unlike the US, venture capitalists are not major investors in Australian biotechnology companies and those that do invest in the sector do not do so with the required scale or patience to develop a drug to any meaningful distance through the clinical trial process (Vitale 2004a).

The amount of capital available to Australian biotechnology firms is significantly less than that available to US firms. Figure 2-6 compares typical capital raisings for US and Australian biotechnology companies and highlights the differences in funding availability across all stages of a biotechnology firm's life cycle. The disparity in capital availability increases as firms move through the cycle, particularly once a research project is spun-off into a private company and begins to look for VC and angel funding. As a result, Australian companies that raise capital through an IPO typically raise less than A$20 million compared to more than $A50 million for US based companies.

**Figure 2-6 Australia vs. US Biotechnology Life Cycle Funding Comparison in $AUD (Australian Government 2004, p. 111)**




Interestingly, Sparling and Vitale (2004) report that although the amount of venture capital funding available to Australian biotechnology firms is significantly less than that available to firms in the US, the average age of Australian biotechnology companies going to IPO was 6.5 years compared to 4.7 years for non-biotechnology IPOs and 5.9 years for US biotechnology IPOs. US companies typically have more mature product pipelines when they opt for an IPO indicating that the rate of product development in Australian companies is slower than their US competitors at least partly due to reduced access to capital.

The lack of venture capital participation in the Australian market is often blamed on Australian VCs having a relatively high level of risk aversion, however, an alternative postulation is that Australian VCs face a lack of attractive investment opportunities (Vitale 2004a). During the 2004-2005 financial year, Australian venture capital firms reviewed more than 10,000 firms for potential investment. Of these, just over 1,000 underwent more detailed evaluation with investment made in 176 companies (Australian Bureau of Statistics 2005). Industry representatives are commonly heard lamenting the lack of venture capital funding available to Australian biotechnology companies whilst the venture capital industry bemoans the lack of attractive investment opportunities available (Vitale 2004c). Despite these protestations, the reality is likely a combination of both. Even so, Australian venture capital firms do seem to be more risk

averse than their US counterparts which may be an impediment to the development of the local industry.

The amount of Australian venture capital available for investment has grown steadily over the past five years at an average compound annual growth rate of 17.7% (Australian Bureau of Statistics 2005). Whilst the total amount of available venture capital has grown, the amount of unallocated funding has grown at a greater rate and at June 2005 there was over A$5 billion in unallocated venture capital funding.

**Figure 2-7 Allocated and Unallocated Australian Venture Capital (Australian Bureau of Statistics 2005)**

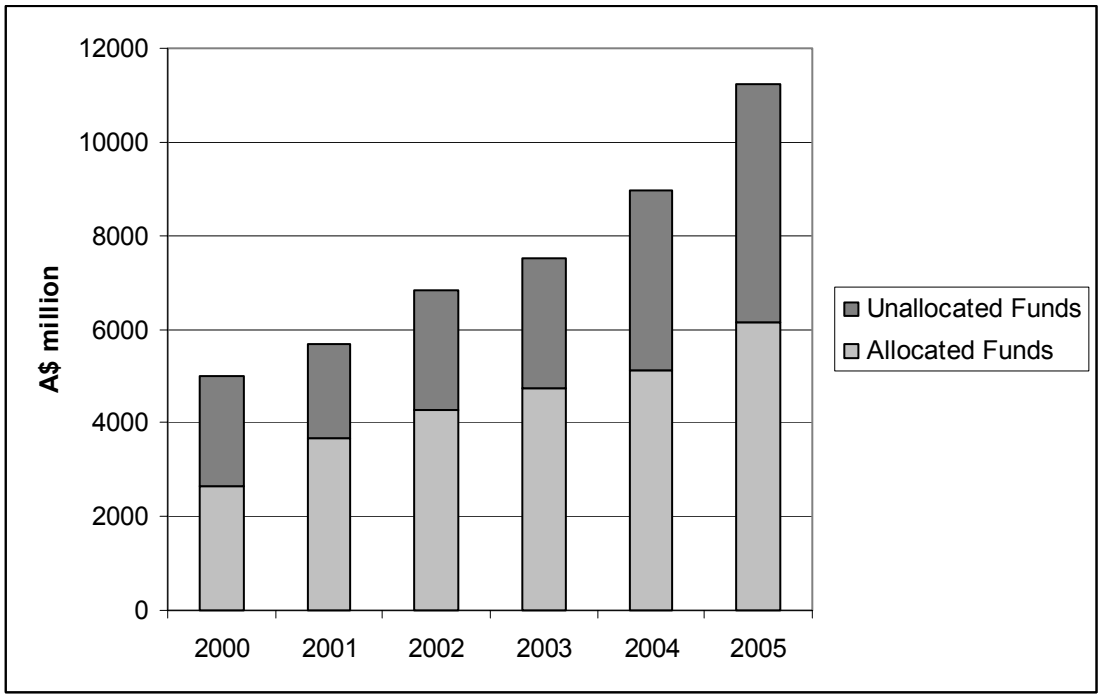
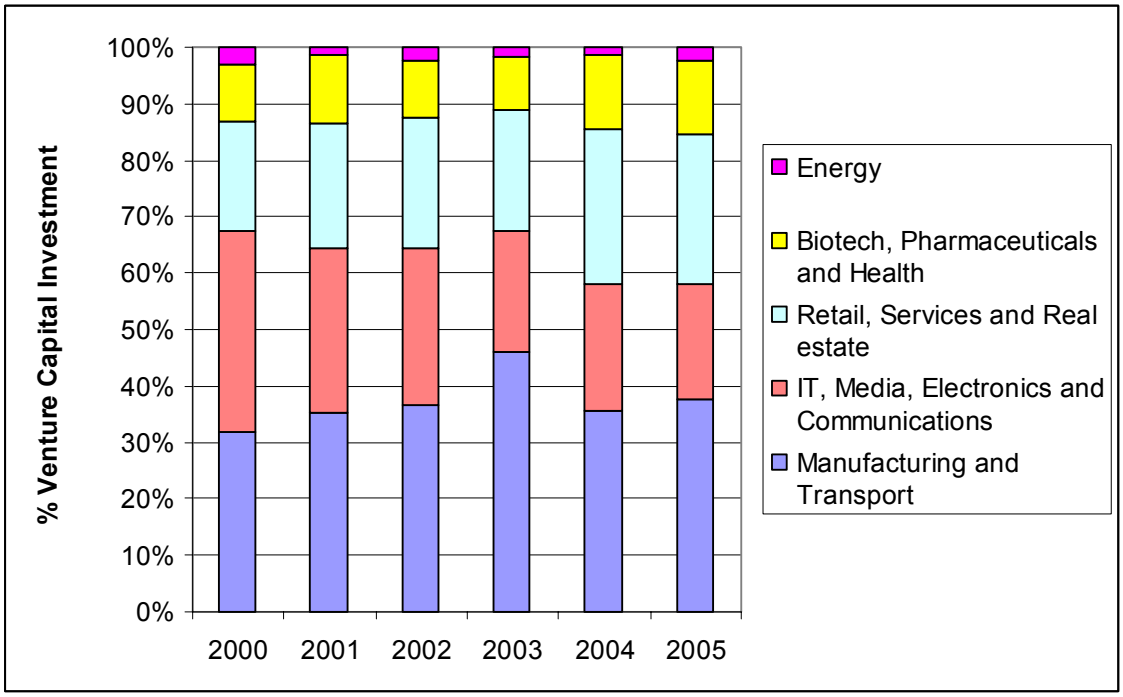


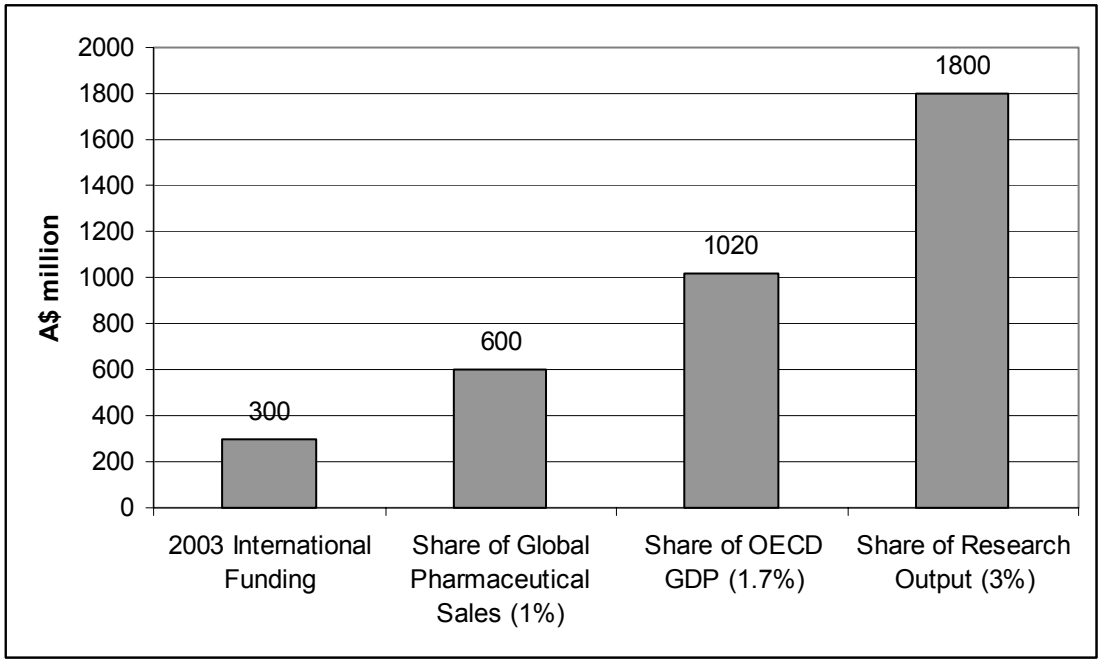

Figure 2-8 shows the activities of firms receiving venture capital backing in the years from 2000-2005. Whilst there has been increased investment in biotechnology, pharmaceutical and health firms (BPH), the increase has not been significantly greater than the total amount of venture capital investment nationwide. During 2004 and 2005 the share captured by BPH firms was constant at 13% of the total. During the year ended June 2005 A$463 million was invested in 192 BPH firms, an increase from A$246 million in 63 firms during the year ended June 2000 (Australian Bureau of Statistics 2005).

**Figure 2-8 Allocation of Australian VC funding by Investee Activity (Australian Bureau of Statistics 2005)**




The Australian health and medical research industry attracts a low share of the global pharmaceutical research and development investment (Australian Government 2004). Figure 2-9 shows that investment by the pharmaceutical industry in 2003 was around A$300 million, or 0.042% of gross domestic product (GDP). Australia's contribution to global pharmaceutical sales, OECD GDP and research output indicates that Australia should aim to capture increased investment from international pharmaceutical companies commensurate with our contribution to the industry. If Australia were to capture a portion equivalent to the amount of research output we would see international pharmaceutical investment increase to around A$1.8 billion. Based on the benchmarks shown in Figure 2-9, the Australian Government proposed that a 'whole of government' approach should aim to attract a total of A$1 billion (2003 dollars) investment from international pharmaceutical companies (Australian Government 2004).

**Figure 2-9 Benchmarking Australia's International Pharmaceutical Investment (Australian Government 2004, p. 100)**




### 2.2.3 Government Support

The Australian Federal Government's National Biotechnology Strategy, which is part of the "Backing Australia's Ability" program. sets out the principles upon which public funds are invested in the sector (Australian Government 2000). Through the strategy, the Federal Government aims to encourage effective commercialisation of intellectual property developed in Australia to generate a commensurate return from its investment and ensure Australia remains competitive in the global biotechnology market. The vision for Australian biotechnology, upon which the strategy is based, states:

> *Consistent with safeguarding human health and ensuring environmental protection, that Australia capture the benefits of biotechnology for the Australian community, industry and the environment (Australian Government 2000, p. 7).*

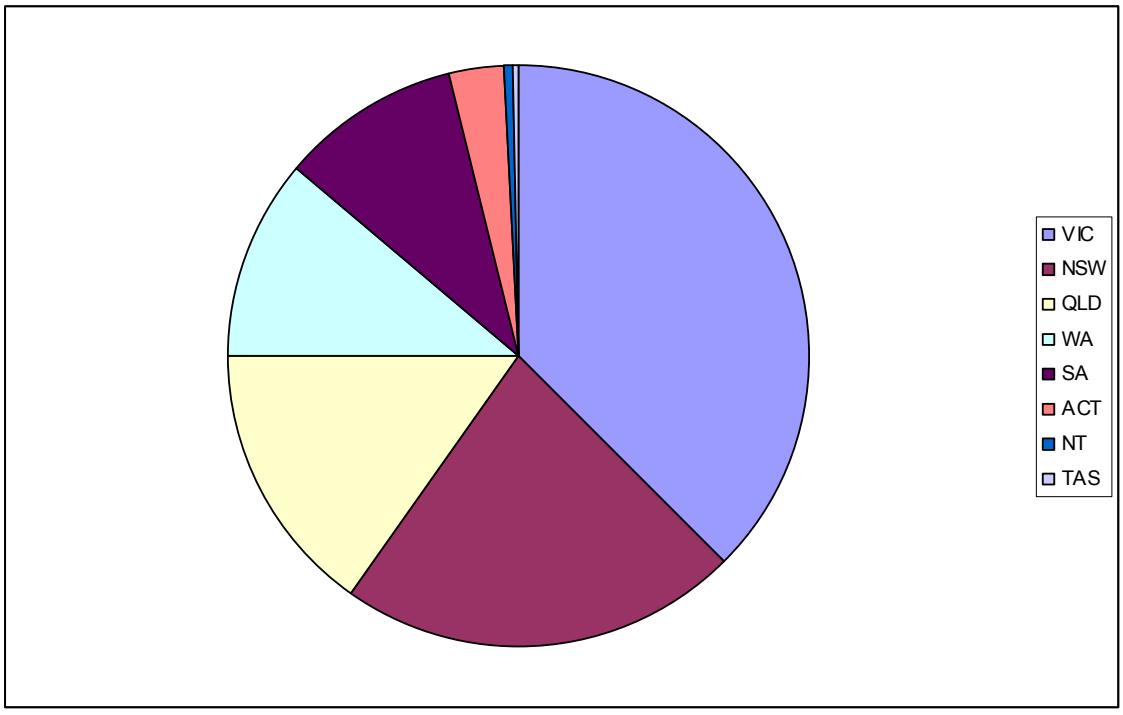
The Australian government believes the nation as offers a competitive advantage to locally based biotechnology companies (Department of Industry Tourism and Resources, Advance Consulting & Evaluation and Aoris Nova 2004) citing the possession of:

- strong economic credentials,
- a highly skilled workforce,

- an innovative culture with excellent research and development infrastructure,
- internationally competitive business costs,
- an open and efficient regulatory environment,
- a dynamic financial services sector.

The Commonwealth government supports biotechnology research and development through a number of programs. The National Health and Medical Research Council (NH&MRC) provides substantial research funding to the sector, with biotechnology related grants totalling around $210m in 2006, the state by state distribution of which is shown in Figure 2-10. Of the biotechnology project grants, 76% were directed to universities, research institutes received 23% with hospitals receiving the balance (Hopper and Thorburn 2006).

**Figure 2-10 State by State Distribution of Biotechnology Related NH&MRC Grants for 2006 (Hopper and Thorburn 2006)**

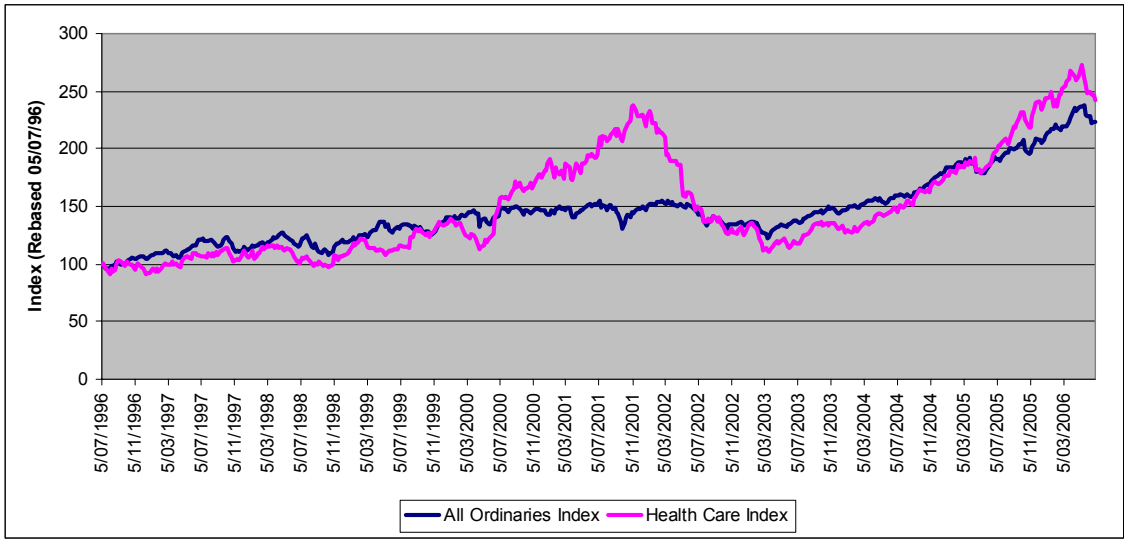



### 2.2.4 Listed Companies

Around seventy biotechnology firms are currently listed on the Australian stock exchange (Australian Government 2006). Biotechnology firms are perceived as being of relatively high risk, owing to the wide range and extent of risks, to which firms in the sector are exposed. Figure 2-11 shows the performance of the Australian Health index relative to the All Ordinaries index over the past 10 years. The Health index (as defined

by the ASX) includes companies who are involved in the research, production and marketing of pharmaceutical products as well as those who manufacture and provide healthcare products and services. The historical performance of the health index displays greater volatility than the All Ordinaries index. The index experienced an industry-wide boom during the end of last century and the beginning of this century which corresponded with the rise of the technology sector and the sequencing of the human genome. The sector suffered from reduced investor interest correlating with the much publicised technology sector bust and the protracted recovery was spread over many years with the index bottoming out late in 2002.

**Figure 2-11 Weekly ASX All Ordinaries and Health Index levels (ASX 2006)**




The Australian biotechnology sector is commonly believed to be an underperforming and immature sector that does not attract the same level of investor interest as the world-leading US biotechnology industry. Interestingly, in their study of Australian biotechnology firms that listed between 1998 and 2002, Sparling and Vitale (2004) find that the Australian biotechnology firms outperformed shares of US biotechnology IPOs, Australian non-biotechnology IPOs and shares of the ASX top 200 listed companies.

Despite the strong reported performance of the Australian listed biotechnology sector the industry continues to have difficulty in attracting institutional investment. The reliance on "unsophisticated" investors for funding combined with a lack of quality news flow exposes the industry to greater fluctuations in value (Aegis 2006b). Unfortunately, during 2005, one of the major institutional investors in the sector, Queensland Investment Corporation, chose to reduce its holdings in a number of life science companies which had a negative impact on the performance of the health and biotechnology index (Hopper and Thorburn 2006).

Sparling and Vitale (2004) cite market conditions and a lack of alternative funding as being the primary motivators for biotechnology listings. Venture capital funding, which is a major provider of funds to American biotechnology firms prior to IPO, is noticeably lacking for the Australian sector. The lack of venture capital funding has forced Australian biotechnology firms to use the public markets as a source of public funding, and indeed, in his 1998-2003 study, Vitale (2004b, p. 2) finds that the returns on these firms "resemble typical venture capital returns – a very few big winners, a few reasonable earners, and a large number of washouts".

### 2.2.5 Australia as a Global Competitor

The Australian pharmaceutical industry is a net importer with annual imports in pharmaceuticals in 2003 of $4.4 billion versus exports of just under $2 billion (Economist Intelligence Unit 2005). The same report goes on to rank Australia's attraction to pharmaceutical investors relative to the UK, USA, Singapore, India, Germany and Japan and finds that overall Australia ranks second behind Singapore. The study assessed each nation based on a range of factors across the pharmaceutical value chain including costs, business environment, industry skills pool and regulatory processes. Whilst Australia scores less well than Singapore and India on costs, it is significantly cheaper than the US and European nations and offers a good business environment, with a strong local talent base operating under a sound regulatory regime. In order to capitalise on the nation's advantages, the report calls for stronger development of the local biotechnology industry to support the pharmaceutical sector. The Asian region has many nations capable of producing pharmaceutical product at lower cost than Australia however this is currently easily outweighed by non-cost benefits (Economist Intelligence Unit 2005).

One of the major challenges facing the Australian biotechnology sector is a lack of post-seed investment capital available to companies (Australian Government 2004). This problem is targeted by the Australian Government in the National Biotechnology Strategy (2000) which flags foreign investment and development partners as a key objective of the strategy.

In its 2003 review of the National Biotechnology Strategy, the Australian Government cites commercialisation difficulties as being the primary weakness in the Australian biotechnology sector. Despite commercialisation difficulties, Australian companies are capturing an increasing portion of global intellectual property, evidenced by the Australian share of US biotechnology patents of 0.64% in 2002 compared with 0.45% in 1979 (Australian Government 2003). In order to overcome the commercialisation challenges, the report suggests that consolidation amongst existing firms will create an industry that is more sustainable and internationally competitive. Despite consolidation reducing the number of firms in the industry, larger, more diversified companies offer a more attractive investment proposition and as a result the amount of commercialisation funding available to the sector from domestic and international sources should increase.

## 2.3 IPOS

Due to the lack of private funding available to Australian biotechnology companies, many cite a lack of alternative funding sources as one of the primary motivators for their IPO capital raising (Herpin, Karuso and Foley 2005). Given the amount of capital required to develop a biotechnology product, it is important that an IPO should raise the maximum amount of available capital. That is to say that the amount of money left on the table should be minimised, such that the amount of underpricing is kept to a minimum.

This research builds on numerous international studies that have investigated the phenomenon of IPO underpricing. An early study by Ibbotson (1975) reports average first day returns of 11.4% to investors in United States companies' common stock new issues during the 1960s. Subsequent studies support the notion of IPO underpricing in both the United States and other parts of the world. Loughran, Ritter and Rydqvist (1994) provide a summary of publications investigating this issue in 25 countries around the world from the 1960s through to the early 1990s with all countries exhibiting an average initial return to IPO subscribers of between 4.2% and 80.3%.

The existing literature describes many theories explaining the existence of the underpricing phenomenon. The following discussion deals with key publications covering the major explanatory hypotheses, viz, information asymmetry, uncertainty,

pricing, wealth retention, and sentiment, as they apply to biotechnology firms in the Australian context

### 2.3.1 Information Asymmetry

Rock (1986) hypothesises that underpricing is a result of information asymmetries between informed investors, uninformed investors and the issuing company. Issues that are more underpriced would face greater demand by informed investors, creating a situation where uninformed investors receive a lower share of stocks issued for highly underpriced issues as compared to lower underpriced issues. This is termed the "winners' curse" as investors are more likely to receive a higher allocation in offerings with lower levels of underpricing. As a result of the "winners curse" uninformed investors will only invest in new offerings if on average new offerings are underpriced. The mechanism whereby the IPO market manages to avoid the "lemons" problem[4] is a result of the investment bank's role as an intermediary between the issuer and investors. The investment bank will need to underprice in order to ensure demand for new offerings by informed and uninformed investors but will also need to ensure that the amount of money left on the table is not so great that future issuing companies will cease to use their services.

### 2.3.2 Uncertainty

Ritter (1984) extends Rock's hypothesis and, in an analysis of 1028 firms that went public in the US during the period from 1977 to 1982, finds evidence to suggest that the level of risk surrounding investment in an issuing firm is indeed positively related to the level of underpricing of that firm's issued capital. Defining risk as the uncertainty that uninformed investors have regarding the aftermarket price of the offer, Ritter (1984) finds that risky firms are more underpriced and that in hot issue periods a greater portion of risky firms come to market.

Beatty and Ritter (1986) further investigated the relationship between investor uncertainty surrounding the value of the issuing company and find that the greater this

[4] Akerlof (1970) proposed the lemons problem in his discussion on information asymmetries and the impact on market based transactions. In his discussion he uses the stylised example of a bad car, or "lemon", will sell for the same price as a good car as the buyer cannot know the difference between a lemon and a good car due to information asymmetries between buyer and seller.

uncertainty, the greater the level of underpricing. They studied the same data set as Ritter (1984) and find that whilst on average underpricing is a persistent phenomenon, there are some issues for which shares decline in price once they start trading. This implies that it is in the investors' interest to devote resources to researching the fair value of the issuing company and thus reduce the ex-ante uncertainty surrounding the issue price. Additionally, they find that whilst underwriters display characteristics indicative of uncertainty regarding the after-market price, those that (on average) under or over price for issue uncertainty suffer from lost market share.

Use of a reputable independent accountant has been shown in previous studies to reduce the level of uncertainty surrounding an IPO. An independent accountant is used to verify the accounts presented in the prospectus for accuracy. It is supposed that a more reputable accounting firm offers greater certainty as to the accuracy of the company accounts presented in the prospectus as a representation of historical earnings performance and thus reduces the uncertainty surrounding the IPO. Titman and Trueman (1986) provide a theoretical model describing the process whereby the choice of auditor is a relevant piece of information for investors assessing an issuing firm's value. Those companies engaging more reputable independent accountants offer shareholders greater certainty and as such shareholders require less underpricing return as incentive for investment.

The price of shares offered has been shown in previous studies to be negatively related to the underpricing of a company's IPO. Chalk and Peavy (1987) analyse a sample of 649 firms that went public in the US during the period from 1975 to 1982 to examine the relationship between issue price and underpricing. They find that low-priced firms are more heavily underpriced and postulate that the returns to shareholders may be compensation for transaction costs, risk, liquidity or a size effect[5]. The argument used to explain this phenomenon is that smaller offerings tend to have a smaller price (Tinic 1988). Informed investors are only able to concentrate their research efforts on a restricted number of companies (due to time constraints) and as such, smaller offerings will attract less scrutiny. Thus IPOs with lower price per share are expected to be

[5] Smaller firms have been shown to have higher risk adjusted returns than larger firms (Banz 1981).

correlated with smaller capital raisings but with greater returns to shareholders in the first day of listing to compensate potential investors for increased uncertainty.

### 2.3.3 Signalling Hypothesis

An investment bank facilitating a flotation has a challenging task. It is required to set the issue price at a level which provides a maximum return to the issuing company while still allowing sufficient underpricing to uninformed investors (Beatty and Ritter 1986). From the perspective of biotechnology companies (which are by nature highly capital intensive), the more funding they are able to generate, the more likely they will be to successfully develop their product pipeline.

The signalling hypothesis suggests that underpricing exists as a signal of a firm's quality in order to ensure demand for subsequent offerings. Allen and Faulhaber (1989) derive a theoretical model based on the assumption that the issuing firm holds the best information about its prospects, and as such, firm valuation. Based on this premise, they derive a model to suggest that in the presence of asymmetric information, firms signal the quality of their offering by underpricing. Further, they provide analysis of previous empirical studies to support this notion.

The signalling hypothesis has not been generally supported and Michaely and Shaw (1994), in their study of United States IPOs from 1984-1988, find that those firms with greater underpricing at IPO tended to return to the market less frequently and for lower amounts than those firms with lower levels of underpricing. In the absence of the signalling hypothesis, an issuing biotechnology company would prefer less underpricing so that more wealth is retained by the company to fund their capital intensive research.

### 2.3.4 Entrepreneurial Wealth

Much of the research effort into the underpricing phenomenon has focused on the relationship between uncertainty and underpricing. Using a theoretical model for IPO pricing equilibrium, Habib and Ljungqvist (1998) propose that, for an issuing entrepreneur, it is not the level of underpricing that is of concern but instead the impact that underpricing has on the issuing entrepreneur's wealth, i.e. the amount of money left on the table. In their later work, Habib and Ljungqvist (2001) analyse a sample of 1376 firms that went public in the US between 1991 and 1995 and find empirical support for

the proposition that owners will care about underpricing to the extent that they stand to lose wealth from it.

This notion is supported by Loughran and Ritter (2002) who provide an explanation for underpricing as a means of underwriter compensation. Their contention is that whilst underpricing represents a loss of company wealth, the extent to which the pre-issue shareholders personally benefit from subsequent increases in share price, offsets concern they may have regarding company wealth.

### 2.3.5 Sentiment

The majority of explanations for the observed underpricing relate to information asymmetry and uncertainty around the offering as described in sections 2.3.1 and 2.3.2. The work of Ibbotson and Jaffe (1975) and Ritter (1984) additionally suggests there are well known sentiment effects that produce hot issue periods in IPO markets.

Hot issue periods are characterised by greater levels of IPO underpricing, with an increased volume of IPO capital raisings, and larger capital raisings (Helwege and Liang 2004; Ibbotson, Sindelar and Ritter 1994). A pioneering paper by Ibbotson and Jaffe (1975) first tested the econometric relationship between underpricing and hot issue periods. Theirs was a time series analysis of IPOs in the US from January 1960 to October 1970 and they find evidence that periods of greater underpricing corresponded with more firms coming to market.

In their more recent work, Brailsford, Heaney and Shi (2004) use a wider data set which included data from all new listings in the US from January 1960 to July 2000. This work supports earlier studies and finds that during periods of greater underpricing more firms came to market as issuers respond to market conditions. Additionally, significant autocorrelation was found between underpricing of IPOs from one period to the next supporting the notion that the new issue market gathers momentum during hot issue periods.

The existence of hot issue markets has been linked to the state of the equity market as a whole, with hot issue periods tending to correspond with times of rising equity markets. In accordance with this, Dimovski and Brooks (2004a) find that times of rising equity

markets correspond with greater underpricing of Australian industrial IPOs. The key challenge is to find variables that capture the movements in market sentiment. Brailsford, Heaney and Shi (2001; 2004) conduct an analysis at the overall market level and find a role for the number of new issues, the level of underpricing and general market conditions. Dimovski and Brooks (2004b; 2004a) find a significant role for variations in the market index as a sentiment variable for Australian IPOs in general. However to date there has been no research published that focuses on biotechnology IPO underpricing and the role of sentiment.

There are alternative variables that can be used to measure sentiment type effects. One possible alternative sentiment variable is media coverage during the issue period. Demers and Lewellen (2003) find that more underpriced offerings receive a greater number of media cites in the months post IPO. Due to data constraints they used a filtered sample of 593 IPOs that went public in the US during the period from January 1990 to February 2000 and find a relationship between media coverage in the month prior to listing and underpricing. With investor sentiment providing a significant contribution to underpricing, media coverage during the issue period and for high first day returns will encourage investment in subsequent listings.

Conversely Pollock and Rindova (2003) put forward a theory of media legitimisation. They analyse a sample of 225 IPOs in the US during 1992 and find that greater levels of media coverage in the period one year prior to IPO is negatively related to the level of underpricing. They put forward this relationship in support of their media legitimisation theory which states that increased media coverage provides a form of validation of a new firm's legitimacy, hence reducing perceived investor risks associated with that firm.

### 2.3.6 Australian Observations

The international phenomenon of IPO underpricing is also found in the Australian capital market. Research focusing on the new issue market in Australia supports the findings of international studies and shows that the underpricing phenomenon exists for new issues on the Australian Stock Exchange.

Using a filtered sample of 93 new issues on the Australian Stock Exchange from July 1966 to June 1978, Finn and Higham (1988) conduct an early investigation into underpricing in Australia with comparison to the more heavily researched international markets. They propose that barriers to entry for Australian brokers prior to 1987 could facilitate non-competitive pricing of new issues however this does not justify the consistency in their results with the international literature.

To investigate the uncertainty argument for the underpricing of new offerings, How, Izan and Monroe (1995) analyse a sample of 340 industrial IPOs in Australia between 1980 and 1990. They proxy uncertainty using the quantity of available information about the listing firm and find that, consistent with Ritter (1984), greater uncertainty regarding the firm is significantly correlated with greater underpricing. Additionally, they find support for Rock's (1986) winner's curse hypothesis and find that firms can reduce the level of underpricing by engaging a reputable underwriter for the issue.

The relationship between uncertainty and underpricing of Australian IPOs is supported by Dimovski and Brooks (2004a) in their study of 358 industrial and resource new issues between 1994 and 1998. They model market sentiment using the All Ordinaries share price movement as a proxy and find that IPOs are more underpriced during periods of rising market sentiment.

Brailsford, Heaney and Shi (2001) analyse IPOs on the ASX between 1976 and 1997 using a time series regression model to investigate the presence of hot and cold issue markets. They find that hot issue periods are related to market conditions and conclude that managers time their listings to capitalise on favourable market conditions. They find that during hot issue periods, issues are more underpriced with a greater number of firms coming to market, however underpricing observations lead observed volume changes by up to six months. The impact of resource stocks was also investigated and these firms were found to be smaller in size with lower issue prices and tended to have greater levels of underpricing.

Consistent with Brailsford, Heaney and Shi (2001), How (2000) finds that Australian mining IPOs are more underpriced than Australian industrial firm issues. How (2000) uses a sample of 130 mining listings on the ASX between 1979 and 1990 and also finds

that the degree of underpricing is dependent on the year of listing consistent with the presence of hot issue periods.

The entrepreneurial wealth hypothesis was supported in an Australian context by da Silva Rosa, Velayuthen and Walter (2003) who find that underpricing does not represent the true wealth impact on the issuing entrepreneurs. In their sample of 333 industrial firm IPOs on the ASX between 1991 and 1999, venture capital backed IPOs exhibited greater levels of underpricing (but not significantly different) than those without venture capital. Conversely, the issuers of venture capitalist backed IPOs experienced less wealth loss (but not significantly different) than those without backing.

### 2.3.7 IPO Underpricing in the Biotechnology Context

For managers of firms such as biotechnology companies who rely heavily on raising external funds to finance their R&D, the IPO process poses a significant challenge. Cash flows generated by intangible assets, particularly internally generated intangibles such as R&D will be less certain (Barron, Byard, Kile and Riedl 2002). The investing public requires details of the nature and success of R&D in order to attempt to put a value on the firm, while managers are often reluctant to disclose this information for fear of expropriation of proprietary knowledge (Deeds, Decarolis and Coombs 1997). Investors in young biotechnology companies will assess the firm in order to establish the likelihood of that firm producing a product(s) that will generate revenues and profits to justify their investment. Deeds, Decarolis and Coombs (1997) focus on US listed biotechnology companies to examine the impact of firm specific data on the amount of equity raised in an IPO. The data set comprised a final sample of 89 biotechnology firms that went public in the US between 1982 and 1993. Using a regression framework they find that factors including the number of products in development, the number of times employees' work had been cited, and the geographic location of a firm had a significant impact on the amount of capital raised in their IPO. The argument they pose is that these factors are signals to the market as to the likelihood of the firm producing revenue (and profit) generating product(s) at some stage in the future and, as such, are indicators of value and correlated with the amount of cash generated by the IPO capital raising.

There are a number of variables that might impact on capital raisings and IPO success for a biotechnology company. Citation indices have been previously used as a proxy measure for the quality of the research team (Deeds, Decarolis and Coombs 1997). A higher quality research team would be expected to better capitalise on existing proprietary intellectual property, develop new intellectual property and indeed see the successful development of the intellectual property into a product capable of delivering returns to shareholders. In the context of a biotechnology IPO it would then be expected that those firms with greater citations of employees' publications offer investment in a superior research team, by definition giving a greater expectation of positive research and development outcomes. If the reduced uncertainty increases the likelihood of research and development success then, *ceteris paribus,* those companies would be expected to raise more capital at IPO with less money left on the table.

In contrast, recent research by Corolleur, Carrere and Mangematin (2004) found evidence that more qualified and senior research staff tend to become involved with projects offering greater potential rewards, albeit at a higher risk of failure. Whilst these projects may offer a more difficult path to valorisation of intellectual property, the potential monetary and reputation gains outweigh the additional risk. The increased uncertainty surrounding the success of a riskier company's product development will see investors in that company's IPO demanding greater return as compensation.

The ability of a biotechnology company to produce high margin products is largely dependent on its ability to protect its intellectual property through the patent process (Carbone 2003). A company that has no patent protection faces increased competitor risk, jeopardising its first to market advantages and profit margins, leading to a reduced share of the target market. This being the case, the increased risk resulting from inadequate intellectual property protection will create additional uncertainty surrounding future cash flows, requiring greater underpricing as compensation to investors in the issue.

Underwriters for companies from new industries have little guidance to value beyond traditional valuation methods in use at the time (Pukthuanthong 2006). Using a sample of 447 biotechnology and 447 non-biotechnology (a total of 894) firms that went public in the US between 1980 and 2004, Pukthuanthong (2006) conducts an analysis looking

for evidence of learning in underwriter valuation of new industry (biotechnology) listings. Underwriters of biotechnology IPOs early in the sample underestimated the value of R&D investment, quality of human capital and large market drugs with these items correlated with smaller IPO values and larger underpricing. Later in the sample these factors correlated with higher value IPOs but were not with underpricing and Pukthuanthong (2006) put forward this as evidence of underwriter learning.

Lack of familiarity with a new industry creates uncertainty surrounding the values of firms operating within that industry. How (2000) finds that resource firms are more likely to come to market in times of positive market sentiment. Pukthuanthong (2006) finds similar results for the biotechnology industry indicating that firms with greater pricing uncertainty exhibit selectivity in IPO timing and choose to come to market when capital markets are buoyant. Similarly, Finkle (1998) and Deeds, Decarolis and Coombs (1997) both find that US biotechnology firms coming to market during hot issue periods had larger IPOs which supports the broader market research into the presence of hot issue periods and the impact on IPOs.

## 2.4 VALUATION

Underpricing has been shown in numerous studies to be related to the degree of uncertainty surrounding the issue. That is to say that those companies with business models that are well understood by the investment community (such as a manufacturing company) tend to have less underpricing at IPO. Conversely, those companies with greater uncertainty (e.g. biotechnology) surrounding valuations tend to be more underpriced and leave more money on the table.

Valuation models provide the analyst with insight into the inherent value associated with a particular project or entity and as such reduce the uncertainty associated with investment in the project or entity under investigation. If the investment community had access to models that provide greater insight into the value of biotechnology investments, some of the uncertainty inherent in these investments would be reduced. This in turn should result in an increase in investment in the industry, enabling firms to maintain ownership of valuable intellectual property for longer through the development process to capture a greater portion of drug development value. Additionally, reduced uncertainty surrounding biotechnology valuation should result in

less underpricing and money left on the table by Australian biotechnology firms, thus increasing the amount of money available for R&D investment.

This section focuses on two primary valuation methods. The initial discussion examines discounted cash flow valuation (DCF) and provides a brief summary of the concept combined with discussion on the limitations and criticisms of this methodology. A number of extensions on traditional DCF models have been proposed in response to common criticisms, the most significant of which are also discussed.

The most telling criticism of DCF valuation is the inability of the method to incorporate the value of management flexibility. Real option analysis is a contemporary capital budgeting tool which incorporates the value of management flexibility. This section provides a summary of the evolution of the underpinning theory together with its advantages and limitations.

### 2.4.1 Discounted Cash Flow

DCF valuation is the term used to describe the valuation method where all cash flows directly attributable to the assets being valued are forecast and then discounted back to a present value using an appropriate discount rate. This valuation method has been in use since the first half of the twentieth century when early publications by Fisher (1930) and Williams (1938) describe valuation methods to account for risk and the time value of money.

DCF and the closely related internal rate of return[6] (IRR) valuation methods have been the most commonly adopted capital budgeting tools in the second half of the twentieth century (Ryan and Ryan 2002). In his 1970 survey of 180 firms Klammer (1972) finds that DCF and IRR methods are the primary capital budgeting tool for 55% of firms, having increased from 14% in 1959 when accounting rate of return and payback period were the most commonly used tools. Ryan and Ryan (2002) surveyed Chief Financial

[6]The internal rate of return (IRR) method involves forecasting all cash flows for a project then using an iterative process to solve for the discount rate that corresponds to a zero net present value. The derived IRR is then compared to a hurdle rate of return to provide an "invest" or "abandon" recommendation. The process for forecasting cash flows is the same as that for a DCF model and the hurdle rate is typically that which would be used as the discount rate in a DCF model.

Officers from 205 Fortune 1000 companies and find that IRR and DCF are the most commonly used capital budgeting methods and that the majority of firms included sensitivity analysis of these models in their assessments.

#### *2.4.1.1 Methodological Summary*

On the surface, typical DCF analysis is a relatively simple process however selection of an appropriate discount rate with which to discount cash flows can pose a significant challenge. The discount rate should be reflective of the risks associated with forecast cash flows however quantification of those risks poses some difficulty and as a result, the weighted average cost of capital (WACC) for the firm is often used as a proxy. This approach assumes that markets are efficient and, as a result, the cost of capital is reflective of the relevant risk exposure of the firm. Where a project differs from those typically undertaken, the use of the WACC may not be appropriate as this is representative of risks of the firm as a whole which is a reflection of the projects historically undertaken by the firm.

#### *2.4.1.2 Limitations*

DCF valuation methods are fundamentally flawed as they do not correctly assess growth options and will understate the value of an investment with a significant portion of value associated with growth options (Myers 1984). This notion is supported by Kester (1984) who argues that the opportunity to invest in a project can be worth more than the net present value of the project itself.

Hodder and Riggs (1985) state that as DCF models consider only the most probable estimate of cash flows, asymmetry in payoffs are ignored and thus project value is underestimated in situations where managers are able to flexibly respond to their environment to minimise losses and maximise profits. Additionally, application of DCF methods provides an invest/discard signal to management at the commencement of the project which does not communicate the inherent uncertainty in the underlying inputs (Junkui Yao and Jaafari 2003). Furthermore, the adoption of a constant discount rate for the term of the project ignores changes in uncertainty and risk as the project moves through to completion and information is revealed (Junkui Yao and Jaafari 2003).

In their widely cited article, Hayes and Abernathy (1980) criticise underinvestment in long-term strategic assets (such as research and development) by corporate America in

the period from 1960 through to 1978 as contributing to a reduction in international competitiveness. In a subsequent paper Hayes and Garvin (1982), argue that widespread adoption of DCF capital budgeting tools compounds research and development underinvestment due to the inherent flaws in DCF methodology.

Gold (1976) postulates that DCF evaluation has a bias towards short term revenue generating projects as the application of large discount rates to cash flows not expected to occur in excess of 3 to 4 years in the future will often render them inferior to alternative short term money market investments. To reject such projects is to risk erosion of competitive strength over time as new technology investments are rejected, creating a long term strategic disadvantage.

Haley and Goldberg (1995) analyse the theoretical shortcomings of DCF capital budgeting tools in a quantitative framework. Their model tests the relationship between management reliance on financial capital budgeting tools and the success of that firm's research and development program. Three measures of research and development success are used, those being: annual patent submissions divided by annual sales relative to the industry median, the annual patent submissions divided by annual expenditure on research and development relative to the industry median, and research and development expenditure as a percentage of sales relative to the industry median. Based on data for the 45 largest firms from each of three industries[7] Haley and Goldberg (1995) find empirical support for the notion that firms who place greater importance on the application of DCF models for R&D assessment have poorer performing R&D divisions. They support the theoretical concerns surrounding application of DCF models to assess research and development projects and conclude that firms who rely heavily on DCF models are exposed to risk of competitive strength erosion over time.

#### *2.4.1.3 Discounted Cash Flow Methodological Extensions*

The merit of DCF project evaluation has been subject to much debate in industry and academia (on both sides of the fence) resulting in a number of extensions to traditional DCF models emerging in response to criticism.

[7] The three industries included in this study were the chemicals, computer and steels/metals.

i Non-constant discount rate

Traditional DCF methods apply a discount rate reflective of the non-systematic risks associated with the cash flows under analysis. This poses particular problems with respect to assessment of biotechnology research and development due to the long lead times in product development and the non-constant nature of project risks over this time frame (Myers and How 1997).

As a result of the inconsistent nature of project risk over time, Hodder and Riggs (1985) propose the use of differing discount rates over the forecast life of the project stating that, once a project and cash flows become more consistent, the use of a lower discount rate is appropriate. Myers and How (1997) similarly argue that risks are time varying and for a biotechnology project, uncertainty surrounding likely development costs is less than that for commercialisation cash flows and hence a reduced discount rate should be adopted.

ii Probability weighted decision tree

Incorporation of probability weighted decision trees is a response to the criticism that DCF models consider only the "average" forecast outcome and therefore assume symmetric distribution of possible alternatives around this average (Trigeorgis 1996). The decision tree facilitates the inclusion of asymmetric cash flow expectations through specific settings of a discrete number of alternative outcomes. Decision tree analysis involves forecasting the cash flows associated with a range of possible outcomes and then discounting cash flows at an appropriate discount rate, which is usually the weighted average cost of capital, and adjusting for the expected probability of occurrence for each outcome (Copeland and Keenan 1998).

A problem with the application of decision tree analysis in this manner is that the assumption of a constant discount rate assumes that risks are equal across all branches of the decision tree and uncertainty is resolved at a constant rate over time (Trigeorgis 1996). Decision tree analysis usually incorporates the abandonment outcome at various points through the model's time horizon and the addition of the option to abandon should have the effect of reducing perceived project risk (Junkui Yao and Jaafari 2003).

The use of decision tree analysis is particularly suited to drug development projects due to the staged nature of the R&D and regulatory approval process (Kellogg and Charnes 2000). A number of industry databases are available which provide industry-wide statistics regarding the likelihood of success at each stage in the process. Unfortunately, direct use of this data in a DCF model with a decision tree framework provides misleading results as the data includes all project failures, many of which occur for financial reasons. An accurate DCF decision tree model should only use the proportion of projects that have been abandoned for safety or efficacy reasons (Villiger and Bogdan 2005).

iii Monte Carlo scenario testing

Despite the incorporation of numerous outcome possibilities, DCF decision tree analysis suffers from one of the pitfalls of the DCF model upon which it is based as it only provides a point estimate of value which is deceptive in its precision because it is based on imprecise assumptions (Gold 1976). Haley and Goldberg (1995) find that incorporating scenario testing within DCF models facilitates outputs beyond traditional point estimates of net present value improves the information available to those responsible for investment decision making, providing some insight into model uncertainties versus project risk.

Hertz (1964) provides an early insight into the advantages of incorporating large scale scenario testing into DCF models for project assessment and valuation modelling. Using a sufficiently large number of iterations based on assumed distributions of possible model input values, an estimate of the model output (e.g. NPV) distribution can be generated.

The term Monte Carlo was coined after the gambling casinos of Monte Carlo in Monaco (Ulam 1991) and is used to describe the process of statistical sampling outlined by Hertz (1964). Improved access to increased computational power in modern times has seen an increase in both the functionality and application of this tool (Boyle and Broadie 1997).

### 2.4.2 Real Options Valuation

In response to mounting criticism of the applicability of DCF models in assessing research and development projects, Myers (1984) first postulates the notion that value in

research and development is effectively option value and coined the expression "real option". Since Myers' publication, a large amount of academic literature has been devoted to espousing the applications of financial option theory to the valuation of real options such as occur in biotechnology research and development.

Research and development is considered to comprise real options as investment in a single stage of R&D gives the owner the right, but not the obligation, to continue to the next stage in development (Copeland and Antikarov 2001). Analysis of R&D using simple DCF models may generate a "do not invest" signal when the project is considered in isolation however when the value of the options created by the R&D investment are included[8] this may well alter the investment signal (Dixit and Pindyck 1995).

The option to continue a R&D program is only one alternative that should be considered when applying real option analysis to project evaluation. In addition, options to defer investment, expand, contract, put on hold, abandon for salvage value and the option to default can also be quantified in a real options model (Trigeorgis 1996).

Despite academic support for quantitative application of real options analysis, there has not been widespread uptake of the theory by industry. In their survey of 28 biotechnology and pharmaceutical companies and 27 financial services companies Hartmann and Hassan (2006) found that the application of DCF related models was at least four times more likely than the use of real option models. Despite the domination of DCF techniques, there was an increase in adoption compared to that observed by Ryan and Ryan (2002) who surveyed over 200 Fortune 1000 firms and found that less than 1% of these always used, and 88% never used, real option methods.

Despite the current lack of support by industry, Copeland and Antikarov (2001) forecast that by 2010 real options analysis will be the dominant tool for investment analysis. Although uptake by industry has not been as strong as forecast, the survey results may provide misleading information as many managers are in fact applying real options

[8] For example, a company may commit to a project with a negative NPV on the basis that this project will lead to other positive NPV opportunities.

analysis in practice without necessarily applying the associated quantitative model (McDonald 2006).

#### *2.4.2.1 Methodological Summary*

The underlying logic supporting application of existing financial option theory to valuation of real options is widely supported by academia, however, the manner in which this is best applied is varied, with three main techniques receiving the majority of support in the literature.

##### i Binomial Decision Tree

Based on a decision tree similar to that used in combination with extended DCF models, the binomial decision tree seeks to overcome some of the inherent problems with a DCF tree. This method is described by Jagle (1999) and applies the notion of the risk neutral replicating portfolio[9] developed by Cox, Ross and Rubinstein (1979). This method allows all values within the tree to be discounted at the risk-free rate using risk adjusted success probabilities for each stage of the tree.

DCF valuation forms an important component of this method in that it is used to value the underlying assets, that being a fully developed product. This is justified based on the "marketed asset disclaimer" which states that the present value of expected cash flows is the best unbiased estimate of value (Copeland and Antikarov 2001). As the value of the underlying asset is forecast for all outcome states, the value of the volatility in the underlying asset is implicit in the DCF calculations for each of those states of being.

##### ii Binomial Lattice

The binomial lattice method is described by Kellogg and Charnes (2000). As with the binomial decision tree, this method also uses the notion of the risk neutral replicating portfolio, however the underlying tree is of a different format. Rather than a decision tree, a binomial lattice is used to model movement in option value through the evolution of the project with the volatility in the underlying asset explicitly calculated based upon forecasts for the optimal project outcome.

[9] Refer to Chapter 6 of this thesis for a discussion of the risk neutral portfolio and an example of the binomial decision tree and binomial lattice methods.

iii Black Scholes

The pre-eminent theory for the pricing of financial options is that provided by Black and Scholes (1973) which built on earlier research by Merton (1973) and for which Merton and Scholes received the 1997 Nobel prize in economics[10]. Benaroch and Kauffman (1999) apply this theory to produce a continuous time model for valuation of real options.

One of the underlying assumptions of the standard Black Scholes option pricing model is that the option is only exercisable at maturity (i.e. a European option) and the underlying asset does not pay dividends (Black and Scholes 1973). In the case of a biotechnology project, cash flows resulting from such activities as milestone payments defined in licensing agreements represent a failure to meet the dividend assumption reducing the practicality of the model for real options analysis.

Extensions to the Black Scholes model have been developed in order to remove the European option and dividend restrictions, however these add computational complexity without necessarily providing greater insight into the valuation problem (Villiger and Bogdan 2006). The complexity of the Black Scholes valuation model inhibits effective understanding for many practitioners which acts as a barrier to application (Copeland and Antikarov 2001).

*2.4.2.2 Limitations*

The main barriers to the uptake of real options analysis are perceptions of computational complexity and onerous assumptions necessary to conduct quantitative analysis. Whilst there is some merit in these arguments, modern literature has sought to overcome these issues through the development of methods that can be graphically displayed in a relatively simple manner to easily communicate the benefit of real options (Fichman, Keil and Tiwana 2005).

Unlike traditional DCF analysis, real options valuation requires an estimation of the volatility in the underlying asset value. Due to the nature of "real" options the underlying asset is usually not tradeable and thus there is no historical data to be used as a guide for price volatility estimation (Godinho 2006). Monto Carlo modelling of the

[10] Black was ineligible for the prize having passed away in 1995.

underlying asset characteristics is proposed as a method for estimation of the volatility (Copeland and Antikarov 2001).

Whilst options analysis quantifies the value of management flexibility, the exercise of that flexibility may not be practically convenient. Stop loss options (or "puts") such as the option of abandonment may be difficult to exercise in practise and as such the value of these may not be as great as predicted by the financial analysis. Fichman, Keil and Tiwana (2005) surveyed managers from 123 firms and found that greater value was placed on positive "call" real options than negative[11] "put" options.

## 2.5 CONCLUSION

Biotechnology has been targeted by Australia's Federal and State Governments as strategically important. The development of a successful biotechnology industry is seen as important for the nation's future economic, environmental and social well-being. One of the key barriers to success in the industry that has been identified by numerous strategic reports is the inability of Australian firms to raise commercialisation capital, particularly when compared to our international competitors.

As a result of the funding shortfall, Australian biotechnology firms have historically turned to the public markets for capital at an earlier stage than in other countries, particularly the US, whose biotechnology industry is the most successful in the world. For any company, an IPO is one of the most important capital raisings in that company's life, however, for a biotechnology company, this is exacerbated by the capital intensive nature of biotechnology R&D and the difficulty in raising additional funds after IPO.

Underpricing is the term used to describe the phenomenon whereby the price of a firm's shares consistently appreciate on the first day of listing. This can also be expressed as money left on the table and new issues with greater uncertainty have been shown to be more underpriced and leave more money on the table. Investment in biotechnology firms is inherently uncertain due to the long lead times in product development, the

[11] A call option is one that enables management to flexibly respond to increase positive cash flows (such as a growth option) where as a put option is one where management is able to decrease negative cash flows (such as an abandonment option).

costs of development and the uncertain nature of R&D. As a result, biotechnology firms, for whom access to capital is a critical issue, tend to leave more money on the table than the market average.

Traditional valuation methodologies such as DCF models provide analysts with insight into project and firm value, reducing the uncertainty of investment. Unfortunately DCF based models fail to capture the value in management flexibility and thus tend to systematically undervalue investments with a significant degree of uncertainty to which management can respond over the life of the project. The widespread adoption of DCF techniques by industry has been blamed for an underinvestment in long term research and development, inhibiting longer-term economic prospects.

Real option analysis is a contemporary capital budgeting tool which captures and quantifies the value associated with management flexibility. At the present time real option methods are not widely applied and it is supposed that this is a result of a lack of understanding of the fundamentals underpinning the models. If the models were more widely understood, increased adoption could serve to decrease the uncertainty in R&D intensive industries, increasing the amount of investment capital available and helping address a critical barrier to the development of Australia's biotechnology industry.

# CHAPTER 3 METHODOLOGY

## 3.1 INTRODUCTION

The research in this project was funded by Australian Research Council Linkage Grant LP0347417. The funding approval was based on the premise that the investigation would focus on the "valuation and business models of Australian biotechnology companies". This research methodology was prepared with consideration of the ARC application which set out the research proposal and methodology outline.

Excluding medical device companies, the Australian biotechnology industry is comprised of around 300 companies (Department of Industry Tourism and Resources, Advance Consulting & Evaluation and Aoris Nova 2004) which operate across a diverse range of business sectors with a marked difference in product under development. Each business sector and product type has fundamental differences in the regulatory framework and requirements and the nature of commercial opportunities. These differences require each biotechnology sub-sector to be analysed specifically to determine the specific valuation and business model idiosyncrasies that exist. This thesis focuses on the largest biotechnology sub-sector in Australia, that being human therapeutic development companies, which comprise in excess of 40% of the total biotechnology industry (Department of Industry Tourism and Resources, Advance Consulting & Evaluation and Aoris Nova 2004).

The research methodological framework which forms the basis for this research is presented in this chapter. Discussion is subdivided into five main areas: research aims and questions, research design, qualitative investigation, quantitative review of Australian biotechnology IPOs and a quantitative review of valuation methodologies.

## 3.2 RESEARCH AIMS AND QUESTIONS

The ultimate aim of this research is to investigate the Australian biotechnology sector and identify the key drivers of value. Through the identification and quantification of the drivers of value for the sector it is hoped that greater investment capital will flow

into the industry, better enabling it to compete internationally given the countries tangible and intellectual resources. This thesis fulfils this aim through the investigation of the following primary research question:

- What are the key drivers of value for models for Australian biotechnology firms?

In addressing the primary question, the following secondary questions are also addressed:

- What are the challenges and opportunities for Australian biotechnology firms?
- What factors endogenous and exogenous to the firm affect the amount of capital raised by Australian biotechnology companies through IPOs?
- How can Australian biotechnology firms signal their fair value to the investing community?
- What is the appropriate methodology for valuation of biotechnology investments?

## 3.3 RESEARCH DESIGN

Epistemology relates to how truth and knowledge are defined in the research context (Lincoln and Guba 2000). How the researcher views epistemology depends on the paradigm operating in that research context, i.e., the "basic belief system or world view that guides the investigation" (Guba and Lincoln 1994, p. 105). This research consists of multiple methods grounded in alternative epistemologies.

### 3.3.1 Multi-Method Research

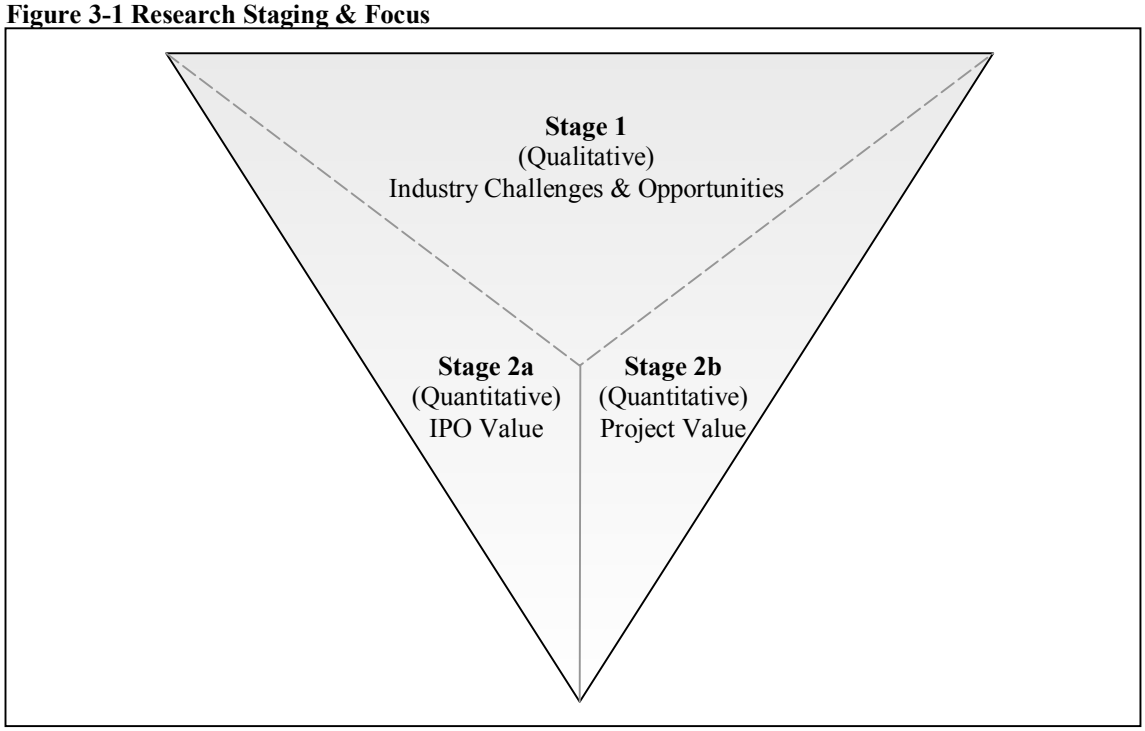
Practical "real world" problems are usually multi-faceted, thus an investigation into the circumstances surrounding those problems and possible solutions also requires a multi-faceted approach. The aim of research utilising a mix of quantitative and qualitative methodologies is to draw from the strengths and minimise the weaknesses of each research paradigm (Johnson and Onwuegbuzie 2004). Denzin and Lincoln (1998) argue against any hierarchy of merit in research techniques, with both qualitative and quantitative researchers providing useful data but with different emphases. Qualitative studies emphasise richness and depth that quantitative studies cannot obtain whilst quantitative studies provide an objective analysis of measurables and causal relationships between variables.

This research consists of multiple methods applied across multiple stages. Schmied (1993) notes that a stage of qualitative research is often a precursor for quantitative analysis as the categories to be included in the analysis need first to be identified. The initial stage was explorative and qualitative in nature and provided the foundations for the subsequent quantitative stages whilst also providing a strong link to the existing literature surrounding the state of the Australian biotechnology sector.

The initial analysis of the qualitative research data supported the literature in identifying particular challenges to Australian biotechnology firms in raising sufficient development capital in the face of valuation uncertainties. Due to the exploratory nature of this phase of the research, and the depth and richness of information being sought, a qualitative research method was adopted.

The second stage of research was grounded in positivism to allow an objective assessment of, and a quantitative reference to, issues highlighted in the qualitative investigation. The quantitative components of this research provide a focused investigation which addresses the secondary research questions and supports the qualitative findings in addressing the primary research questions. Figure 3-1 provides a diagrammatical representation of the research methods starting with the breadth of the qualitative research, leading to the more focused quantitative analysis.

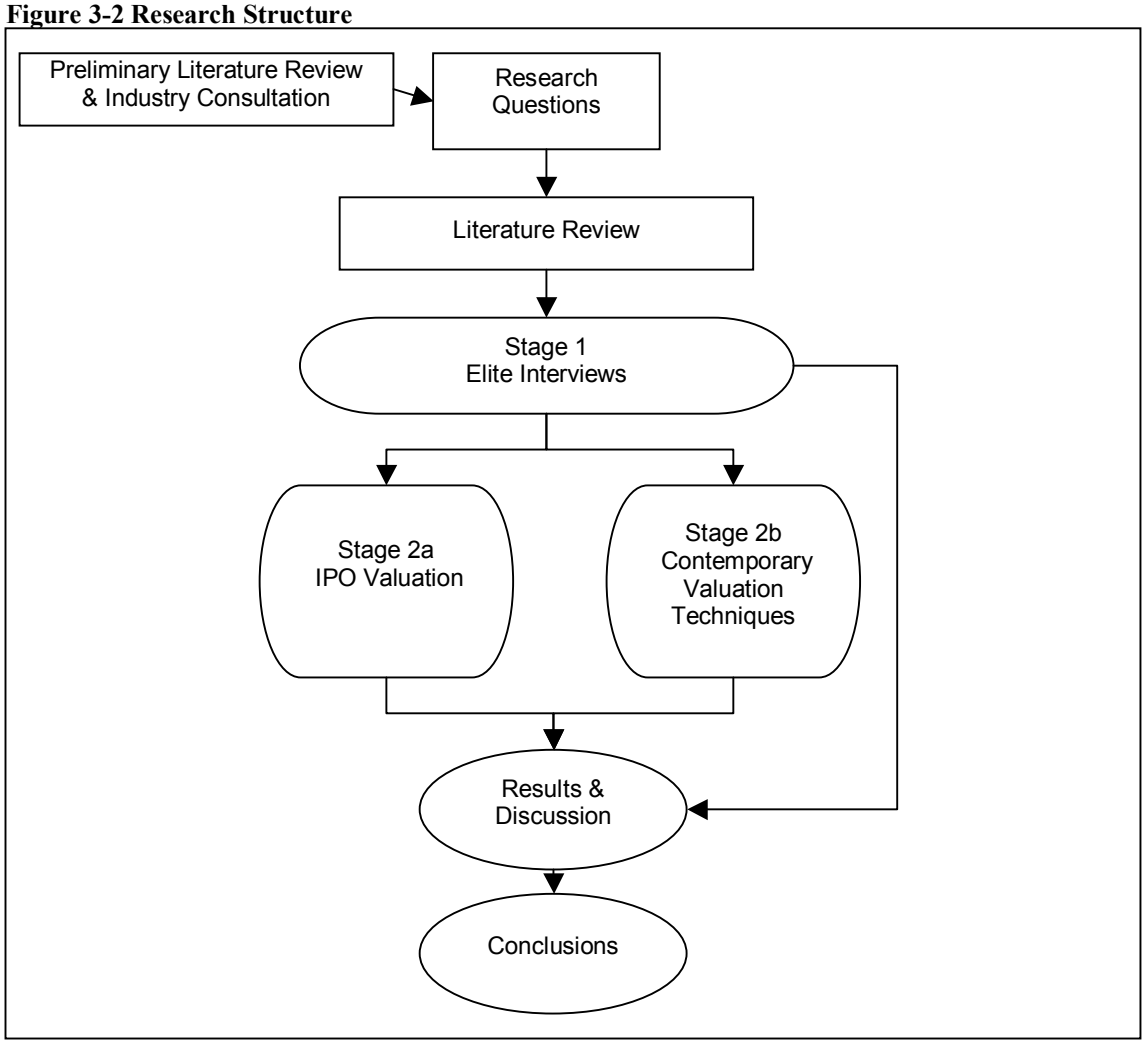
**Figure 3-1 Research Staging & Focus**




### 3.3.2 Research Structure

The multiple research methods formed components of the research design as illustrated in Figure 3-2. The research question was formed based on an initial survey of the existing literature and discussions with BioDiem Ltd, an Australian biotechnology company and the industry sponsor of this research. From this initial foray, the research questions were formed which were then used to guide a more detailed review of the literature.

**Figure 3-2 Research Structure**




There were two major themes that were identified in the literature that were crucial to this study. Firstly, high levels of uncertainty surrounding valuation of biotechnology assets, namely intellectual property. Secondly, the early stage at which Australian biotechnology companies were likely to raise capital through an IPO when compared with participants in the USA, home of the largest and most successful biotechnology industry in the world. This guided the research towards an investigation of the Australian biotechnology industry and the factors influencing the behaviour of firms contained therein.

The challenge Australian biotechnology companies face when raising development capital was highlighted through the qualitative data gathering process, providing direct support for the relevance of the stage two investigation into Australian IPOs and the factors that influence "underpricing" and the amount of money left on the table during the floatation process.

The two quantitative components of this research were conducted concurrently. The investigation of Australian biotechnology IPOs supports the notion that investors show behavioural patterns consistent with valuation uncertainties, providing supporting motivation for the second quantitative component of this research. Contemporary valuation techniques attempt to provide realistic assessment of firm value thus reducing the uncertainty surrounding biotechnology valuations. Thus the second quantitative analysis used a number of contemporary valuation models to assess the value of a typical biotechnology product to allow a comparison between the different techniques applied.

## 3.4 QUALITATIVE SECTOR INVESTIGATION

The data collection method for this component of the study was designed to collect rich data under the broad topic "what are the challenges and opportunities facing Australian biotechnology companies". Qualitative data collection provides "richness" that quantitative data is unable to provide (Denzin and Lincoln 2005) and provides a depth to the context and picture of the Australian biotechnology scene. Semi-structured interviews were chosen as the data collection method to allow greater breadth than more focused "structured" interviews are able to do (Denzin and Lincoln 2005).

### 3.4.1 Interview schedule

From the literature review, key themes were identified which warranted further investigation. These themes formed the basis of the interview schedule and questions were developed accordingly. An initial generic schedule was developed and then provided to BioDiem for expert comment. Feedback from BioDiem was incorporated into the proposed schedule to produce a generic schedule as the basis for the interview process. The diversity of products developed under the "biotechnology" definition and the differing challenges and opportunities associated with each warranted some unique investigation for each participant. The generic interview schedule was adapted for each participant to allow investigation of the unique circumstance facing each company. However themes and issues presented in Table 3-1 were common to all interview schedules.

**Table 3-1 Qualitative Research Themes**

| Theme | Issues |
|---|---|
| Funding | • Availability & the impact on the Australian biotechnology industry |
| Initial Public Offerings | • Influence of alternative funding sources on the motivation to float<br>• Determinants of success<br>• Impact of public listing on business success |
| Business model | • Description, risks, strengths and opportunities<br>• Sustainability, product development and business model evolution<br>• Relationship between management and business model. Impact of evolution.<br>• Role of alliances<br>• Role for pharmaceutical companies and academia. |
| Valuation | • Valuation methodologies<br>• Drivers of value |

The interview schedule was designed to allow all topics to be covered within a 1 hour discussion. The interviews were recorded on a digital voice recorder and the recorded data was then transcribed verbatim into Microsoft Word format to allow the detailed exploration of data described in section 3.4.4.

### 3.4.2 Ethical Considerations

A plain language summary of the project together with the proposed interview schedules and participant disclaimer were submitted to the RMIT Human Ethics Committee (HEC) for approval. The project was deemed to be of medium level ethical risk due to the participants being recorded and Australian Stock Exchange (ASX) listing requirements that all price sensitive information be made available via dissemination through the ASX.

During the recruitment process participants were advised that the interviews would be recorded with the recordings and subsequent transcripts to be stored in a secure area. Both the participant and the researcher signed a consent form to acknowledge that they understood this process.

To protect participants' privacy, a pledge of anonymity was given with only the researcher having access to the raw data. There was some concern from one participant that even as anonymous contributors they may be inadvertently identified as a result of data descriptions included in resulting publications. The small number of listed Australian biotechnology firms does expose participants to risk of identity revelation,

however this was mitigated through careful presentation of the data in all resulting publications.

As an additional security precaution, participants were advised that they would be provided with a copy of all research findings prior to publication. In the event that they were unhappy with the presentation of their input the researcher would have the opportunity to revise the submission. In the event that the researcher was unable to appease the participants' concerns, they had the right to withdraw from the project at any time without prejudice.

### 3.4.3 Invitation process & participant information

"Elite" interviewing is a technique borrowed from the political sciences when conducting semi-structured interviews with "elite" decision makers or persons, who are able to inform on a particular area under enquiry (Burnham, Layton-Henry, Grant and Gilland 2004). Elite interviewing is an appropriate term whenever the respondent is an expert in the topic under investigation (Kezar 2003).

Senior executives from listed Australian biotechnology firms were targeted for participation in this study because of their experience in the topic areas. The subset of listed biotechnology firms captures the more mature firms in the industry, likely to have been through numerous rounds of capital raisings prior to IPO. Executives from listed biotechnology companies were targeted as "elite" respondents to comment on the problems facing the industry as a whole.

Senior executives come from a variety of backgrounds which can influence the relative importance which they place on the various challenges and opportunities facing the industry. To capture this diversity, the invitation process targeted Chief Executive Officers (CEOs), Chief Financial Officers (CFOs) and Chief Scientific Officers (CSOs). Victoria is home to the largest population of listed and unlisted biotechnology companies in Australia with the capital, Melbourne, housing six biotechnology precincts which are home to over a third of the nations biotechnology companies and around half of all employees in the industry (Department of Industry Tourism and Resources, Advance Consulting & Evaluation and Aoris Nova 2004). The diversity of Melbourne's biotechnology industry was deemed to protect the project from sampling

bias and thus, to contain data collection costs, the project targeted Melbourne based firms.

Initially firms were sent a hard copy invitation via Australia Post outlining the project aims and methods and the potential benefits to participants and the industry. Invitations were addressed directly to senior executives and a follow up phone call was made one week after posting. On the basis of the phone call, those invitees who were interested in learning more of the project were sent a soft copy of the plain language statement, disclaimer, and a proposed interview schedule. All three of these documents were previously approved by the RMIT HEC.

No limit was placed on the number of respondents required for the study and recruitment continued until the information generated through the interview process approached saturation. In the initial rounds of interviewing a wide and varied commentary was collected however as the number of respondents increased commonalities in the data emerged. In total 24 invitations were issued with eight acceptances. The eight acceptances comprised of three CEOs, three CFOs and two CSOs with a diverse range of experience both in Australia and abroad.

The interviews took place between September 2004 and August 2005 and were conducted at the participants' workplaces for their convenience.

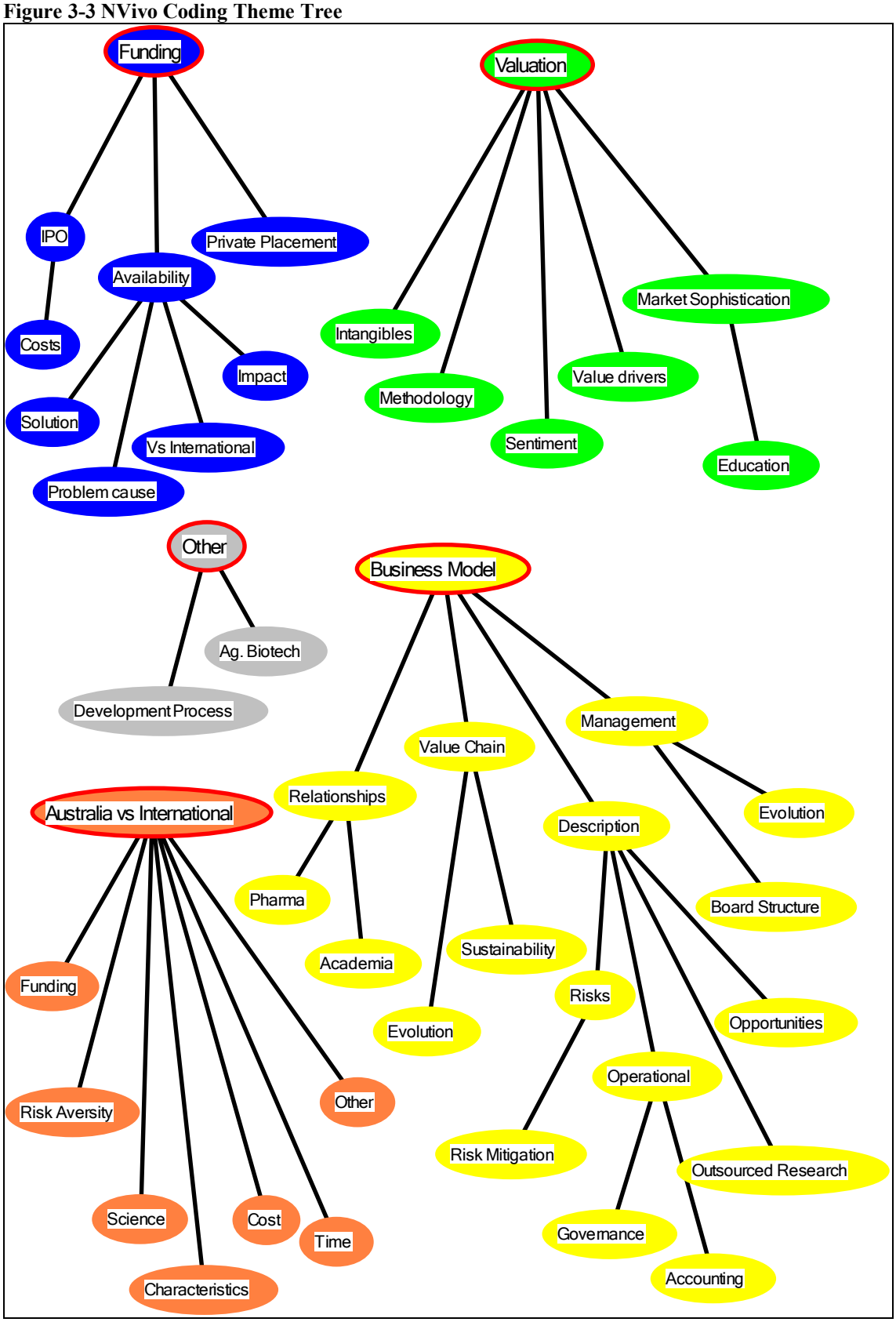
### 3.4.4 Data Analysis

The interview transcripts were entered into NVivo qualitative software to manage and analyse the data. This software package assisted in the coding, sorting and storage of data according to recurrent themes, as defined in the interview schedule, and others that emerged during data collection and analysis. The data analysis process consisted of four separate components:

- Transcription and Nvivo import
- Review and coding
- Report printing for themes identified
- Data reduction and discussion

The review and coding was an important part of this research as it allowed a detailed examination of the data from which common themes and contrasts emerged. The documents were coded according to the themes that were identified in the interview schedules as well as other themes that emerged during the course of the discussion. The themes were sorted according to five broad headings and the information contained within each subheading was separated into narrower subheadings. This process was continued until the data under each subheading was of a common context. The final coding theme "tree" that resulted from this process is shown in Figure 3-3.

**Figure 3-3 NVivo Coding Theme Tree**




Each of the nodes in the coding theme tree contained verbatim transcription of the discussion relating to that topic which was printed to produce a coagulation of all discussion pertaining to that particular theme. These reports were then used to inform a discussion highlighting the similarities and differences of opinion that were presented,

as well as linking the discussion to recent literature. This process required several drafts as the data was incrementally condensed with each draft. This process was deemed to be complete once the data could no longer be condensed without reducing the value of the data. The final version was then distributed to interview participants for their comment prior to final review and inclusion in this thesis.

## 3.5 QUANTITATIVE REVIEW OF INITIAL PUBLIC OFFERINGS

The motivations for a company to raise capital via an IPO can be many and varied. However a key concern is usually to gain a successful injection of a significant amount of capital into the business (Arkebauer and Schultz 1991). For biotechnology companies, which are inherently capital intensive businesses with long product lead times, the amount of capital raised that they can dedicate towards development of their product pipeline is a critical measure of the success of their IPO (Deeds, Decarolis and Coombs 1997). Stuart, Hoang and Hybels (1999) support this notion in their study of venture capital backed biotechnology IPOs which used the total capital raised by venture capital backed biotechnology IPOs as a measure of listing success. Success of IPO capital raisings can be measured by the size of the capital raising, level of underpricing, and the performance of the issuing company in the years post-listing (Brau, Brown and Osteryoung 2004). A listing that raises less capital, is more underpriced and leaves more money on the table, will have been less successful in meeting the primary requirement to inject significant capital into the business.

This thesis analyses biotechnology IPOs in Australia from 1994 to 2004 in three key dimensions related to their capital raising – underpricing returns, money left on the table and total proceeds raised. The analysis tests the relationship between the information provided to potential investors within the IPO prospectus and these key measures of listing success and performance. Three models have been used: first using the amount of money left on the table (measured as the number of shares issued multiplied by the first day share price movement) as the dependent variable; second using underpricing (the first day shareholder returns) as the dependent variable; and third using total proceeds raised (measured as number of new shares issued multiplied by the issue price) as the dependent variable. While all companies that list on the stock exchange are interested in these three measures, they are of particular concern for biotechnology companies given the high cost and long lead time in product development, and the

uncertainties regarding the valuation of their intellectual property assets (Schwartz 2004).

The models developed in this stage of the research test the relationships between data contained within Australian biotechnology company prospectuses and the success of their IPO, as measured by the amount of money left on the table, the amount of underpricing, and the total proceeds raised. Significant relationships identified in previous literature were used as the foundation from which the models were built and tested using an ordinary least squares regression framework. The data set used in this paper was constructed by extracting information from the prospectus documents of 34 biotechnology companies which listed on the Australian Stock Exchange between June 1994 and May 2004. Where possible, a copy of the prospectus was used in its original format (either electronic or hardcopy). In cases where this was not available, prospectus information was sourced from the Connect4 Company Prospectus database. Market pricing data was sourced from Datastream. Only those biotechnology firms coming to the market for the first time were considered. Of the 34 biotechnology companies, twenty-nine focused their research efforts on human therapeutics, four on medical devices and one on animal health.

## 3.6 QUANTITATIVE REVIEW OF VALUATION METHODOLOGIES

In the past, organisations were able to hold their competitive advantage by possessing certain tangible assets, such as manufacturing equipment, that enabled the production of goods in the most efficient and effective way possible. However, the most valuable assets of knowledge-based organisations (such as biotechnology companies) are intellectual assets with a high degree of uncertainty in value and application. Measuring and valuing intellectual capital, such as patents or individual and organizational knowledge, is a difficult task in any industry sector but the degree of difficulty is multiplied exponentially in biotechnology due to the unique and complex and costly nature of its resources, dependence on continuing research and development (R&D), volatility of outcomes and increasing global competitive pressures (Nicol and Nielsen 2001).

Beatty and Ritter (1986) found that the greater the uncertainty surrounding the value of a firm, the greater the level of underpricing for that firm's IPO. The cash flows

generated by intangible assets, particularly internally generated intangibles such as R&D, are less certain than those generated by traditional tangible assets (Barron, Byard, Kile and Riedl 2002). This phase of the research seeks to investigate the application of alternative valuation techniques for biotechnology investment valuation in an effort to expose the key value drivers in a biotechnology project and reduce the level of uncertainty surrounding investment in biotechnology assets.

Following from the discussion in Chapter 2, two common real option valuation methods were chosen for a detailed analysis and comparison with traditional DCF and eDCF models. The simple binomial option proposed by Jagle (1999) was chosen for its simplicity and the additional valuation accuracy with regards to life science project valuation claimed by the author. The decision tree which forms the basis for this binomial option valuation method is the same as that for more common eDCF valuation, making for an interesting comparison between the two methods.

Kellogg and Charnes (2000) compare the use of binomial lattice option valuation with eDCF valuation for a biotechnology firm in the US between 1994 and 1996. They found the binomial lattice valuation works well in the early stages of development when valuation uncertainty is highest. The binomial lattice valuation method was included in this research to allow comparison between the alternative option and DCF methods and to test all models using current data on biotechnology drug development.

Monte Carlo simulation is a method of statistical sampling to examine the behaviour of physical or mathematical systems and was named after the gambling casinos of Monte Carlo in Monaco (Ulam 1991). This method is particularly useful when examining functions with large numbers of degrees of freedom as it allows an examination of the relationships between dependent and independent variables that may not be possible with complex integral calculus. The application of Monte Carlo simulation in finance is particularly useful given the complex nature of valuation equations resulting from the large number of degrees of freedom. This analysis enables the practitioner to gain insight into expected values and the probability of these values occurring (Razgaitis 2003). The use of Monte Carlo simulation provides insight into the complex scenarios in order to gain a clearer understanding of the relative merit of differing valuation techniques (Lohmann and Baksh 1993).

A theoretical biotechnology project was created using publicly available industry data. Industry averages were adopted wherever possible in order to simulate a typical biotechnology project. The project was assumed to have completed preclinical research and development and was about to commence phase 1 clinical trials. The data required to build the two DCF and real option valuation models is described in Table 3-2. Data for each of these inputs was collected from publicly available sources, details of which are provided in Chapter 6.

**Table 3-2 Valuation Model Inputs**

| | |
|---|---|
| Development Time | Time expected for each of the three clinical trials required for regulatory approval plus the time required by the regulator to assess the product. |
| Development Cost | Costs associated with clinical trials and regulatory approval. |
| Commercialisation Cash Flows | All cash flows generated in the event of successful product registration with the regulator. |
| Project Risk | The probabilities of successfully completing each clinical trial as well as the probability of receiving regulatory approval. |
| Discount Rate | The appropriate discount rate for development and commercialisation cash flows to reflect the inherent risk in each. |
| Inflation | Expected inflation rate over the life of the project. |
| Risk Free Rate | The expected risk free rate of return over the life of the project. |

A valuation model was built for the theoretical biotechnology project described above using each of the real option methods described by Jagle (1999) and Kellogg and Charnes (2000) as well as traditional DCF and eDCF methods. These models predicted value estimates for the project at critical points in the project development cycle. Monte Carlo simulation was then used for each valuation model to determine the expected distribution of each value estimates and to test the sensitivities of each model to the underlying input assumptions.

## 3.7 CONCLUSION

This research methodology outlines a multi-method approach to investigate the multi-faceted aspects of the valuation challenges facing Australian biotechnology companies.

The first stage of this proposal consists of a detailed literature review upon which subsequent research is based.

A qualitative investigation of the issues facing Australian biotechnology companies forms a broad foundation, providing context for the two focused quantitative research components. A greater understanding of the challenges facing biotechnology firms provides direction for the subsequent valuation focus.

Two quantitative components of this research delve into the issue of biotechnology valuation at the firm and project level. An analysis of biotechnology initial public offerings provides insights into the key value drivers for firms during this critical capital raising period. Additionally, Monte Carlo simulation of contemporary valuation models provides insight into the key value drivers for a biotechnology project with implications for both managers and investors.

# CHAPTER 4 THE AUSTRALIAN EXPERIENCE IN PRACTICE

## 4.1 INTRODUCTION

The Australian biotechnology sector faces significant challenges that must be overcome if industry participants are to establish themselves as sustainable businesses with attractive long term prospects. Current practices encourage the spinning off of promising ideas into new entities with one or few products which are forced to compete for scarce development capital. As a result of a lack of capital from venture capitalists and other sources, firms are often forced into an IPO whilst their products are still in the early stages of development, and as a result the amount of capital they are able to raise is limited. Once listed, companies are faced with the additional costs associated with being a listed company and, due to the risky nature of early stage biotechnology projects, have difficulty in attracting long term educated investors such as institutional investors.

Biotechnology shareholder registers are typically highly fragmented with a significant portion of "mum-and-dad" investors. Unfortunately a lack of understanding by shareholders of the underlying science and the long term nature of the industry means that trading decisions are often based on sentiment, driving significant share price movements unrelated to changes in the value drivers. As a result, building lasting value is a challenge to firms which then face difficulties raising additional capital to finance their development programs.

This chapter looks in detail at the challenges facing the Australian biotechnology sector elicited from discussion with senior executives from eight ASX listed biotechnology firms. The challenges facing the industry can be overcome through greater collaboration between all sector participants including academics, private industry, and government. A greater emphasis needs to be placed on building firms with sustainable business

models which will help improve the risk profile of the sector and attract additional investment.

The key findings from the interview data were subdivided into five main discussion points: capital raising and the availability of funds, the Australian business model, biotechnology valuation, and Australia's challenges and opportunities as a global competitor.

## 4.2 CAPITAL RAISING AND AVAILABILITY

> *"Development capital is the biggest issue for the Australian biotech industry or any of the Australian technology industries." – Executive E*

By far the most common issue that emerged from the interview process was that Australian Biotechnology companies face a significant challenge with respect to the ability to raise sufficient capital to develop their product to a level which would enable optimum profits to be retained by the business. The industry is immensely capital-intensive, with the estimated "out of pocket" cost to fully develop a drug from discovery through to market launch estimated at USD $100 million (DiMasi, Hansen and Grabowski 2003). When allowance is made for capital costs over the development period, combined with the low probability of success, this estimate increases to greater than $800 million[12] for each drug successfully developed (DiMasi, Hansen and Grabowski 2003). The amount of available Australian investment capital is much less than that required to bring a product to market, and less than that available to international competitors, particularly in the US.

The sources of funds available to Australian biotechnology companies are diverse and include pre-seed funding, early development funding from government, private investment (from venture capitalists, high net worth individuals, business angels, and pharmaceutical partners) and the public markets via an initial public offering (IPO). The

[12] The capitalised cost of drug development is the subject of much debate however DiMasi, Hansen and Grabowski (2003) support the findings of Landers (2003) using an alternative data set. However significant variance exists around this number with Bain & Co. estimating that the capitalised cost to produce a blockbuster drug is as much as $1.7b USD including some marketing costs (Ernst & Young 2006).

availability of each of these avenues to funding will depend on the individual business characteristics. However, even in the most optimistic case, it is highly unlikely that an Australian business will be able to raise $100m USD in order to fully develop a single product (Executive G).

Biotechnology companies will require multiple rounds of capital raising throughout their lifetime. It is important that capital raisings are carefully planned to avoid disappointing investors who have contributed in earlier rounds and who often participate in subsequent rounds (Executives A, B) . The magnitude of the costs associated with drug development are commonly known, however investors will require evidence of tangible progress between fund raisings to satisfy themselves that invested capital is being efficiently managed to accrue value in the business (Executive B).

### 4.2.1 Pre IPO

#### *4.2.1.1 Start-up phase*

*"There is almost an overabundance of funds now available to start up new entities." – Executive E*

In the early phase of product development, Australia has a relatively large amount of capital available (Executives C, D, E, F, H). A potentially commercially relevant piece of scientific research can quite easily be used to attract initial rounds of funding to enable the company to pursue development of its science. The risky nature of the drug development industry means that the majority of projects will never make it through the rigorous regulatory approval process to become a marketable product (refer section 4.3.1). The abundance of early stage funding has encouraged the development of a large number of businesses with one or few products which therefore have a high chance of failure[13] (Executives C, F, E, H). Investors seem to be generally wary of the industry because of the high risk profile of biotechnology firms, encouraged by the ease in raising start-up capital.

[13] This notion is supported by Vitale (2004a) who recommends a shift away from the current focus on company formation from IP generated within research institutions.

*"Probably three-quarters of the [biotechnology] companies out there are not viable." – Executive E*

As a result of having a fragmented industry with a large number of small companies consisting of one or few research products a long way from reaching the market, the competition for subsequent rounds of development funding is fierce. Added to this competition is the lack of funds available to more mature businesses which has far-reaching effects through the restrictions it places on business models.

The risk profile of the industry could be improved if there were fewer businesses with each having a larger number of research and development projects (Executives A, C, E). This would improve the probability of those businesses successfully bringing a product to market and would decrease the competition for scarce development funds. A reduction in the number of businesses can be achieved through merger and acquisition amongst existing businesses, exits of underperforming businesses and a reduction in the number of new entities created. Many of the interviewees believe this would allow the development capital currently available to be more efficiently allocated towards the most viable companies.

Many biotechnology research projects are spawned in academia and the current funding mechanisms encourage the spinning out of new business entities. These new entities are then forced to compete with existing biotechnology companies for subsequent rounds of scarce development capital. If the amount of early stage government funding was reduced as a disincentive to spin off new entities, these new ideas could instead be fed into existing biotechnology companies that have the expertise in early stage development projects. This would allow greater collaboration between university and industry whilst creating biotechnology firms with more sustainable product pipelines and reducing the number competing for development funding (Executive C, E).

*"Government money is probably best spent on keeping Australian science competitive, so you hire and retain the best [academic scientists] and it is up to the companies to be creative, to translate that into something, rather than subsidizing more companies to be fed with capital." – Executive H*

#### *4.2.1.2 Subsequent funding – Venture Capital*

Following initial rounds of pre-seed and seed funding to start up biotechnology businesses there is a lack of funding available to sustain the core business activity of research and development. In the United States (US), participants in the most successful biotechnology industry in the world[14] have traditionally been able to source substantial development funding from venture capitalists (VCs). The impact of this has been that biotechnology companies seeking a public listing in the US are generally more mature than those in Australia, with significantly more scale and more advanced research and development programs (Ernst & Young 2006) which have already passed a number of regulatory hurdles prior to IPO.

The nature of the biotechnology industry, with its high risk profile and long lead times in product development, means that likely returns to local venture capitalists will often not meet their expectations. An Australian venture capitalist will often invest with a goal of achieving an annualised return of around 40% over a three to four year period (Executive A). Given that the average time to develop a pharmaceutical product is 12 years[15] (DiMasi, Hansen and Grabowski 2003), there is significant contrast between the industry value chain and VC return preferences (Executive A).

In order to overcome this disparity between product development times in excess of 10 years and a three to four year investment horizon, an IPO is often used as a vehicle to provide a return to the venture capitalist (Executive C, E). This requires VC funded biotechnology companies to move to IPO whilst their products are still at a stage where significant investment of time and capital is required prior to market release. The immaturity of the development pipeline means that the issuing company has a limited size at IPO and as a result can only raise limited funds and often an order of magnitude less than that required to successfully develop a product. If the VCs had a longer investment horizon they could work with the businesses to bring in secondary investors and grow the business to a more sustainable size prior to IPO (Executive C).

[14] In 2005 the US was home to 49% of the worlds public biotechnology companies who contributed 76% of the revenues produced globally by the sector (Ernst & Young 2006).

[15] Debate exists as to the impact of increased regulation on the time required for clinical trials however Keyhani, Diener-West and Powe (2006) find that the time spent in development has not increased between 1992 and 2002 which supports DiMasi, Hansen and Grabowski (2003).

The short term investment horizon of local venture capitalists is not a phenomenon that is experienced in the US. Successful biotechnology companies in the US often go through numerous rounds of venture capital fund raisings prior to listing which enables them to raise significantly more funds at IPO which, in turn, improves the likelihood of success through more diversified development programs (Executive C).

As an alternative source of venture capital funding, successful biotechnology companies can look to international markets to secure development capital prior to listing. The US venture capitalists are a potential source of funds for the local biotechnology industry. However, competition for funding at an international level will ensure that only those businesses able to compete internationally will be successful (Executive F).

The risky nature of the drug development industry implies that firms able to diversify their research effort should be able to improve their risk profile. Conversely, venture capitalists will often invest in a biotechnology company with the proviso that funds will be channelled into one lead product (Executive H). In a cash starved industry this may be a necessity, however, it serves to exacerbate the risky nature of the industry and further promotes the creation of businesses with narrow product pipelines.

Whilst the lack of venture capital funding in the biotech industry is often cited as having a negative impact, at the firm level there is also a downside to VC involvement. As the biotechnology industry is a comparatively risky business, VCs wanting to minimise their investment risk will negotiate extremely tough terms. To protect their investment, VCs will often demand preferred shares to ensure that in case of business failure they would receive some return prior to any remaining assets being divided amongst the remaining shareholders.

> *"VC involvement is not always good. If you were a founder, it is bad. ... VCs take preferred shares, and if you are a founder you only get common shares. So everything is fine if everything is fine, but once you start having to liquidate a company a VC extracts a 200% or 300% return before the pie gets divided." – Executive H*

Given the difficulties with raising development capital from VCs, biotechnology companies will often go to the public markets as an alternate source of capital. Whilst

there are additional costs and issues associated with being a listed entity, relative to the onerous demands of a VC term sheet, the public markets can be a more accessible and less restrictive source of funding for many Australian businesses (Executive E).

### 4.2.2 IPO

As a result of the lack of development funding available through venture capitalists and other sources, Australian biotechnology companies tend to go to the public markets for funding through an IPO at a much earlier stage compared with those in other developed countries.

> *"In effect the public listing market in Australia has acted like a venture capital market, because we have not had a venture capital market." – Executive E*

Raising capital via an IPO is likely to be the largest capital raising in a young biotechnology company's life, however, the amount of capital raised will be well short of that required to successfully develop a new pharmaceutical product. In the analysis presented in Chapter 5, involving 34 Australian biotechnology IPOs between 1994 and 2004, the average amount of capital raised was $23.4 million or $11.2 million excluding CSL and Cochlear. A capital raising of $11.2 million is an order of magnitude below what is required to successfully bring a product to market and, if the probability of success is included in the calculation, it is two orders of magnitude below what is required. If additional capital were available, biotechnology companies would have a more mature product pipeline when they eventually go through the IPO process. This would enable them to raise larger amounts of capital from the public markets, thus creating a more sustainable group of publicly listed biotechnology firms (Executive B). Having a more mature product pipeline and more capital for product development would change the risk profile of the listed biotechnology sector and, in turn, encourage greater investor interest in the secondary markets.

A listed company faces increased administration and corporate governance costs on top of the huge investment required to successfully bring a pharmaceutical product to market. Whilst an IPO may be a source of funds accessible to Australian biotechnology businesses in the event that there are no alternative options of sufficient scale, they should be wary of pursuing this avenue without due consideration of the associated costs of being a listed company.

*"The whole system here really pushes companies out [into the public market] prematurely and sets them up for failure." – Executive C*

### 4.2.3 Life after IPO

The aim of going through an IPO is to source a significant amount of funds. However, for a small biotechnology company, the costs related to being ASX listed can represent a significant proportion of total costs, taking away money that could otherwise be invested in the core business of research and development. On top of the direct costs of meeting listing obligations, the increased administrative workload means that staff is distracted from operational roles within the business, restricting the resources that are available for value-generating research and development. This is a heavy burden on cash starved businesses in the sector which could be avoided if companies were able to find sources of funds other than the public markets (Executive A, E).

Whilst the industry could benefit from consolidation (refer section 4.2.1.1), owners of the businesses will often be reluctant to hand over control of their research and development project. This can be especially relevant where the owner is a founding scientist.

*"There is talk about M and A's coming in, aggregating the industry and in theory that is fine ... [However] you have still got owner interaction at the research and development level and they are not prepared to give up their babies at this stage." – Executive A*

#### *4.2.3.1 News Flow*

Continuous disclosure obligations of the ASX require that listed businesses must disclose all price sensitive information to the public as and when the company becomes aware of it. This news flow is assessed by the investing public which estimates the impact on the business and hence on the value of its shares. For biotechnology companies, the volume of news flow produced is often relatively low compared with the market as a whole and this is magnified when a biotechnology company has only one or few products in development (Executive C, G). A lack of news flow potentially creates investor uncertainty regarding the state of the business and, as uncertainty increases, ceteris paribus, the company value potentially decreases.

*"Australian Biotechs are forced into the public domain early, and the consequence of that is your share price is being re-rated daily, usually on information that is unrelated to your actual progress." – Executive G*

#### *4.2.3.2 Secondary Market*

Demand for biotechnology shares in secondary markets is generally low as typified by low trading volumes and limited involvement from institutional investors and investment funds. Poor demand for shares makes it difficult for listed biotechnology companies to raise additional funds in the domestic market (Executive E). Whilst an IPO is a funding mechanism which generates a substantial inflow of capital, firms need to be wary of their longer term capital requirements prior to committing to a public listing. Additionally, given the small market capitalisation of firms, sale of additional shares will result in dilution of control of the existing shareholders (Executive H).

Performance of biotechnology shares in the secondary market will be dependent on mainstream investor confidence in the biotechnology value proposition. As business models mature and products are launched, improved company risk profiles will see increased investor interest, which will drive greater attention from financial analysts. As investors become more familiar with the industry, confidence in the value proposition should improve. This should see increased investment in the sector enabling firms to capture more value from their IP as they are able to finance products further down the value chain.

*"Private funding tends to be fairly small amounts of money. It need not be if super funds or investment funds gain more confidence over time." – Executive G*

#### *4.2.3.3 The Investment Community*

The high risk profile of businesses in the sector is exacerbated by the infancy of the industry, which in turn does not inspire investor confidence in the value proposition. The immaturity of businesses is exemplified by the high proportion of businesses with products in the early stages of product development and the lack of diversity in product pipelines.

*"Apart from two or three, no one has a product even close to the real market stage, where they will have a large distribution income coming in … While that is the case, the investment market, is going to be, naturally, a bit wary." – Executive B*

As businesses mature and we begin to see models for success, interest in the sector from the investment community should begin to rise. Increased investor attention will demand greater analyst coverage of the sector which, as the analyst base gains experience, will help to direct cash flows into the sector. Currently there is a lack of experienced analysts with the ability to adequately evaluate investment opportunities and offset some of the investment risks associated with the industry (Executives C, E, G).

Without an experienced analyst base, an important moderator of investment opinion is missing from the sector. This is compounded by the low levels of news flow generated by industry participants, the result of which is stock market valuations which are subject to large variations and largely sentiment driven (Aegis 2006a).

> *"In the biotech research and development area the market is not particularly sophisticated and can be very speculative because people jump to conclusions" – Executive A*

Whilst the risks associated with investment in biotechnology may deter potential investors there is investment money available for risky ventures such as the mining industry (Executives A, G). Similar to biotechnology, the mining industry evolved from a base of speculation-driven investment to become an industry with an informed analyst base, able to assess opportunities and provide the investment community with a comparative indication of quality (Executive A, E, G).

The diversity of the biotechnology industry makes evaluation of opportunities difficult because, unlike the mining industry, there is no homogenous information base (such as mineral purity levels) which can be used as a measuring stick (Executive G). Despite this challenge, development of an educated and experienced analyst base would provide the industry with a mechanism for directing funds into the sector.

> *"[Australian investment] fund, are quite happy to have a go at speculative things such as mining ventures … however there isn't a good analyst base in the Australian biotech markets. There are not people who are the gatekeepers of what is good and who is not good." – Executive E*

As a result of a lack of an informed investor base, money is not efficiently channelled out of underperforming businesses into those with product portfolios of higher potential and more sustainable business models. As a result we have not seen a significant number of failures in the industry and the businesses that require and deserve additional funding have greater difficulty in sourcing it due to the increased competition.

> *"There is no culling process in the Australian market. ... time will sort that out to some extent, but the more non-informed money is available, the less of that culling process occurs." – Executive E*

#### i Superannuation Investment

The superannuation sector is a potentially significant source of funds for the biotechnology industry, through direct investment in IPOs and secondary markets as well as indirect investment through VC funds (Executives E, G). Given the risky nature of the industry, any investment by superannuation funds would have to be carefully managed to protect the retirement nest eggs of fund members.

> *"I would be ropable if I thought that my super fund was investing in these companies which are no place for widows and orphans." – Executive A*

In the US, superannuation funds invest in VC funds, which in turn invest a proportion into the biotechnology sector (Executive E). In this way, the experienced VC industry acts as a mechanism to direct capital towards the most attractive opportunities, helping to mitigate some of the risk associated with the sector.

#### ii Institutional Investors

Investors in biotechnology companies listed on the ASX are primarily retail, consisting of mostly 'mum and dad' investors with minimal representation from institutional investors. For a listed business, this means their shareholder base is very diverse, with few large holdings, and often held by investors without a strong knowledge of the sector. Problems also arise in that shareholders do not fully appreciate the challenges faced by the business and as a result are unsatisfied with their short-term returns (Executive C).

The diverse and segmented nature of a typical listed biotechnology company shareholder base creates an additional administration workload for management in

having to communicate with a large number of shareholders, many of whom do not fully understand the biotechnology business model and its associated challenges (Executives C, D, E). Time spent by staff managing their shareholder base is considerable and distracts staff from the core business. This is particularly a problem for companies which have no investor relations team between senior executives and the shareholders.

If there were greater involvement in the sector from institutional investors, the breadth of the shareholder base could be reduced as the institutional investors have the scale to hold large parcels of shares (Executive C). To facilitate greater institutional investment in biotechnology, a more experienced and educated analyst base is required to direct capital to the most deserving firms (Executive E). This would benefit the industry, enabling those businesses with large institutional investors to more efficiently communicate with their more consolidated shareholder base. Additionally, an increase in 'educated money' in the sector would reduce the dramatic impact that sentiment currently has on share prices (Shiller 2005).

### 4.2.4 An International Comparison

The therapeutic drug market is globally competitive, thus it is important that the environment in Australia be structured to allow locally-based companies to compete on a global scale. As a result of the relatively meagre availability of funds to the domestic market, Australian biotechnology firms are much smaller than those in the US with less diverse product pipelines and the subset of companies listed on the stock exchange typically have products at a much earlier stage in development.

The biotechnology industry in the US leads the world, with the average revenue per US listed biotechnology company being more than three times that of the rest of the world (Ernst & Young 2006). Unlike Australia, VCs in the US are actively involved in the sector and a typical firm could expect multiple rounds of VC funding prior to IPO. As a result, the average size of biotechnology IPOs in the US is significantly larger than those in Australia. During 2005 there were 13 IPOs in the US at an average of over USD $48 million compared with 10 in Australia at an average of around USD $5 million (Ernst & Young 2006).

One interviewee with extensive first-hand US experience describes the contrast with the Australian situation:

> *"The model in Australia seems to be to get some early stage funding drip feeding into the company and with no idea of building value before being subjected to the vagaries of the public market. In the US a company would start off funded by a university or whatever and it would go maybe 4 rounds of private equity and build itself to the point where, at IPO it could come out with a market capitalisation of $100m. It would not want to come out until it had some products in the clinic and ... a reasonable news flow." – Executive C*

#### *4.2.4.1 Foreign Listings*

For Australian companies to access the US financial markets requires a scale not currently seen in the domestic sector, apart from the most mature players who do not have the same capital requirements as the early stage businesses. Typical US investment banks require firms to have a market capitalisation of greater than $150m before being able to access public markets in the US (Executive E).

Australian firms face a significant challenge to achieve the scale required to source capital through a public listing in the US. If they can overcome this challenge, the rewards are potentially significant as a cross-listing in the US has been shown to improve valuation multiples (such as price-to-book and price-to-earnings) for foreign based firms (Sundaram and Logue 1996). Thus if Australian-based firms can list on the US markets then they should realise a higher valuation as well as greater access to capital (Executives B, C, E).

US investors prefer a local presence as this enables efficient management of communications (Executives C, E). Unfortunately, the cost of setting up and maintaining a foreign base challenges the viability of maintaining that base (Executive D). Whilst this is a significant consideration, the potential rewards in the form of improved valuations and access to capital to drive growth in the company make the additional expense a worthwhile investment if the expansion is strategically managed.

The Sarbanes-Oxley reporting requirements currently being implemented in the US create an almost insurmountable financial burden for a firm the size of a typical Australian biotechnology company. Conversely, educated investors will realise that it is

not in their interests to have small research and development firms spending their limited capital resources on reporting when those funds could otherwise be spent on productive research (Executive B). It remains to be seen what reporting requirements will be placed on the smaller firms, however, whilst this is being decided, the availability of the US public markets to smaller biotechnology firms remains uncertain.

> *"If the US regulators are going to try and put the same standards for larger companies on to the smaller ones, costs will be horrific." – Executive B*

## 4.3 BUSINESS MODEL

The immaturity of the Australian biotechnology sector means that very few products have been successfully developed. As a result there is no proven road map for success in the local sector which adds to the uncertainty in the industry (Executive C). Until successful business models emerge we will continue to see diversity in the manner in which firms extract value from the field.

Typically an Australian biotechnology business looks to develop its products as far through the development cycle as possible, given the firms funding constraints. Once the business approaches a point where it is unable to fund further development, management will look to licence the product to a partner, usually a pharmaceutical company, which has the ability to fund the remaining development process and facilitate commercialisation. Generally, the partner will provide the biotechnology firm with cash flows in the form of a sign-on fee, milestone payments attached to key development hurdles and a royalty based on the sales volume of the final product (Executive D).

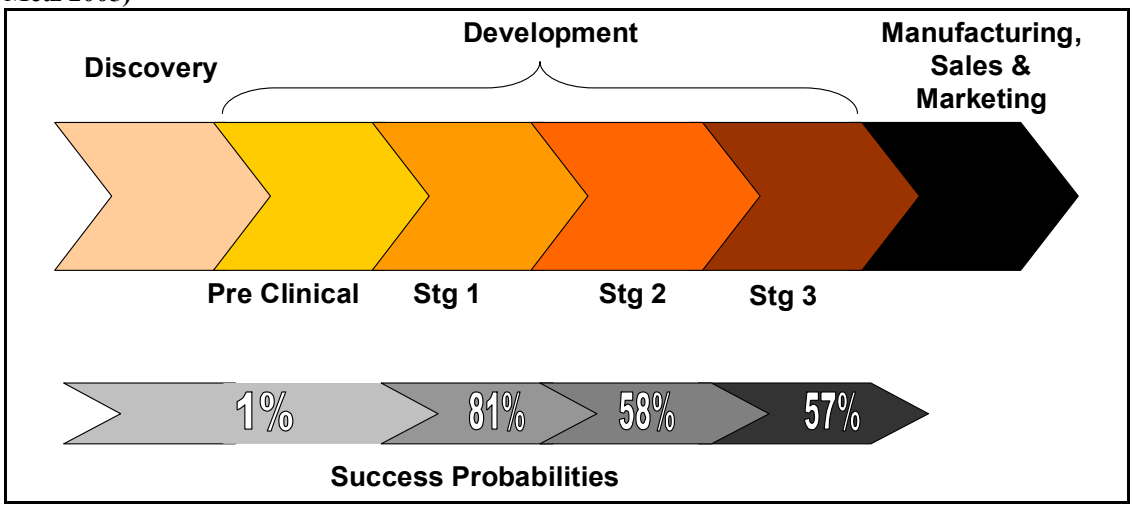
Traditionally, a firm would look to reinvest a portion of profits into the business to fund research and development in order to maintain a competitive advantage and protect future income streams. Unfortunately, very few Australian biotechnology companies have evolved to the stage where they have a reliable income stream from which they can finance research and development efforts. As a result of the shortfall in capital available to the local industry, firms are wholly dependent on their ability to out licence their products in order to further their research and development programs.

*"I see the business model in Australia as completely flawed. Discover something, sell it early and wait for somebody else to do something." – Executive F*

### 4.3.1 The Biotechnology Value Chain

A simple depiction of the drug development value chain is shown below in Figure 4-1. Based on data from the US, only 1% of the total number of new therapeutic research projects that are commenced can expect to make it into clinical trials, and of those that do make it into clinical trials, only around 25% will successfully make it through to registration with the Food and Drug Administration (FDA) (Abrantes-Metz, Adams and Metz 2005).

**Figure 4-1 Biotechnology Value Chain & Development Success Rates (Abrantes-Metz, Adams and Metz 2005)**




The set of Australian biotechnology firms listed on the ASX represents a subset of the biotechnology industry as a whole and comprises the most mature firms in the industry. Among those, generally the most advanced product in the pipeline will be in the early stages of development, with only a minority having a product at phase two clinical trials or later. For a product entering phase two clinical trials, the probability of successfully bringing that product to market is only 33% (0.58 * 0.57) thus a company with only one or two products in their pipeline has considerable exposure to the risk that none of its products make it to market.

**Table 4-1 Benefits of Diversified Development Portfolio - Probability of Market Launch**
This table shows the probability of at least one product in a portfolio of X products being successfully launched on the market (where X is a number from 1 to 5). For the sake of simplicity, this table assumes all X products are at the same stage of development. The probabilities shown in this table have been calculated based on the probabilities of successfully passing each round of clinical trials published by Abrantes-Metz, Adams and Metz (2005) and assume that the probability of successful completion of each round of clinical trials is independent of the result in the previous round or the results of other products in the pipeline.

| | Number of Products | | | | |
|---|---|---|---|---|---|
| Development Phase | 1 | 2 | 3 | 4 | 5 |
| 1 | 26% | 46% | 60% | 71% | 78% |
| 2 | 33% | 55% | 70% | 80% | 86% |
| 3 | 57% | 81% | 92% | 96% | 98% |

In order to minimise the exposure to the risk of failing to successfully bring a product through clinical trials, a biotechnology company must have more than one product in its pipeline. Table 4-1 above has been computed based on the data from Figure 4-1 and shows the diversification benefit of each additional project in the pipeline. The table shows the probability of a firm successfully bringing a product to market depending on the number of projects in the pipeline and the development phase of those projects. Interestingly a company with three products in phase 1 clinical trials has a 60% chance of successfully bringing at least one of those to market whilst a company with two products in phase 2 clinical trials has only a 55% chance of successfully bringing at least one to market.

> *"If you want to build something of substance, something that has any chance of viability, it has to have a portfolio." – Executive C*

A company that has a project closer to completion of clinical trials has a greater likelihood of converting that expense-generating project into a consistent revenue-generating product and thus producing profits. Without a fully developed product, biotechnology firms are reliant on milestone payments for revenue which are uncertain and lumpy by nature and, if they are the only form of revenue that a firm has, the business will be challenged to manage the regular expenses of a development program.

*"Take science out of it and have a look at the fundamentals of the businesses that we are building here. They are flawed. ... You cannot actually build a business on lumpy milestones. You might get a milestone but if the project falls over then you are back to square one. So should we not actually be going the other way and saying, right, let's get products first, let's get revenue and from that, build up the intellectual property. ... We have in-licensed a later stage product, because it has a very high probability of success. ... Ideally we would go after something that was on the market, so that we could actually sell and make profit. It is all about making profit; businesses only grow because of profit." – Executive F*

#### *4.3.1.1 Evolution*

*"One never really realises the full benefit of pharmaceuticals until one is actually the owner of the marketed product and shares very substantially in the final market product" – Executive D*

Currently Australian biotechnology companies are at the early stages of product development and dependent on licensing deals with pharmaceutical companies to generate revenues. As products are developed and move through the value chain to eventual market launch, the revenue stream for biotechnology companies will lose the inconsistency of milestone payments and begin to correlate with product sales. This will provide biotechnology companies with a source of capital to fund further research and development enabling them to maintain ownership to a point closer to market launch prior to seeking a licensing partnership with a larger pharmaceutical company. Biotechnology companies would thus be able to capture more of the value created through product development which will in turn generate greater returns to shareholders.

As a product in development moves through the value chain, the likelihood of successfully making it to market increases with each step in the process. Thus, *ceteris paribus,* a biotechnology company with product(s) closer to market launch has a reduced risk profile. Biotechnology companies will naturally evolve with their products and move down the value chain. However, to expedite the process and improve the business risk profile, acquisition of products further down the development pathway can improve the value proposition for potential investors and increase the amount of development capital flowing into the business. Unfortunately, due to the capital

constraints of the sector, acquisition of late stage research is an option only available to a subset of the industry.

> *"We had too many things at the start end of the pipeline. We needed to get hold of something that was closer to fruition so that we had a better story to tell." – Executive B*

Movement down the value chain brings a new set of challenges and biotechnology firms will need to expand their existing skill sets to meet those challenges. Once a product has regulatory approval there is considerable investment required to successfully manufacture, market and distribute the product. Existing pharmaceutical companies have proven competencies in manufacturing therapeutics to meet global demand, combined with distribution networks with global reach and established sales and marketing teams. A small biotechnology company cannot hope to compete with these established players, however, opportunity exists for biotechnology companies to move into this space with niche products.

i Expansion through Specialisation

Product sales ultimately depend on those responsible for treating a particular disease or condition prescribing that drug for treatment. A product that is typically sold through a pharmacist via referral from a general practitioner will require an extremely large marketing effort and sales team to reach the general practitioners. Products that are administered directly through a specialist clinician will require significantly less marketing and sales investment as the number of specialist clinicians will be far less than the number of general practitioners. The reduced cost to distribute and market a product to specialist clinicians provides biotechnology companies with the opportunity to expand beyond pure product development and into sales and distribution, enabling them to capture more value from the therapeutic development chain (Executives C, F).

An example which highlights the differing marketing resource requirements of drug are a cancer chemotherapy treatment versus an asthma treatment. The asthma drug is administered by the patient and distributed through a retail chemist via prescription from a general practitioner, whereas, the cancer chemotherapy treatment will be distributed and administered directly through the treating clinician. The number of

treating clinicians will be significantly less than the number of general practitioners allowing a much smaller sales force to service the former market.

The concept of distribution to specialist clinicians using a small sales team was coined a "specialty pharmaceutical business" by Executive F. A small sales team is able to work closely with the research team responsible for developing the drug which should see the evolution of a highly educated sales team able to more effectively interact with the administering clinicians. Development of close relations with the clinicians allows information to flow from the research team to those administering the product and back from the clinician and patient to the research team (Executive F). This assists the biotechnology company in effectively managing and responding to challenges and opportunities as they occur.

The small size of the Australian relative to the global market creates an opportunity for local biotechnology companies to move down the value chain locally whilst partnering with a larger pharmaceutical company to supply to the larger global markets. This strategy will allow the biotechnology company to expand their business model and gain expertise in sales and distribution in Australia. As additional products move through the development pipeline, opportunity exists for the biotechnology firm to leverage off this experience and expand into nearby emerging markets. This process of regional expansion into product commercialisation was described as a company goal for the majority of executives in the study.

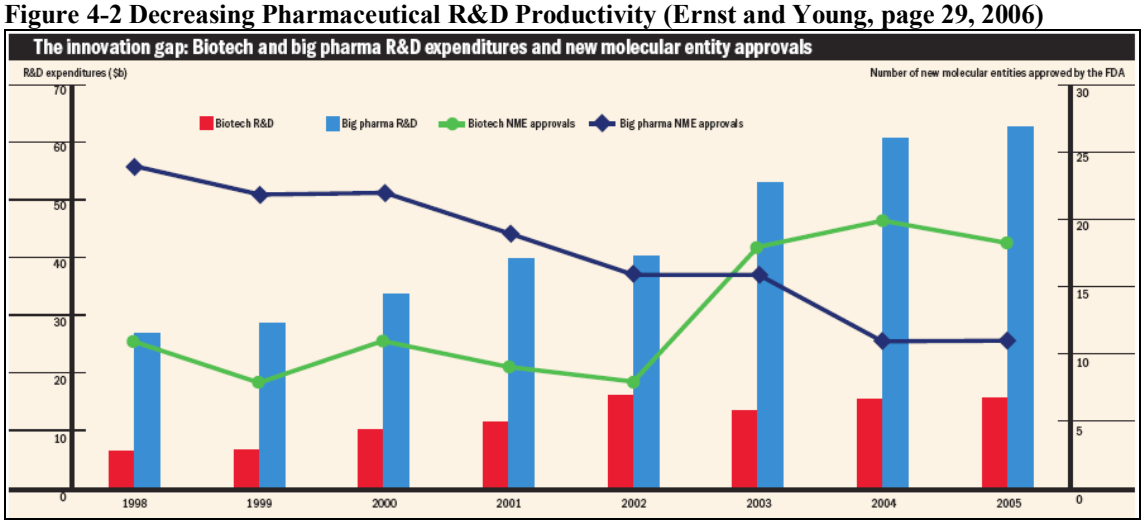
> *"Once you build something in Australia you can build it out regionally. Obviously there are emerging markets that are closer to us than to our potential partners overseas." – Executive C*

### ii Business Evolution and Value Capture

Evolution of the biotechnology business model down the drug development value chain is seen as the mechanism for capturing a greater portion of the total value generated in the process. The notion of capturing additional value as products move through the value chain is based on historical deal terms for out-licensing products at different stages in the development cycle. Traditionally there has been a disproportionate increase in the value of terms negotiated (compared with the additional cost incurred) for each successful step in the chain (Kalamas, Pinkus and Sachs 2002).

Recently there has been a change in the competitive landscape for biotechnology products, with existing pharmaceutical companies challenged by ageing pipelines and increasingly looking to in-license biotechnology products to fill the shortfall in development stage products. Figure 4-2 below shows how pharmaceutical firms have been investing greater amounts of capital for decreased return in contrast to the biotechnology sector.

**Figure 4-2 Decreasing Pharmaceutical R&D Productivity (Ernst and Young, page 29, 2006)**




With reduced internal research and development productivity, pharmaceutical companies have increasingly come to rely on biotechnology firms as a source of new products. This has seen an increase in the demand for biotechnology products at all stages in development (Belsey and Pavlou 2005).

The stage at which a biotechnology company is willing to out-licence a product will be largely determined by the terms of trade they can negotiate at that stage in development. If biotechnology firms were offered/able to negotiate more favourable deal terms for earlier stage products, we could see an increase in the number of deals done earlier in the value chain and a shift in value capture, away from the later stages back through the pipeline.

The amount a pharmaceutical company should pay for early stage products will be influenced by the likelihood of a product successfully reaching the market, thus an early stage product should have a lower value than a later stage product. Kalamas, Pinkus and Sachs (2002) state that the terms offered by pharmaceutical companies to in-license products from biotechnology firms are disproportionately higher for later stage products

given the probability of successfully developing an early stage product. Their Monte Carlo analysis of drug licensing deals shows that pharmaceutical companies would be better off increasing the number of products in their portfolio to diversify product development risk by offering more attractive terms for earlier stage products. Recent financing trends indicate that large pharmaceutical companies are indeed looking to partner with biotechnology firms to develop products from earlier stages in the product development chain (Anderegg, Thayer and Williams 2006).

If pharmaceutical companies offered more attractive terms for early stage products, early stage biotechnology firms would be able to capture a greater portion of the value generated through the drug development value chain. Dwindling efficiency of in-house pharmaceutical research and development has resulted in an increased focus by big pharma on early stage biotechnology research (Jones and Clifford 2005). Should this trend continue, the potential exists for a paradigm shift in the traditional biotechnology model, away from evolution down the value chain, towards biotechnology specialization in discovery and early stages of drug development. This shift towards a more segmented industry, with participants focused on one or few components of the value chain, is comparable to the personal computer industry where different components, such as the processing chip and memory, are manufactured by different suppliers. Greater focus on a narrower segment of the value chain would allow firms to focus their expertise and could lead to increased efficiencies industry-wide (Executive H).

#### *4.3.1.2 Sustainability*

The current Australian biotechnology business model, which has one or few products in early stage clinical trials and aims to out-licence to a big pharmaceutical company in exchange for milestone payments and royalties, is not seen to be sustainable given the low probability of successful development and current deal terms. In order to develop into sustainable businesses, Australian biotechnology companies need to increase their expected return on investment, which could be accomplished by carrying their products further through the value chain and/or negotiation of better deal terms with pharmaceutical companies.

The ageing pipelines of pharmaceutical companies (see Figure 4-2 above) provide evidence of the difficulty in sustaining the biotechnology business model. With the

majority of value generation skewed towards later stages in the development cycle, pharmaceutical companies have increasingly evolved to focus on late stage development, manufacturing, distribution and sales with discovery and early development done by small biotechnology firms (Executive D).

The majority of participants in the study saw the successful biotechnology firm of the future occupying a greater space in the drug development value chain. In order to sustainably occupy the development space, firms would need to continue to bring new products into their pipeline to replace older products as they mature and move towards patent expiry. New products could come from internal discovery programs and would also require firms to license in early stage products. (Executives A, B, C, D, F).

To mitigate the risk of project failure and improve the sustainability of the biotechnology business model, firms should look to increase the number of research projects in their pipeline (refer section 4.3.1). The capacity for increasing the number of projects in their pipeline is limited by access to capital, however, through merger and acquisition, economies of scale can help to realise cost saving synergies at the same time as reducing the business risk profile. Recent activity in the industry, such as the acquisition of Meditech by Alchemia, improves the survival prospects of the industry, by improving administrative efficiencies and diversifying product development risk.

### 4.3.2 A Response to the Funding Environment

> *"The lack of funding is definitely going to have an impact on the model because models are usually a consequence of environments." – Executive F*

Australian biotechnology firms are constrained by a lack of capital from broadening their business model to occupy a greater portion of the drug development value chain. To achieve this will require additional funding, both from sources external to the business coupled with internally generated cash flows as current products in the pipeline begin to reach the market and generate royalty revenue streams (Executive F). Therefore, without access to substantial capital in the near term, expansion of scope across a broader section of the value chain will be achieved in incremental steps.

The typical business model of a biotechnology firm is to undertake research and development to identify new chemical entities and develop them to a point where they are able to get a return commensurate with the investment, and exposure of the business (Executive D). Unfortunately for Australian biotechnology firms, the point at which they are forced to out-license their product is often determined by their ability to continue to fund development as opposed to development reaching a point where a sale would generate optimal returns for the business.

For the local industry, the lack of development funding means that firms are forced into a sale of their intellectual property (IP) at too early a stage, with the purchaser usually being a foreign company (Executive F). As the major part of value capture is skewed towards the later stages in product development this means that significant potential wealth gain is lost from Australia to the benefit of competing international industries.

The nature of the Australian biotechnology industry means that the majority of firms in the sector have their business models influenced by their access (or lack thereof) to capital. However, firms need to be careful in their communication with investors and potential investors during fund raising activities as the message they portray regarding the urgency of their capital requirements can affect their ability to raise capital. If investors are aware that fund raising is driving the business then the company will be penalised in the form of reduced valuations combined with greater difficulty sourcing capital (Executive B).

The largest risk to a biotechnology firm is the risk of failure in product development (Executives B, E). Following product development risk is the risk that a firm will be unable to source the level of funding required to run their development program to a point where they are able to capture a commensurate portion of the value generated (Executive E). Whilst the business model should not be entirely dictated by access to capital, the formation of the company should be determined with consideration of potential investors (Executive A). For a company with multiple research opportunities, a focus on one which has greater potential for external investment will allow the company to source more capital to drive development of proprietary technology which can later be applied to subsequent products in the pipeline (Executive E).

The inability of Australian companies to raise the level of capital necessary to develop their pipelines to a point where a sale is motivated by fulfilment of firm objectives as opposed to a need for funding has had some positive impacts on Australian businesses. Firms are forced to look at international funding opportunities, which is appropriate given the global nature of the market for therapeutic drugs (Executive B). Additionally, Australian biotechnology companies have evolved into more streamlined businesses compared with their US competitors (Executives A, B, C, D, E, F).

The reduced scale of Australian firms has allowed them to control costs, however, it can also affect their ability to be internationally competitive. By keeping staff numbers low, the ability of a firm to recruit the range of skills necessary to be internationally competitive is compromised and this is evidenced in the lack of products that have been successfully developed by the local sector (Executive E). The reduced level of funding also encourages the model of a one-product company which will more than likely fail given the historical probabilities of successful development of pharmaceutical drugs (Executive C).

#### *4.3.2.1 Product Focused Companies*

A product focused company is one which is based on development of new therapeutic drugs – the product. These biotechnology companies rely on the successful development of their pipeline for revenues. However, given the funding environment in Australia, they will typically have one product that is the focus of their research effort and expenditure, with others at earlier stages in the development chain. Obviously the survival of a company is dependent on the successful development of products, however, given the historical probabilities of successful drug development, they are likely to fail if they have only one or few products in development. Unfortunately investors will often demand that efforts be focused on the most advanced product in the pipeline, which is setting the company up for failure (Executives C, G, H).

Those companies that are able to successfully bring a product to market have a revenue stream to fund their alternative research projects. Conversely, those companies unable to bring their initial product to market are in the unenviable position of having limited funding for their alternative projects in the early stages of development as a result of previous investment in one (failed) project. Once a company has invested a significant portion of their capital in their lead product, the survival of the business becomes

increasingly tied to the success of that product. As more capital is invested into that project it is progressively more difficult for the company to justify investment in alternative projects (Executive G).

Whilst investors may wish to increase the likelihood of the most promising product being successfully developed by focusing research effort and expenditure, the repercussions are potentially damaging for the business and sector as a whole (Executives A, C, E, G). Historical probabilities suggest that companies focused on one lead product are more likely to fail. Given the current level of investor uncertainty towards biotechnology, combined with the large impact of investor sentiment on company values, failure of one or few biotechnology companies is likely to see an exodus of capital out of the industry which will further jeopardize the prospects of the remaining firms (Executive A).

The benefits of diversification need to be carefully considered given the complexity associated with each research project. Whilst there are obvious benefits to diversification in terms of risk management, firms should try to match their pipeline with their proprietary knowledge. The level of technical complexity involved with the development in one therapeutic area means that it is very difficult for a small firm to possess the knowledge required to run a second development project in a second therapeutic research area.

> *"In this business you want to be very focused on what you do. You build expertise in a particular area and you stick to it until such time as an expansion beyond that area makes sense." – Executive D*

Consolidation in the industry would see the formation of teams with greater diversity in research experience, enabling companies to sustain more diverse research interests. Despite the benefits of diversity in research specialisation, care must be taken to ensure that the complexities of all the research interests are understood at senior management level to enable intelligent strategic decisions.

#### *4.3.2.2 Technology Platform Companies*

Many biotechnology companies have ownership of a novel piece of technology with potential application to a variety of areas. Owners of a technology platform are usually

focused on developing one or few products using the technology, and through successful product development, generate significant revenues for the business and provide a form of validation for the technology.

The diversity of research alternatives generated by a technology platform creates opportunities for the owning biotechnology company to bring revenues into the business at an early stage by out-licensing the platform to firms with expertise relevant to a particular research application. In this way, the research is being conducted by those with expertise in its application, at the same time generating revenues for the owning business which can help fund its own product development pipeline (Executives C, H).

> *"I like to call it the 'pay as you go' model. You don't have anything yet, but you let other people use your platform, so that you can get something in return while you are building your own pipeline. It allows you to establish a business with cash flows as soon as possible." – Executive H*

The variety of potential applications for a technology platform provides the owning company with numerous research alternatives, providing a potentially diverse product pipeline for the business. This diversity poses similar challenges as those faced by a product focused company, in that there is often difficulty in assembling research teams with the ability to develop products from differing research areas (Executives C, E).

#### *4.3.2.3 Virtual Companies*

The "virtual" biotechnology company is one that conducts its drug discovery and development work external to the firm through a contractor(s) (Broderson 2005). This model has evolved in response to the scarcity of funding and allows more effective management of the operational costs of the business. This model allows managers to be flexible in choosing the best supplier of development talent whilst maintaining the ability to change the scope or scale of research activities quickly at minimal cost.

By outsourcing research and development work, virtual companies can potentially manage a more diverse product pipeline by ensuring that each project is in the hands of those with the necessary skills. This allows the firm to enjoy the risk mitigation benefits of diversification whilst still having projects optimally developed.

Despite the benefits of having a diverse pipeline being developed in the hands of experts in each of the relevant fields, management is still exposed to operational risks as a result of actual and perceived difficulties in understanding the complexities for each project. Whilst external consultants can provide expert opinion on the research programs, it is important that management have a high level of understanding in all of the firm's research areas in order to assess opportunities as they arise, and ensure firm resources are efficiently allocated. Investors will also be wary of an overly diverse product portfolio owing to concerns around management's lack of adequate expertise in all project areas (Executive A).

> *"Having somebody else outside developing [a product] means that you never properly develop the expertise within." – Executive A*

The virtual model relies on people external to the business working on product development, the key value driver for the business. The business is exposed to additional risks resulting from the loss of control through having people who are not employees of the business spending 100% of their time on the most important value driver for the firm. If the people working on the development projects are employed directly by the firm then the employees can feel truly a part of the company and in effect take some ownership of the program (Executive C). Additionally this means that the expertise that is developed throughout the process is kept in-house, enhancing the firm's level of proprietary knowledge.

### 4.3.3 Management

The quality of the management team is vitally important in ensuring that a company is able to successfully capitalise on its IP.

> *"I would rather have a first-class management team and a good product as opposed to a first-class product and a rotten management team." – Executive G*

Despite the magnitude of the capital requirements to produce a drug, participants in the Australian industry are mostly small businesses who are forced to actively manage their costs, including keeping staffing levels to a minimum. In the US the average number of employees per biotechnology company is around 100 which is in stark contrast to the

Asia-Pacific region which has an average of around 20 employees per biotechnology company (Burrill 2006).

The process of raising capital in a small company with limited human resources often requires personnel from different parts of the business to assist in the process. Staff are thus drawn away from core competencies. For a biotechnology company this will often mean taking scientists out of the laboratory, away from the primary value driver of the business and adding further delays to the long lead times associated with product development (Executive B).

In keeping staffing levels at a minimum to control costs, often staff will be required to manage a number of different components of the business, which can have employees working outside their primary skill set. The drug development industry is internationally competitive, thus, in order to successfully compete, Australian biotechnology companies must employ teams of internationally competitive experts. At current funding levels this is extremely difficult to manage and as a result the ability of the local industry to compete on a global scale is compromised (Executive E).

As products are successfully launched, the more consistent revenues generated through product royalties will allow biotechnology firms to expand the expertise of their management teams. This will enable them to conduct in-house a greater range of the tasks required to develop a product and facilitate evolution of the firm down the value chain (Executives C, E).

A particularly sensitive issue for the industry is the role of scientists in management of the business. A person with limited scientific background will have great difficulty in understanding the science driving the research and development programs and, as a result, find it very difficult to manage a biotechnology company with products at the early stages in development (Executive C). Managers of early stage companies should have the ability to understand the science and at the same time possess the skills required to be able to manage the research programs.

> *"You don't have to be a brilliant scientist to be a good scientific manager." – Executive D*

A biotechnology company that moves down the value chain and evolves from being a loss-making research and development company to a commercial operation will require a different set of management skills (Executive C). Management change can be a particularly sensitive issue for biotechnology firms where the founding scientists are involved in the management of the firm and are reluctant to give up control of their research and development programs (Executives A, E). Despite the challenges of management change, Sparling and Vitale (2004) found that firms at IPO were dominated by CEOs with a science background but in the years to follow a greater portion of CEOs with a business background moved into the industry.

### 4.3.4 External Relationships

The ability of biotechnology companies to maintain open communication lines with their suppliers, customers and competitors is vitally important. The sustainability of the biotechnology business model is dependent on the firm's ability to bring research projects into the company, add some value then move the project out to another company with the scale to complete clinical trials and provide manufacturing, sales and marketing expertise. Some discoveries will require development expertise that the biotechnology firm does not possess, requiring the project to be placed in the hands of a firm with the expertise to successfully add value to the project (Executive C). Without industry-wide links, the biotechnology business model becomes unsustainable and growth opportunities are limited.

Formation of partnerships to facilitate product development is a mechanism for biotechnology firms to develop expertise outside their core competency (Executive C). This can be particularly relevant for a company whose platform technology has application to a diverse range of research projects, some of which will likely require technical expertise that the firm does not possess. Through partnerships, biotechnology firms can expand their level of expertise which allows them to diversify their research pipeline, in turn improving the risk profile of the business.

Partnerships provide a form of validation of a firm's technology (Nicholson, Danzon and McCullough 2005) which can flow on to positively improve the ability of a biotechnology firm to attract additional partners as well as improve investor assessments of value (Executives C, H). Prior to the formation of a partnership, the

potential partner will assess the IP. Partnership formation is thus an indicator of the quality of that IP.

> *"As a small company it is important for us to get the credibility of working with companies that have names, size, and experience, much greater than us" – Executive C*

#### *4.3.4.1 Academia*

Academic institutions allow discovery research to be conducted with less commercial focus than industry-based research. All of the study participants agreed that the research done in the academic environment is vitally important for ensuring the continued development of IP to supply the Australian biotechnology industry.

> *"Academics are very good at the cornerstone research. It's not cost effective for an organisation to go and start to discover stuff, so all of our projects are collaborative with academia, perhaps with one or two exceptions." – Executive F*

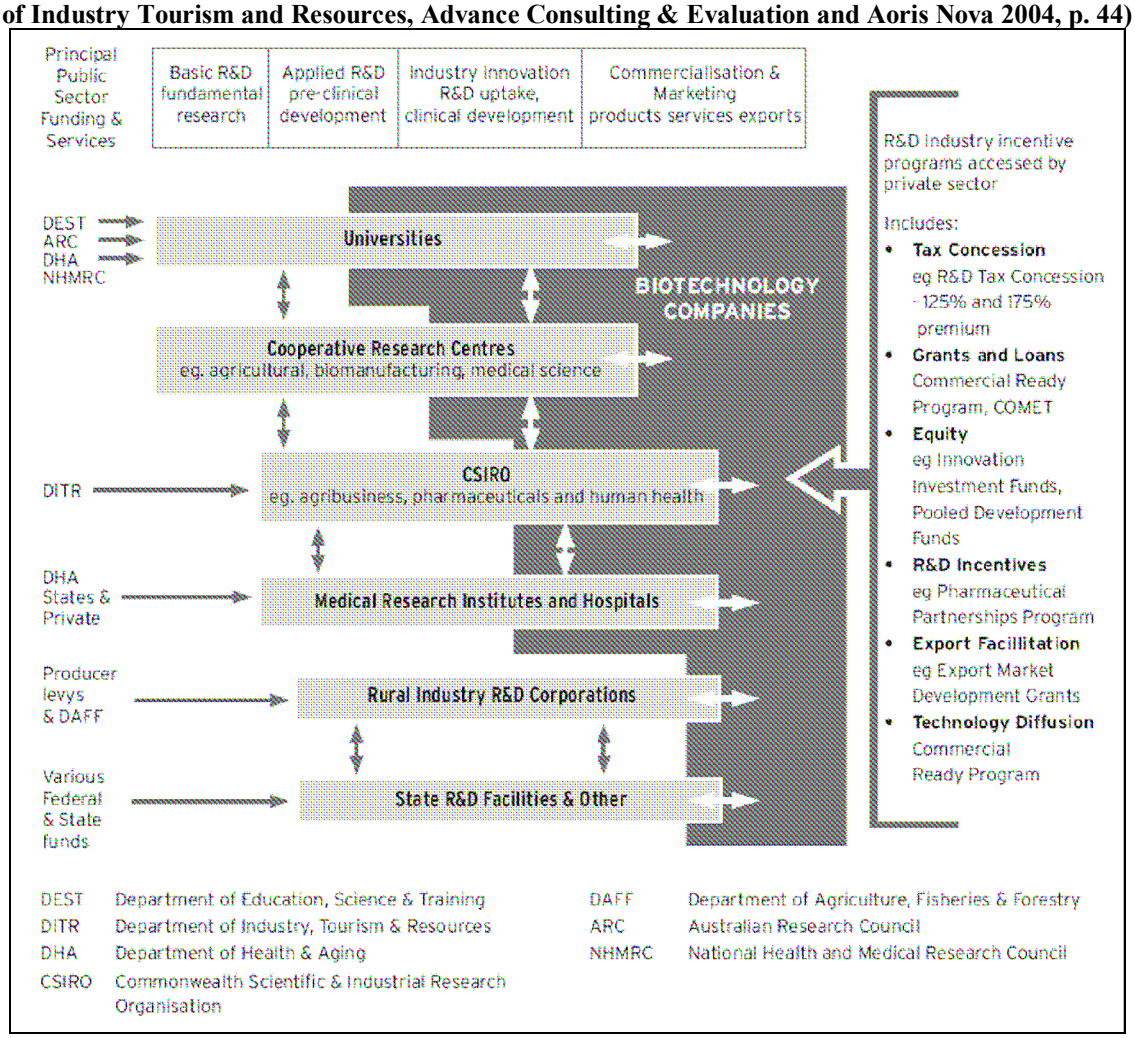
As the biotechnology sector matures, existing businesses will need to replenish their product pipeline, and academic spawned research will form an important source of new research and development projects (Executives B, C, D, E, F, H). The reduced commercial focus of research done in academic institutions allows for greater flexibility, providing an environment conducive to innovative research and discovery. A potential pitfall in the biotechnology sector relying on academia to supply early stage discovery research is that the flexibility and lack of commercial focus that is allowed also means that the outcomes from investment in academic research are uncertain (Executive H).

In order to ensure the sustainability of the biotechnology business model, a number of the study participants cited greater interaction with academic researchers as important. Executive F saw greater collaboration through focused funding from industry to academics as allowing them to focus on research thus reducing the time spent raising money through government grants. The biotechnology company would work closely with the academic and in return for providing funding would have some influence in the direction of research.

The current availability of seed funding encourages promising new discoveries in the academic system be spun off into new business entities (Herpin, Karuso and Foley

2005) with two thirds of all start-ups in the year from July 2002 to July 2003 coming from research institutes (Department of Industry Tourism and Resources, Advance Consulting & Evaluation and Aoris Nova 2004). Figure 4-3 shows the diversity in funding initiatives available to public sector research. The large number of small start-up companies serves to increase competition amongst existing biotechnology companies.

**Figure 4-3 Public Sector Funding Initiatives to the Australian Biotechnology Industry (Department of Industry Tourism and Resources, Advance Consulting & Evaluation and Aoris Nova 2004, p. 44)**




Once existing biotechnology firms begin to move products out of the laboratory and into the market, proven pathways of successful product development will emerge (Executive C). Rather than being spun off into new business entities, new ideas from academia should be commercialised through the leading biotechnology firms with a proven history of development and success in taking research discoveries through to products on the market (Executives C, E). To facilitate this process, greater communication between industry and academia is necessary, combined with creation of a culture within universities of assisting industry as an integral part of the

commercialisation process as opposed to acting as a competitor to industry (Executive E). Governments can encourage this process through an adjustment to the current funding regime, with more considered funding of start-up ventures and greater funding for successful development programs (refer section 4.2.1.1). The current research and development tax concessions are designed as an incentive for innovation, however for loss-making biotechnology companies, the value of the future tax offsets are reduced as short term capital requirements could cause firm failure prior to profitability and realisation of the tax concession[16].

#### *4.3.4.2 Big Pharma*

The later stages of drug development are dominated by the pharmaceutical industry. Large multinational pharmaceutical companies have developed the infrastructure to successfully manufacture, distribute and sell therapeutic drugs on a global scale (Executives B, C). The relative size of Australian biotechnology companies compared to the existing infrastructure owned by pharmaceutical firms means that they are unable to compete in the late stages of the value chain in the large world markets (Executives A, B, C, D). Pharmaceutical patent expiries and difficulties in replenishing their product lines from in-house research creates opportunities for biotechnology companies to work with pharmaceutical firms in the earlier stages of the development cycle and gain exposure in the large international markets (Executives A, B, C, D, E).

With Australian biotechnology companies unable to raise the capital required to fully finance development of their products, they are dependent on external relationships to bring products to market. The partner provides the capital, scale and expertise to bring the product through the final stages of development, registration with the relevant regulator, manufacturing, distribution, sales and marketing. In the majority of cases this partner will be a large international pharmaceutical or biotechnology company and biotechnology companies must manage their development programs with consideration of potential partnership opportunities.

[16] Companies having revenues less than AUD $5 million and research and development expenditures of less than $1 million are entitled to a tax rebate payable in cash in the year the expenditures are incurred. Clinical trials costs will greatly exceed $1m per annum thus many biotechnology firms are ineligible to receive the rebate and instead receive a tax concession which can be claimed against other tax liabilities or future tax debt.

When a biotechnology company out-licences a product to a pharmaceutical company to complete the final stages of development, the pharmaceutical company is effectively purchasing the IP surrounding the product. So whilst the product in development will be a therapeutic drug, for the biotechnology company, the product to be sold to the pharmaceutical company is the information and data package associated with the therapeutic drug in development (Executive G).

As in any industry, firms need to be aware of their customers needs and design their products to meet those needs. A biotechnology firm needs to have potential pharmaceutical partnerships in mind early in the development cycle and they need to design their research programs with consideration of those partnerships (Executive D). Design of the development programs with a partner in mind requires the biotechnology company to carefully consider the commercial aspects of the ultimate product, including the route to market, the market size and the competitive landscape (Executive C). Furthermore, in the process of negotiation with potential partners, firms should continuously be assessing the marketplace for biotechnology products and this information should be fed back to guide development at the early stages in the pipeline (Executive D).

The market for therapeutic drugs is global, thus the scale required to manufacture, distribute and run the sales and marketing campaign is well beyond the capabilities of the current Australian biotechnology sector. The global pharmaceutical industry consists of numerous large scale firms with the proven capacity to produce drugs to meet global demand and run effective sales and marketing campaigns. The infrastructure necessary to run these campaigns means that biotechnology firms will continue to be dependent on pharmaceutical partnerships (Executives C, D, F).

Traditionally pharmaceutical companies “owned” the drug development space, however, as they have grown in scale, the efficiency of their development programs has fallen. Smaller biotechnology firms are now recognised as more efficient innovators and the pharmaceutical industry is increasingly dependent on biotechnology research programs to sustain their product pipelines (Executives E, F). The market for therapeutic drugs is protected by patents which only have a finite lifespan. As current

pharmaceutical patents expire pharmaceutical companies become further dependent on the biotechnology industry to replenish their product lines and cover their fixed overhead costs (Executive A).

The relationship between biotechnology and pharmaceutical firms is one of co-dependency, which introduces risks to both businesses. When a biotechnology firm out-licenses a product to a pharmaceutical company they relinquish control over the remainder of the development program as well as the sales and marketing strategy. As a result, the biotechnology company is exposed to the risk that the pharmaceutical partner may make a decision surrounding the product that could affect the development and/or sales of the product. The size of pharmaceutical businesses means that one product in development will not receive the same level of focus, nor be as critical to the business, as it is for a smaller biotechnology firm.

> *"Australian biotechnology companies are very exposed to 'big pharma'. [The latter] can make a decision or change a policy which can challenge a small biotechnology firm's existence" – Executive A*

Biotechnology companies need to actively manage their relationships with pharmaceutical partners to control their exposure to the risks generated through the relationship. Management of this relationship through contractual means should be a tool of last resort to be used when all other options have been exhausted (Executive D). Australian firms have not been particularly good at managing this relationship in the past (Executive A), however, there is an increasing awareness of the importance of continuous liaison management as a preventative measure to manage this exposure (Executive D).

## 4.4 VALUATION

> *"The valuations and business models for biotechnology businesses are so completely different from everywhere else. From a traditional point of view, there is no business. There are no cash flows. There is no product, there are none of the tangibles that basic business premises rely on." – Executive B*

The uncertainty surrounding biotechnology research and development makes valuation of biotechnology projects, and the businesses involved in sector, a daunting task. This

task is made more difficult by the complexity of the underlying science which adds to the uncertainty surrounding firm prospects.

If more accurate valuation methods were applied by experienced investment analysts who possess an in-depth knowledge of the unique nature of the industry, then we should see a more efficient allocation of investment funds in the biotechnology sector towards those companies with the most attractive risk/return profiles (Executive E). This process would see the best companies in the sector attracting greater levels of funding at the expense of firms less attractive to investors. With time, this would allow the successful biotechnology firms to forge pathways of success, and sift out the underperforming businesses, encouraging consolidation in the industry. The underlying premise of this is a more accurate valuation of biotechnology investment opportunities which is facilitated by improved valuation methodologies.

The level of uncertainty surrounding biotechnology valuation is related to the difficulty in forecasting the business cash flows. For a company with products in the early stages of development, regular predictable revenues are not likely until a product, which can be more than 10 years in development, is on the market. Whilst it is in the company's interest to generate revenues in the near-term in order to minimise the burn rate of cash reserves this does not always have a positive impact on company valuations. With the uncertainty of biotechnology investments, much of the value is related to the "blue sky" potential of products in development. Once cash flows start coming into the business, the investment community will look at those cash flows as a more tangible premise upon which to value the business at the expense of the "blue sky" potential of the development programs (Executive E). This focus on current cash flows at the expense of future potential will often reduce company values.

### 4.4.1 Current Application

*"In biotechnology there is really no proven model for valuation." – Executive H*

The level of uncertainty involved in the assessment of a biotechnology opportunity implies that any valuation tool will be based on assumptions regarding those uncertainties, thus reducing the value of any insights provided by the model (Executive C). Whilst the outcome of the model may only be of limited benefit, the process of

estimation of the cash flows resulting from a project help to give the company a commercial focus for their research programs (Executive A, C).

Traditional discounted cash flow (DCF) methodology is the most common valuation method employed by participants in the biotechnology industry (Executives A, B, C, D). Despite its widespread use, the significance of a DCF valuation is not highly regarded as the models are easily manipulated to give the user a desired estimate of value (Executives A, B, C). The application of DCF valuation to biotechnology projects suffers from an inability to capture management flexibility, which is particularly relevant given the long lead times associated with biotechnology product development (Executives D, F).

DCF valuation requires the analyst to estimate the cash flows resulting from a project. For a biotechnology project this requires the analyst to forecast revenues well into the future as a result of the long lead times in product development. Cash flow forecasts assume that the development program is successful, which is unlikely, given the historical success rates of biotechnology product development (Executive D). Where revenues are not likely to be generated within three years, the validity of DCF valuation is compromised (Executive F).

To incorporate the possibility of a failure in product development, DCF theory is combined with a biotechnology development decision tree. This allows the analyst to incorporate the likely probabilities of a research project successfully moving through the development chain in incremental steps. This decision tree analysis provides useful insight to management of biotechnology firms allowing them to see the incremental change in value as each phase of development are successfully negotiated (Executives A, B, C, D).

Estimation of the likelihood of successful product development is usually based on an assessment of the likelihood of successfully passing each incremental stage of the clinical development process. This information is then fed back into the model to form the probabilities of occurrence of each of the cash flows associated with the decision tree. The range of products that fall under the umbrella of biotechnological drug development is very broad and the risk factors facing these products are equally diverse.

Thus the use of broad industry averages to inform the valuation can quickly render a model irrelevant (Executive E).

The high levels of uncertainty of biotechnology projects, particularly those in pre-clinical or early clinical development, mean that the majority of biotechnology opportunities will not be economically viable under a DCF assessment (Executive C). The application of option pricing theory to biotechnology investment allows management flexibility to be incorporated into the investment analysis. Despite potentially offering superior assessments of investment opportunities, the majority of the study participants saw the complexity of real option theory as a barrier against its application.

> *"If you take the time and effort to build a very thorough real options model with Monte Carlo analysis of the various combinations and permutations, I think you can build a very, very good model. The problem is I have not got two months to go and actually build one." – Executive F*

The number of assumptions required to assess a biotechnology opportunity introduces a high level of sensitivity to user inputs in the model outcomes. Through manipulation of the underlying assumptions, the analyst is easily able to alter the results to point towards a predetermined belief (Executives A, C). The sensitivity of biotechnology valuation models to the underlying assumptions dilutes the significance of the valuations (Executives A, B, C, D, E). The valuation estimated by the model may be of only minor significance, however, useful insight can be gained through a more detailed examination. Sensitivity analysis of the model output by varying the underlying assumptions provides useful information about the critical drivers of value (Executive C). This insight allows managers to focus their efforts towards issues that the firm is most dependent on for value generation.

In addition to providing management with insight regarding the drivers of firm value, the process of valuing a firm's projects provides a tool that can be used to signal the commercial orientation of the firm to potential investors. A firm that is able to produce a model valuing the business sends a signal to potential investors that the company has commercial understanding (Executive B). Despite the benefits to the business from

conducting a thorough evaluation of company value, ultimately firm value is determined by market forces (Executives A, E, H).

*"It doesn't matter what your model says if you just can't do the deal." – Executive A*

#### *4.4.1.1 Drivers of Value*

Biotechnology valuations in Australia have a history of being widely speculative. The high degree of uncertainty surrounding the likelihood of successful development combined with the lack of a sophisticated investor community able to discern the critical value drivers contributes to the variation in firm valuations (Executive E). As a result of valuation uncertainty, the industry is subject to sentiment driven fluctuations in value. In effect this has created a situation where the ability to create 'hype' and excitement surrounding a firm's product pipeline can be a value driver for the business (Executives A, E). Whilst value can be created through 'hype' in the short term, this is not a method for sustainably growing value and can be detrimental to the long term prospects of the firm (Executive A).

Sensitivity analysis of a valuation model can provide insight into the issues that drive the valuation output. The time value of money means that biotechnology projects are particularly sensitive to time as a result of the long lead times in product development. The importance of time can outweigh the costs of development. A company that is able to decrease development times, even at additional cost, can improve the value of the firm (Executive C).

The quality of a firm's IP underlies its ability to develop a valuable product. Along with a high quality patent portfolio, the firm needs to possess the right people with the necessary skills to realise the portfolio value. Coupled with this, is the necessary ability to access sufficient levels of capital in order to fund IP development to a point where a return is generated commensurate with the associated risks (Executive D).

In assessing the quality of a firm's IP, a detailed analysis of the firm's ability to protect its patent portfolio is a critical component in maintaining a competitive advantage. It is not the quantity of patents a firm holds but instead the quality of its patent protection that is important (Executive E). This is an issue that is often not examined to the level of detail that it requires.

*"You need to do an analysis of whether the patent is likely to stick or not and what the true patent position is. Have you got a patent grant in the United States? Has it been challenged? What are the closest related patents? What is the opportunity for people to develop patents around it? Are there alternate technology strategies around your product? All those issues are really critical." – Executive E*

#### *4.4.1.2 Assessment of Opportunities*

When examining a potential project, the valuation of the opportunity is not critical in forming an investment decision due to the inherent uncertainties in biotechnology valuations (Executive B). The valuation process can provide insight, helping management focus on the key value drivers for the project. However, this is not information critical to forming the investment decision (Executive C). Of primary importance are the strategic fit of the opportunity with the existing development programs and the ability of the firm to manage the project (Executives A, B, C, D, E, F).

A new opportunity that does not match well with existing projects has the potential to negatively affect the overall business. Resources will be required to develop the necessary expertise in the new area, which for resource constrained biotechnology firms, can reduce their ability to maintain support for their existing programs (Executive B). Additionally, if the firm does not possess the necessary skills to understand and appreciate the science, management will be restricted in its ability to add value to the research, thus those opportunities may be better off being placed in the hands of those with the expertise to do justice to the research (Executives C, D).

## 4.5 AUSTRALIA AS A GLOBAL COMPETITOR: CHALLENGES AND OPPORTUNITIES

The drug development industry is a global industry with a broad range of competing businesses ranging from small niche operators to the large multinational pharmaceutical companies. To successfully compete, Australian firms must overcome the local challenges and capitalise on their strengths and opportunities to evolve into internationally competitive businesses (Executives D, E, F).

*"The reality is that if you are going to be internationally competitive in the biotechnology industry, there is no prize for second. You have to be either first or don't do it." – Executive E*

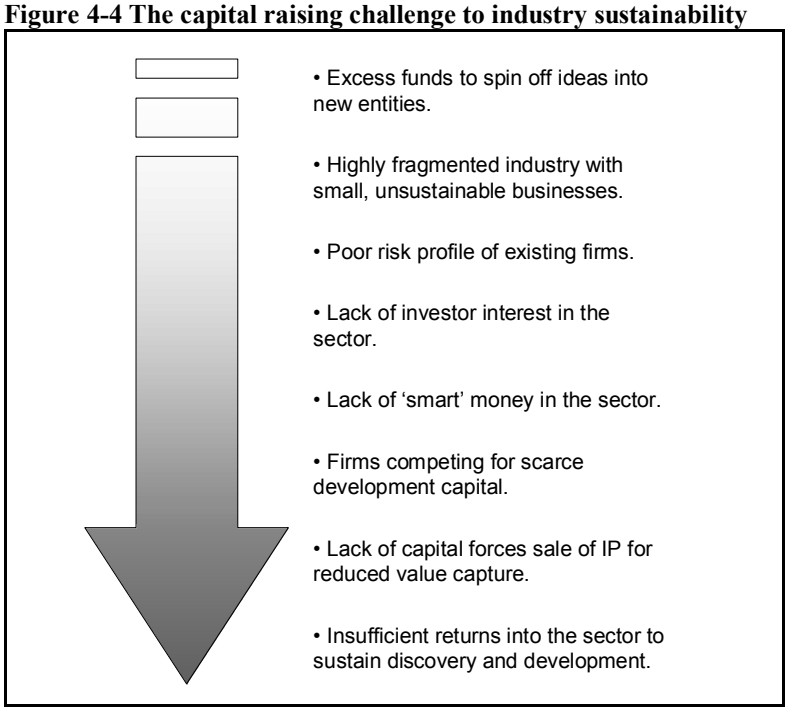
The fundamental mechanism which allows participants in the drug development industry to generate a return from their research and development efforts is the ability to protect their IP through legal and other means (Executive E). The Australian legal system provides a framework that the industry can rely on to protect IP and this encourages investment in research and development (Executive A).

Australia has a reputation for good quality early stage discovery research (Executives B, C, D, E, H). The challenge is for the industry to successfully leverage this opportunity. The current environment encourages new ideas spawned in academia to be spun-out into a new business entity[17], with the number of new businesses created seen as a measure of the success of academic research programs (Executives C, E, F). Given the likelihood of successful development of a new therapeutic, it seems that the majority of these projects will fail, and with them the supporting company. A more accurate measure of the success of university research programs should be the number of sustainable businesses created as a result of academic research discoveries (Executives C, E).

The effect of an excess of early stage funding, and shortfall of subsequent development capital, ripples through the industry to pose a significant challenge to the sustainability of Australian biotechnology firms, as shown below in Figure 4-4. Due to the unattractive nature of their risk profile, many small biotechnology firms have difficulty raising sufficient development capital and are forced into an early sale of their IP. The revenue stream resulting from this sale is insufficient to fund a diverse research and development pipeline and as a result the success of the company hinges on the success of one or few products.

[17] For example see the Strategic Development Plan for Victoria (The Victorian Government 2004) which quotes the number of new biotech start-ups as a measure of the government success in servicing the industry.

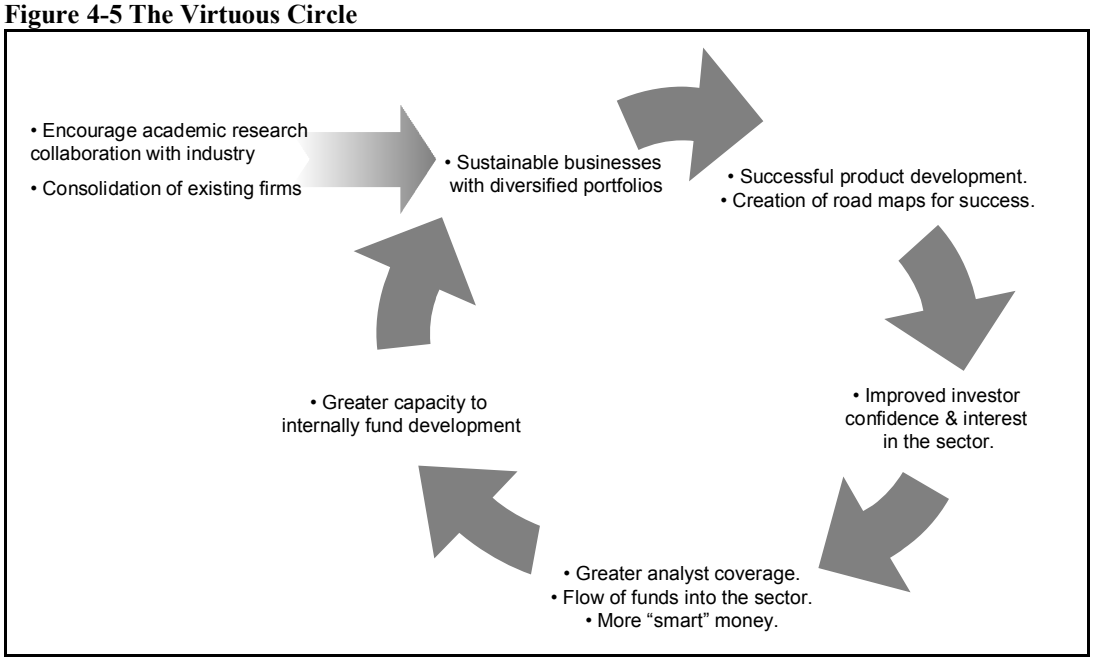
**Figure 4-4 The capital raising challenge to industry sustainability**




An opportunity exists to create stronger links between academia and industry and to encourage the formation of larger, more sustainable biotechnology firms with more diverse product pipelines and improved risk profiles. A reduced focus on the importance of spinning out new ideas into start-ups allows government to shift funding away from early stage initiatives towards support of capital intensive development programs. Industry can become more directly involved in funding academic research, facilitating greater communications between the two, and providing a mechanism for synergetic improvements in the drug development process.

The lack of funding available to Australian drug development companies is limiting the sector's potential (Executives A, C, D, E, F). To overcome this challenge and be internationally competitive, the industry needs to experience some success to give investors an improved sense of confidence and provide a pathway to success for other firms. With greater investor interest, the sector should attract more scrutiny from investment analysts who act as the gatekeepers between industry and investment funds (Executive E). Improved investor education will assist in a more efficient allocation of capital in the sector, away from the unsustainable business models, towards the sustainable firms with good prospects. Success in the industry will generate greater investment in the sector and feed continuous success in a virtuous circle as illustrated below in Figure 4-5.

**Figure 4-5 The Virtuous Circle**




The cost of research and development in Australia is relatively low compared with other leading biotechnology nations (Executives A, B, C, D, E, H). The relatively low cost of research provides an opportunity for local based firms competing in a global market. Unfortunately, price alone is not a competitive advantage for Australia because scientific research costs in many developing countries are lower than here (Executives C, F). Australia, however, does have opportunity as a provider of relatively low cost and high quality scientific research. One of the most important drivers of value in the drug development industry is the ability to move a product through the development cycle as quickly as possible. Australia can further leverage the low cost and high quality of its research if it is able to consistently move products through the development pipeline at a rate faster than international competitors (Executive C).

Melbourne is home to a large portion of the Australian biotechnology sector and is also a centre of excellence in the field of oncology research (Executive A). Development of a new cancer therapeutic differs from some other fields because of the terminal nature of cancer and the relatively small number of oncology clinicians. As a result clinical trials can be conducted at less expense and relatively quickly, which creates an opportunity for investors with a shorter investment horizon than other biotechnology fields. Opportunity exists for Australian biotechnology firms to leverage local expertise

in oncology research with investors seeing a return over a relatively short period of time.

When compared with investors in the US, Australians seem to be more risk averse and have a reduced tolerance for failure (Executives C, D). Most biotechnology projects are doomed to failure, thus, over time, we will see an increasing number of managers with experience in managing a failed biotechnology firm. If investors are not willing to accept managers with experience in biotechnology failure, a valuable resource is left untapped. Failure provides valuable education and indeed an acceptance of this is necessary to encourage entrepreneurship in the industry (Executives C, D).

## 4.6 CONCLUSION

The overwhelming theme to emerge from this study is the significant challenge that Australian biotechnology firms face in attracting sufficient capital to fund their product development programs. Current funding mechanisms which encourage new ideas to be spun out into new entities, has created an industry comprised of small firms with few products in development.

Given the risks associated with pharmaceutical product development, biotechnology firms without a sufficiently broad pipeline are poised for failure and as such face significant hurdles in attracting additional capital. The scarcity of development capital is exacerbated by the fierce competition for funding as a result of the capital intensive nature of biotechnology product development and the number of firms competing.

The biotechnology sector has a high proportion of “mum-and-dad” type investors who are stakeholders in the industry without fully understanding the challenges facing the firms due to the complexity of the underlying products. As a result of this ‘uneducated’ money, there has not been a flow of funds away from the underperforming, lower potential firms to the more deserving ones. This has thwarted the Darwinian “survival of the fittest” mechanism and has meant that the underperforming firms continue to exist, consuming capital at the expense of the higher potential firms.

Small unsustainable business models do little to inspire investor confidence and draw additional funds into the sector. As a result, firms are forced to prematurely sell their IP

to allow continued development of their product without capturing the optimal level of value growth along the development chain. This restricts the ability of the firm to fund additional research and development programs and dampens shareholder returns.

Whilst the local industry faces significant challenges that must be overcome if it is to develop into a self-sustaining entity, careful management in these early stages should facilitate the desired outcome. To attract greater levels of investment into the sector the formation of sustainable business models with diverse product pipelines needs to be encouraged. Rather than encourage promising research to be spun off into new entities, the structure of early stage government funding should be revised to reduce the motivation to create start-ups. If closer links were fostered between industry and academia, new ideas could be out-licensed to existing firms with successful relevant histories. This would slow growth in the number of firms in the industry and at the same time diversify existing firms' pipelines creating more sustainable business models with reduced risk profiles.

Merger and acquisition activity between existing firms should also be encouraged to reduce the number of firms competing for development capital and diversify the firms' product pipelines. Consolidating firms would increase the likelihood of successfully bringing a product to market and improving the sustainability of the business model.

As the industry matures, successful firms will emerge, creating road maps for success to guide younger participants and investors. Investors will take confidence from successes in the industry and current concerns regarding the excessive risks associated with biotechnology investment will be mitigated through more diverse product pipelines. Improved investor confidence will see greater interest in the sector and capital flowing into the industry in all stages of development.

Increased investor interest in the industry will create demand for investment analysts who over time will develop the expertise to effectively assess potential investments. This should allow a more educated distribution of investment capital, with funds flowing to the more deserving firms and away from the less deserving. This mechanism should improve the efficiency of the industry and encourage further growth of successful firms in the sector.

With greater levels of funding available to the sector, firms will be able to fund development of their products through a greater portion of the development process extracting more value as a result. Increased return to firms will allow them to divert funding back into their research and development programs. Through internal funding, the reliance on external capital providers is reduced, thus minimising their exposure to the risk of not being able to source sufficient capital. Reduced risk further enhances the sustainability of the firms' business models and this similarly flows on to additional growth in the industry.

# CHAPTER 5 MONEY LEFT AND UNDERPRICING IN AUSTRALIAN BIOTECHNOLOGY IPOS[18]

## 5.1 INTRODUCTION

The previous chapter described in detail the challenges that Australian biotechnology companies have in raising sufficient capital to fund their research and development programs. Australian firms have access to sufficient early stage start-up funds, however, subsequent development funding is significantly more difficult to source. In the US, venture capitalists are a significant source of funds for the biotechnology sector. In Australia the biotechnology industry has not had the same level of support from the venture capitalists with the result that companies are forced to find alternative sources of funds. This is evidenced by the relative immaturity of biotechnology firms raising capital via an IPO.

An IPO is the process where a company first offers stock for sale to the public on the stock exchange. The process is managed by an investment bank and enables the issuing company to source an inflow of funds whilst the new shareholders receive potential profits in the form of future dividend returns and capital gains. "Underpricing" is a term used to describe the process in which the price of the listing company's stock increases well above the issue price on the first day of listing, a phenomenon that has been reported consistently in studies around the world [see (Loughran, Ritter and Rydqvist 1994)].

Development of a viable and successful biotechnology industry is a key contributor to Australia's economic growth, international competitiveness and quality of life

[18] The data presented in this chapter has been previously presented in two peer reviewed publications, for details, refer to Jens, P, Brooks, R, Nicoletti, G and Russell, R 2006, 'Media Coverage and Biotechnology IPOs: Some Australian Evidence', *Journal of Commercial Biotechnology*, vol. 13, no.1, pp. 43-47 and Jens, P, Brooks, R, Nicoletti, G and Russell, R 2006, 'Capital Raising by Australian Biotechnology IPOs: Underpricing, Money Left and Proceeds Raised', *Accounting Research Journal*, vol. 19, no. 1, pp. 31-45.

(Department of Education Science and Training 2004) and is supported through the Australian Federal government's commitment of $8.3 billion in funding to science and innovation over the years from 2001-2011. Unfortunately, whilst Australia has relatively good levels of government-provided seed funding, subsequent research and product development, which is typically funded by venture capitalists and other sources of financial support, faces a shortfall in funding. As a result of this, Australian biotechnology companies are often prematurely forced to source finance from the public through an IPO (Herpin, Karuso and Foley 2005), increasing the importance of a successful listing for these businesses.

The motivations for a company to raise capital via an IPO can be many and varied however a key concern will be the successful injection of a significant amount of capital into the business (Arkebauer and Schultz 1991). For biotechnology companies, which are inherently capital intensive businesses with long product lead times, the amount of capital raised that they can dedicate towards development of their product pipeline is a critical measure of the success of their IPO (Deeds, Decarolis and Coombs 1997). Stuart, Hoang and Hybels (1999) support this notion in their study [of venture capital-backed biotechnology IPOs which used the total capital raised by venture capital-backed biotechnology IPOs as a measure of listing success. Success of IPO capital raisings can be measured by the size of the capital raising, level of underpricing, and the performance of the issuing company in the years post-listing (Brau, Brown and Osteryoung 2004). A listing that raises less capital, is more underpriced and leaves more money on the table will have been less successful in meeting the primary requirement to inject significant capital into the business.

This chapter analyses Biotechnology IPOs in Australia from 1994 to 2004 in three key dimensions related to their capital raising – underpricing returns, money left on the table and total proceeds raised. The analysis tests the relationship between the information provided to potential investors in the IPO prospectus and these key measures of listing success and performance. Three models have been used: first, using the amount of money left on the table (measured as the number of shares issued multiplied by the first day share price movement) as the dependent variable; second, using underpricing (the first day shareholder returns) as the dependent variable; and third, using total proceeds raised (measured as number of new shares issued multiplied by the issue price) as the

dependent variable. While all companies that list on the stock exchange are interested in these three measures, they are of particular concern for biotechnology companies given the high cost and long lead time in product development, and the uncertainties regarding the valuation of their intellectual assets (Schwartz 2004).

The impact of market sentiment on the instantaneous values that the market assigns biotechnology assets at any time, is exacerbated by the uncertainty surrounding valuations of those assets. This chapter explores the impact of sentiment on IPO valuations using share market performance and popular press citations as proxy measures for sentiment levels.

The plan of this chapter is as follows: Section 5.2 develops the base models following a similar study in the US by Deeds, Decarolis and Coombs (1997), Section 5.3 augments the base models to further explore the impact of sentiment on IPO performance, and Section 5.4 concludes.

## 5.2 BASE MODELS

This research follows on from a similar study by Deeds, Decarolis and Coombs (1997) who studied 92 biotechnology company IPOs within the United States after 1982 to investigate the influence of factors endogenous and exogenous to the firm on the amount of capital raised.

### 5.2.1 Data

The models developed here test the relationship between data contained within Australian biotechnology company prospectuses and the success of their IPO, as measured by the amount of money left on the table, the amount of underpricing, and the total proceeds raised. Significant relationships identified in previous literature were used as the foundation from which the models were built and tested using an ordinary least squares regression framework. The data set used in this paper was constructed by extracting information from the prospectus documents of 34 biotechnology companies who listed on the Australian Stock Exchange between June 1994 and May 2004. Where possible, a copy of the prospectus was used in its original format (either electronic or hardcopy). In cases where this was not available, prospectus information was sourced

from the Connect4 Company Prospectus database. Market pricing data was sourced from Datastream.

A subset of publicly listed biotechnology companies have been previously listed as technology development or mining exploration entities. These companies were excluded from this research which considered only those biotechnology firms coming to the market for the first time. During the time span, 34 biotechnology companies were listed on the ASX for the first time. Of these, twenty-nine focused their research effort on human therapeutics, four on medical devices and one on animal health. Due to the limited population size, all 34 listings were included in this analysis.

Initially a large data set was constructed based on significant variables from previous studies. The independent variables included in the first cut models are shown in Table 5-1. Note that no earnings data variables were included as the majority of companies in the sample were not generating revenues at time of IPO.

**Table 5-1 Set of Potential Independent Variables**

This table provides details on the set of potential explanatory variables for the IPO models, including a brief description of the variable and its expected sign, as well as reference in the previous literature.

| Variable | Expected Sign | Citation | Description |
|---|---|---|---|
| Issue Price per Share | Negative | (Chalk and Peavy 1987; Tinic 1988) | Issue price per share as detailed in the prospectus |
| Total Capital Raised | Negative | (Beatty and Ritter 1986; How, Izan and Monroe 1995; Michaely and Shaw 1994; Tinic 1988) | Equals the number of new shares issued multiplied by the issue price per share |
| Subscriber Options | Negative | (Jain 1997; Schultz 1993) | Dummy variable, 1 where subscriber options offered, 0 otherwise |
| Underwriter | Negative | (Beatty and Ritter 1986; Tinic 1988) | Dummy variable, 1 where issue is underwritten, 0 otherwise |
| Underwriter Options | Negative | (Dunbar 1995) | Dummy variable, 1 where underwriter receives options as payment (or part thereof), 0 otherwise |
| Independent Accountant Reputation | Negative | (How, Izan and Monroe 1995; Michaely and Shaw 1995; Titman and Trueman 1986) | Dummy variable, 1 for reputable independent accountant, 0 otherwise |
| Age | Negative | (Ritter 1984) | Company age measured as the number of days between incorporation and listing |
| Location | Negative | (Deeds, Decarolis and Coombs 1997) | Dummy variable, 1 head office location within a biotechnology hub, 0 otherwise |
| Capital Retained | Negative | (Deeds, Decarolis and Coombs 1997) | Amount of capital retained by the company after listing expenses and special dividends |
| Research Projects | Negative | | Number of research projects yet to commence clinical trials |
| Products in Development | Negative | (Deeds, Decarolis and Coombs 1997) | Number of products in clinical trials |
| Products | Negative | (Deeds, Decarolis and Coombs 1997) | Number of fully developed products |
| Services | Negative | | Number of revenue-generating services |
| Health & Biotech Market Sentiment | Positive | | Movement in ASX Health and Biotechnology Index from the date of the independent accountants report to the day of listing |
| Market Sentiment | Positive | (Dimovski and Brooks 2004a) | Movement in ASX All Ordinaries Index (orthogonalised from the Health & Biotech index) from the date of the independent accountants report to the day of listing |
| Momentum | Positive | | Underpricing of previous biotechnology listing divided by the number of days between the previous and current listing |
| R&D Forecast Expenditure | Negative | | Future research and development forecast as per prospectus |
| R&D Historical Expenditure | Negative | (Deeds, Decarolis and Coombs 1997) | Historical research and development forecast as per prospectus |
| %IPO Raisings for R&D | Negative | | % of total capital raised through the IPO to be allocated for research and development as per prospectus |
| Total Citations | Negative | (Deeds, Decarolis and Coombs 1997) | Total citation count for publications by staff listed in the prospectus (Web of Science database used to calculate for this sample) |
| Patent Family | Negative | | Patent coverage measured as the number of patent families described in the prospectus |
| Patents | Negative | (Deeds, Decarolis and Coombs 1997) | Total number of awarded patents as per prospectus |
| Patent Applications | Negative | | Total number of patent applications as per prospectus |

A set of three full models was created where all of the independent variables listed in Table 5-1 were regressed against the three dependent variables with the White adjustment applied to manage heteroskedasticity problems impacting on the t-statistics. The models were then refined using a stepwise process where the least significant variable was removed from the regression framework and the parameters re-estimated. The process was systematically repeated until only those variables shown to be significant at the 10% level were retained[19]. With multicollinearity a potential problem (refer to Appendix A for a comprehensive correlation matrix) impacting on the reliability of this model, and to confirm that no significant variables were omitted, an F-test for redundant variables was then conducted using all omitted variables. This model selection process was conducted for the 'money left on the table', 'underpricing' and 'log money raised' models. Descriptive statistics for the dependent and significant independent variables are reported in Table 5-2.

[19] A 10% level of significance was chosen (in preference to the more common 5%) in order to reduce the likelihood of a type II error during the stepwise process. Type II error concerns were exacerbated by the potential impact of multicollinearity on the unrestricted model t-values.

**Table 5-2 Descriptive Statistics**
This table reports measures of central tendency and variability for the dependent and independent explanatory variables. *MoneyLeft* is the amount of money left on the table (in $,000) which is equal to the number of shares issued * (price on close – issue price). *Underpricing* is the share price return on the first day of listing. *MonRias* is the amount of money raised (in $,000) in the capital raising which is equal to the number of shares on issue * issue price. *Ln_MonRais* is the natural logarithm of the amount of money raised by the IPO. *CIT* is the total number of citations of employees' and members of the scientific advisory boards' work as per the "web of science" database. *INDACC* is a dummy variable for the use of a reputable independent accountant. *PRICE* is the issue price of the listing. *PROD* is the number of fully developed products described in the prospectus. *SENT_AO* is the movement on the ASX all ordinaries index (orthogonalized to be independent of movement in the health and biotechnology index) from the date on the independent accountants report to date of listing. *SENT_HB* is the moment of the ASX health and biotechnology index) from the date on the independent accountants report to date of listing. *TOT_APP* is the total number of awarded patents and patents under application at the time of listing with each country treated as a separate application. *TOT_PAT* is the number of awarded patents at the time of listing.

| | Mean | Median | Maximum | Minimum | Std. Dev. |
|---|---|---|---|---|---|
| **Dependent Variables** | | | | | |
| *MoneyLeft* | 2,360 | 450 | 17,500 | -2,700 | 4,781 |
| *Underpricing* | 20.16% | 2.67% | 125.00% | -50.00% | 42.40% |
| *MonRais* | 23,419 | 7,025 | 312,000 | 1,606 | 55,912 |
| *Ln_MonRais* | 16.09 | 15.76 | 19.56 | 14.29 | 1.07 |
| **Significant Independent Variables** | | | | | |
| *CIT* | 10106 | 4465 | 66459 | 0 | 16174 |
| *INDACC* | 0.47 | 0 | 1 | 0 | 0.51 |
| *PRICE* | 0.68 | 0.50 | 2.50 | 0.20 | 0.62 |
| *PROD* | 2.00 | 0.00 | 27.00 | 0.00 | 6.31 |
| *SENT_AO* | 0.00 | 0.82 | 14.61 | -14.62 | 6.14 |
| *SENT_HB* | 3.20 | 1.24 | 24.34 | -12.13 | 9.44 |
| *TOT_APP* | 26 | 11 | 168 | 0 | 38 |
| *TOT_PAT* | 6.88 | 1.00 | 42 | 0 | 11.09 |

### 5.2.2 Results

This research makes use of White (1980) standard errors even though the sample size is small. The properties of the White (1980) approach in finite samples has been the subject of some analysis in the literature, see *inter alia* MacKinnon and White (1985), Godfrey and Orme (1999), Cribari-Neto (2004) and Godfrey (2005). Godfrey (2005) uses a sample size of only 27 observations in his Monte Carlo analysis, and finds the conventional White (1980) test to be over-sized (that is, more likely to reject the null hypothesis of variable insignificance) in small samples, although the test is also found to have reasonable power relative to other available corrections to the test statistic. In the context of this research, the use of the conventional approach has a bias towards finding significant variables. Thus, the fact that these results did not show many variables to be significant can be seen as robust given that the nature of the bias in the test is in the opposite direction.

All three full models together with their final reduced forms are shown in Table 5-3. The table reports OLS parameter estimates and significant White corrected p-values are highlighted by asterisks.

**Table 5-3 Regression Results**

This table reports the results of estimating the full and reduced form models for each of the three specifications of the dependent variables. The table reports OLS parameter estimates with significant White corrected p-values at the 10%, 5% and 1% level of significance shown by *, **, and *** respectively. The table also reports a range of regression diagnostics including the adjusted R squared, the White test, and the F test for the exclusion restrictions in the reduced for model. *AGE* is the age of company measured as the number of days between incorporation and listing. *CAPRET* is the amount of capital raised from the IPO allocated to the company (i.e. total raisings less brokerage fees and shareholder dividend). *CIT* is the total number of citations of employees' and members of the scientific advisory boards' work as per the "web of science" database. *INDACC* is a dummy variable for the use of a reputable independent accountant. *LN_CAPRAIS* is the amount of capital raised by the issue with the natural log taken to control for outliers (not that this variable is used as an independent variable for the money left and underpricing models but is used as the dependent variable for the log money raised model). *LOC_METRO* is a dummy variable for those companies whose head office is located in a metropolitan area of Adelaide, Brisbane, Melbourne, Perth or Sydney. *MTUM* is the amount of underpricing of the most recent previous listing divided by the number of days between that listing and the current listing. *PRICE* is the issue price of the listing. *PAT_FAM* is the number of patent families (includes patents granted and under application) identified in the prospectus. *PROD* is the number of fully developed products described in the prospectus. *PROD_DEV* is the number of products under development defined as the number of products in clinical trials. *RD_FORC* is the amount of research and development expenditure forecast in the prospectus. *RD_HIST* is the amount of historical research and development expenditure described in the prospectus. *RDPERCENT* is the percentage of capital raised from the IPO which will be allocated to research and development. *RES_PROJ* is the number of research projects defined as any research project still in pre-clinical development. *SENT_AO* is the movement on the ASX all ordinaries index (orthogonalized to be independent of movement in the health and biotechnology index) from the date on the independent accountants report to date of listing. *SENT_HB* is the movement of the ASX health and biotechnology index from the date on the independent accountants report to date of listing. *SERV* is the number of revenue generating services at the time of listing. *SUBOPT* is a dummy variable for the inclusion of subscriber options as part of a listing. *TOT_APP* is the total number of awarded patents and patents under application at the time of listing with each country treated as a separate application. *TOT_PAT* is the number of awarded patents at the time of listing. *UNDOPT* is a dummy variable where options are issued to underwriters. *UWRIT* is a dummy variable for those offerings that are underwritten.

| Variable | Full Model Coefficients | | | Stepwise Model Coefficients | | |
|---|---|---|---|---|---|---|
| | *MoneyLeft* (,000) | *Underpricing* | *Ln_CapRais* | *MoneyLeft* (,000) | *Underpricing* | *Ln_CapRais* |
| *Constant* | -28013.955 | 4.5563 | 15.7294*** | -2269.752** | 0.2016*** | 15.1244*** |
| *AGE* | -0.158 | -0.0001 | -0.0001 | | | |
| *CAPRET* | 1245.876 | 1.1243 | 0.1242 | | | |
| *CIT* | 0.078 | 0.0000 | 0.0000 | 0.066*** | | |
| *INDACC* | -3925.340 | -0.1636 | 0.4503 | -3839.288** | | 0.2795* |
| *LN_CAPRAIS* | 1474.904 | -0.3417 | -------- | | | -------- |
| *LOC_METRO* | 2752.084 | 0.0219 | -0.3071 | | | |
| *MTUM* | -9883.800 | -0.5873 | -0.8622 | | | |
| *PRICE* | 3656.250 | 0.4137 | 0.0512 | 8092.745*** | | 1.3036*** |
| *PAT_FAM* | -313.240 | 0.0252 | 1.3288** | | | |
| *PROD* | -770.867 | -0.0272 | 0.0795 | -356.160** | | 0.0308*** |
| *PROD_DEV* | 427.008 | 0.0528 | 0.0215 | | | |
| *RD_FORC* | 29.961 | 0.0452 | 0.0515* | | | |
| *RD_HIST* | 213.260 | 0.0223 | -0.0191 | | | |
| *RDPERCENT* | 5155.051 | -0.0163 | -0.6930 | | | |
| *RES_PROJ* | 28.645 | -0.0294 | -0.0374 | | | |
| *SENT_AO* | 26930.504 | 1.7644 | -2.9983 | 23304.290*** | | |
| *SENT_HB* | 2437.248 | -1.4863 | -2.2662 | | | -1.3797* |
| *SERV* | 75.106 | 0.0807 | 0.0261 | | | |
| *SUBOPT* | -1782.948 | -0.4853 | -0.2072 | | | |
| *TOT_APP* | 36.042 | 0.0036 | 0.0034 | 38.152** | | 0.0060*** |
| *TOT_PAT* | 182.071 | -0.0146 | -0.0377*** | | | -0.0319*** |
| *UNDOPT* | 2624.105 | 0.4302 | 0.0645 | | | |
| *UWRIT* | -486.492 | 0.0284 | -0.0750 | | | |
| Adjusted R2 | -0.10 | -1.03 | 0.80 | 0.43 | 0.00 | 0.87 |
| F-stat omitted variable (p-value) | -------- | -------- | -------- | 0.227 (0.995) | 0.271 (0.995) | 0.435 (0.937) |
| Observations | 34 | 34 | 34 | 34 | 34 | 34 |

#### *5.2.2.1 Money Left Model*

Of the 34 biotechnology IPOs, the majority left money on the table. The market capitalisation of 21 offerings increased on the first day of listing, 9 saw a decrease in market capitalisation, and 4 offerings had no change in share price at close of the first day of trading from the issue price. The average amount of money left in the investors hands at the end of the first day's trading was $2.36 million.

The model selected at the end of the iterative estimation method described previously was:

$$MoneyLeft = \beta_0 + \beta_1 CIT + \beta_2 INDACC + \beta_3 PRICE + \beta_4 PROD + \beta_5 SENT\_AO + \beta_6 TOT\_APP + \varepsilon_i$$

*MoneyLeft* is the amount of money left on the table which is equal to the number of shares issued * (price on close – issue price). *CIT* is the total number of citations of employees' and members of the scientific advisory boards' work as per the "web of science" database. *INDACC* is a dummy variable for the use of a reputable independent accountant. *PRICE* is the issue price of the listing. *PROD* is the number of fully developed products described in the prospectus. *SENT_AO* is the movement on the ASX All Ordinaries Index (orthogonalized to be independent of movement in the health and biotechnology index) from the date on the independent accountants report to date of listing. *TOT_APP* is the total number of awarded patents and patents under application at the time of listing with each country treated as a separate application.

The number of times academic publications by employees and members of the scientific advisory board were cited was collected using the "web of science" database. The average number of citations for companies contained within this sample was 10,106 ranging from 0 to 66,459. If it is assumed that a higher quality research team will have a greater number of citations of their academic work, then the positive and significant coefficient on the citation variable is counter to the argument that a biotechnology company with a quality research team has a greater chance of research success and offers relatively lower investment uncertainty. In support of Corolleur, Carrere and Mangematin (2004), the positive and significant coefficient for the *CIT* variable supports the notion that more qualified and senior research staff tend to become involved with projects at higher risk of failure albeit offering greater potential rewards.

Of the 34 companies included in the sample, 16 were deemed to have engaged a reputable independent accountant to verify the accounts presented in the prospectus. The negative significant coefficient for the *INDACC* variable supports the hypothesis that having a reputable independent accountant prepare the financial statements for an IPO prospectus reduces the uncertainty surrounding investment in that company and hence investors demand less capital gain on the first day of listing.

The positive and significant *PRICE* variable is inconsistent with the hypothesis that higher priced offerings are associated with larger offerings which are more closely scrutinised by the investing community and as a result have reduced uncertainty of investment. This may be the result of sampling bias resulting from the focus of this research specifically on Australian Biotechnical companies. In this sample the range of asking prices for shares is from $0.20 to $2.50 with a mean of $0.68. This compares with Dimovski and Brooks' (2004a) more general study of 358 Australian Industrial IPOs between 1994 and 1999 which had asking prices ranging from $0.20 to $4.70 with an average of $0.82.

Those firms with products already fully developed and generating sales revenue obviously offer more certainty regarding future cash flows than those firms with no existing products which are wholly dependent on their ability to develop their proprietary intellectual property into a successful product. The greater the number of existing products a firm has on offer, the more diversified their revenue streams and the less uncertainty surrounding future cash flows (Amit and Livnat 1989). For an investor considering investment in a company with an established product, the greater certainty implies that they will rationally demand less underpricing return. Similarly the amount of capital that a firm could expect to raise will be greater if they can effectively demonstrate the value of their offering, such as with evidence of existing sales revenues.

From the 34 companies in the sample, only 10 possessed fully developed products capable of generating revenues, with an average number of 2 products per company. The negative significant coefficient for the *PROD* variable indicates that the greater the number of fully developed products at time of listing, the less money was left on the table by the issuing company. This is consistent with the expectation that a pipeline of

products still in development offers less certainty of future cash flows than a firm which contains fully developed, revenue generating products. Lower uncertainty surrounding an IPO investment will reduce the amount of compensatory capital gain demanded by investors on the first day of listing.

The *SENT_AO* variable is used as a proxy to capture investor sentiment in the period between the date of the release of the independent accountants report and the date of listing. As the movement in the ASX health and biotechnology index was also included in the full model, the *SENT_AO* variable was orthogonalised to remove any collinearity between the two measures. The proxy measures the return of the Australian All Ordinaries Index over this period and, where the independent accountant's report was not provided or was not dated, the date of the independent expert's report was used. Where no independent expert's report was provided, the date of the prospectus was used. The average *SENT_AO* over the 34 observations was 0.00%, with the sample ranging from -14.62% to +14.61%. Based on the literature we would expect a positive co-efficient, that is, the greater the increase in the All Ordinaries in the period leading up to listing, the greater the first day movement in share price and money left on the table. The positive and significant coefficient supports this hypothesis.

*TOT_APP* measures the total number of patent applications and awarded patents at the date of prospectus publications for each of the listing companies. An application for one innovation across two countries was considered as two applications. Of the 34 companies in the sample, 7 had no awarded patents or patent applications, however, on average, companies had 26 awarded patents and patent applications (ranging from 0 to 168). Successful patent protection is critical to controlling competitor risk and thus we would expect a negative coefficient, that is, a greater number of patents is negatively correlated to the amount of money left on the table. The positive and significant coefficient for the *TOT_APP* variable is inconsistent with this hypothesis and may be a result of investors demanding a research and development program which focuses its limited finances on fewer promising candidates. Patent protection is costly and the amount of funds available to Australian biotechnology companies is significantly less than that required to successfully bring a new drug to market. As a result, a company which is focused on fewer research and development activities is better able to finance these activities than one whose research and development program is more broadly

focused. Accordingly, investors may require greater first day returns to compensate for increased uncertainty regarding the ability of the company to adequately finance its research and development program.

It should be noted that a firm focusing on one or few products has a greater exposure to development failure risk. An investor can mitigate this risk through diversification across multiple firms in order to efficiently minimise their portfolio exposure risk whilst maintaining their expected return. Managers of firms looking to minimise the amount of money left on the table at IPO should be wary of focusing on one or few products given the exposure to development risk that this creates.

#### *5.2.2.2 Underpricing Model*

From the 34 observations, 21 offerings were underpriced, 9 overpriced and for the remaining 4 offerings the share price at close of market on the first day of trading was equal to the issue price. Using the iterative procedure outlined earlier, the full model was incrementally condensed. However unlike the money left model, none of the independent variables were found to have a significant relationship with underpricing. For high intensity research and development firms (such as biotechnology firms) it is imperative that they raise as much capital as possible at their IPO. These results suggest that it is the amount of money left on the table and not underpricing returns that is more important (Habib and Ljungqvist 1998).

#### *5.2.2.3 Log Capital Raised Model*

The sample of 34 biotechnology IPOs raised an average of $23.4m, with the size of the capital raisings ranging from $1.6m to $312m. The natural log of the amount of capital raised at IPO was taken to control for large capital raisings in the sample of biotechnology IPOs. The stepwise procedure previously described produced the model outlined below and detailed in Table 5-3.

$$Ln\_CapRais = \beta_0 + \beta_1 INDACC + \beta_2 PRICE + \beta_3 PROD + \beta_4 SENT\_HB + \beta_5 TOT\_APP + \beta_6 TOT\_PAT + \varepsilon_i$$

Where *Ln_CapRais* is the natural logarithm of the amount of money raised by the IPO. *INDACC* is a dummy variable for the use of a reputable independent accountant. PRICE is the issue price of the listing. *PROD* is the number of fully developed products

described in the prospectus. *SENT_HB* is the movement of the ASX health and biotechnology index measured from the date on the independent accountants report to date of listing. *TOT_APP* is the total number of awarded patents and patents under application at the time of listing with each country treated as a separate application. *TOT_PAT* is the number of awarded patents at the time of listing.

The positive and significant *INDACC* variable supports the notion that larger offerings are more likely to afford the additional expense required to employ a reputable independent accountant to prepare their financial statements for presentation in the prospectus.

Previous studies have found that IPOs with a larger issue price per share are generally less underpriced (Chalk and Peavy 1987; Tinic 1988). The explanation for this is based on the assumption that shares in larger issues are generally sold at a higher price per share (Tinic 1988). The positive and significant coefficient for the *PRICE* variable supports the notion that issues with larger issue price per share generally raise more capital.

The time and resources required to successfully develop a product imply that those companies with fully developed products will generally be larger than those without a product on the market. This is supported by the positive and significant variable for the PROD variable indicating the greater the number of developed products a company owns, the greater the amount of capital they are likely to raise at their IPO.

The insignificance of the *SENT_AO* indicates that there is no relationship between the amount of capital raised at IPO and the movement in the ASX All Ordinaries in the immediate period prior to listing. Interestingly, the negative significant coefficient of the *SENT_HB* indicates that the times when the ASX Health and Biotechnology Index is rising, there is an association with smaller capital raisings of Australian biotechnology companies. For this sample the ASX Health and Biotechnology share price index increased on average 3.2% in the period between the date on the independent accountants report and the day of listing, with the movement ranging between a fall of 12.1% and a rise of 24.3%.

Those companies which had a greater number of patent approvals and patent applications were found to raise larger amounts of capital at their IPO, as demonstrated by the positive and significant coefficient for the *TOT_APP* variable. Conversely, those companies with fewer patent approvals were observed to raise more capital. On average, companies from the sample had 7 patent approvals with the total number ranging from 0 to 42.

### 5.2.3 Discussion

A useful comparison can be made between the results of this study and the results obtained by Deeds, Decarolis and Coombs (1997) who studied 92 biotechnology company IPOs in the United States after 1982. They found significant relationships between the amount of capital raised at IPO and company location, number of products in development, and the number of citations of employee research publications. In their paper, Deeds, Decarolis and Coombs (1997) use the amount of capital raised (less listing expenses) as the dependent variable, and use the amount of assets reported in the prospectus to control for size of issuing company. The size control variable was not used in our analysis due to differences in the samples, as Australian biotechnology companies come to market at an earlier stage in their development and as such have few fixed assets on their balance sheet[20].

Deeds, Decarolis and Coombs (1997) found that the sum total number of developed products and products in development had a positive relationship with the amount of capital raised at IPO which was significant at the 0.1% level. Interestingly, contrary to Deeds, Decarolis and Coombs (1997) findings, this study found no significant relationship between the number of products in development and the amount of money left on the table, the level of underpricing, or the total capital raised. Perhaps the use by Deeds, Decarolis and Coombs (1997) of total assets listed on the balance sheet as a control variable does not capture the size of the companies' growth options, and thus this effect has therefore captured a positive significant relationship with the number of

[20] Deloitte Touche Tohmatsu (2002) found that by market capitalisation listed Australian biotechnology companies are on average 1/10, 1/24, 1/42 the size of listed biotechnology firms in Canada, the United States and the United Kingdom respectively (refer figure 1). The same report goes on to suggest that a lack of venture capitalists willing to invest in Australian biotechnology firms is resulting in those companies being forced into a premature listing.

products in development as a result of size effects. Whilst this study finds no significant impact from the number of products in development, the number of developed products in the market is shown to significantly increase the amount of capital raised and reduce the amount of money left on the table. This is likely a result of increased certainty surrounding future cash flows.

The value of historical or forecast research and development expenditure was not found to be related to the amount of capital raised by Australian Biotechnology IPOs. This is a similar finding to that of Deeds, Decarolis and Coombs (1997). Additionally, no relationship was identified between the amount of money left on the table and research and development expenditures. In her study of 120 US pharmaceutical companies, Shortridge (2004) found that the market provided a value premium to those companies with proven research and development success. The measure of total research and development expenditure fails to quantify the quality of the work undertaken and thus if this metric could be refined to measure quality as well as quantity of research and development, perhaps an improved insight could be obtained.

This research found that the number of patents held had no significant relationship with the amount of money left on the table by Australian Biotechnology companies, however those companies with more approved patents were found to raise significantly less capital at their IPO. In their fully developed model, Deeds, Decarolis and Coombs (1997) found that the number of patents held by the listing company had no impact on the amount of money raised at IPO for United States Biotechnology companies. The positive significant coefficient on the sum total number of patents and patent applications variable indicates that firms with more patent applications will raise more capital at their IPO but leave more money on the table. More capital raised at IPO is likely a size effect, however the observation that more money is left on the table seems to highlight the need for Australian biotechnology companies to focus their limited amount of capital resources on a few core projects within their pipeline. This relationship was not captured by Deeds, Decarolis and Coombs (1997), however the greater volume of capital available to US biotechnology ventures may allow increased diversification in their research and development pipeline.

The citation index which Deeds, Decarolis and Coombs (1997) use as a measure of the firms scientific capabilities was found to have a positive relationship with the amount of capital raised at IPO which the authors propose is a result of the better scientific teams engaging in more productive R&D. The negative and significant variable of the *CIT* coefficient presented in this thesis does not support the Deeds, Decarolis and Coombs (1997) hypothesis but instead supports recent research by Corolleur, Carrere and Mangematin (2004). If more senior and qualified scientific research people are engaging in riskier projects then the increased uncertainty surrounding the success of those projects would see investors requiring greater profits on the first day of listing.

This research aimed to investigate in an Australian context the knowledge transfer effect found by Deeds, Decarolis and Coombs (1997) who showed a positive significant coefficient for the dummy variable to control for firms located within biotechnology clusters. They propose that the concentration of biotechnology firms in the geographical region surrounding a listing biotechnology company will have a positive impact on the amount of capital raised at IPO. Australian biotechnology companies are not clustered to the extent that they are in the US, thus having a head office located within a metropolitan region of a capital city was used as a proxy for a biotechnology cluster. The metropolitan location dummy variable used in this study was found to be insignificant suggesting that a metropolitan location is a poor proxy for a biotechnology cluster. Further refinement of this variable is necessary to determine if the effect captured by Deeds, Decarolis and Coombs (1997) is replicated in this set of Australian biotechnology IPOs.

## 5.3 SENTIMENT AUGMENTATION

The majority of explanations for the observed underpricing relate to uncertainty around the offering (see Rock (1986), Beatty and Ritter (1986)), although, since the work of Ibbotson and Jaffe (1975) and Ritter (1984), there are well known sentiment effects that produce hot issue periods in IPO markets. Hot issue periods are characterised by greater levels of IPO underpricing, with an increased volume of IPO capital raisings, and larger capital raisings (Helwege and Liang 2004).

The key challenge is to find variables that capture the movements in market sentiment. Brailsford, Heaney and Shi (2001; 2004) conduct an analysis at the overall market level

and find a role for the number of new issues, the level of underpricing and general market conditions. The purpose of the present analysis is to explore this issue in the context of individual IPOs in the Australian biotechnology sector. Dimovski and Brooks (2004b; 2004a) find a significant role for variations in the market index as a sentiment variable for Australian IPOs in general which was shown to hold true for Australian biotechnology IPOs (refer Table 5-3).

There are alternative variables that can be used to measure sentiment type effects. One possible alternative sentiment variable is media coverage during the issue period. Demers and Lewellen (2003) find that more underpriced offerings receive a greater number of media cites in the months post-IPO. They also show a relationship between media coverage in the month prior to listing and underpricing. With investor sentiment providing a significant contribution to underpricing, media coverage during the issue period and for high first day returns will encourage investment in subsequent listings. Conversely Pollock and Rindova (2003) found that a greater level of media coverage in the period one year prior to IPO was negatively related to the level of underpricing supporting their media legitimisation theory that increased media coverage provides a form of validation of a new firm's legitimacy, hence reducing perceived investor risks associated with that firm.

This section extends the previous analysis of market sentiment and media effects in the context of Australian biotechnology IPOs. The biotechnology sector provides an interesting analysis given the general uncertainty that applies to valuation in that sector. More specifically, market sentiment is explored through the addition to previous modelling of variables capturing media coverage during the issue period. Those companies with greater levels of direct (company name mentioned specifically) and indirect (for example discussions about the disease area the company hopes to treat) media coverage could expect to face differing levels of investor sentiment compared to more inconspicuous listings.

### 5.3.1 Data

The models developed in section 5.2 which follow the analysis in Deeds, Decarolis and Coombs (1997) are used as base models for this analysis, however, the underpricing model was excluded as none of the explanatory variables were found to have a

significant coefficient. In this section these models are augmented with additional variables to capture media coverage.

Media coverage was measured as the number of media cites in major Australian publications in the period between the date specified on the independent accountant's report and the day of listing. The Factiva database was used as the source to capture data on media coverage. To ensure consistency across the sample period, only those publications with electronic access over the entire sample period were included, specifically, The Age (a major Melbourne paper), The Sydney Morning Herald, The Australian Financial Review, and The Business Review Weekly. Media coverage data was collected at three levels: the industry level, the firm level, and the therapeutic impact level. "Biotech*" was used as the search term at the industry level, "<company name>" at the firm level, and at the therapeutic impact level, key words describing the areas of treatment and disease were selected from the prospectus. To control for variation in the length of the window of the issue period this information was standardised to produce a measure of media cites per day.

**Table 5-4 Media Coverage Descriptive Statistics**
This table reports measures of central tendency and variability for the media coverage explanatory variables. Where *IND* is the standardised count of daily media articles about biotechnology, *DIS* is the standardised count of daily media articles relating to the disease and treatment keywords and *CO* is the standardised count of daily media articles mentioning the company name.

| Variable | Mean | Median | Maximum | Minimum | Std. Dev. |
|---|---|---|---|---|---|
| *IND* | 1.787 | 1.942 | 3.091 | 0.289 | 0.866 |
| *DIS* | 2.052 | 0.636 | 17.200 | 0.000 | 3.468 |
| *CO* | 0.144 | 0.096 | 1.196 | 0.012 | 0.214 |

To control for outliers, the natural log was taken of all of the media coverage variables. Additionally, larger offerings are intuitively expected to attract a greater level of media attention. To control for this potential bias, the natural log of the total capital raised was also included in the money left model as an independent variable.

Thus, the models augmented with the media coverage variables are:

$$MoneyLeft = \beta_0 + \beta_1 CIT + \beta_2 INDACC + \beta_3 PRICE + \beta_4 PROD + \beta_5 SENT\_AO + \beta_6 TOT\_APP + \beta_7 LN\_CAPRAIS + \beta_8 LN\_IND + \beta_9 LN\_DIS + \beta_{10} LN\_CO + \varepsilon_i$$

$$Ln\_CapRais = \beta_0 + \beta_1 INDACC + \beta_2 PRICE + \beta_3 PROD + \beta_4 SENT\_HB + \beta_5 TOT\_APP + \beta_6 TOT\_PAT + \beta_8 LN\_IND + \beta_9 LN\_DIS + \beta_{10} LN\_CO + \varepsilon_i$$

*LN_IND* is the standardised count of daily media articles about biotechnology, *LN_DIS* is the standardised count of daily media articles relating to the disease and treatment keywords and *LN_CO* is the standardised count of daily media articles mentioning the company name.

From the previous literature, there are two competing hypotheses about the impact of the media coverage variables. Following Demers and Lewellen (2003), one expects that increased media coverage in the period prior to the IPO results in improved investor sentiment towards the issue, resulting in more money being left on the table on the first day of listing. Conversely, following Pollock and Rindova (2003) one expects that increased media coverage provides investors with additional information regarding the nature of the company, thus reducing investor uncertainty resulting in less money being left on the table on the first day of listing.

### 5.3.2 Results and Discussion

The results of estimating the models, with and without the media coverage variables, are reported in Table 5-5. The table presents OLS parameter estimates and White-corrected p-values. The results in Table 5-5 reveal the following patterns. First, the introduction of the media citation variables has marginally increased the explanatory power of the *MoneyLeft* model, with the adjusted R squared of the model rising from 0.44 to 0.47. Of the three media variables, only the variable measuring the number of times the company has been named directly is found to have a significant impact on the amount of money left on the table. This positive and significant coefficient supports the Demers and Lewellen (2003) hypothesis that increased media exposure prior to listing has a positive influence on investor sentiment and thus increases the amount of money left on the table. In contrast, based on the "media legitimation" effect proposed by Pollock and Rindova (2003) one could expect some negative coefficients, especially in relation to direct media coverage of the company name. The positive and significant coefficient for the company media variable, combined with the insignificant coefficients for the disease target and industry citations leads to a conclusion against the media legitimation hypothesis for the underpricing of Australian biotechnology IPOs. Finally, the positive and significant coefficient for the market sentiment variable, shown in section 0 to

support research by Dimovski and Brooks (2004b; 2004a), retains its positive sign but loses its significance, suggesting that the media coverage variables might be a better measure of sentiment for Australian biotechnology IPOs.

Augmentation of the *Ln_CapRais* with the media variables did not significantly increase the explanatory power of the model, with the adjusted R squared remaining at 0.87. The *INDACC* variable became insignificant, likely a result of a positive relationship between firm size, independent accountant quality and media coverage. The positive coefficient for the *LN_IND* variable indicates that periods with increased discussion of the biotechnology sector in the popular press were associated with larger IPOs. Interestingly, neither specific company references nor discussion of relevant therapeutic field was found to be significant, indicating that an awareness by readers of the popular press of the biotechnology sector as a whole is more influential on the magnitude of individual biotech company capital raisings.

**Table 5-5 Sentiment Augmented Models**

*MoneyLeft* is the amount of money left on the table which is equal to the number of shares issued * (price on close – issue price). *Ln_CapRais* is the natural logarithm of the amount of capital raised by the IPO. *CIT* is the total number of citations of employees' and members of the scientific advisory boards' work as per the "web of science" database. *INDACC* is a dummy variable for the use of a reputable independent accountant. *PRICE* is the issue price of the listing. *PROD* is the number of fully developed products described in the prospectus. *SENT_AO* is the movement on the ASX all ordinaries index (orthogonalized to be independent of movement in the health and biotechnology index) from the date on the independent accountants report to date of listing. *SENT_HB* is the moment of the ASX health and biotechnology index) from the date on the independent accountants report to date of listing. *TOT_APP* is the total number of awarded patents and patents under application at the time of listing with each country treated as a separate application. *TOT_PAT* is the number of awarded patents at the time of listing.

| Variable | Base Models | | Augmented Models | |
|---|---|---|---|---|
| | *MoneyLeft* (,000) | *Ln_CapRais* | *MoneyLeft* (,000) | *Ln_CapRais* |
| | Parameter estimates (p-value) | Parameter estimates (p-value) | Parameter estimates (p-value) | Parameter estimates (p-value) |
| Constant | -2269.752 (0.0116) | 15.1244 (0.0000) | 14627.235 (0.5635) | 15.11890 (0.0000) |
| CIT | 0.066 (0.0032) | | 0.065 (0.0106) | |
| INDACC | -3839.288 (0.0233) | 0.2795 (0.0879) | -3351.009 (0.1582) | 0.164099 (0.4566) |
| PRICE | 8092.745 (0.0001) | 1.3036 (0.0000) | 8858.387 (0.0018) | 1.446753 (0.0000) |
| PROD | -356.160 (0.0266) | 0.0308 (0.0004) | -373.745 (0.0294) | 0.029396 (0.0166) |
| SENT_AO | 23304.290 (0.0027) | | 8867.474 (0.5021) | |
| SENT_HB | | -1.3797 (0.0788) | | -2.289866 (0.0239) |
| TOT_APP | 38.152 (0.0143) | 0.0060 (0.0008) | 32.267 (0.0447) | 0.006231 (0.0013) |
| TOT_PAT | | -0.0319 (0.0000) | | -0.036517 (0.0000) |
| LN_CAPRAIS | | -------- | -851.360 (0.6131) | -------- |
| LN_IND | | | -490.619 (0.6130) | 0.171105 (0.0993) |
| LN_DIS | | | -246.312 (0.5947) | -0.065647 (0.2907) |
| LN_CO | | | 1666.307 (0.0046) | 0.016413 (0.7841) |
| Adjusted R2 | 0.43 | 0.87 | 0.47 | 0.87 |
| Observations | 34 | 34 | 30 | 30 |

## 5.4 CONCLUSION

This chapter found evidence that during their IPO capital raising, Australian biotechnology companies leave significant amounts of money on the table. For Australian biotechnology companies, the amount of money left on the table was found to be more critical than the level of underpricing. This was evidenced by the significant relationships observed between the information contained within the prospectus and the amount of money left on the table, and the lack of significance with the level of underpricing.

Australian biotechnology companies were able to reduce the amount of money left on the table at their IPO by having a fully developed product selling in the market prior to

listing, and by engaging the service of a reputable independent accountant to prepare their financial history for presentation in the prospectus. Interestingly, those companies possessing large numbers of patents and patent applications were found to leave more money on the table suggesting investors look for a narrower focus on one or few potential products. Companies with staff whose research work had been more frequently cited were found to leave more money on the table and this was interpreted as evidence of higher quality research staff being attracted by the reputation-enhancing and financial rewards that high risk projects offered.

Similar to the findings of Deeds, Decarolis and Coombs (1997), information contained within the issuing prospectus was found to have an impact on the amount of funds retained by the floating company, however, some differences were found regarding the direction of influence of that information. As with Deeds, Decarolis and Coombs (1997), those companies with more developed products and a greater number of patent applications were found to raise more capital at IPO. Additionally, Australian biotechnology companies were found to raise more capital when they had engaged a reputable independent accountant and had a greater issue price per share. Conversely, no evidence of a reward for knowledge transfer orientation or research and development investment was observed.

A large body of literature surrounds the question of IPO underpricing and the reasons for its persistent occurrence around the world, with a significant portion of that literature dedicated to examining the relationship between underpricing, hot issue periods and investor sentiment. This analysis of Australian biotechnology companies that went public between 1994 and 2004 provides an exploration of the role of hot issue conditions and market sentiment in underpricing. Hot issue periods are typically characterised by increased media coverage and greater levels of money left on the table by new issues. This research supports the proposition that increased media coverage in the lead up to IPO is positively related to the amount of money left on the table for Australian biotechnology IPOs.

# CHAPTER 6 CRITICAL EVALUATION OF CONTEMPORARY VALUATION METHODOLOGIES

## 6.1 INTRODUCTION

Chapter 4 of this thesis described the challenge that Australian biotechnology companies face in raising sufficient capital to fund expensive research and development programs. As a result of the scarcity in development capital, Australian biotechnology firms are forced to consider a public sale through IPO and, as a result, the industry has a significant number of publicly listed firms which are still many years from successfully launching a product on the market. Whilst an IPO may provide a short term injection of funds to the company, these early stage firms often have difficulty with subsequent capital raisings due to the unattractive risk profile of an early stage biotechnology product.

Chapter 5 investigated the phenomenon of IPO underpricing and found that the level of underpricing for biotechnology firms was greater than the average level of underpricing across all industrial sectors. Underpricing is also termed "money left on the table" as the new investors benefit from share price movement at the expense of the listing firm. If uncertainty surrounding biotechnology investment could be reduced, the amount of money left on the table by Australian biotechnology firms at their IPO might be reduced, providing additional capital towards product research and development.

This chapter investigates the suitability of contemporary valuation methodologies for assessing biotechnology investments. If the uncertainty surrounding biotechnology investment can be reduced through modern investment tools, it is hoped that the industry should see an increase in the amount of funds directed into the sector.

A model to analyse and compare contemporary valuation methodologies was developed following the process described in Chapter 3. The following discussion is subdivided into five areas: alternative valuation methodologies, biotechnology value drivers and

model input assumptions, valuation and the product development cycle, valuation model sensitivities and implications of valuation methodological choice for investors and management.

## 6.2 ALTERNATIVE VALUATION METHODS

Four valuation methods are analysed in this thesis. Two discounted cash flow (DCF) models were included, the standard DCF as well as an extension of this model called the expected discounted cash flow (eDCF). Two real option valuation models were also included, binomial option valuation and binomial lattice option valuation.

### 6.2.1 Discounted Cash Flow

Discounted cash flow (DCF) models are a commonly used tool to value investment opportunities that date back to early publications by Fisher (1930) and Williams (1938) who described the DCF method as a valuation tool accounting for the time value of money.

Valuation using a DCF model requires that all cash flows associated with a prospective investment are forecast over the life of the project and are then discounted back to a present value using an appropriately chosen discount rate. The discount rate should be chosen to reflect the risks associated with the forecast cash flows, however this requirement can be problematic due to difficulties quantifying the risks upon which the discount rate is based.

Modern financial theory uses the capital asset pricing model (CAPM) as a means for quantifying investment risk. This method quantifies firm sensitivity to systematic risk relative to the market as a whole. If an investment is more risky than “the market” then it should offer returns in excess of the market in order to compensate investors for that additional risk. To overcome difficulties in quantification of the risks and return characteristics of “the market”, the bundle of all publicly listed companies on the stock market is used as a proxy for “the market”.

In addition to the underlying assumptions inherent in the CAPM, the use of this method to calculate the discount rate for a project assumes that the risks associated with the cash flows generated through the project are comparable to those of the firm for which a

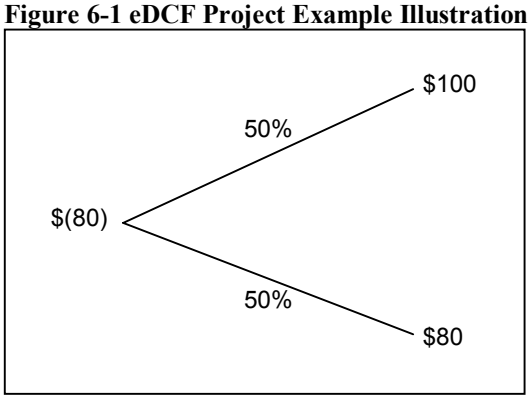
CAPM based discount rate is calculated. For a firm that is not publicly listed, a comparable publicly listed firm must be found in order to calculate a cost of capital using the CAPM. For an early stage biotechnology company this may pose some difficulty as there may be no listed firm with similar risk sensitivity which can be used as a basis for calculating a comparable discount rate.

A DCF model was used to value a typical drug development project based on the inputs described in section 6.3.2 below. The DCF model does not incorporate the ability of management to respond flexibly to issues that arise throughout the project, and as such no flexibility is included in the cash flows forecast using this method. For this analysis, an average commercialisation outcome was assumed as the basis from which cash flows were estimated. No allowance was made for product development success risks as these are assumed to be diversifiable and quantified by selection of an appropriate discount rate.

### 6.2.2 Expected Discounted Cash Flow

The expected discounted cash flow model (eDCF) relies on the same principles as simple DCF models, however, it seeks to incorporate known project risk into cash flow forecasts. This is achieved by evaluating more than one cash flow outcome, best described in the form of an example. Let us say that a firm is deciding whether to invest in a project which requires an $80 investment and has two possible outcomes, A and B. A is more favourable than B with expected revenues one year from now of $100 whilst outcome B has expected revenues one year from now of $80. Additionally, each outcome has an equal likelihood of occurrence, that being 50% probability and the discount rate is assumed at 10%. This project is presented diagrammatically in Figure 6-1.

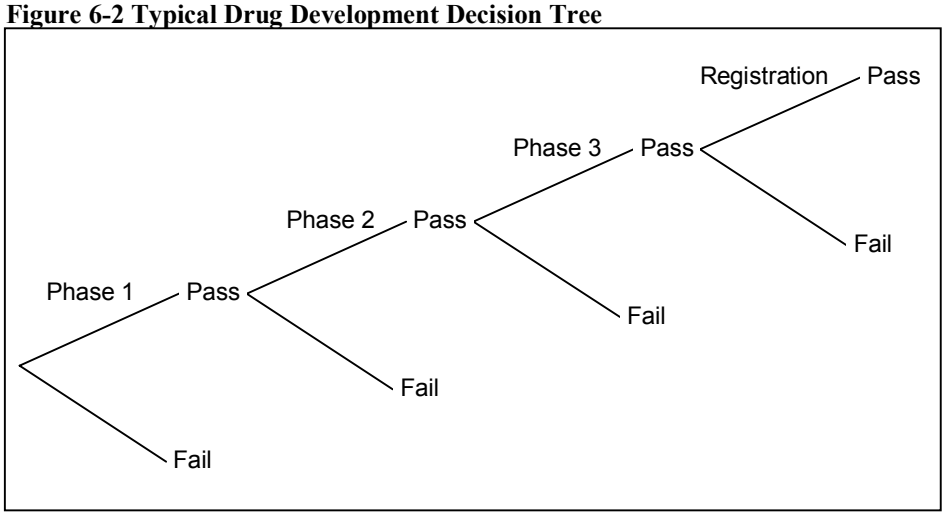
**Figure 6-1 eDCF Project Example Illustration of Cash Flows**




The present value of this investment is calculated as the probability weighted sum of the present values for all cash flows associated with the project. Thus the eDCF value for this project is equal to 100%*$(80) + 50%*$100/1.10 + 50%*$80/1.10 = $1.82. Therefore, on the basis of this calculation, the firm should choose to invest the required $80 in this project as it has a positive expected net present value. The input data required to compute this valuation were the discount rate, the cash flows (size, timing) and the probability of those cash flows occurring.

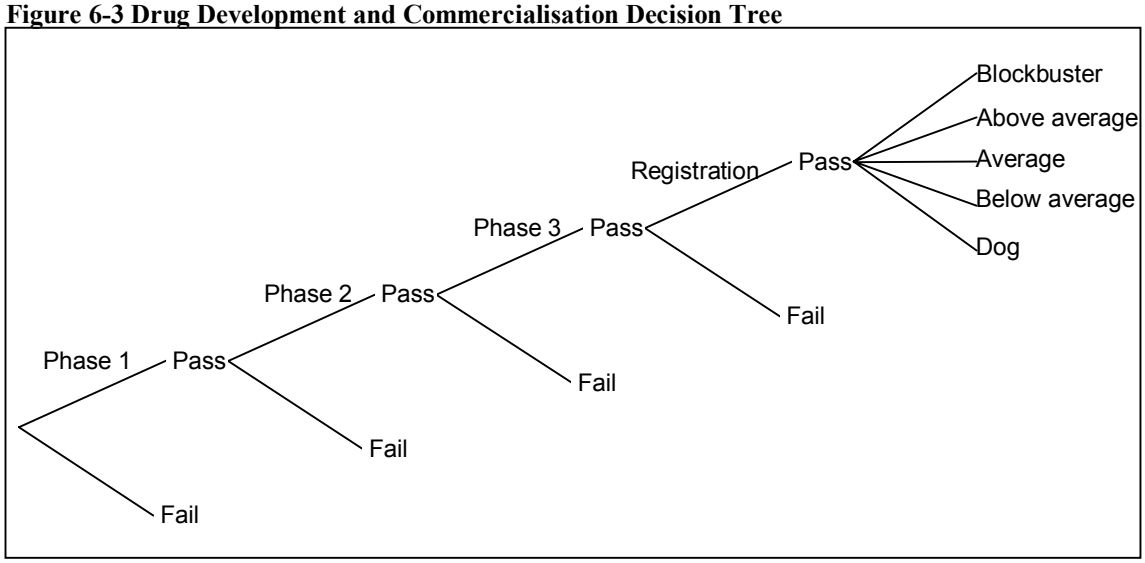
This form of valuation is particularly suited to pharmaceutical investments due to the clearly defined hurdles that must be overcome during the product development phase. Once a product has undergone pre-clinical development and assessment, the product must undergo phase 1, 2, and 3 clinical trials prior to all documentation pertaining to the development being submitted to the regulator (for example the Therapeutic Goods Administration (TGA) in Australia) for approval. If the regulator is satisfied with the documentation and results of the clinical trials, then the product may be released on the market. This process is shown in decision tree form in Figure 6-2.

**Figure 6-2 Typical Drug Development Decision Tree**




Factors such as the competitive landscape, efficacy of a treatment, side effect profiles, development cost (and drug pricing) and age of a product all have an impact on the revenues generated by a therapeutic. When conducting valuation of a pharmaceutical product in the early stages of development, great uncertainty exists around many of these factors hence significant uncertainty exists around the commercialisation stage cash flows that may be realised should the product pass all regulatory requirements and make it to a marketable product. To capture this uncertainty, Kellogg and Charnes (2000) propose that five separate commercialisation outcomes be included in valuation analysis. They labelled these outcomes as dog, below average, average, above average and breakthrough (or blockbuster). These outcomes can be simply added to the final branch of the decision tree in Figure 6-2 to produce the drug development and commercialisation decision tree shown in Figure 6-3.

**Figure 6-3 Drug Development and Commercialisation Decision Tree**



The eDCF model in this chapter uses the decision tree shown in Figure 6-3 as the foundation for possible project outcomes. The method follows Kellogg and Charnes (2000), however, the input data has been updated to incorporate recent literature. Similar inputs to the simple example shown earlier are required to calculate an estimate of value:

1. Probability of each outcome occurring (include probability of successfully completing each development phase as well as the probability of each of the commercialisation outcomes occurring).
2. Commercialisation cash flow details (timings and size).
3. Discount rate.

The input values adopted for the model are described in greater detail in section 6.3.2.

The eDCF valuation methodology allows the valuer to incorporate perceptions of project risk into the development model. With pharmaceutical products, a significant amount of information is available to help model the likelihood of each of the outcomes described in the decision tree. Use of this information enables the valuer to build a more powerful model which also allows a more quantitative description of the risks included in the model. Whilst the first cut of an eDCF valuation model may be based on industry wide data regarding the likelihood of success at each stage of clinical development, the specific manner in which this is incorporated into the model allows the valuer to easily adjust these risks to more accurately reflect the risks associated with the opportunity under assessment.

Unfortunately, whilst the project risk can be specifically modelled with some accuracy, inclusion of this information in the model creates an inconsistency with the underlying valuation theory. As discussed, the discount rates should be chosen to reflect the risks associated with the project under assessment. This being the case, the addition of project risk estimates in the model effectively creates a double counting of this risk. To overcome this, the discount rate can be reduced to exclude project level risk, however, this requires knowledge of what portion of the discount rate reflects the specific project risk included in the decision tree. Calculation of the discount rate using the CAPM and weighted average cost of capital (WACC) does not allow the user to identify the components of risk included in the discount rate, thus, to estimate the portion attributable to project risk becomes a significant challenge. Fortunately, an underlying

assumption of the CAPM stipulates that the WACC only captures the impact of systematic risk. A biotechnology firm is able to reduce its exposure to project failure through diversification, hence a project risk contains at least some portion of unsystematic risk. The extent to which the project risk is systematic or unsystematic determines the extent to which the eDCF model incorporates a double counting of project risk.

### 6.2.3 Binomial Option Valuation

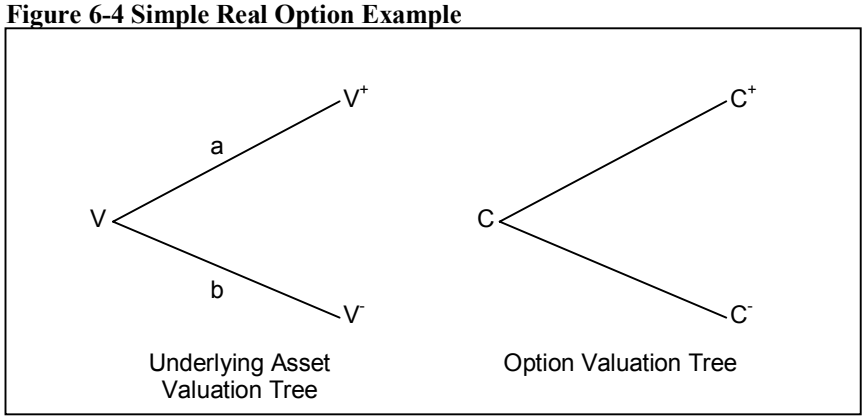
To overcome the problem of double counting of the project level risk in eDCF valuation models, Jagle (1999) proposes a solution based on binomial option valuation theory. Jagle provides a brief description of the methodological process, however, more detail can be found in Trigeorgis (1996) and Copeland and Antikarov (2001).

> *A real option represents the right but not the obligation to undertake an action at a predetermined cost called the exercise price (Copeland and Antikarov 2001).*

A drug development project can be considered in the context of option valuation theory as a series of real options. The commercialisation cash flows are the underlying asset, and the discovery stage research and development costs represent the exercise price on call options to proceed to the next phase of development. If the drug development project is considered in this manner, then the value of the project at any stage in development is the value of the call option at that time.

The underlying premise of option valuation is the concept of the risk neutral portfolio which forms the foundation for the following derivations. Consider an asset which has a present value, $V$, and two possible future values $V^+$ and $V^-$ with the probability of these outcomes eventuating being $a$ and $b$ respectively. A call option on this asset also exists which has a present value of $C$, and two possible future values of $C^+$ and $C^-$. This scenario is diagrammatically shown below in Figure 6-4.

**Figure 6-4 Simple Real Option Example**




By investing in a portfolio consisting of a long position in the underlying asset and selling short *m* call options on that asset, a risk neutral position can be held whereby the value of the portfolio is the same regardless of the eventual value of the underlying asset. That is to say that any increase in the value of the asset will be offset by the corresponding decrease in the value of the short call option(s), and visa versa.

Thus:

$$V^+ - mC^+ = V^- - mC^-$$

If *u* and *d* are defined as:

$$u = \frac{V^+}{V} \text{ and } d = \frac{V^-}{V}$$

Then:

$$uV - mC^+ = dV - mC^-$$

Transposing for *m* gives:

$$m = \frac{(u-d)V}{C^+ - C^-}$$

As the value of the portfolio is the same regardless of the movement in the value of the underlying asset, the *law of one price*[21] says that this portfolio must have returns equal to the risk free rate of return, *r*. Thus over a period of time, *t*, the change in portfolio value is:

$$(V - mC) * (1+r)^t = uV - mC^+ \quad (= dV - mC^-)$$

Substituting the derived equation for *m*, above, and transposing for *C* gives:

[21] The *law of one price* states that in an efficient market two assets having identical returns, regardless of the state of nature, must have the same value (Copeland and Antikarov 2001). This makes intuitive sense as any variation between the prices of two assets having identical returns would create an arbitrage opportunity for risk free profits.

$$C = \frac{pC^{+} + (1-p)C^{-}}{(1+r)^{t}}$$

Where:

$$p = \frac{(1+r)^{t} - d}{u - d} \text{ and } 1 - p = \frac{u - (1+r)^{t}}{u - d}$$

Substituting our known values for $u$ and $d$ gives:

$$p = \frac{V(1+r)^{t} - V^{-}}{V^{+} - V^{-}}$$

Thus if $V$, $V^{+}$, $V^{-}$, $C^{+}$ and $C^{-}$ are known, then the concept of risk neutrality allows the calculation of the value of $C$. The estimate of $p$ is known as the "risk neutral success probability" and is used (along with the risk free rate) to discount the future option values to calculate the present option value.

To calculate $C$, the estimates of $V$, $V^{+}$, and $V^{-}$ must first be calculated. $V^{+}$ and $V^{-}$ are the values of the expected cash flows that would occur in favourable or unfavourable market conditions respectively. DCF can be used to calculate an estimate for the values of these inputs. Copeland and Antikarov (2001) assume that the present value of the expected cash flows is the best unbiased estimate for the value of the underlying asset. This assumes that management is without flexibility around project implementation and is called the Marketed Asset Disclaimer (MAD). This allows $V$ to be calculated using the eDCF tools using $a$, the actual probability of a favourable outcome.

Once all values in the underlying asset value tree are known, then the corresponding risk neutral success probability can be calculated. The next step is calculation of $C^{+}$ and $C^{-}$. At expiry, the value of a call option is entirely made up of its intrinsic value which equals the value of the underlying asset less the exercise price. In the case of a drug development project, the exercise price is research and development cost of that phase. On this basis $C^{+}$ and $C^{-}$ can be estimated and the value for $C$ can be calculated by discounting $C^{+}$ and $C^{-}$ using the risk free rate and applying the risk neutral probabilities, $p$ and 1-$p$ to each outcome.

The option of project abandonment can be incorporated into this model by specifying that $C^{+}$ and $C^{-}$ are respectively equal to the maximum of $V^{+}$ and $V^{-}$ less development costs or zero. That is to say, if the expected value dips below zero, the project would be

abandoned, hence the value of future cash flows will be zero. For the purposes of this study, and given the identical decision trees used for the binomial and eDCF models, the abandonment option was not incorporated into this model in order that a clearer comparison can be made with eDCF value estimates throughout the life of the project. This will also allow clearer exploration into the purported issue of double counting of project risk within the decision tree and discount rate.

By expanding the binomial decision tree to incorporate each development phase as per Figure 6-2, a drug development project can be valued using this method. Whilst the size of the decision tree increases the computational workload, the process is the same as the simple example above. First, calculate the values in the underlying asset tree (similar to the eDCF model, however development costs are not included), then calculate the risk neutral probabilities, then calculate the option values at the end points, and finally, rolling back through the option tree (using the risk free rate and the risk neutral probabilities), calculate the present value of the option to invest in a drug development project.

Following Jagle (1999), this model was built with each development phase representing one branch in the decision tree. For the purposes of this investigation, development costs incurred during each phase of development were assumed to occur at the commencement of that phase. This provides a conservative estimate of the actual development costs as in reality these costs would be spread throughout the phase. Allowing for the time value of money, the present value of actual development costs would be less than that assumed for this model.

### 6.2.4 Binomial Lattice Option Valuation

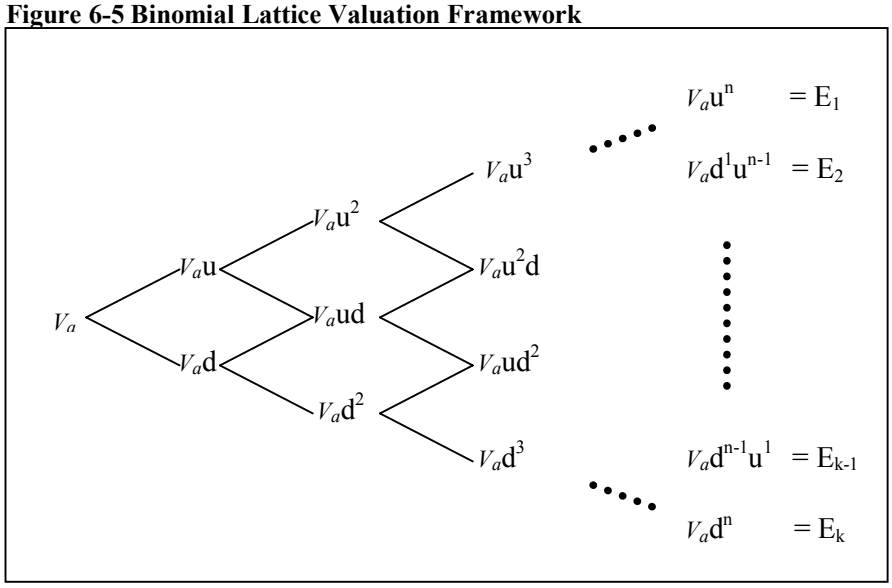
The binomial lattice option valuation method follows that described by Kellogg and Charnes (2000) which relies on the risk neutral valuation approach similar to the binomial option model described in section 6.2.3. In contrast to the previous methods, rather than a decision tree, a binomial lattice is used to model cash flows. The required inputs to value an asset with this methodology are:

1. Current value of the asset, $V_a$.
2. The standard deviation of the asset value, $\sigma$.
3. The risk free rate, $r$.

4. The exercise prices of the call options (these are the costs incurred in order to proceed to next stages in development).
5. The probability of proceeding from one stage in development to the next.

The project is broken up into a finite number of time increments, *n*, and the value of the asset is assumed to move either up or down through each of those increments. This allows construction of the binomial lattice shown below in Figure 6-5.

**Figure 6-5 Binomial Lattice Valuation Framework**




The asset is the final product, thus the current value, $V_a$, is defined as the current value of the commercialisation cash flows at time zero. This is calculated by rolling the commercialisation cash flows through the decision tree in Figure 6-3. The development costs (i.e. the exercise prices), are ignored at this stage as we are only valuing "the asset".

In this case the value of $V_a u^n$ is equal to the value of the commercialisation cash flows in the event of a blockbuster commercialisation outcome, $CF_{block}$. These cash flows are forecast in section 6.3.2.5, with the value of these cash flows at time *n* calculated using a DCF model of the blockbuster cash flows once the product is successfully launched. Following Amram and Kulatilaka (1999) as per Kellogg and Charnes (2000), *u* is set to $e^{\sigma}$ and *d* to $e^{-\sigma}$. Thus:

$$V_a u^n = V_a\, e^{\sigma n} = CF_{block}$$

Transposing gives:

$$\sigma = (1/n)\ln(CF_{block}/V_a)$$

With $CF_{block}$ and $V_a$ calculated using a DCF model, $\sigma$ can easily be calculated allowing all of the asset values through the binomial lattice in Figure 6-5 to be computed.

The next step is to calculate the risk neutral probabilities of success, $p$, and failure, 1-$p$, according to:

$$p = \frac{e^{r\Delta t} - d}{u - d}$$

The actual probability of successfully completing a development stage is defined as $\theta_n$. Where a development stage takes longer than one time period, the probability of successfully moving from one time period to the next is assumed as 1 for all but the last period, which is assumed to be $\theta_n$. This allows the value of the call option, that being the value of the pharmaceutical development project, to be calculated by incrementally rolling back through the binomial lattice. The $E_k$ values (for $k = 1$ *to* $n+1$) form the foundation of the calculation and subsequent values in the lattice are calculated according to:

$$V_{n,k} = \max\left\{\left[V_{n+1,k}\,p + V_{n+1,k+1}(1-p)\right]e^{-r\Delta t}\theta_n - DCF_n, 0\right\}$$

$DCF_n$ is equal to the value of development costs during time period n. It should be noted that according to this formula the value of the pharmaceutical project, $V_{n,k}$, can never be negative due to the max{X,0} statement. The theoretical basis for this is that if a negative number is expected in the next branch of the lattice, the project will be abandoned, and hence the value of future cash flows is zero. This is effectively capturing the value of abandonment of the project if the expected value of the underlying asset drops below that required to generate the necessary return for the given level of risk. Consistent with Kellogg and Charnes (2000), the abandonment option was incorporated in this model allowing some exploration of the value benefits of management flexibility around project abandonment.

This model was constructed with each branch representing one month in development time. Development costs for each phase were assumed to be spread evenly over the duration of that phase and, as per Kellogg and Charnes (2000), the probability of an upward movement in the underlying asset value tree was assumed to be one for all branches other than the last month of development for each particular phase. For the last month the success probabilities are defined in Table 6-1.

## 6.3 MODEL INPUT ASSUMPTIONS

### 6.3.1 Population Sampling Distributions

To generate the model input data within a Monte Carlo simulation, a population distribution for each valuation input was estimated. The chosen distribution was based on the publicly available information describing the distribution for each of the input variables. The particular normal distribution was deemed to be unsuitable due to the skewed nature of the available sample data, together with the tendency for the variables to be contained within certain limits (for example development time cannot be less than zero). Data including development costs and development time were assumed to be clustered around a mode value, with fewer observations down (up) to a minimum (maximum) value.

To model the input data, a version of the beta distribution was chosen for its attributes of being contained between an upper and lower limit and clustered around the mode. This distribution allows generation of more realistic input data as the tails are narrower than the triangular distribution, a similarity shared with the normal distribution.

The beta distribution is defined by the probability density function:

$$f(x) = \begin{cases} \dfrac{x^{v-1}(1-x)^{w-1}}{B(v,w)} & 0 \le x \le 1 \\ 0 & otherwise \end{cases}$$

Where $B(v,w)$ is the beta function:

$$B(v,w) \equiv \int_0^1 t^{v-1}(1-t)^{w-1}\,dt$$

Where $v$ and $w$ are two shape parameters.

A subset of the beta distribution called the betaPERT distribution allows the population mode to be used to generate the shape parameters. In the betaPERT distribution the mean $\mu$ is calculated:

$$\mu = \frac{x_{\min} + x_{\max} + \lambda x_{mode}}{(\lambda + 2)}$$

Where $\lambda$ is a scale parameter which determines the height of the distribution.

The mean can then be used to calculate the shape parameters according to:

$$v = \frac{(\mu - x_{\min})(2x_{mode} - x_{\min} - x_{\max})}{(x_{mode} - \mu)(x_{\max} - x_{\min})}$$

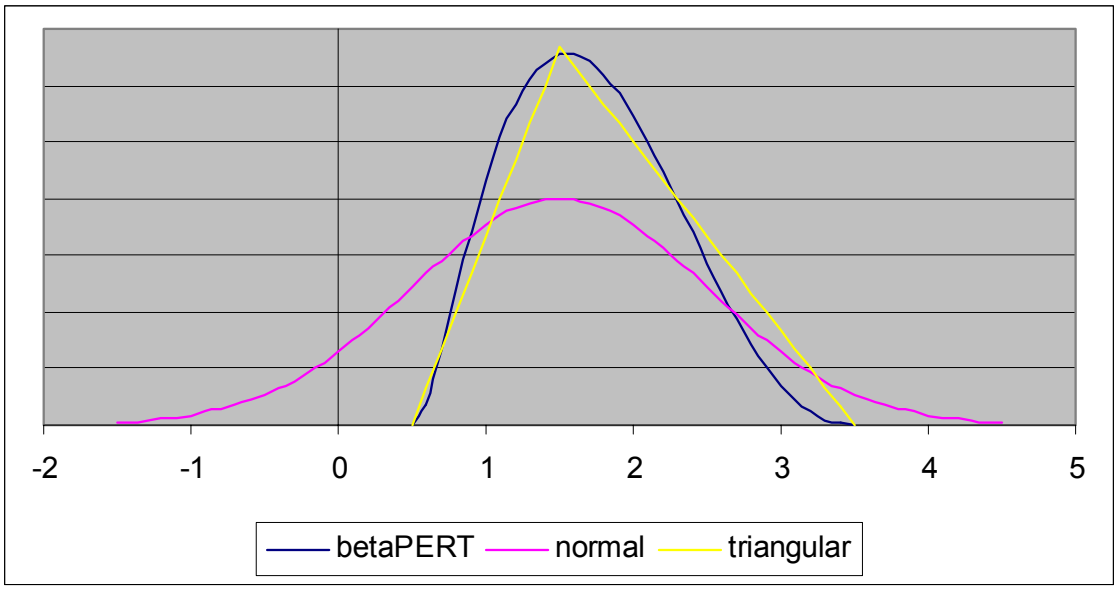
$$w = \frac{v(x_{\max} - \mu)}{(\mu - x_{\min})}$$

Thus, with a minimum, maximum, mode and scale parameter, the betaPERT distribution can be used to model input data for Monte Carlo scenario generation.

Figure 6-6 below provides a graphical comparison of a normal, betaPERT and triangular distributions. The normal distribution has a mean of 1.5 with a standard deviation of 1. To represent data such as development time, the population distribution must be contained within a minimum parameter as negative (or very low) values are not possible. In this example, the standard deviation of the normal distribution was used as the basis for calculating the minimum and maximum values of the betaPERT and triangular distributions. For the minimum value, this was chosen as the mode less one standard deviation which equals 0.5. The maximum was chosen as 3.5 representing two normal distribution standard deviations greater than the mode.

For the betaPERT distribution, a lambda (shape factor) of 4 was adopted. The graphical representation shows that the betaPERT distribution with lambda of 4 is similar to the triangular distribution, having a comparable mode expectation, however, as with the normal distribution, the extremes have narrow tails rather than straight lines.

**Figure 6-6 Comparison of BetaPERT, Normal and Triangular Distribution Probability Mass Functions**




### 6.3.2 Inputs Range Specification

Table 6-1 below summarises all of the input data included in the valuation models and tested using Monte Carlo scenario analysis. The betaPERT distribution was adopted as the population sample for all inputs and the population descriptors of minimum, maximum and mode are shown. In all cases a shape factor (lambda) of 4 was chosen. Details regarding the selection of the population descriptors are provided in the subsequent subsections.

**Table 6-1 Model Inputs and Population Descriptors**

| Item | | Population Descriptors* | | |
|---|---|---|---|---|
| | | Min | Max | Mode |
| R&D Cost ($,000) | Phase I | -40,800 | -2,400 | -15,200 |
| | Phase II | -67,700 | -1,400 | -23,500 |
| | Phase III | -207,500 | -25,700 | -86,300 |
| | NDA Application | -4,900 | -1,000 | -3,300 |
| R&D Time (months) | Phase I | 3.7 | 57.4 | 21.6 |
| | Phase II | 4.4 | 68.3 | 25.7 |
| | Phase III | 5.2 | 81.0 | 30.5 |
| | NDA Application | 3.1 | 48.3 | 18.2 |
| | Post Approval | 1.5 | 23.9 | 9 |
| Probability Development Success | Phase I | 53% | 89% | 71% |
| | Phase II | 33% | 55% | 44% |
| | Phase III | 57% | 95% | 76% |
| | NDA Application | 85% | 95% | 90% |
| Salvage Value ($,000) | Phase I | 0 | 650 | 325 |
| | Phase II | 0 | 800 | 400 |
| | Phase III | 0 | 1000 | 500 |
| | NDA Application | 0 | 1000 | 500 |
| Probability of Average Drug Sales | - | 50% | 70% | 60% |
| Post Approval R&D ($,000) | | -371,908 | -24,046 | -140,000 |
| Revenues from Drug Sales ($,000) | Dog | 4,000 | 9,000 | 6,500 |
| | Below Average | 9,000 | 20,000 | 14,500 |
| | Average | 20,000 | 400,000 | 210,000 |
| | Above Average | 400,000 | 1,500,000 | 950,000 |
| | Breakthrough | 1,500,000 | 2,500,000 | 2,000,000 |
| Discount Rate (Real) | Commercial | 10.00% | 12.00% | 11.00% |
| | R&D | 7.00% | 9.00% | 8.00% |
| Inflation | - | - | - | 2.82% |
| Risk Free Rate | - | - | - | 5.50% |

* A shape factor (lambda) of 4 was adopted for all population distributions.

#### *6.3.2.1 Research and Development Costs*

Estimates for the research and development costs at each phase of product development prior to market launch were based on data provided in DiMasi, Hansen and Grabowski (2003). This paper has been widely cited and has also been the subject of extensive debate about the actual costs of drug development. The more recent analysis by Adams and Brantner (2006) uses data from an alternative source (the Pharmaprojects database which is a collation of data from publicly available sources assembled by the vendor, PJB Publications) and generally supports the findings of DiMasi, Hansen and Grabowski (2003).

The sample used by DiMasi, Hansen and Grabowski (2003) included costs of 68 drugs in development by 10 pharmaceutical firms obtained from the proprietary Tufts Center for the Study of Drug Development (CSDD) database. The drug development programs

had begun between 1983 and 1994 and were in development though to 2000. Whilst they provide mean, median and standard deviation of the "out of pocket" drug development costs, no additional information was given regarding the distribution characteristics of the sample of costs.

The mean costs were adopted as the mode for the purposes of this study and it was observed that, for all phases of product development, the mean cost was marginally greater than one standard deviation above zero. The minimum cost cannot be less than zero and the level of work required to develop a new drug implies that the cost cannot be near zero. For the purposes of this study, the mean cost of development in each phase less one standard deviation was adopted as the minimum cost boundary for our model.

Greater possibility exists for costs being significantly higher than average depending on the particular characteristics of the drug in development. Some products with significantly increased development costs will be financed by drug development companies depending on the ultimate potential for commercial return of those products. To allow for this possibility of greater upwards variance in development costs, the mean cost plus two standard deviations was adopted as the maximum cost boundary for our model.

#### *6.3.2.2 Research and Development Time*

DiMasi, Hansen and Grabowski (2003) provide data regarding the mean time in each of the research and development phases prior to products being launched, however, no data is provided regarding the shape of the distribution of development times. In the absence of any additional descriptive data, the length of time taken in each development phase was assumed to be correlated to the cost incurred in that phase, with a similar shaped population distribution. The ratios of the standard deviations of phase one, two and three clinical trial costs compared with the mean costs for each are 0.84, 0.94 and 0.70 respectively, with an average of 0.83.

A ratio of 0.83 was assumed between the standard deviation and mean of development times. Applying this ratio enabled estimates of the standard deviation to be calculated, allowing calculation of minimum development times as one standard deviation less than the mean, and maximums of two standard deviations greater than the mean.

#### *6.3.2.3 Research and Development Success Probabilities*

The probability of successful product development is a subject of much debate with a broad range of estimates depending on data source, drug characteristics and the time at which the data was collected. DiMasi, Hansen and Grabowski (2003) provide data regarding the probabilities of drugs moving from one phase to the next within their sample which was used as the basis for this study. Whilst not directly stated, their data implied that the probabilities of successfully moving from one development phase to the next were 0.71, 0.44 and 0.69 for phase one, two and three clinical trials respectively. The phase three success rate includes a successful new drug application (NDA) with the US Food and Drug Administration. In order to split this stage of the development process out from the phase three probabilities, a 0.90 success probability was assumed for a NDA after completion of phase 3 clinical trials. This implied a probability of successful completion of phase 3 clinical trials of 0.76.

Due to the uncertainty surrounding actual success probabilities of specific drugs, a range of plus or minus 25% of the expected success rate was used as the maximum and minimum success probabilities for the clinical trial phases. Once a product has passed through clinical trials, the likelihood of successful NDA registration is high (DiMasi 2001). Rather than apply a variation of plus or minus 25%, which would potentially generate excessively pessimistic success forecasts, the probability of successful new drug registration with the FDA was assumed to vary from a minimum of 0.85 to a maximum of 0.95.

#### *6.3.2.4 Salvage Values*

Salvage values represent the value of a research project in the event that a decision was made not to continue product development. The decision to terminate product development could be due to critical flaws in the product itself (such as efficacy or toxicity concerns), or for other matters such as the commercial viability of the final product or strategic decisions to withdraw from an area of product development.

Whilst termination of a project will inevitably result in a significant revaluation of the associated intellectual property, potential remains for some value to be realised. For example the technology could be applied to a different product or the data generated in product development process may be valuable to a competitor. The value that can be

realised in the event of project termination is difficult to quantify, however, to test the sensitivity of the models for illustrative purposes, nominal figures for value were chosen. In his real option valuation example, Jagle (1999) adopted relatively large values for these termination values[22], however, due to the uncertainty surrounding these salvage values, conservative numbers were chosen for this analysis. For each stage of development the termination values were generated based on a minimum value of $0 up to a maximum of $650,000, $800,000, $1,000,000, or $1,000,000 for products terminated after phase 1, 2, 3, and new drug registration respectively. The mode was chosen as the midpoint between the minimum and maximum values.

#### *6.3.2.5 Commercialisation Cash flows*

The commercialisation cash flows are dependant on a large number of underlying factors. The method for forecasting the commercialisation cash flows is based on the method outlined by Kellogg and Charnes (2000). For simplicity, costs are assumed as a percentage of sales and sales are forecast over a defined timeline. The operational costs assumed for this analysis is outlined below in Table 6-2.

**Table 6-2 Commercialisation Cash flow Cost Assumptions**

| Cost Item | % of Sales |
|---|---|
| COGS | 25.5% |
| Sales & Marketing Expense | Varies* |
| General & Admin Expense | 11.1% |
| Tax | 30.0% |
| Working Capital | 17.0% |

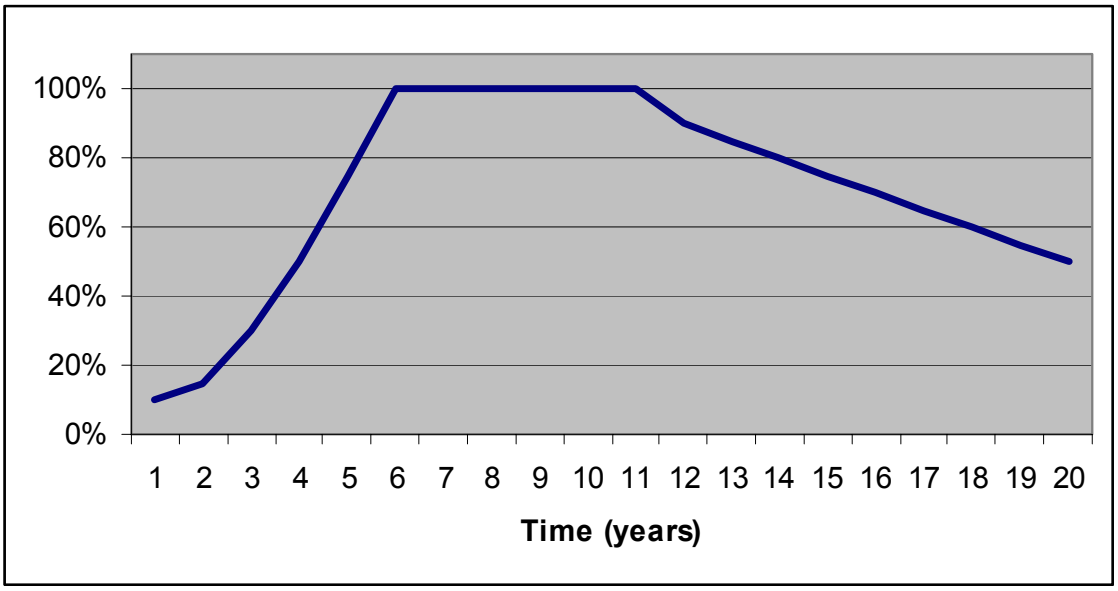
* Broadly in line with Kellogg and Charnes (2000), sales and marketing expenses are assumed as a percentage of revenues, decreasing from 100% in year 1, 50% in year 2, 25% in years 3 & 4, 20% in years 5-13, and 5% in years 14-20.

Revenues are forecast over the entire life of the project with five possible revenue outcome expectations as defined by Myers and Howe (1997) and adopted by Kellogg and Charnes (2000). The quality of the revenue stream is defined by five possibilities: dog, below average, average, above average, breakthrough (blockbuster). The population descriptors for each of these revenue scenarios are shown in Table 6-1 and

[22] In his base case binomial option Jagle (1999) chose salvage values which were between 10% and 22.5% of the value of forecast commercial cash flows generated if the development is assumed to be successful.

are based on current product revenue expectations[23]. However, it should be noted that these figures represent the maximum annual revenue realized over the life of the product. To forecast revenues over the product life cycle, the revenues for each year were estimated as a percentage of peak annual revenues based on the forecasts by Kellogg and Charnes (2000) and shown in Figure 6-7. These are forecast over 20 years to capture the impact of the Hatch-Waxman Act (1984) in the US which allowed patent holders to add a maximum of five years development and review time (to a total not longer than 14 years after FDA approval) to the length of the patent (Chahine 2000). Whilst the patent will expire during the 20 year forecast period, lag between patent expiry and loss of market share moderates the rate revenue shrinkage (Grabowski, Vernon and DiMasi 2002).

**Figure 6-7 Revenue Forecast as a % of Peak Annual Revenue Estimates**




Kellogg and Charnes (2000) assumed that the probability of a drug generating 'average' sales was 60% with a 10% chance of each of the other four revenue forecasts. To capture variation in the likelihood of each of these outcomes the probability of an average revenue outcome was allowed to vary as shown in Table 6-1 and with the other four outcomes assumed to have an equal probability of occurrence. Thus if the

[23] See for example Duggan and Morton (2004) who quote an average revenue for their sample of the top 200 drugs in 2002 as USD $583m ranging from $117m up to $5.68b. A blockbuster drug has been defined as having annual revenues exceed USD $1b (Datamonitor 2003; Decision Resources 2005).

probability of average sales was 68%, then each of the other four outcomes would have an 8% chance of occurring.

Post approval research and development costs are those associated with additional research and development after the product has been successfully launched on the market. This investment may be undertaken to investigate the potential for the drug to be used for alternative indications or to provide additional information to assist with product marketing. According to a report by the Tuft Centre for the Study of Drug Development (2003), the average amount spent on post approval research and development is $140m. This was used as the mode of the expected cost and, as with other research and development expenditures, the mode less 83% was used as the minimum bound, and the mode plus 166% was used as the upper bound. These expenses were assumed to form part of the commercialisation cash flows and, as per Kellogg and Charnes (2000), it was assumed that only products having 'average' or better commercial outcome were assumed to have had sufficient commercial return to warrant additional post approval expenditure.

#### *6.3.2.6 Discount Rate*

Following Myers and Howe (1997), separate discount rates were chosen for the development and commercialisation phases of the product cycle. Kellogg and Charnes (2000) adopted real discount rates of 6% for the development phase and 9% for the commercialisation phase of the product cycle. More recently, DiMasi, Hansen and Grabowski (2003) estimated that the cost of capital for pharmaceutical companies varied between 10.6% and 12% around a mean of 11% over the life of their study[24]. The discount rates chosen for this study were greater than those by Kellogg and Charnes (2000) in order to capture the estimates by DiMasi, Hansen and Grabowski (2003). The real commercialisation discount rate and was allowed to vary between 10% and 12% around a mean of 11% and the real discount rate for development cash flows was also increased to vary between 7% and 9% around a mean of 8%. All discount rates were converted from real to nominal by adjusting for inflation (defined below).

[24] DiMasi, Hansen and Grabowski (2003) calculated the discount rate using the CAPM and compared the result with similar estimates by Myers and Howe (1999) and Myers and Shyam-Sunder (1996) to establish the appropriate discount rate for their study.

#### *6.3.2.7 The Risk Free Rate and Inflation*

The risk free rate was chosen as the average yield on 10 year Commonwealth treasury bonds over the four years between 2002 through to 2005 as shown below in Table 6-3.

**Table 6-3 Risk Free Rate Source Data (Australian Bureau of Statistics 2006b)**

| Year | 10 Year Treasury Bond Yield |
|---|---|
| 2002 | 5.99% |
| 2003 | 5.01% |
| 2004 | 5.87% |
| 2005 | 5.11% |
| Average | 5.50% |

The inflation forecast was based on the average of the year on year annualised quarterly Australian Consumer Price Index (CPI) growth over the period from June 2005 through to March 2006 as shown in Table 6-4. There is research to suggest that drug development costs are increasing at a greater rate than CPI inflation (DiMasi, Hansen and Grabowski 2003), however, the issue is clouded by concerns that the increases are related to increasing complexity of the clinical trials process (Barnes 2006). For simplicity, this model assumes that the cash flows associated with development and commercialisation of drugs will increase with headline inflation.

**Table 6-4 Inflation Forecast Source Data (Australian Bureau of Statistics 2006a)**

| Quarter Ending | Year on Year Annualised CPI Increase |
|---|---|
| Jun-2005 | 2.49% |
| Sep-2005 | 3.03% |
| Dec-2005 | 2.80% |
| Mar-2006 | 2.98% |
| Average | 2.82% |

## 6.4 VALUATION AND THE PRODUCT DEVELOPMENT CYCLE

In this section the alternative valuation methodologies were used to value a typical biotechnology product at four stages in the product development process, those being: after the product has completed all pre-clinical testing and is about to enter phase one clinical trials; as the product is about to enter phase two clinical trials; as the product is about to enter phase three clinical trials; and finally, at the point when all clinical trials are complete and a regulatory filing is being made.

Initially, the models were run using the expected mode of the inputs shown in Table 6-1. The model outcomes for each of the valuation methods are shown in Table 6-5 and represent the expected valuations at each stage in product development in the absence of Monte Carlo scenario modelling. The DCF model consistently values this drug development project lower than each of the alternative valuation methods. As the DCF model does not quantify management flexibility and the potential for a commercial outcome greater than "average", the difference in value is not unexpected.

**Table 6-5 Fixed Input Expected Valuations ($ ,000)**

| Development Stage | DCF | eDCF | Binomial | Binomial Lattice |
|---|---|---|---|---|
| Prior to Phase 1 | -$2,247 | $38 | -$1,384 | $0 |
| Prior to Phase 2 | $18,963 | $26,604 | $23,378 | $19,216 |
| Prior to Phase 3 | $55,677 | $140,854 | $132,395 | $134,989 |
| Prior to filing | $175,048 | $376,342 | $376,142 | $376,171 |

The three remaining valuation methods allow for management flexibility throughout the project and have values that are similar and converge as the project moves towards commercialisation. The eDCF and binomial tree use the same decision tree through the development process, however the eDCF model consistently places a higher value on the project, particularly in the earlier stages of development. A contributing factor for this is that both methods incorporate the same levels of project risk into the same decision tree, however the eDCF uses the cost of capital to discount all cash flows back though the tree to the present. The binomial tree effectively discounts development costs (considered to be option exercise costs) at the risk free rate. As the cost of capital is greater than the risk free rate, the present value of development costs in the binomial tree is greater than for the eDCF model, thus producing consistently lower estimates of value.

The binomial tree method uses the concept of a replicating portfolio to adjust the probabilities of success and failure at each decision node to represent "risk-free" probabilities which then enables all the cash flows to be discounted at the risk free rate. As the project moves from the early stages of development closer to the market launch, the differential between the eDCF and the binomial tree narrows. This is consistent with the notion that a project in later stages of development has less future development expenditure, hence the impact of the differential in discount rates applied to development stage costs is reduced.

Interestingly, whilst the binomial lattice method proposed by Kellogg and Charnes (2000) uses a unique lattice, it provides valuations broadly in line with the eDCF and binomial calculations. The zero valuation of the project prior to phase 1 clinical trials indicates that management should consider termination of the project unless motivations other than the cash flows directly associated with the project exist. This is a decision supported by the DCF and binomial valuations.

Valuation analysis is useful to management in providing an estimate of project value at a specific point in time as well as providing data regarding the expected incremental changes in value throughout the project (see section 4.4.1). Table 6-6 shows the value accretion if each stage in the drug development process is successfully completed. Interestingly, the value accretion for the DCF model through phase one clinical trials is similar to those calculated using the alternative methods. However, the value accretion predicted using the DCF model through the remaining clinical trials is significantly less than that predicted with the alternative models. The DCF valuation assumes commercial cash flows in the event of an "average" outcome, whereas the remaining three methods allow for potential changes in the commercial success of the product. This difference in model structure seems to be less significant in the quantification of value accretion in the early stages of development.

**Table 6-6 Expected Value Accretion between Development Stages ($ ,000)**

| | DCF | eDCF | Binomial | Binomial Lattice |
|---|---|---|---|---|
| Through Phase 1 | $21,210 | $26,566 | $24,762 | $19,216 |
| Through Phase 2 | $36,714 | $114,250 | $109,017 | $115,773 |
| Through Phase 3 | $119,371 | $235,488 | $243,747 | $241,182 |

The value of the project prior to commencement of stage 1 clinical trials is low, and considering the risks associated with drug development, may lead management to abandon the project. However this decision should not be made without analysis of the expected value accretion if it were to go ahead. Whilst the expected cost of a phase one clinical trial is $15m (to be spent over 22 months), the expected increase in value if the trial is successful is between $19m and $27m depending on the valuation method that is adopted. This information may justify additional investigations into the likelihood of phase one clinical trials being successful before a decision is made to abandon the project.

### 6.4.1 Scenario Analysis Prior to Commencement of Clinical Trials

In this section the valuation inputs are allowed to vary according to the population descriptions in Table 6-1. At each stage of product development, all of the model inputs were generated 1000 times, with the results then fed through the valuation models to produce 1000 corresponding estimates of value for each method.

Figure 6-8 below shows the probability mass function for the estimates of value prior to commencement of phase one clinical trials. The DCF valuation model has the widest dispersion of valuation estimates in comparison with the decision tree valuation models. The DCF model requires less input data than the alternative valuation models, however this translates to a higher level of uncertainty surrounding the project valuation.

**Figure 6-8 Valuation at Commencement of Phase 1 Clinical Trials – Probability Mass Function Comparison between Alternative Valuation Methodologies**

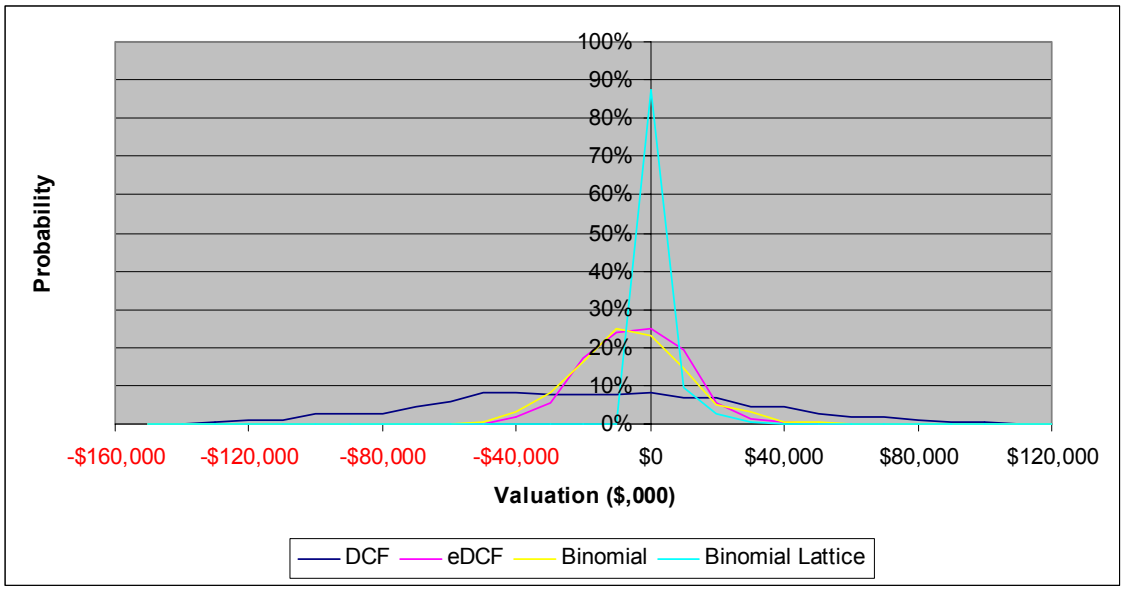



Table 6-7 below shows descriptive statistics for the sample of valuation estimates generated by each method and the binomial lattice is the only method that has an average valuation greater than zero. The binomial lattice incorporates the value of project abandonment at each node according to:

$V_n = \max\{E_k(\theta_n) - DCF_n, 0\}$ (Kellogg and Charnes 2000)

Where $V_n$ is the value at the node $n$, $E_k$ is the value at the end branch $k$, $\theta_n$ is the probability of continuation from one node to the next and $DCF_n$ is the R&D payment that occurs in year $n$. Those cases where zero is chosen as the maximum represent value maximisation through project abandonment.

In the early stages of development, zero was taken as the maximum value in the majority of cases, with only 15% of the simulations generating a value greater than zero using the binomial lattice method at the commencement of phase one clinical trials. Thus, whilst the average valuation of the project using this method was positive, the majority of simulations placed a zero value on the project, hence the positive value is misleading when compared with the output from the alternative valuation methods. Similarly, the standard deviation and inter quartile range provide misleading information regarding the certainty of the valuation when compared with alternative methods.

The eDCF valuation provides the highest average value for the pre phase 1 product, however, it is also a negative value. Of the sample of 1000 simulations, 27% of the eDCF model outcomes were greater than zero. The eDCF valuation method also produced valuations with the lowest standard deviation and inter-quartile range.

The DCF valuation provides the largest variation in valuation estimates with a standard deviation of close to $50m. This implies that any valuation derived using this method for an early stage drug development project should be viewed with caution due to the significant impact that the choice of input variables has on the estimate of value. The eDCF and binomial option methods provide valuation estimates that are less sensitive to assumptions regarding the underlying data and as such their outcomes provide a more robust foundation for management decisions.

For a biotechnology firm looking to out-licence an early stage product, *de novo* valuation of the product provides an important tool for the negotiation of the terms of the deal. Razgaitis (2003) discusses this issue in detail and proposes that, in an open competitive market, the likely deal will be structured such that value (and the likelihood of value) will be split at around the 25$^{th}$ percentile. The actual terms will depend on the assumptions used by both sides in their financial models as well as market forces, thus,

there is often variation around the 25th percentile of the distribution of values. In this case the biotechnology company would argue for valuation using an eDCF method (the binomial lattice data provides misleading statistics as discussed above) whereas the licensor would argue for a valuation based on a DCF model.

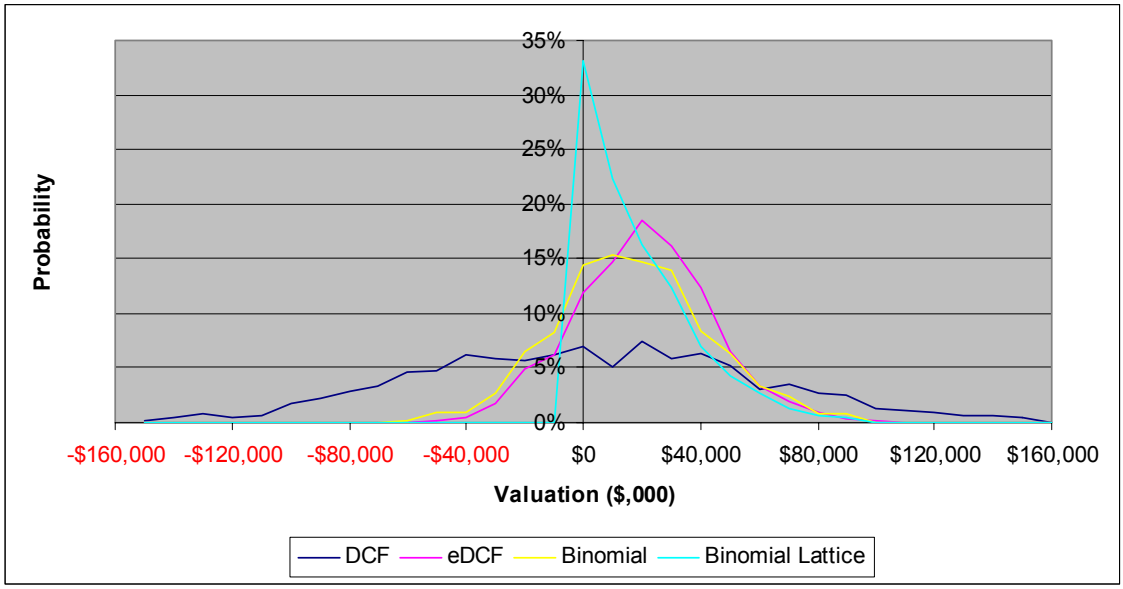
**Table 6-7 Valuation Comparison at Commencement of Phase 1 Clinical Trials**

| | DCF | eDCF | Binomial | Binomial Lattice |
|---|---|---|---|---|
| Mean | -$23,273 | -$9,420 | -$10,954 | $790 |
| Median | -$23,246 | -$9,164 | -$11,336 | $0 |
| Std Deviation | $46,765 | $14,165 | $16,085 | $3,207 |
| 25th Percentile | -$55,908 | -$19,889 | -$21,433 | $0 |
| 75th Percentile | $8,156 | $734 | -$717 | $0 |
| Prob V>0 | 31% | 27% | 23% | 13% |

### 6.4.2 Scenario Analysis Prior to Commencement of Stage 2 Clinical Trials

Figure 6-9 below shows the probability mass function for the estimates of value prior to commencement of phase two clinical trials. As with the valuation estimates prior to phase one, the DCF valuation model has the widest dispersion of valuation estimates in comparison with the decision tree valuation models. The binomial lattice output is still impacted by a high proportion of zero values, making inference of value of the project at this stage difficult. The eDCF values are consistently higher than those calculated using binomial option methods, however, both these methods give estimates that are strongly correlated and similar in magnitude.

**Figure 6-9 Valuation at Commencement of Phase 2 Clinical Trials – Probability Mass Function Comparison between Alternative Valuation Methodologies**




The data in Table 6-8 show that the eDCF valuation again provides the highest average value, that being $15m for a product about to enter phase two clinical trials. Of the sample of 1000 simulations, 75% of the eDCF model outcomes were greater than zero. Apart from the eDCF model, the binomial valuation method produced valuations with the lowest standard deviation and inter quartile range.

The DCF valuation again provides the lowest average value, that being -$3.2m, with greatest uncertainty shown by a standard deviation of close to $58m and a larger inter quartile range. The standard deviation has increased from the earlier product stage, indicating that even though the product has overcome some of the risks associated with product development, there is no more certainty regarding value. Despite this, DCF valuation predicts that the project has a 47% chance of having a value greater than zero.

Many Australian biotechnology firms require additional funding in order to commence phase two clinical trials. Based on valuations for this product, they will struggle to find a partner willing to licence in the product at this stage as the 25$^{th}$ percentile value remains less than zero. Valuation using the eDCF method gives a likely value to be realised in a licensing deal of around -$0.3m which is very low given the costs of developing a product to this stage.

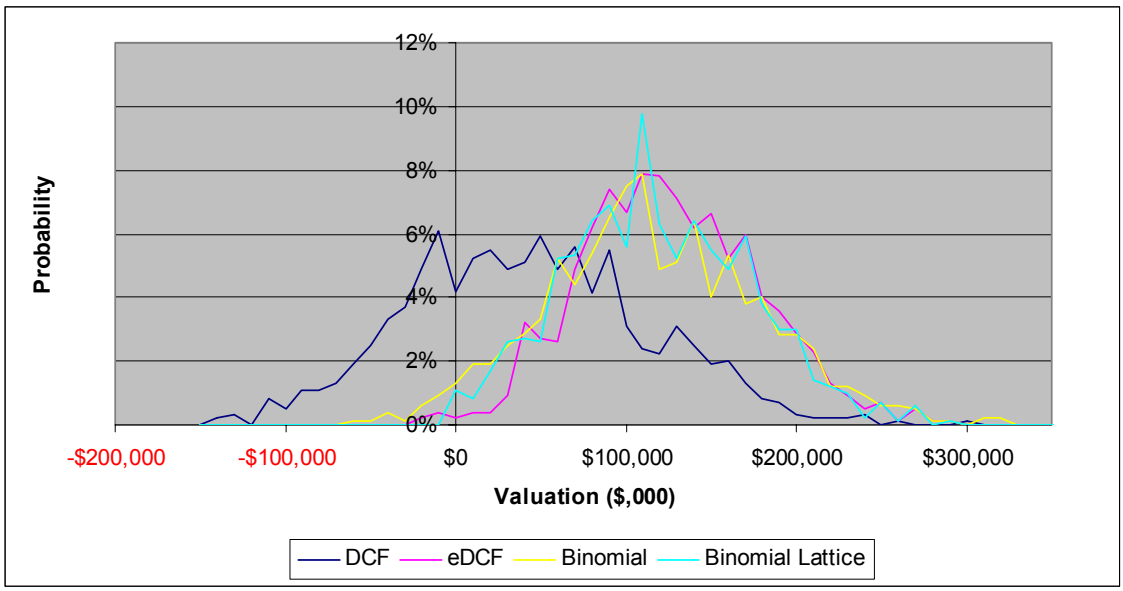
**Table 6-8 Valuation Comparison at Commencement of Phase 2 Clinical Trials**

| | DCF | eDCF | Binomial | Binomial Lattice |
|---|---|---|---|---|
| Mean | -$3,252 | $15,265 | $11,466 | $13,671 |
| Median | -$3,609 | $15,178 | $10,536 | $6,982 |
| Std Deviation | $58,357 | $23,165 | $25,845 | $17,023 |
| 25th Percentile | -$44,883 | -$263 | -$5,621 | $0 |
| 75th Percentile | $35,191 | $30,162 | $27,505 | $22,803 |
| Prob V>0 | 47% | 75% | 66% | 67% |

### 6.4.3 Scenario Analysis Prior to Commencement of Stage 3 Clinical Trials

Valuation prior to the commencement of phase three clinical trials yields values which are significantly greater than those for products in earlier stages of development. The binomial lattice is no longer so affected by the high proportion of zero valuations and is shown in Figure 6-10 to produce similar results in terms of magnitude and dispersion as the eDCF and binomial methods. The eDCF model again estimates values that are consistently higher while the DCF valuation has a dispersion which is converging on the alternative methods, however values are consistently lower.

**Figure 6-10 Valuation at Commencement of Phase 3 Clinical Trials – Probability Mass Function Comparison between Alternative Valuation Methodologies**




All four methods have an average value greater than zero, which is not unexpected given that the product has only one remaining clinical trial (albeit the largest and most expensive of the three) before NDA submission. The DCF method again has the largest uncertainty as indicated by the standard deviation and inter quartile range shown in Table 6-9 below. Valuation using the DCF model still only estimates the project value

to be positive in 68% of cases, a symptom of the inability of this method to capture the possibility of sales significantly higher (or lower) than 'average'.

**Table 6-9 Valuation Comparison at Commencement of Phase 3 Clinical Trials**

| | DCF | eDCF | Binomial | Binomial Lattice |
|---|---|---|---|---|
| Mean | $37,000 | $120,202 | $110,614 | $113,500 |
| Median | $35,670 | $117,724 | $106,114 | $109,362 |
| Std Deviation | $69,796 | $51,487 | $62,430 | $53,882 |
| 25th Percentile | -$16,282 | $83,346 | $69,103 | $74,842 |
| 75th Percentile | $83,124 | $156,490 | $153,702 | $151,063 |
| Prob V>0 | 68% | 99% | 97% | 99% |

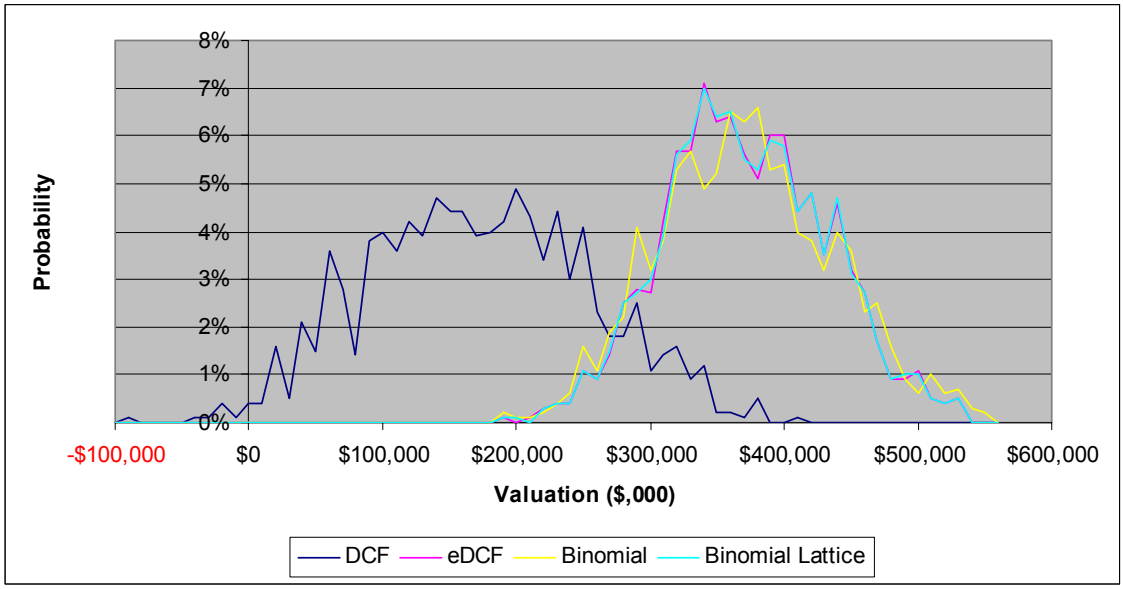
The eDCF and option valuation methods all estimate a 97-99% probability of having positive value. The eDCF method again produces the estimate which is least sensitive to the underlying input assumptions shown by the lowest standard deviation and inter quartile range.

At the 25$^{th}$ percentile of valuation estimates, the eDCF model produces the highest estimate of value, followed by the binomial lattice then the binomial tree with the DCF model once again producing the lowest estimate. The difference between the outcomes of each of the valuation methods highlights the importance that participants in licensing negotiations should place on the methodologies used to generate value estimates as the foundation for deal terms.

### 6.4.4 Scenario Analysis Prior to Regulatory Registration

After the completion of clinical trials, the product is ready for filing with the regulator for NDA approval. Successful completion of the clinical trial process means that the project has overcome a significant portion of the risks inherent in the drug development pipeline, however, some risk still exists around the receipt of NDA approval. Figure 6-11 below shows that the values determined using the decision tree models are closely correlated with the binomial model producing values with slightly greater positive variation.

**Figure 6-11 Valuation Prior to Product Registration – Probability Mass Function Comparison between Alternative Valuation Methodologies**




The standard deviations for value estimates produced by all methods increased with respect to valuations at earlier stages in the product development chain as shown below in Table 6-10. The eDCF and binomial lattice methods produced estimates that were least sensitive to the underlying input assumptions (shown by low standard deviations of value estimates).

**Table 6-10 Valuation at Commencement of New Drug Application**

| | DCF | eDCF | Binomial | Binomial Lattice |
|---|---|---|---|---|
| Mean | $166,570 | $366,684 | $366,611 | $366,514 |
| Median | $164,480 | $363,099 | $364,249 | $362,838 |
| Std Deviation | $82,358 | $60,268 | $64,957 | $60,275 |
| 25th Percentile | $106,385 | $323,886 | $320,185 | $324,013 |
| 75th Percentile | $225,448 | $409,259 | $411,002 | $409,020 |
| Prob V>0 | 99% | 100% | 100% | 100% |

All methods predict value to be positive with 99-100% probability. Predictably, as per earlier discussion, the DCF method again produced the lowest estimates of value. The 25$^{th}$ percentile estimate of market valuation in the event of a sale of the product indicates that application of a decision tree method generates an expected deal price of around $320m, a significant increment from the similarly calculated values in the previous phase of development.

### 6.4.5 Value Accretion at the 25th Percentile

Value accretion at the 25th percentile is weighted towards the later stages of the clinical trial process as shown below in Table 6-11. The significant acceleration in value accretion (at the 25th percentile) as a product moves through the development process provides motivation for biotechnology firms to endeavour to maintain ownership of the product as long as their resource levels allow. Unfortunately, the amount of capital available to Australian biotechnology firms means that few firms are able to fund development beyond phase 1 trials before out-licensing to a larger partner.

**Table 6-11 Value Accretion at the 25th Percentile between Development Stages ($ ,000)**

| | DCF | eDCF | Binomial | Binomial Lattice |
|---|---|---|---|---|
| Through Phase 1 | $11,025 | $19,626 | $15,812 | $0 |
| Through Phase 2 | $28,601 | $83,609 | $74,724 | $74,842 |
| Through Phase 3 | $122,667 | $240,540 | $251,082 | $249,171 |

Australian biotechnology companies will likely look to partner with a large pharmaceutical company with the experience and expertise to successfully bring the product to market. The largest pharmaceutical companies are based outside Australia and are foreign owned, thus, once a product is out-licensed from an Australian biotechnology firm, subsequent value accretion (resulting from successful development) is shared with the international partner. If more value could be retained by locally owned and based firms, the potential for these firms to subsequently reinvest in the local industry would be increased, improving the long term prospects of the industry. Australian shareholders would also benefit from not sharing the generated value with foreign listed firms.

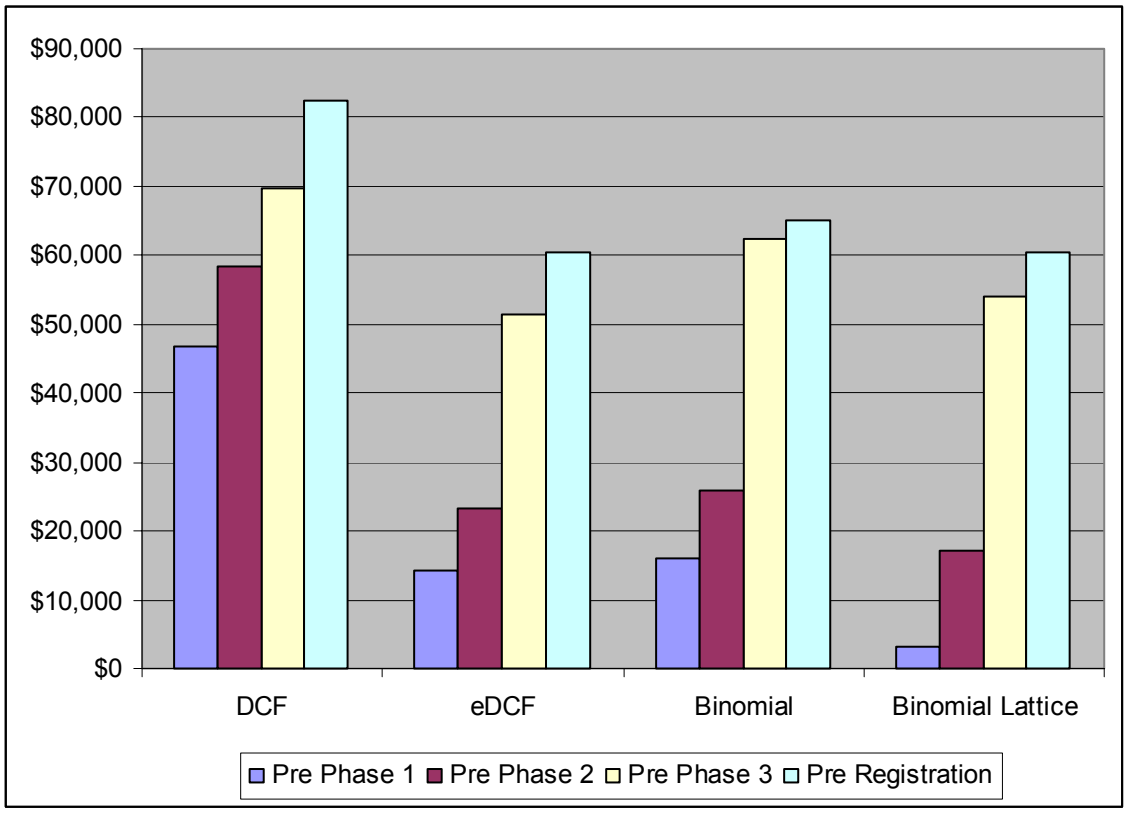
## 6.5 VALUATION MODEL SENSITIVITIES

The standard deviations of the value estimates have been discussed in the earlier sections however Figure 6-12 provides a visual representation of the evolution of valuation uncertainty as the product moves through the development cycle. The DCF model generates values with much greater uncertainty, particularly in the earlier stages of development. All of the models exhibit greater uncertainty in value estimates of projects in the later stages of development when compared to those in earlier stages. This should be read in context, given that the value estimates themselves are much higher in the later stages of development, thus the level of uncertainty is not as critical. In the early stages, a $10m variation in valuation may mean the difference between

continuing or abandoning a project, whereas in the later stages $10m may represent less than 5% of the project value.

The decision tree models generate estimates with similar levels of uncertainty throughout the project. The binomial lattice had the lowest levels of uncertainty in the early stages however this is a deceptive result due to the impact of the abandonment option (see section 6.4.1), hence reducing the standard deviation of value estimates.

**Figure 6-12 Valuation Standard Deviations for Unrestricted Models**
This figure shows the standard deviations of valuation estimates (expressed in $,000) allowing all input variables to vary according to the distribution characteristics defined in Table 6-1. 1000 simulations were used, generating estimates at four stages in the development cycle; prior to phase 1 clinical trials, prior to phase 2 clinical trials, prior to phase 3 clinical trials, and prior to regulatory registration.




In this section the four valuation models were tested for sensitivity to the variations in the values of the underlying inputs on an individual basis. The models were restricted by allowing one input group to vary in isolation for 1000 simulations and fixing all other inputs at the mode of their expected values (see Table 6-1). This process was repeated for each of the input groups (development time, development cost, salvage value, commercialisation cash flows, discount rate, development risk) in order to ascertain the influence that each input group has on the valuation estimates for each method. The standard deviation of values produced by each of the models was used as a

measurement of the influence that each input group had on value and the results are shown in graphical format in the subsequent sections.

Generally, the sensitivity in value estimates to each of the specific inputs progressively increased as a project moved through the product development stages. Specifically, value estimate sensitivity increased for variations in: development time, development costs, commercialisation cash flows and discount rate. These results should be interpreted with consideration of to the magnitude of the value estimates at each stage.

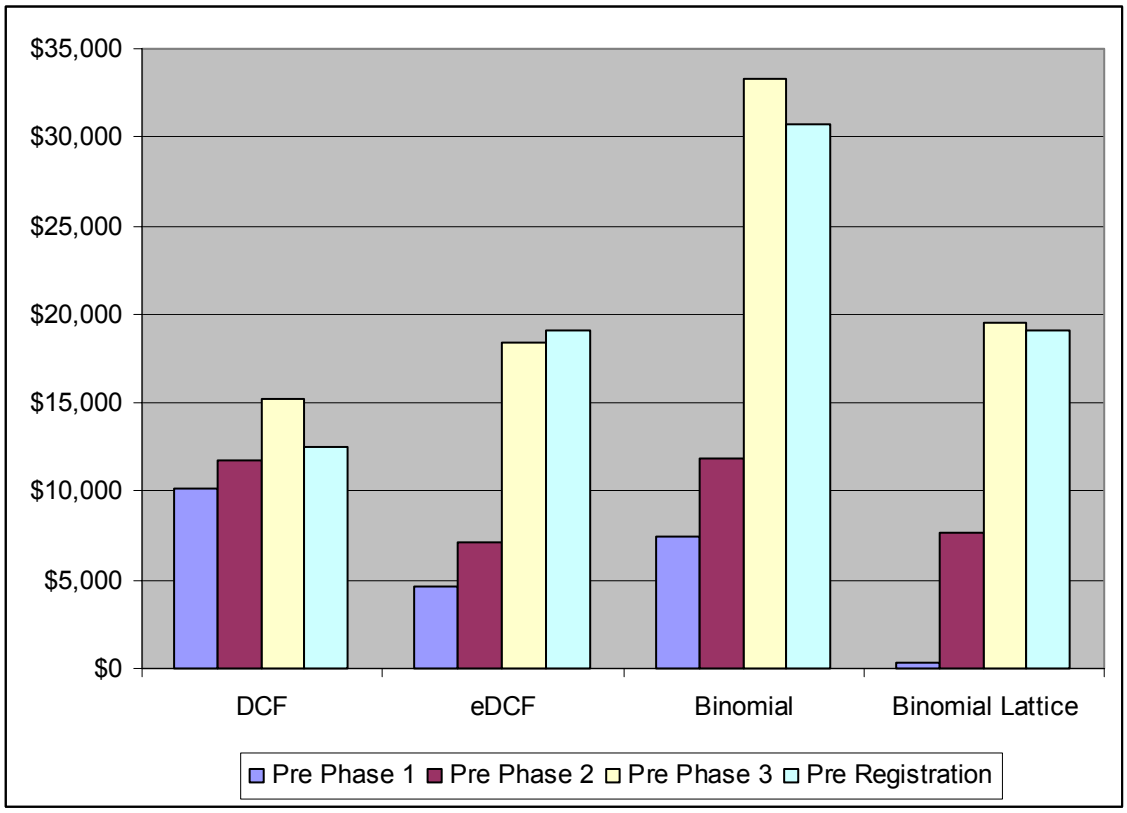
The values, $V$, produced by each of the models are a function of each of the specific input variables $X_i$. Thus the sensitivity of the value estimates to the input variables is represented by $\partial V/\partial X_i$. Monte Carlo simulation was used to generate estimates for $\partial V/\partial X_i$ for each $X_i$ across the range of possible values defined in Table 6-1. To estimate $\partial V/\partial X_i$ all inputs were set at the mode of their expected value, with one input allowed to vary. The model was then asked to incrementally vary the unrestricted input through the entire specified population for that input. For each data point, value estimates for each valuation model were calculated allowing the change in value to be calculated for each specified change in input, hence estimating $\partial V/\partial X_i$.

This method provides an estimate of $\partial V/\partial X_i$ for a two dimensional estimation of the response surface (as all inputs other than that under investigation were set at their expected mode value). This process was repeated for each input variable with the results presented in graphical format in the subsequent sections.

### 6.5.1 Development Time

Variation of the time spent developing the product contributes to the uncertainty in valuation estimates as shown in Figure 6-13. In the early stages of development, time had the greatest impact on estimates produced by the DCF model, with the standard deviation of restricted model value estimates greater than double that for early stage eDCF estimates. Interestingly, in the later stages of development, the alternative valuation models were more influenced by variation in estimates of development time. Time was most influential for valuations of projects entering phase 3 clinical trials for all valuation methods except eDCF. The binomial model was most affected by development time for projects entering or having finished phase 3 clinical trials.

**Figure 6-13 Valuation Standard Deviations for Restricted Development Time Model**
This figure shows the standard deviations of the valuation estimates (expressed in $,000) for each methodology allowing development time to vary and holding all remaining inputs fixed. 1000 simulations were used to generate estimates at four stages in the development cycle; prior to phase 1 clinical trials, prior to phase 2 clinical trials, prior to phase 3 clinical trials, and prior to regulatory registration.




The sensitivity of estimates to time spent in phase 1 clinical trials is shown in Figure 6-14. The sensitivity to this input reduces as the expected time to complete this stage of development increases and the impact of increased development time on values is negative. The DCF model is most sensitive to phase one development time with $\partial V/\partial X_i$ ranging from -$300,000 down to less than -$150,000. The alternative valuation methods were less sensitive to changes in phase 1 development time with sensitivities in the range -$190,000 down to -$80,000. The implication of this finding is that for an additional month spent in phase 1 clinical trials, the value estimate for the project was reduced by an amount between $80,000 and $300,000.

Figure 6-15 shows the sensitivity of value estimates to time spent in phase 2 clinical trials. The sensitivity to this input reduces as the expected time to complete this stage of development increases and the impact of increased development time on values is negative. The DCF model is again more sensitive than the eDCF and binomial models, however, for valuations calculated immediately prior to phase 2 commencement, the

alternative methods are more sensitive when phase 2 development time is greater than around 51 months. The binomial lattice valuations are most sensitive to phase 2 development times for values calculated immediately prior to phase 2 commencement. The time spent in phase 2 trials has a greater impact on valuations than that spent in phase 1 trials with $\partial V/\partial X_i$ ranging from -$700,000 down to around -$150,000 (excluding binomial lattice valuation for phase 1 projects),.

The sensitivity of estimates to time spent in phase 3 clinical trials is shown in Figure 6-16. The impact of increased development times on value estimates are negative with sensitivity reducing as time increases. As with earlier stage models, the DCF model is more sensitive than the eDCF and binomial models for valuations calculated immediately prior to commencement of phase 1 or phase 2 trials. Prior to the commencement of phase 3 clinical trials the DCF model is substantially less sensitive than the alternative methods with one additional month in phase 3 trials reducing DCF values by around half as much as the corresponding alternative valuation models. $\partial V/\partial X_i$ ranges from -$2500,000 down to around -$250,000 (excluding binomial lattice valuation for phase 1 projects), with the time spent in phase 3 trials having a greater impact on valuations than that spent in phase 1 or 2 trials. A project entering phase 3 trials will face a reduction in value of between -$2,500,000 and -$500,000 for each additional month that the phase 3 trial is expected to run.

The sensitivity of estimates to time spent in regulatory assessment is shown in Figure 6-17. The sensitivity to this input reduces as the expected time to complete this stage of development increases and the impact of increased development time on values is negative. The DCF model is again more sensitive than the eDCF and binomial models for valuations calculated immediately prior to commencement of phase 1 or phase 2 trials. Prior to the commencement of phase 3 clinical trials and again prior to regulatory filing, the DCF model is substantially less sensitive than the alternative methods with one additional month in regulatory assessment reducing DCF values by around half as much as the corresponding alternative valuation models. The sensitivity of the value estimate, $\partial V/\partial X_i$, ranges from -$3700,000 down to around -$250,000 (excluding binomial lattice valuation for phase 1 projects), with the valuations being more sensitive to movements in the time spent in NDA assessment than that in phase 1, 2, or 3 trials. A project entering phase 3 trials will face a reduction in value of between -$2,500,000 and

-$900,000 for each additional month that the regulatory assessment is expected to run. For a project that has finished phase 3 trials the impact of an additional month of assessment time jumps to between -$3,700,000 and -$1,200,000.

**Figure 6-14 δV/δX for X = Phase 1 Development Time**

This figure shows estimates for δV/δX (in $,000) where X equals the time taken to complete phase 1 clinical trials (in months). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying phase 1 trial times through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. This process was conducted for valuation estimates prior to phase 1 clinical trials. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1 clinical trials (represented suffix 1).

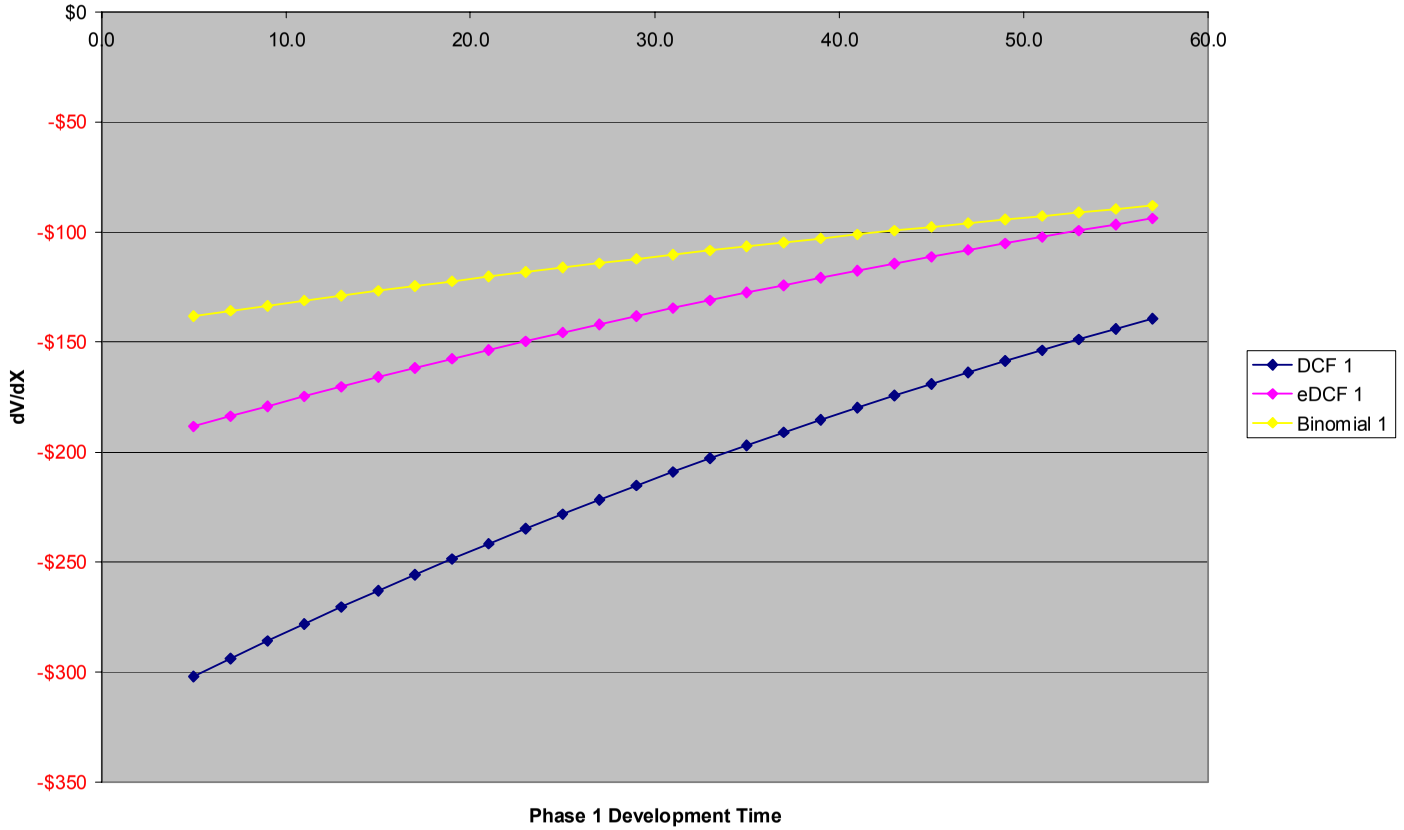


**Figure 6-15 δV/δX for X = Phase 2 Development Time**

This figure shows estimates for δV/δX (in $,000) where X equals the time taken to complete phase 2 clinical trials (in months). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying phase 2 trial times through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. This process was repeated for valuation estimates prior to phase 1 clinical trials and phase 2 clinical trials. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1, and 2 clinical trials (represented by suffixes 1and 2 respectively).

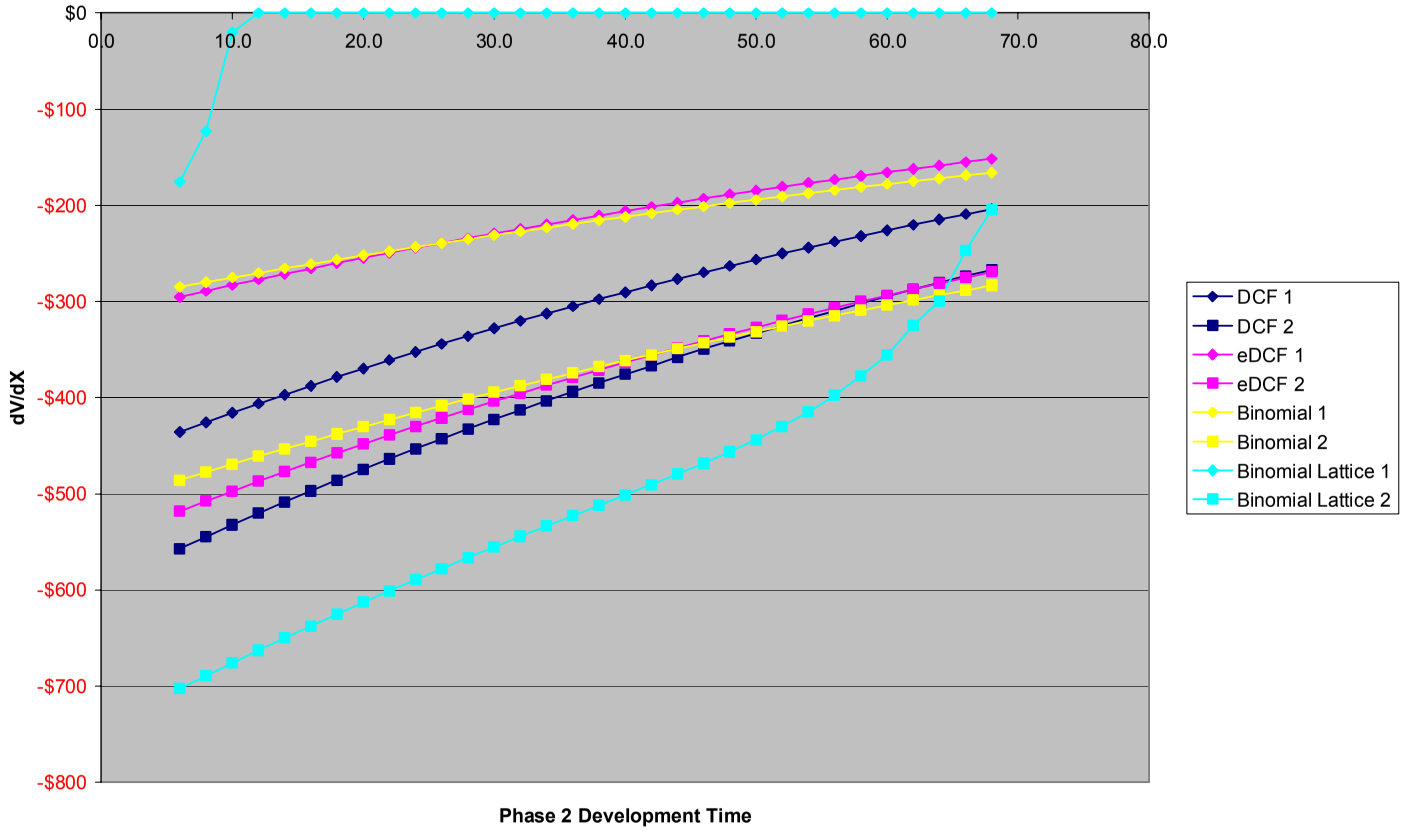


**Figure 6-16 δV/δX for X = Phase 3 Development Time**

This figure shows estimates for δV/δX (in $,000) where X equals the time taken to complete phase 3 clinical trials (in months). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying phase 3 trial times through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. This process was repeated for valuation estimates prior to phase 1 clinical trials, phase 2 clinical trials and phase 3 clinical trials. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1, 2, and 3 clinical trials (represented by suffixes 1, 2 and 3 respectively).

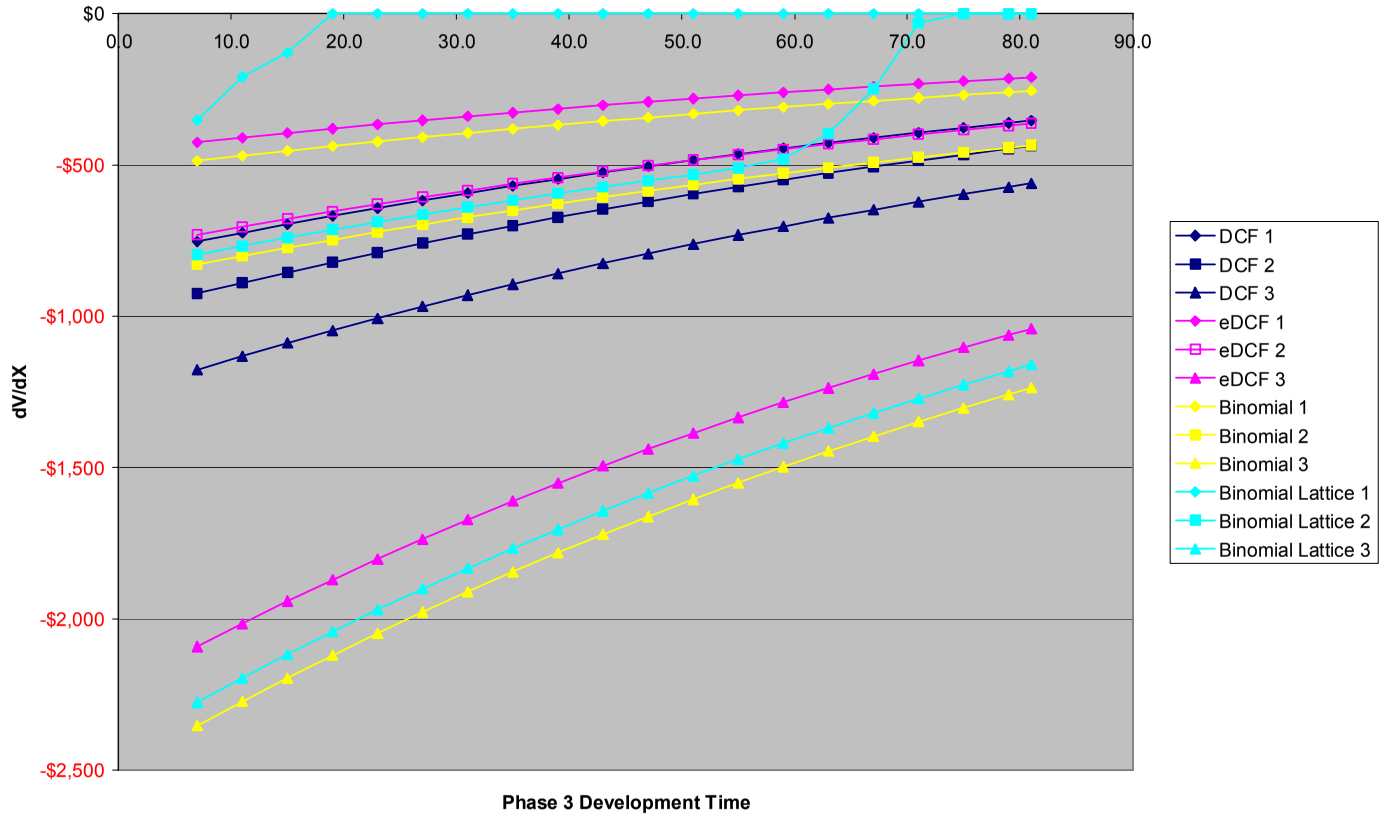
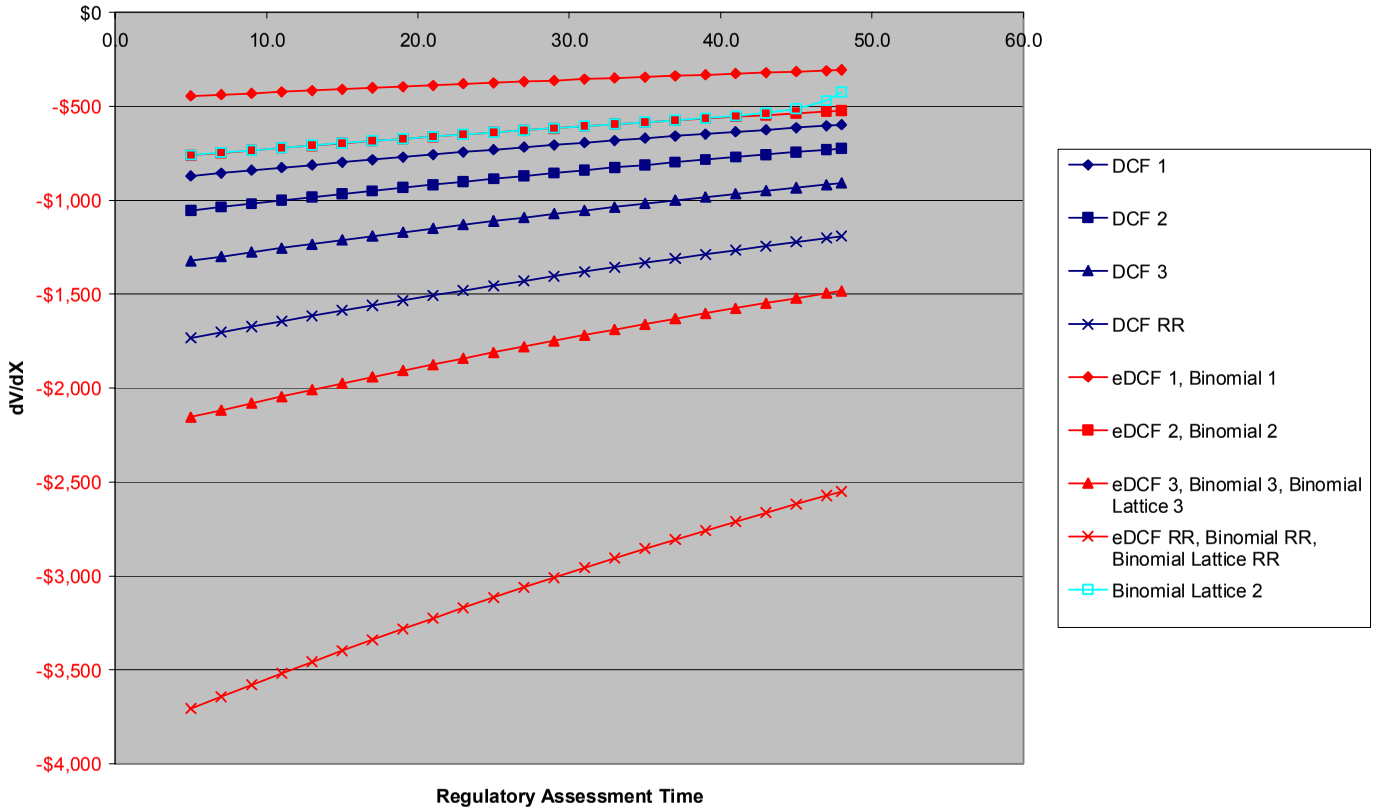


**Figure 6-17 δV/δX for X = Product Registration Assessment Time**

This figure shows estimates for δV/δX (in $,000) where X equals the time taken for product registration and marketing approval from the regulator (in months). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying NDA assessment time through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. This process was repeated for valuation estimates prior to phase 1 clinical trials, phase 2 clinical trials, phase 3 clinical trials and prior to regulatory registration. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1, 2, 3 clinical trials and regulatory registration (represented by suffixes 1, 2, 3 and RR respectively).



### 6.5.2 Development Costs

The impact of variation in development costs on valuation uncertainty is shown in Figure 6-18. The DCF model was the most sensitive to variation in development costs for early stage projects with the standard deviation of restricted model value estimates greater than double that for early stage alternative model estimates. Upon completion of clinical trials, the impact of cost was significantly less as a result of the substantially reduced costs associated with regulatory assessment as compared with clinical trials (see Table 6-1). For all models, cost had the most influence on valuation estimates for values calculated prior to the commencement of phase 3 trials.

**Figure 6-18 Valuation Standard Deviations for Restricted Development Cost Model**
This figure shows the standard deviations of the valuation estimates (expressed in $,000) for each methodology allowing development costs to vary and holding all remaining inputs fixed. 1000 simulations were used to generate estimates at four stages in the development cycle; prior to phase 1, 2 and 3 clinical trials and prior to regulatory registration.

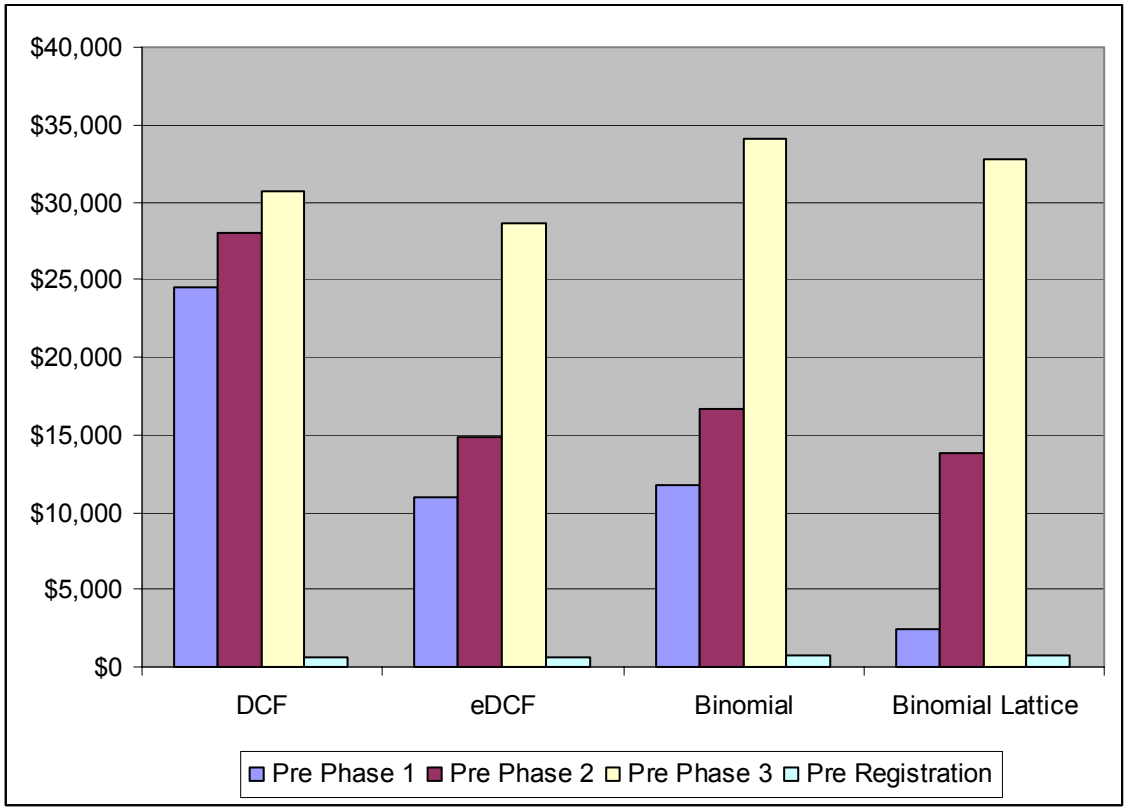



Figure 6-19 shows the sensitivity of valuation estimates to phase 1 clinical trial costs. The sensitivity to this input is constant for all expected values (excluding the binomial lattice valuations which are affected by the abandonment option). The binomial model is most sensitive to changes in expected phase 1 development costs with a $1 reduction

in cost increasing value by the same amount. The reason that the change in value is directly offset by the change in costs is due to the assumption in the binomial model that the development costs are incurred at the beginning of that phase, thus, the time value of money does not impact this cost. The DCF and eDCF models expect a reduction in value of around $0.90 for a $1 reduction in development cost.

The sensitivity of estimates to phase 2 clinical trial costs is shown in Figure 6-20. As expected, the time value of money dictates that the greater the time between the point of valuation and the incurring of the cost, the less the cost impacts on expected value. For valuations conducted prior to the commencement of phase 1 trials, the DCF model is most sensitive to changes in the expected cost of phase 2 trials. DCF values reduced by around $0.80 for a $1 increase in costs versus eDCF and binomial values which reduced by slightly less than $0.60. Conversely, if costs are reduced the corresponding value gain is greatest for DCF valuation estimates.

The sensitivity of estimates to phase 3 clinical trial costs is shown in Figure 6-21. For valuations conducted prior to the commencement of phase 1 trials, the DCF model is again most sensitive to changes in the expected cost of phase 3 trials. DCF values reduced by around $0.65 for a $1 increase in costs versus eDCF and binomial values which reduced by slightly more than $0.20. Prior to the commencement of phase 2 trials the difference remains substantial but is less pronounced, around $0.75 versus $0.35.

The DCF model remains the most sensitive to changes in the expected regulatory registration costs for valuations prior to phase 1 trials, as shown in Figure 6-22. DCF values reduced by around $0.55 for a $1 increase in costs versus eDCF and binomial values which reduced by slightly more than $0.15. The binomial lattice model produced values with sensitivities greater than the eDCF and binomial models but less than the DCF for projects in all development stages excluding those directly due to commence regulatory registration.

**Figure 6-19 δV/δX for X = Phase 1 Development Cost**

This figure shows estimates for δV/δX (in $,000) where X equals the cost to complete phase 1 clinical trials ($,000). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying phase 1 trial costs through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. This process was repeated for valuation estimates prior to phase 1 clinical trials. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1 clinical trials (represented suffix 1).

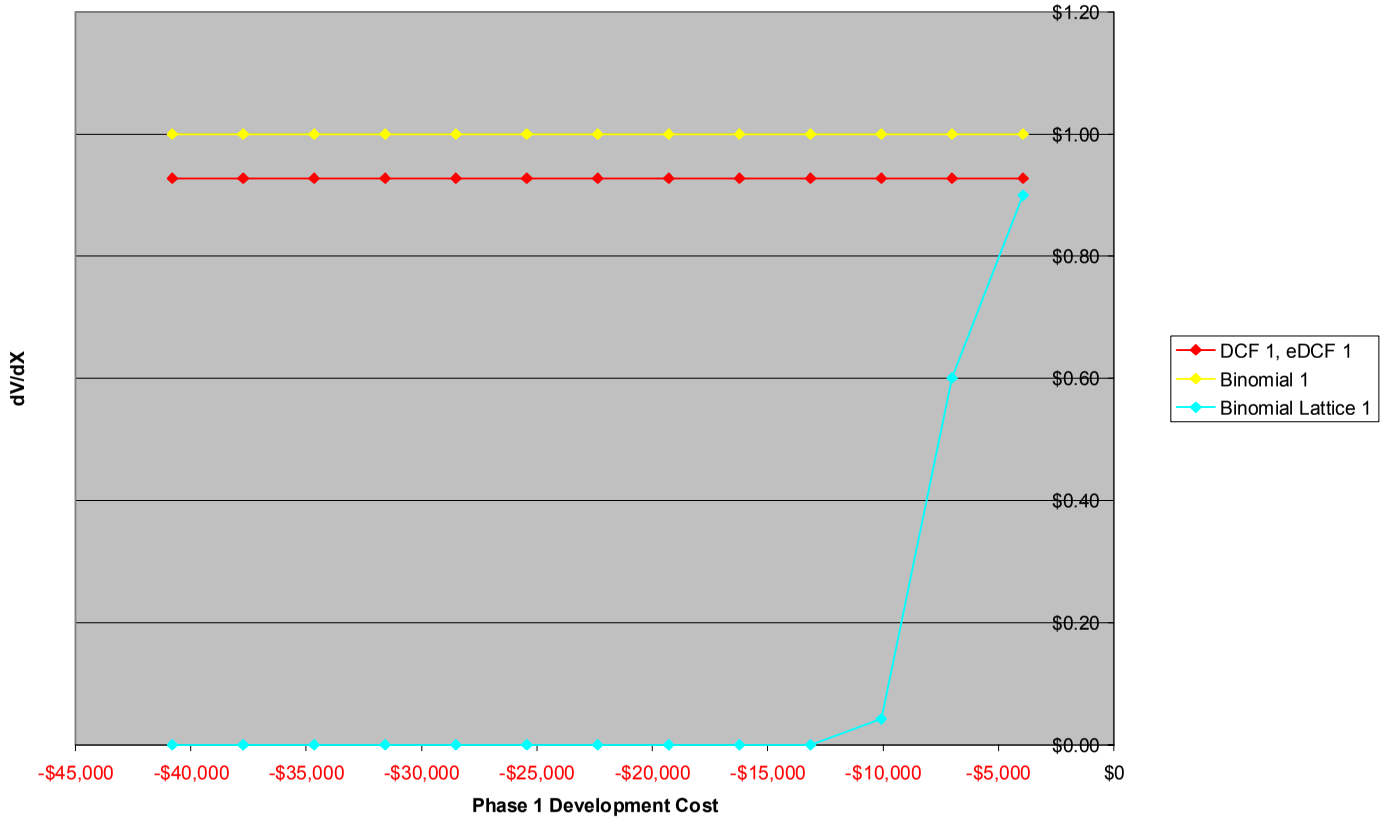


**Figure 6-20 δV/δX for X = Phase 2 Development Cost**

This figure shows estimates for δV/δX (in $, 000) where X equals the cost to complete phase 2 clinical trials ($,000). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying phase 2 trial costs through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. This process was repeated for valuation estimates prior to phase 1 clinical trials and phase 2 clinical trials. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1, and 2 clinical trials (represented by suffixes 1and 2 respectively).

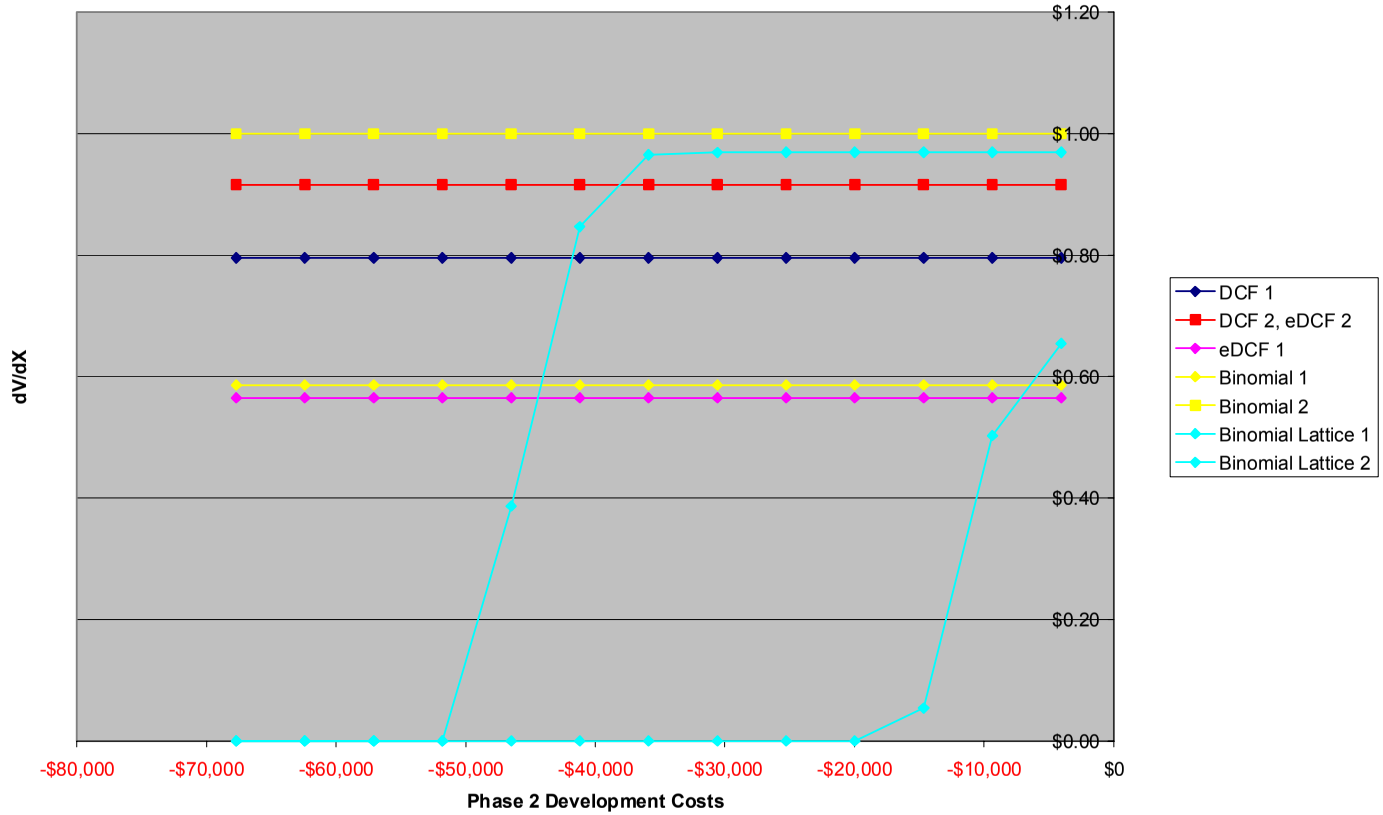


**Figure 6-21 δV/δX for X = Phase 3 Development Cost**

This figure shows estimates for δV/δX (in $, 000) where X equals the cost to complete phase 3 clinical trials ($,000). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying phase 3 trial costs through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. This process was repeated for valuation estimates prior to phase 1 clinical trials, phase 2 clinical trials and phase 3 clinical trials. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1, 2, and 3 clinical trials (represented by suffixes 1, 2 and 3 respectively).

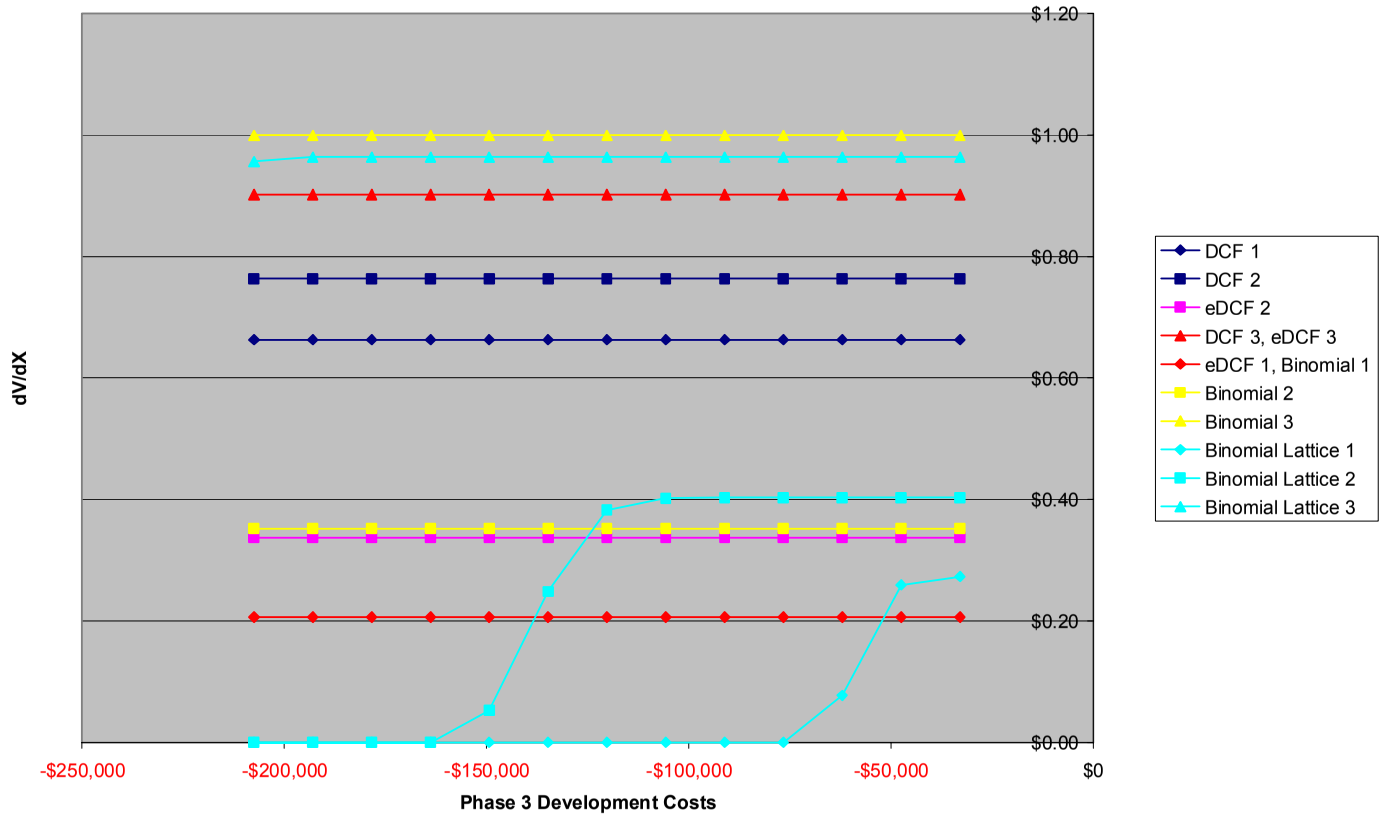
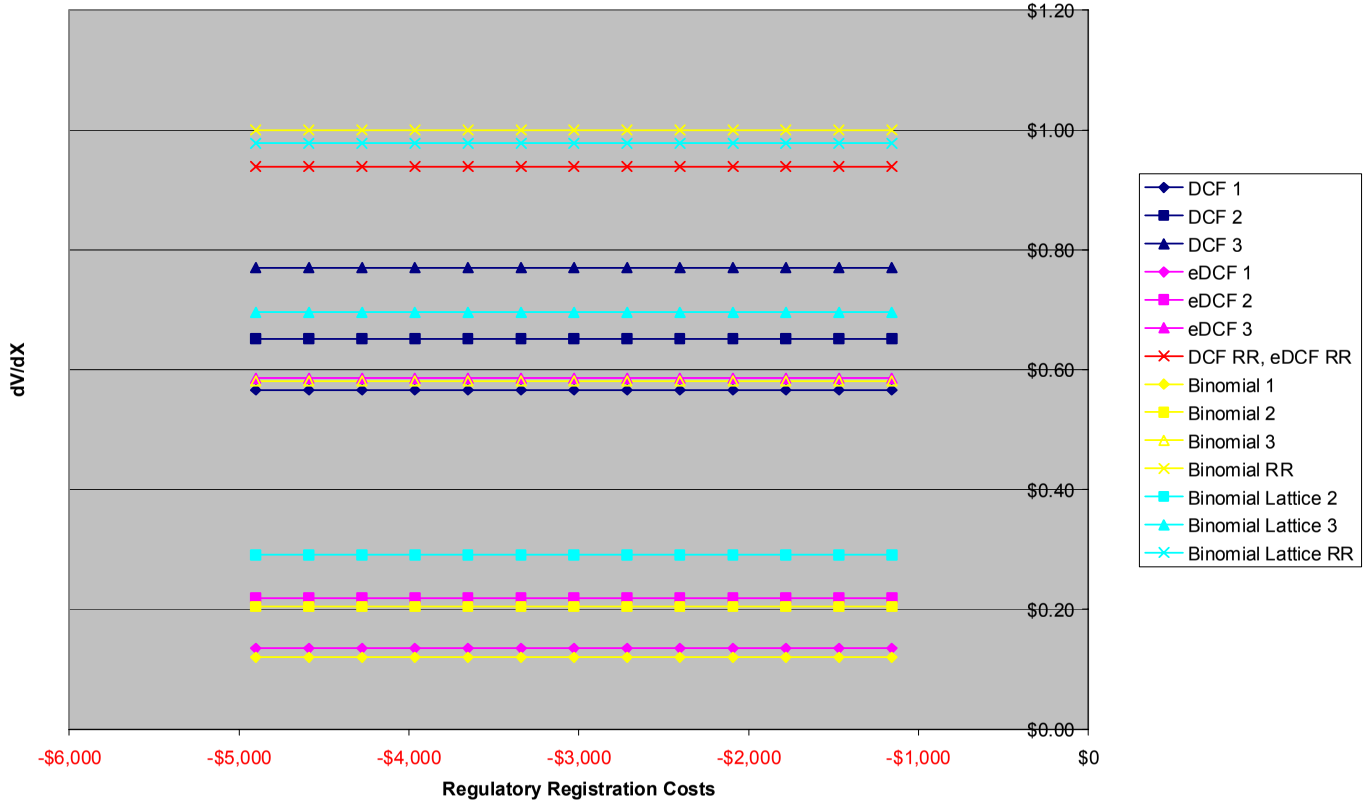


**Figure 6-22 δV/δX for X = Regulatory Assessment Costs**

This figure shows estimates for δV/δX (in $, 000) where X equals the cost to complete regulatory assessment for marketing approval ($,000). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying NDA assessment costs through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. This process was repeated for valuation estimates prior to phase 1 clinical trials, phase 2 clinical trials, phase 3 clinical trials and prior to regulatory registration. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1, 2, 3 clinical trials and regulatory registration (represented by suffixes 1, 2, 3 and RR respectively).

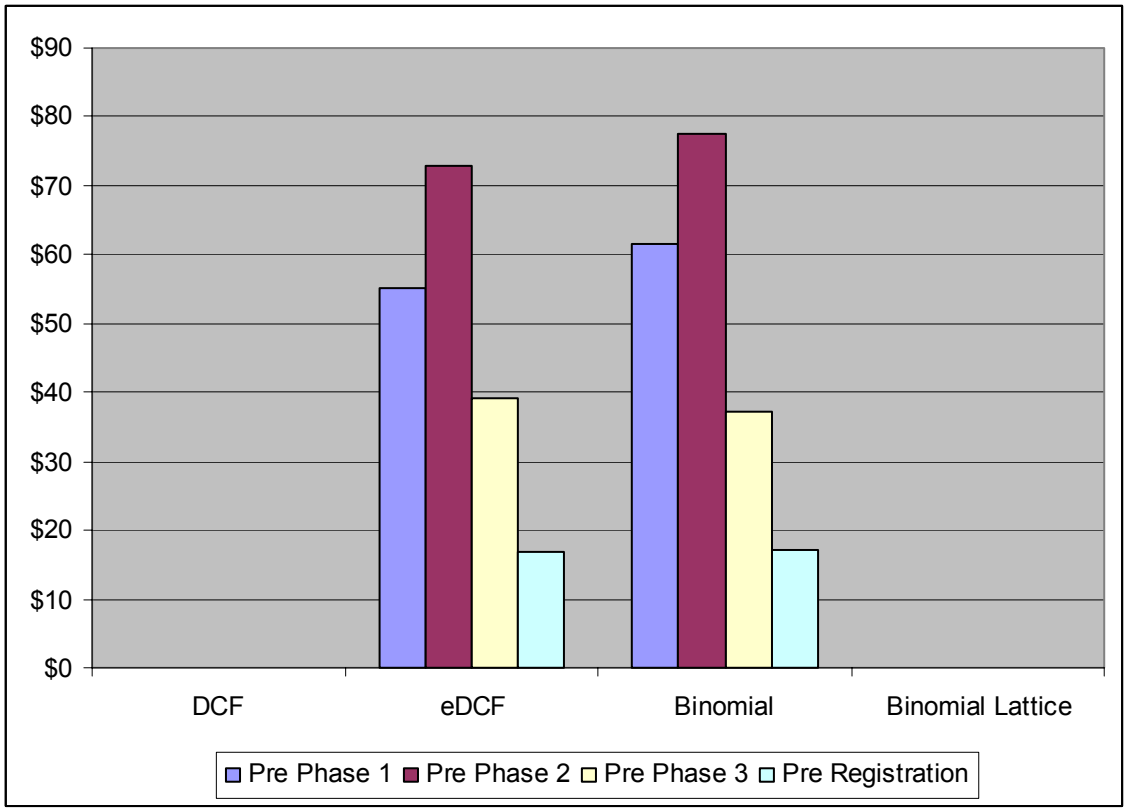


### 6.5.3 Salvage Values

Variation of salvage value, should the project be abandoned and sold, contributes to the uncertainty in valuation estimates as shown in Figure 6-23. The standard deviation in value estimates caused by variation in salvage values was greatest for projects having completed phase 1 and about to enter phase 2 clinical trials. The magnitude of variation is significantly less, with standard deviations between $10,000 and $80,000. In the later stages of development, the potential value of a fully developed drug grows significantly in relative terms compared with the potential salvage value, thus the influence of salvage value on project value reduces once the product moves in to phase 2 clinical trials.

The DCF and binomial lattice methods do not incorporate salvage values as one of the model inputs, thus salvage values are therefore not relevant to value estimates for these methods. The impact on eDCF and binomial models was similar with the binomial model slightly more affected by variations in salvage values.

**Figure 6-23 Valuation Standard Deviations for Restricted Salvage Value Model**
This figure shows the standard deviations of the valuation estimates (expressed in $,000) for each methodology allowing salvage value to vary and holding all remaining inputs fixed. 1000 simulations were used to generate estimates at four stages in the development cycle; prior to phase 1 clinical trials, prior to phase 2 clinical trials, prior to phase 3 clinical trials, and prior to regulatory registration.




The sensitivity of estimates to salvage value after phase 1 clinical trial failure is shown in Figure 6-24. Sensitivity to this input is constant for all phase 1 salvage values with the binomial model being more sensitive to changes in value. A $1 increase in the expected salvage value increases the expected valuation produced by the eDCF model by around $0.25 versus around $0.33 for the binomial model. As the expected salvage values are low, the expected impact of salvage value on product value is small.

Value estimates are more impacted by salvage values after a phase 2 clinical trial failure than phase 1 as shown in Figure 6-25. Due to the time value of money, the impact of phase 2 salvage values is most influential on those estimates produced immediately prior to the commencement of phase 2 trials. The binomial model is again more sensitive to changes in the expected salvage value with $\partial V/\partial X_i$ for valuations prior to phase 2 commencement with a $1 increase in salvage value increasing value estimates by around $0.50 versus $0.45 for the eDCF model. Valuation prior to phase 1

commencement produces very similar sensitivities to phase 2 salvage values of around $0.30.

The sensitivity of estimates to salvage value after phase 3 clinical trial failure is shown in Figure 6-26. Valuation estimates are less sensitive to changes in phase 3 salvage values than earlier salvage values. Interestingly, in contrast to phase 1 and 2 salvage values, the binomial model is less sensitive to changes in phase 3 salvage values than the eDCF model for valuations at all development stages.

The probability of successful regulatory registration is assumed at 90% which reduces the impact that salvage value after regulatory assessment failure has on product value shown in Figure 6-27. As well as having reduced impact on product valuations, the differential in $\partial V/\partial X_i$ between the eDCF and binomial models are close to zero.

**Figure 6-24 δV/δX for X = Phase 1 Failure Salvage Value**

This figure shows estimates for δV/δX (in $,000) where X equals the project salvage value after phase 1 clinical trials failure ($, 000). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying salvage value after phase 1 clinical trials failure through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. This process was repeated for valuation estimates prior to phase 1 clinical trials. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1 clinical trials (represented suffix 1).

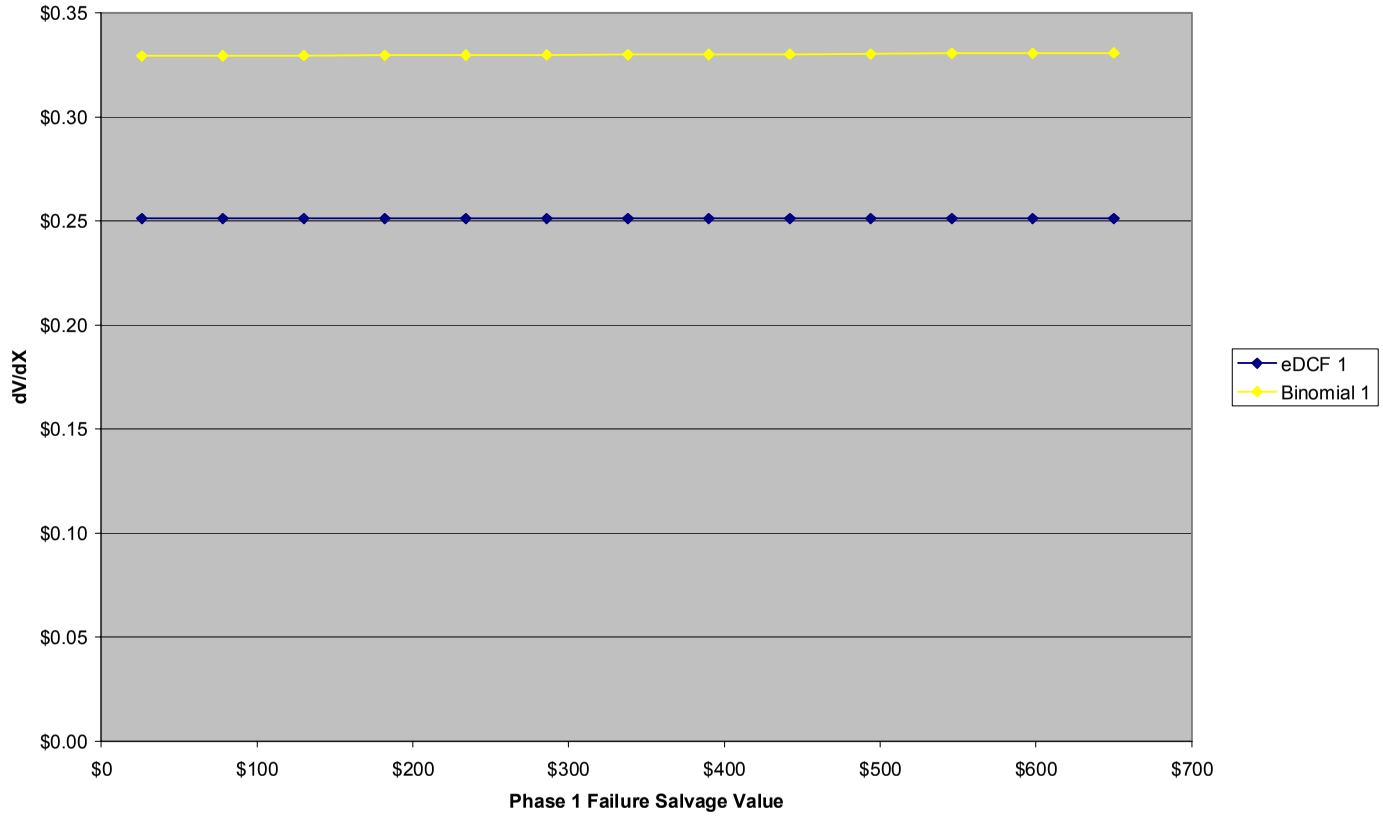


**Figure 6-25 δV/δX for X = Phase 2 Failure Salvage Value**

This figure shows estimates for δV/δX (in $,000) where X equals the project salvage value after phase 2 clinical trials failure ($, 000). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying salvage value after phase 2 clinical trials failure through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. This process was repeated for valuation estimates prior to phase 1 and phase 2 clinical trials. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1, and 2 clinical trials (represented by suffixes 1and 2 respectively).

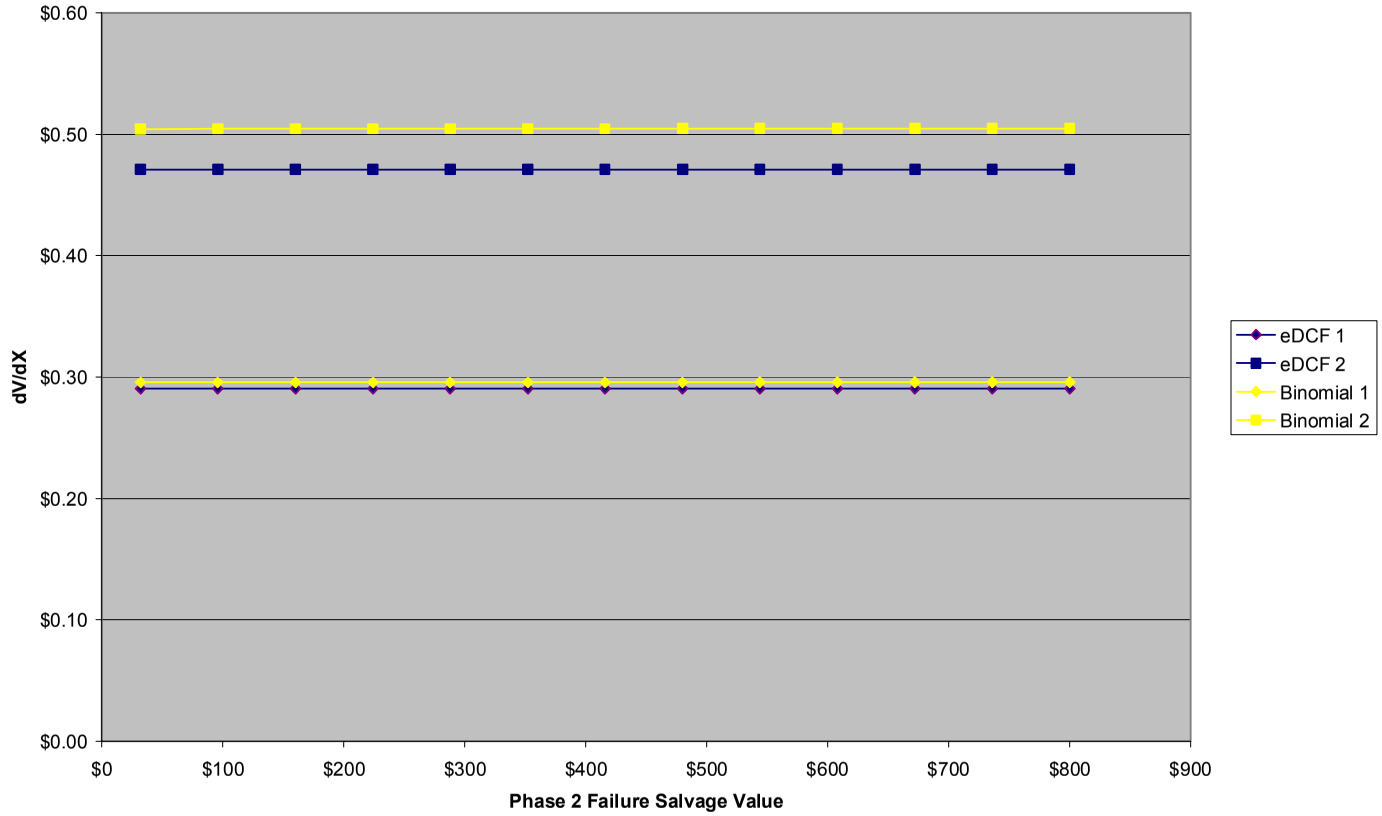


**Figure 6-26 δV/δX for X = Phase 3 Failure Salvage Value**

This figure shows estimates for δV/δX (in $,000) where X equals the project salvage value after phase 3 clinical trials failure ($, 000). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying salvage value after phase 3 clinical trials failure through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. This process was repeated for valuation estimates prior to phase 1, 2 and 3 clinical trials. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1, 2, and 3 clinical trials (represented by suffixes 1, 2 and 3 respectively).

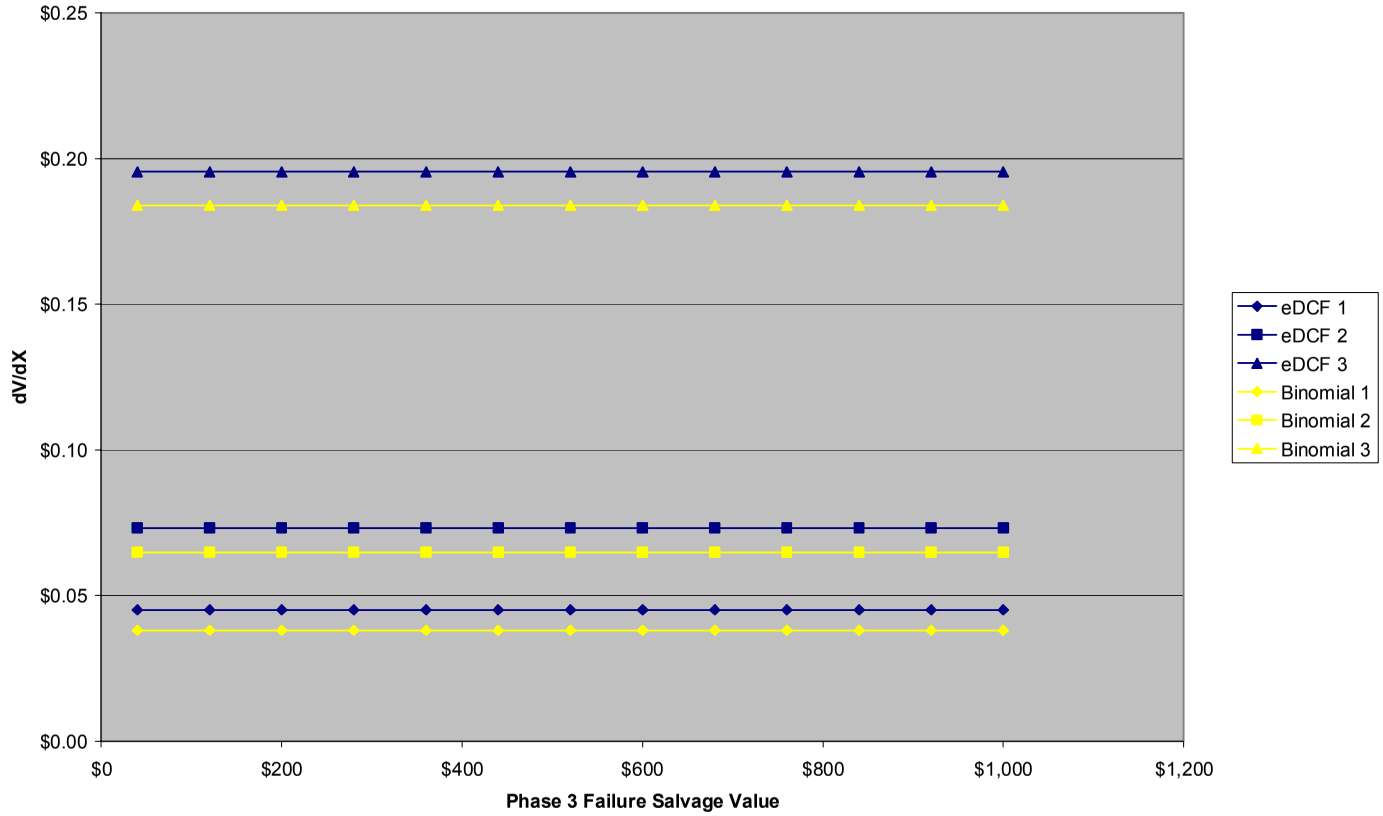
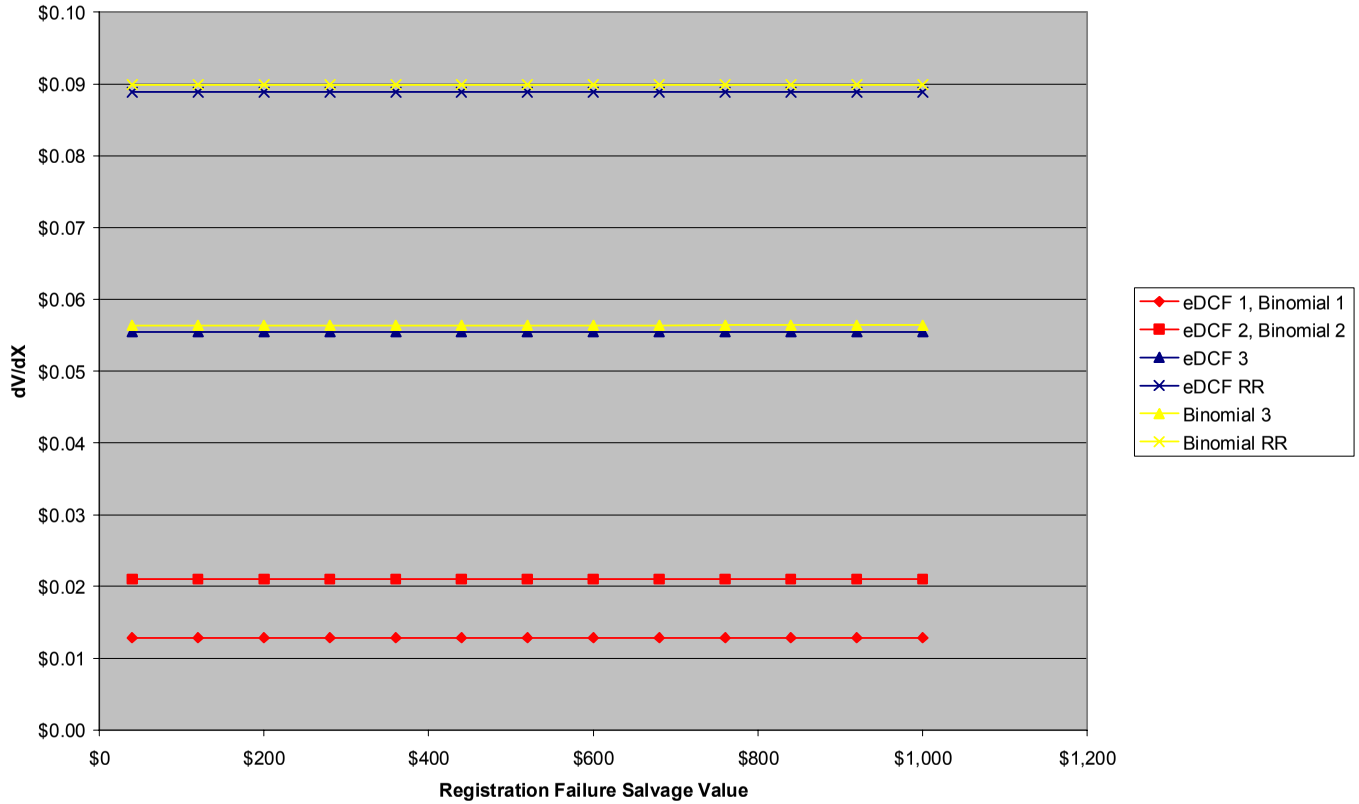


**Figure 6-27 δV/δX for X = Registration Rejection Salvage Value**

This figure shows estimates for δV/δX (in $,000) where X equals the project salvage value after failure to pass regulatory assessment for marketing approval ($, 000). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying salvage value after NDA rejection through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. This process was repeated for valuation estimates prior to phase 1 clinical trials, phase 2 clinical trials, phase 3 clinical trials and prior to regulatory registration. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1, 2, 3 clinical trials and regulatory registration (represented by suffixes 1, 2, 3 and RR respectively).

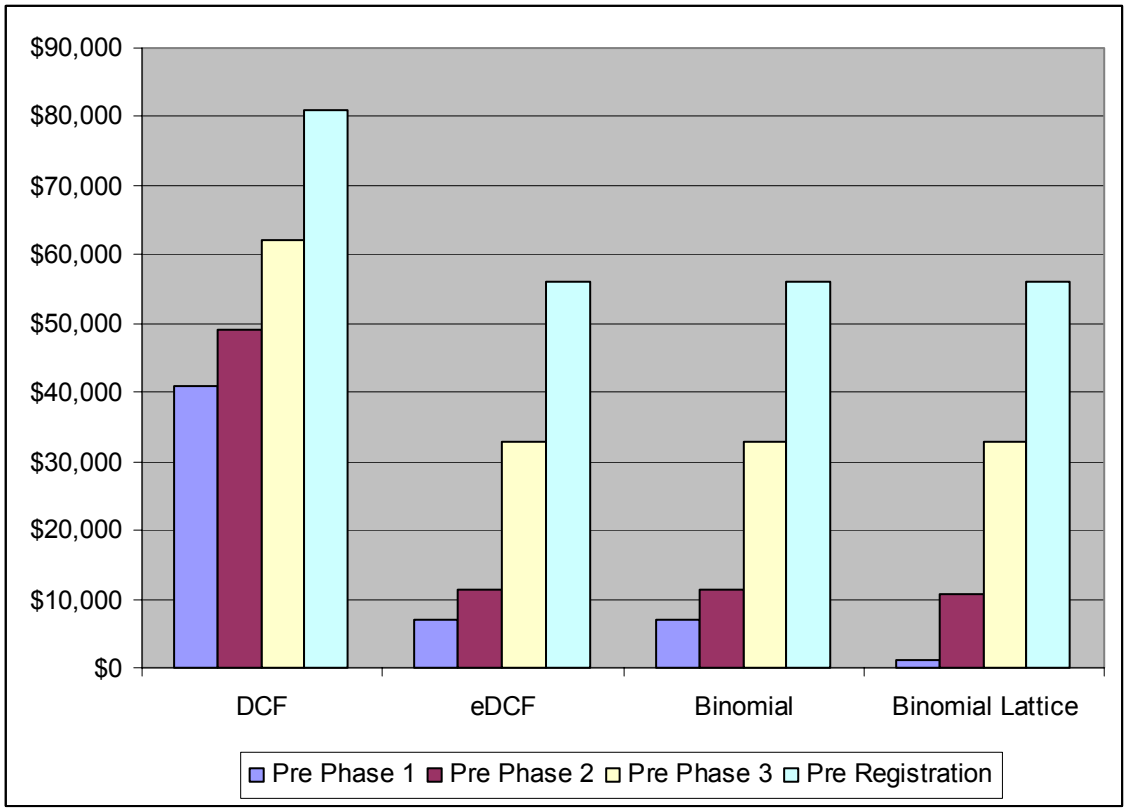


### 6.5.4 Commercialisation Cash Flows

Variation of the commercialisation cash flows contributes to the uncertainty in valuation estimates as shown in Figure 6-28. In all stages of development, commercialisation cash flows had the greatest impact on estimates produced by the DCF model. The difference was most significant in the early stage valuations with standard deviations of around $40m for the DCF model compared with less than $10m for the alternatives. This difference is particularly relevant given that an early stage project will often have a value of less than $10m.

For later stage valuations, the influence of commercialisation cash flows had a greater influence on the values for all methods as the impact of the time value discount diminished. All three alternative valuation methods were similarly influenced by the commercialisation cash flows throughout development, however, the binomial lattice was again less influenced for very early stage valuations due to the impact of the zero values predicted at project abandonment events.

**Figure 6-28 Valuation Standard Deviations for Restricted Commercialisation Cash flows Model**
This figure shows the standard deviations of the valuation estimates (expressed in $,000) for each methodology allowing commercialisation cash flows to vary and holding all remaining inputs fixed. 1000 simulations were used to generate estimates at four stages in the development cycle; prior to phase 1, 2 and 3 clinical trials and prior to regulatory registration.




The DCF model does not take into consideration any commercial outcomes other than the "average" expectation, effectively assuming that the probability of this outcome is fixed at 100%, thus, this variable only influences the eDCF, binomial and binomial lattice models. The sensitivity of estimates to the expected likelihood that an "average" sales outcome will be achieved is shown in Figure 6-29. The instantaneous grade. $\partial V/\partial X_i$, is constant for all probabilities and for all decision tree models at the same development phase. Sensitivity to this input is greatest for valuations immediately prior to regulatory registration, again due to the time value of money and the impact that this variable has on commercialisation cash flows. $\partial V/\partial X_i$ varies between -$500m and -$100m implying that for a 1% increase in the probability of an "average" revenue outcome, the expected valuation is reduced by between $5m and $1m depending on project maturity.

The sensitivity of estimates to the expected revenues for an "average" sales outcome is shown in Figure 6-30. As the DCF model is most sensitive to this input as it does not

consider any alternative commercialisation outcomes. As expected, the later stage valuations are most influenced by variation in this factor which influences expected commercialisation cash flows. For valuations immediately prior to regulatory registration, the DCF model forecasts that a $1 increase in expected "average" revenue created a $1.10 increase in value whilst the alternative models expect a more modest $0.60 increase in value.

The sensitivity of estimates to the expected revenues for "non-average" sales outcomes are shown in Figure 6-31. The DCF model is not sensitive to changes in this input. As expected, for all decision tree models the later stage valuations are most influenced by variation in this factor which impacts expected commercialisation cash flows. Interestingly, despite the differing "non-average" commercialisation outcomes existing on different branches of the decision tree (see dog, below average, above average and blockbuster in Figure 6-3), $\partial V/\partial X_i$ is constant for all changes in revenue across each of these outcomes. The sensitivity to "non-average" revenue expectations is less than that for "average" revenue expectations for all three decision tree models. Despite this, the larger range in possible "non-average" revenues means that the range in values estimates produced is similar to the range produced by fluctuating "average" revenues.

The DCF model is most sensitive to changes in post approval research and development time for valuations at all stages in development as shown in Figure 6-32. For all models $\partial V/\partial X_i$ is not constant, reducing as time increases although remaining positive across the range of times specified. The sensitivity of all models to changes in post approval time means that for a product about to commence regulatory filing, the expected impact of post approval research and development time is a decrease in value of between $0.7m and $3.5m for each additional month expected to be spent on this research.

The sensitivity of estimates to the expected post approval research and development costs is shown in Figure 6-33. The DCF model is again most sensitive to changes in this input across all stages in development. For all models, $\partial V/\partial X_i$ is constant, hence regardless of the anticipated expenditure, the three alternative valuation methods have equal sensitivities. For a product about to submit for regulatory approval, the expected impact of this variable on value estimated by the alternative models is a decrease in value of $0.26 for each additional dollar of anticipated research and development

expenditure. This compares with the DCF model which expects a decrease in value of $0.37 for each additional $1 of post approval research and development expenditure.

**Figure 6-29 δV/δX for X = Probability of "Average" Sales**

This figure shows estimates for δV/δX (in $,000) where X equals the probability of an "average" sales outcome (in %). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying the probability through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1, 2, 3 clinical trials and regulatory registration (represented by suffixes 1, 2, 3 and RR respectively).

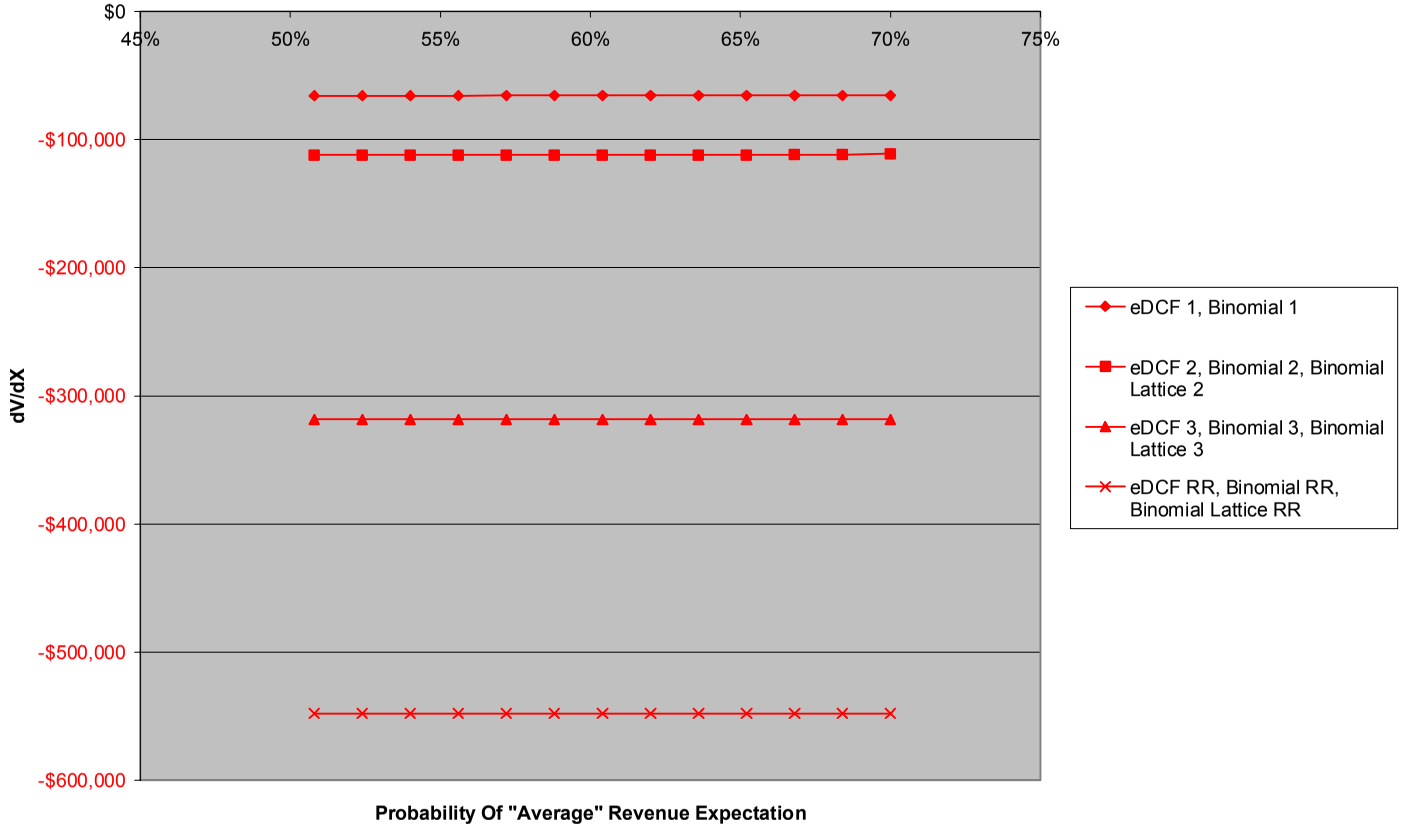


**Figure 6-30 δV/δX for X = "Average" Revenue Expectation**

This figure shows estimates for δV/δX (in $,000) where X equals the revenue expectation of an "average" sales outcome (in $, 000). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying the "average" revenue expectation through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1, 2, 3 clinical trials and regulatory registration (represented by suffixes 1, 2, 3 and RR respectively).

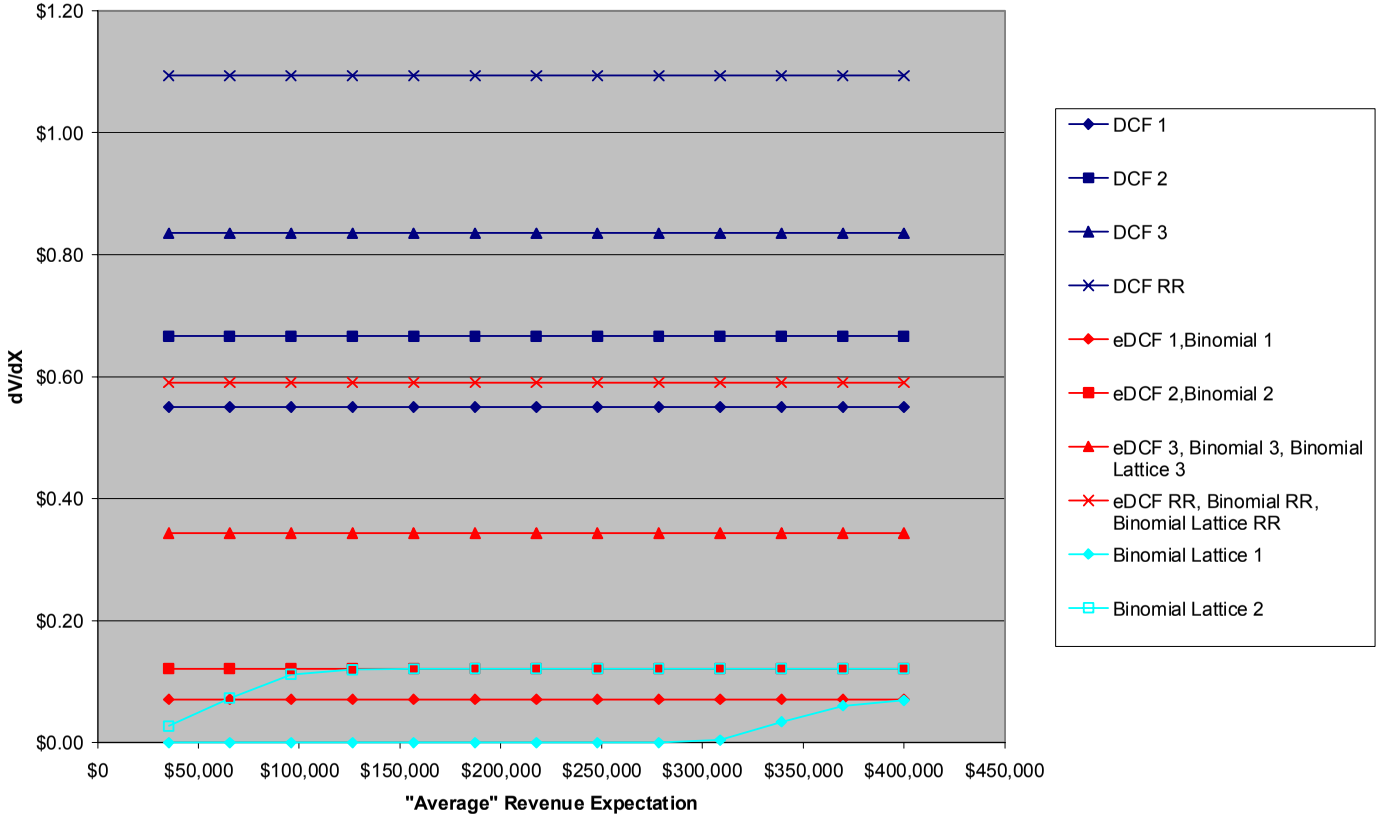


**Figure 6-31 δV/δX for X = "Non-Average" Revenue Expectation**

This figure shows estimates for δV/δX (in $,000) where X equals the revenue expectation of a "non-average" sales outcome (in $, 000). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying the "non-average" revenue expectation through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. Note that there is a gap in the lines representing the range of revenues corresponding to an "average" outcome. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1, 2, 3 clinical trials and regulatory registration (represented by suffixes 1, 2, 3 and RR respectively).

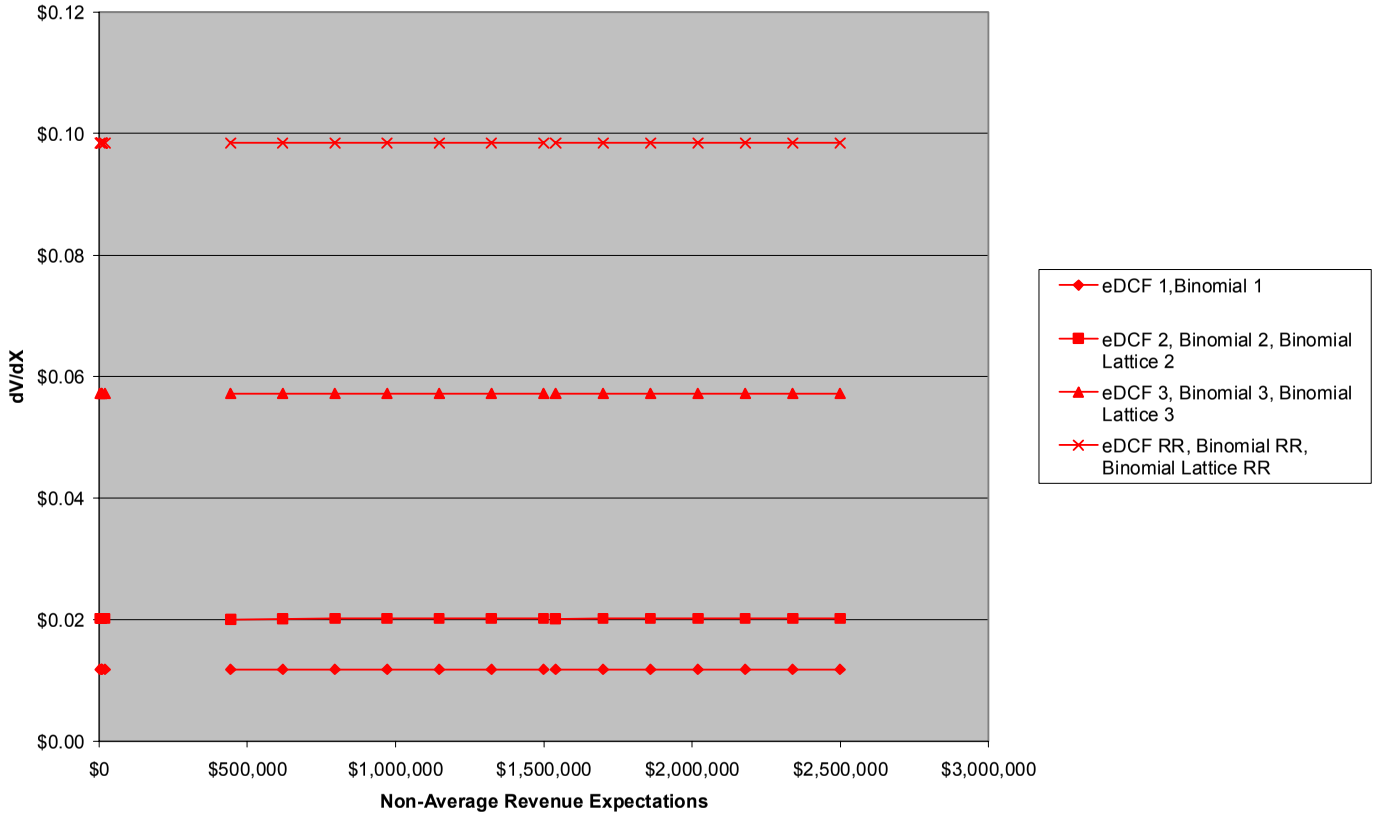


**Figure 6-32 δV/δX for X = Post Registration R&D Time**

This figure shows estimates for δV/δX (in $,000) where X equals the post registration research and development time (in months). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying post registration research and development times through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1, 2, 3 clinical trials and regulatory registration (represented by suffixes 1, 2, 3 and RR respectively).

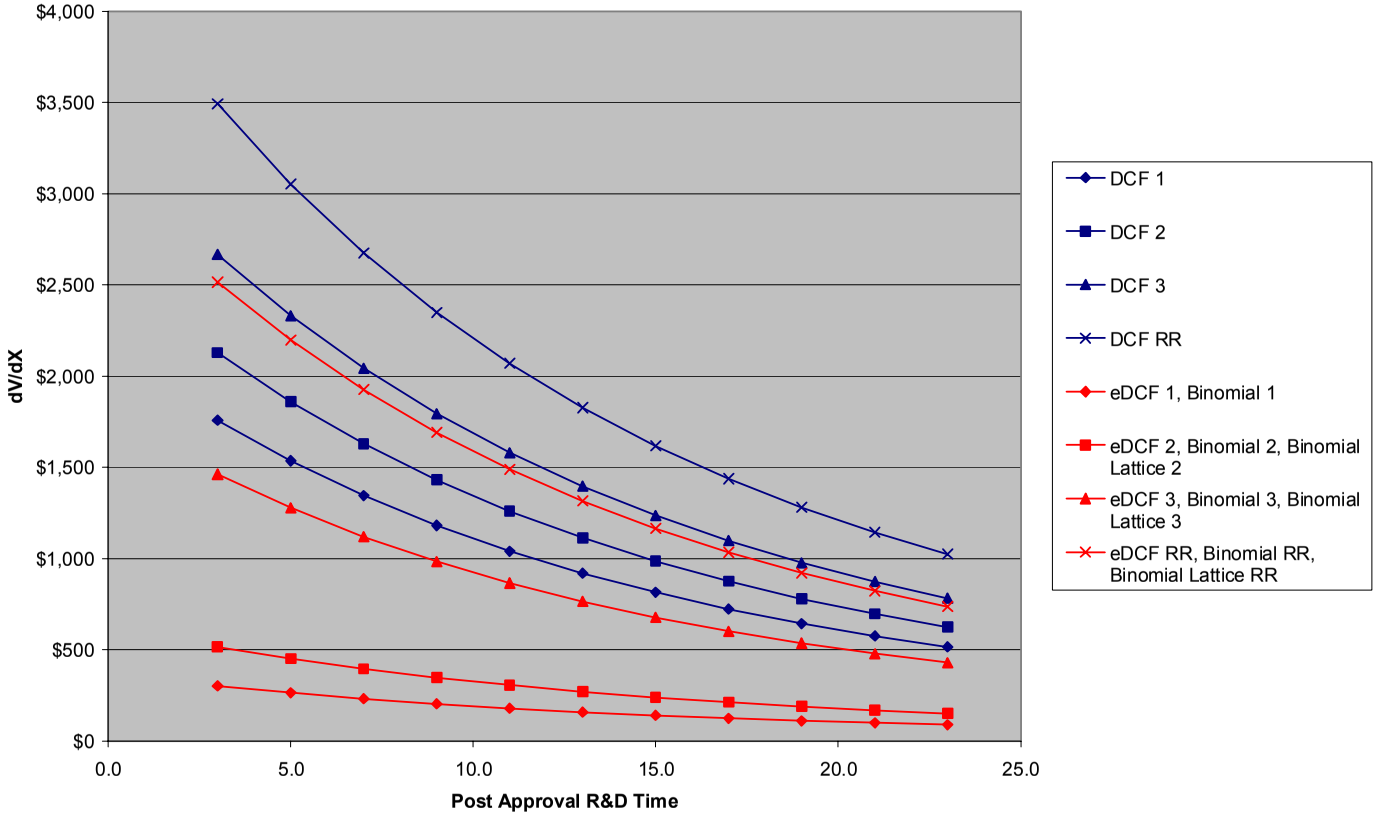
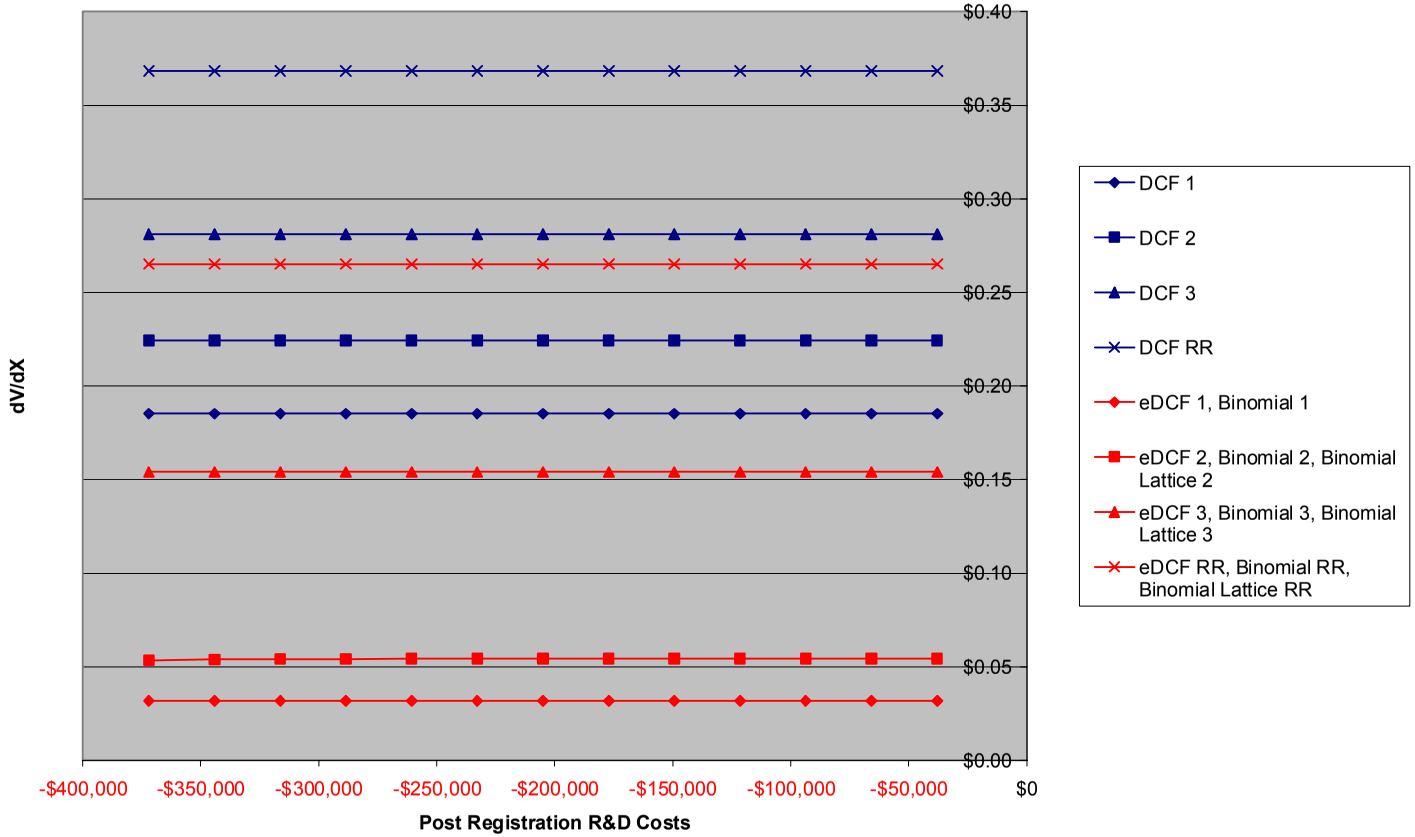


**Figure 6-33 δV/δX for X = Post Registration R&D Expenditure**

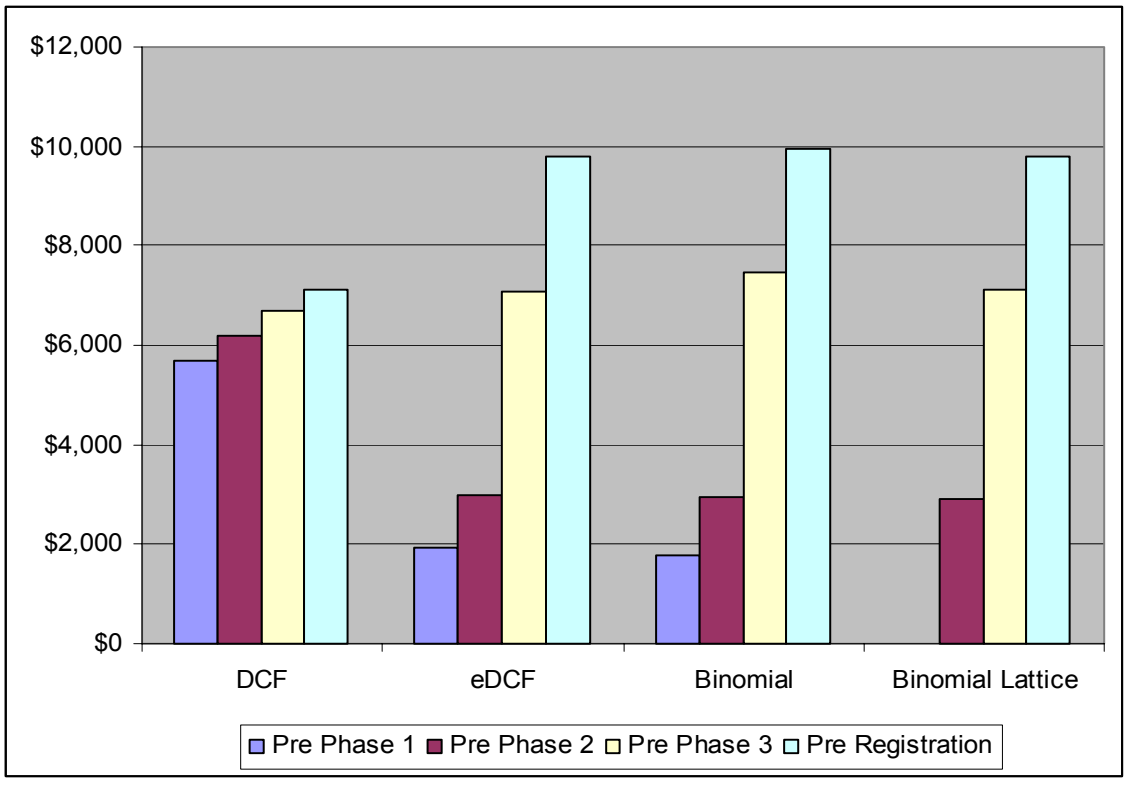
This figure shows estimates for δV/δX (in $,000) where X equals the post registration research and development expenditure ($, 000). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying post registration research and development expenditures through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1, 2, 3 clinical trials and regulatory registration (represented by suffixes 1, 2, 3 and RR respectively).



### 6.5.5 Discount Rate

In the early stages of development, discount rates had the greatest impact on estimates produced by the DCF model, with the standard deviation of restricted model value estimates greater than double that for early stage alternative model estimates as shown in Figure 6-34. Interestingly, upon completion of phase 2 clinical trials, the impact of discount rates on valuations produced by the alternative valuation methods increased significantly to produce estimates with standard deviations greater than those produced by the DCF model. For all three alternative methods, the impact of discount rates was similar, however, the binomial lattice was again less influenced for very early stage valuations due to the impact of abandonment events.

**Figure 6-34 Valuation Standard Deviations for Restricted Discount Rate Model**
This figure shows the standard deviations of the valuation estimates (expressed in $,000) for each methodology allowing discount rates to vary and holding all remaining inputs fixed. 1000 simulations were used to generate estimates at four stages in the development cycle; prior to phase 1,2 and 3 clinical trials and prior to regulatory registration.




Only the DCF and eDCF models are sensitive to changes in this variable due to the manner in which the two option pricing models treat and discount expected development costs as shown in Figure 6-35. The option models treat development stage costs as the strike price of the option to continue research and development into the

subsequent stage (as discussed in section 6.2). These models rely on the principle of the risk neutral replicating portfolio which allows the option values to be discounted at the risk free rate. As a result, the exercise prices (development costs) are not discounted at the development stage discount rate, but instead at the lower risk free rate.

The DCF and eDCF models both have a positive and reducing $\partial V/\partial X_i$. As this discount rate is used to discount negative cash flows (costs), the greater the discount rate, the smaller the present value of costs, and hence the greater the expected value of the product. The DCF model is more sensitive to the development discount rate, particularly in the early stages of development. For a product entering in phase 1 clinical trial a 1% increase in development phase discount rate equates to an increase in DCF expected value of between \$3.3m and \$3.8m, whereas the corresponding eDCF increase is between \$1.3m and \$1.5m.

The sensitivity of estimates to commercialisation stage discount rates is shown in Figure 6-36. All models are sensitive to changes in this variable with $\partial V/\partial X_i$ negative and reducing across the range of expected discount rates. In early stages of development (valuations prior to phase 1 or phase 2 clinical trials) the alternative models are less sensitive to the commercialisation discount rate than the DCF model, however, the situation is reversed for valuations of more mature products.

The valuations are more sensitive to changes in the commercialisation discount rate than the development stage rate. For a product entering in phase 3 clinical trial a 1% increase in commercialisation phase discount rate equates to a decrease in DCF expected value of between \$15m and \$20m, whereas the corresponding alternative models expect a decrease of between \$23m and \$30m.

**Figure 6-35 δV/δX for X = Development Stage Discount Rate**

This figure shows estimates for δV/δX (in $,000) where X equals the development stage discount rate (in %). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying discount rate through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1, 2, 3 clinical trials and regulatory registration (represented by suffixes 1, 2, 3 and RR respectively).

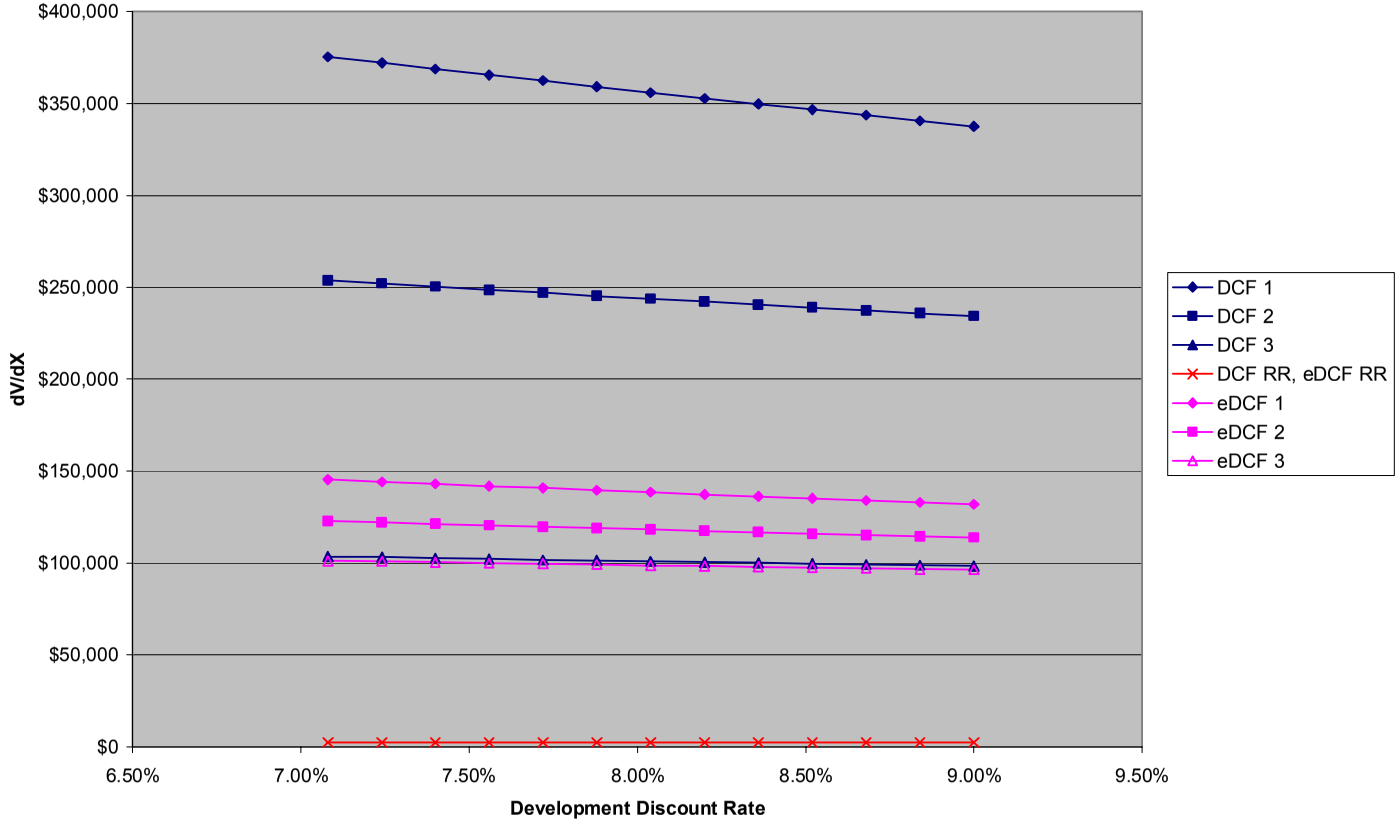
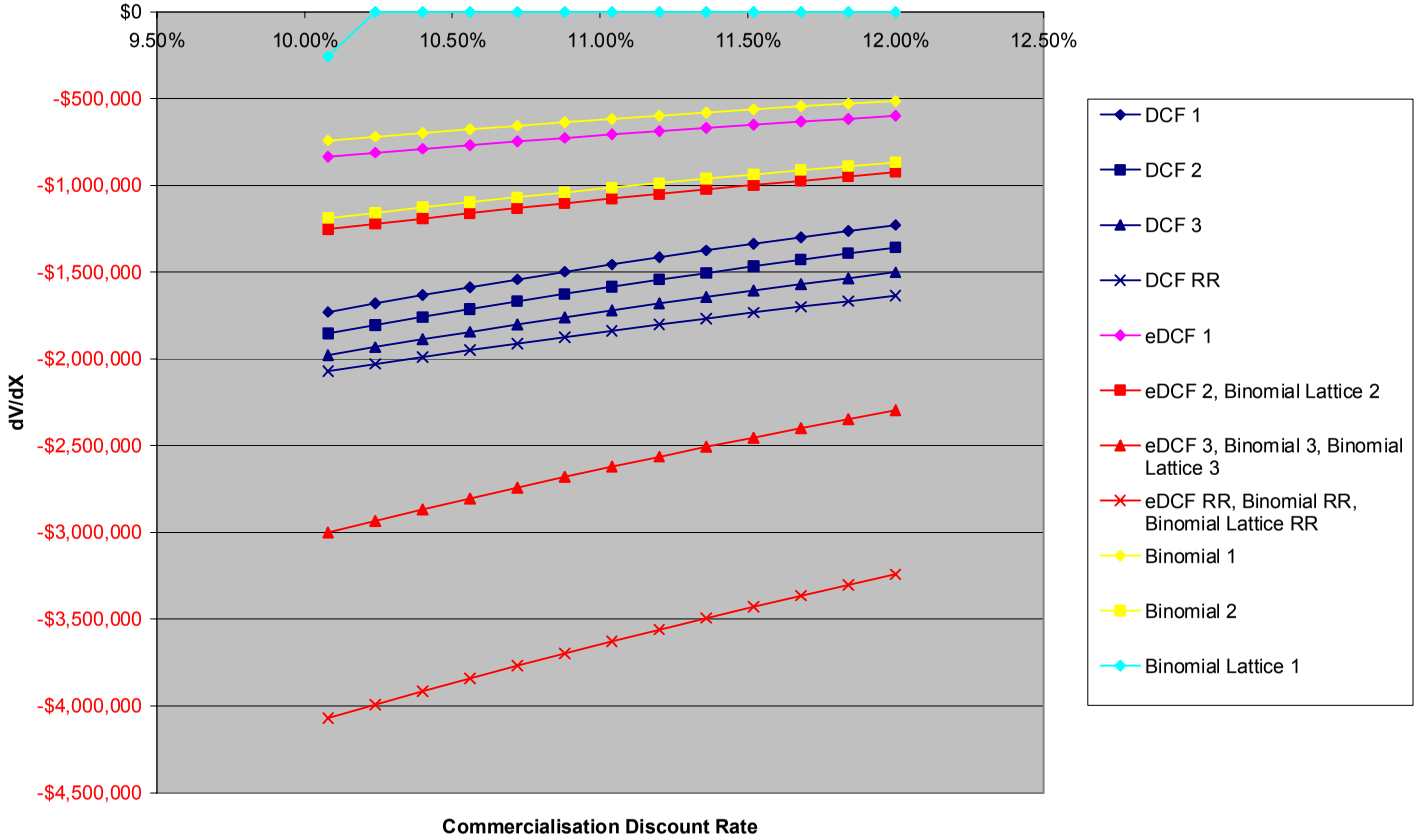


**Figure 6-36 δV/δX for X = Commercialisation Stage Discount Rate**

This figure shows estimates for δV/δX (in $,000) where X equals the commercialisation stage discount rate (in %). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying discount rate through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1, 2, 3 clinical trials and regulatory registration (represented by suffixes 1, 2, 3 and RR respectively).

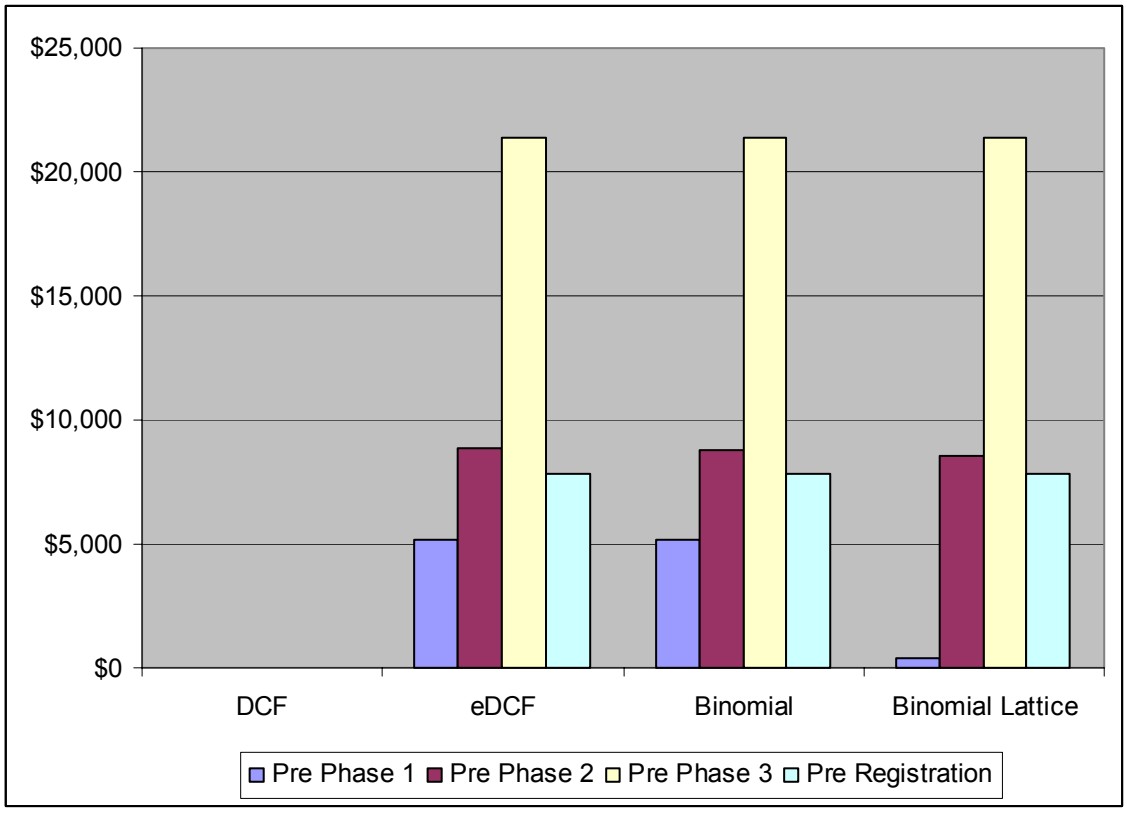


### 6.5.6 Development Risk

The effects of variation in development risks on the standard deviation of value estimates are shown in Figure 6-37. The standard deviation in value estimates caused by variation in development risks were greatest for projects entering phase three clinical trials.

The DCF model does not directly include the success probabilities as a valuation input. This risk is included indirectly as the discount rate is chosen to reflect all risks associated with the cash flows being forecast. For this reason, variation in the success probabilities had no impact on values produced by the DCF model. For all three alternative methods the impact of development risks were similar, however, the binomial lattice was again less influenced for very early stage valuations due to the impact of the zero values adopted in the modelled project abandonment events.

**Figure 6-37 Valuation Standard Deviations for Restricted Development Risk Model**
This figure shows the standard deviations of the valuation estimates (expressed in $,000) for each methodology allowing expected development risks to vary and holding all remaining inputs fixed. 1000 simulations were used to generate estimates at four stages in the development cycle; prior to phase 1, 2 and 3 clinical trials and prior to regulatory registration.



The sensitivity of estimates to risk of phase 1 clinical trial failure is shown in Figure 6-38. Sensitivity to this input is constant for all expected phase 1 success probabilities, with the eDCF being less sensitive to changes in success probability than the binomial model. The binomial lattice model is not influenced by variation in this input at this early stage due to the zero value adopted for the abandonment alternative. A 1% increase in the expected success probability increases the expected valuation produced by the eDCF model by around \$190,000 versus around \$195,000 for the binomial model.

The $\partial V/\partial X_i$ values are higher (for $X$ equals to the probability of phase 2 clinical trial success) than those for phase 1 as shown in Figure 6-39. The eDCF model is the most sensitive immediately before commencement of phase 2 clinical trials. The binomial lattice is least sensitive to changes in expected success probability, a 1% increase in the expected success probability increasing the expected valuation produced by the eDCF model by around \$1.1m versus around \$1.05m for the binomial model and \$0.95m for the binomial lattice.

The sensitivity of estimates to the expected phase 3 clinical trial success probabilities are shown in Figure 6-40. The $\partial V/\partial X_i$ values are higher than those for phase 1 or 2 success probabilities and the alternative models are now equally sensitive to variation in expected success probability (where the binomial lattice is not impacted by zero value abandonment option). Variation in expected value for fluctuation in this variable is similar to that expected for the other stage development rates with 1% increase in the expected success probability increasing expected valuations by \$0.6m, \$1.0m and \$2.9m for valuations prior to phase 1, 2, and 3 clinical trials respectively.

Figure 6-41 shows the sensitivity of value estimates to variation in the expected probability of successful regulatory registration with $\partial V/\partial X_i$ values similar, but slightly less than, the previous development phase expectations. A 1% increase in the expected success probability of NDA filing increases expected valuations by \$0.5m, \$0.9m and \$2.4m and \$4.2m for valuations prior to phase 1, 2, 3 clinical trials and regulatory filing respectively. The impact of a 1% change in the expected success probability on the value of a project immediately prior to regulatory submission provides a clear signal regarding the importance of the quality of the regulatory submission.

**Figure 6-38 δV/δX for X = Phase 1 Success Probability**

This figure shows estimates for δV/δX (in $,000) where X equals the probability of successful completion of phase 1 clinical trials (in %). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying the success probability through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. . For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1 clinical trials (represented suffix 1).

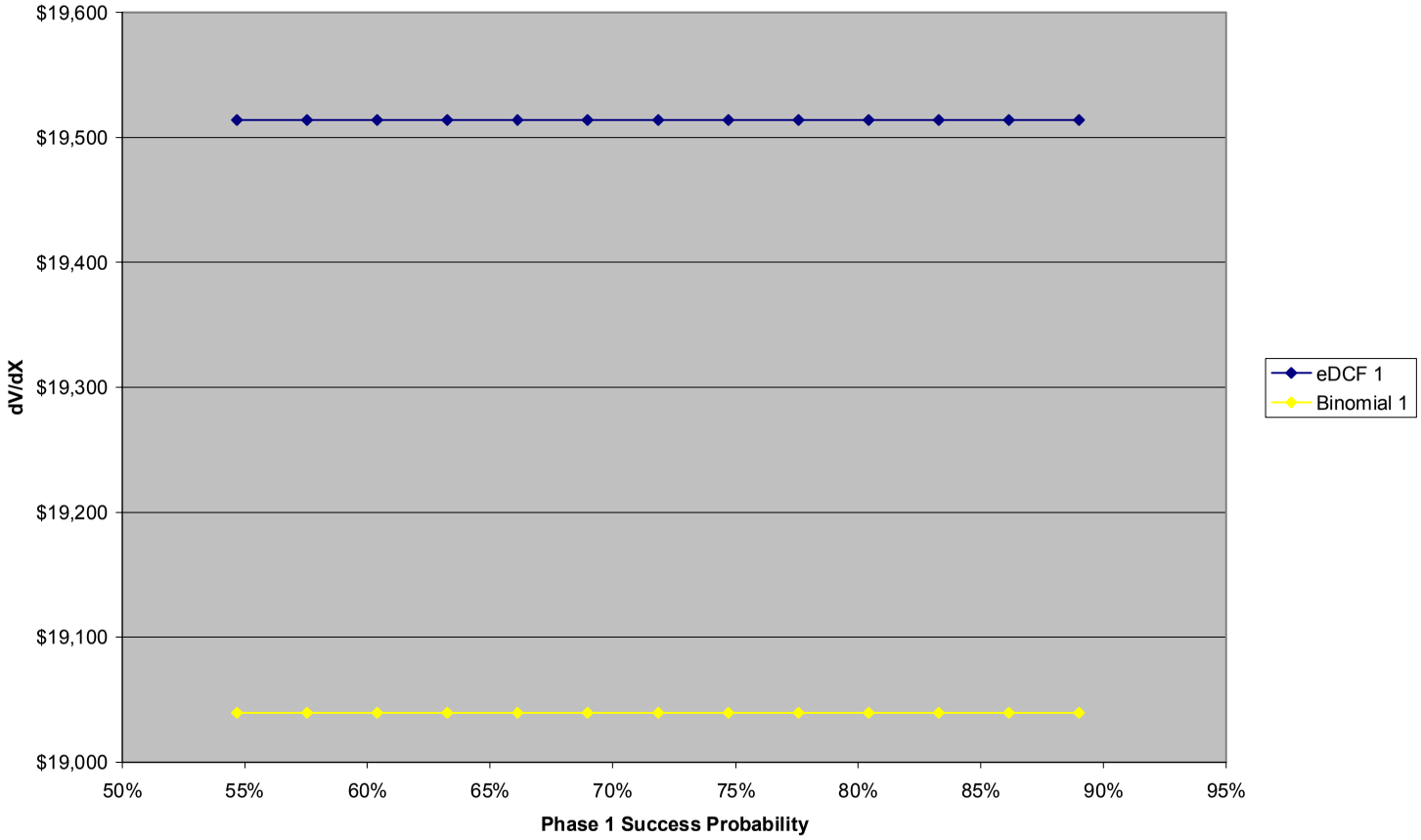


**Figure 6-39 δV/δX for X = Phase 2 Success Probability**

This figure shows estimates for δV/δX (in $,000) where X equals the probability of successful completion of phase 2 clinical trials (in %). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying the success probability through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1, and 2 clinical trials (represented by suffixes 1and 2 respectively).

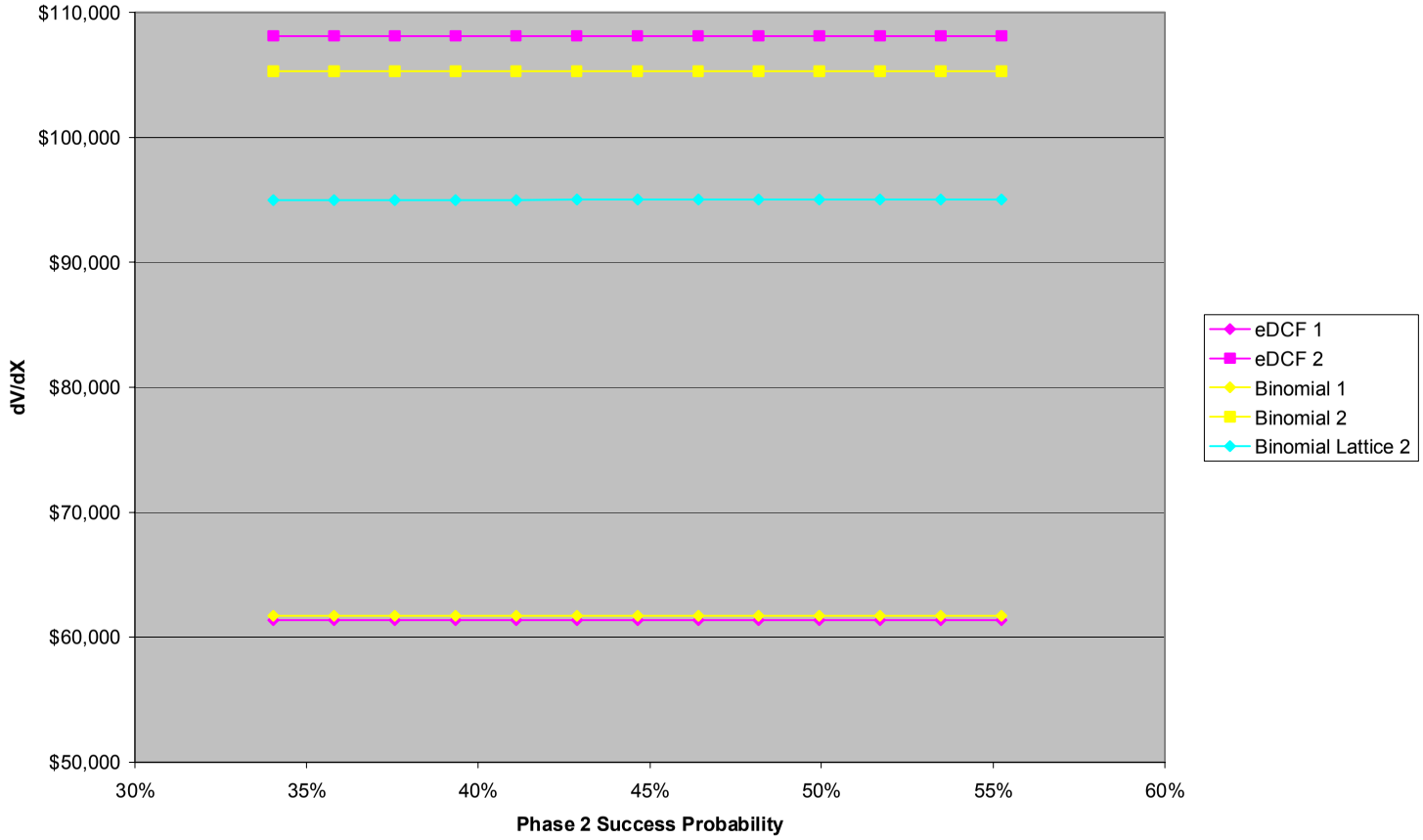


**Figure 6-40 δV/δX for X = Phase 3 Success Probability**

This figure shows estimates for δV/δX (in $,000) where X equals the probability of successful completion of phase 3 clinical trials (in %). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying the success probability through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1, 2, and 3 clinical trials (represented by suffixes 1, 2 and 3 respectively).

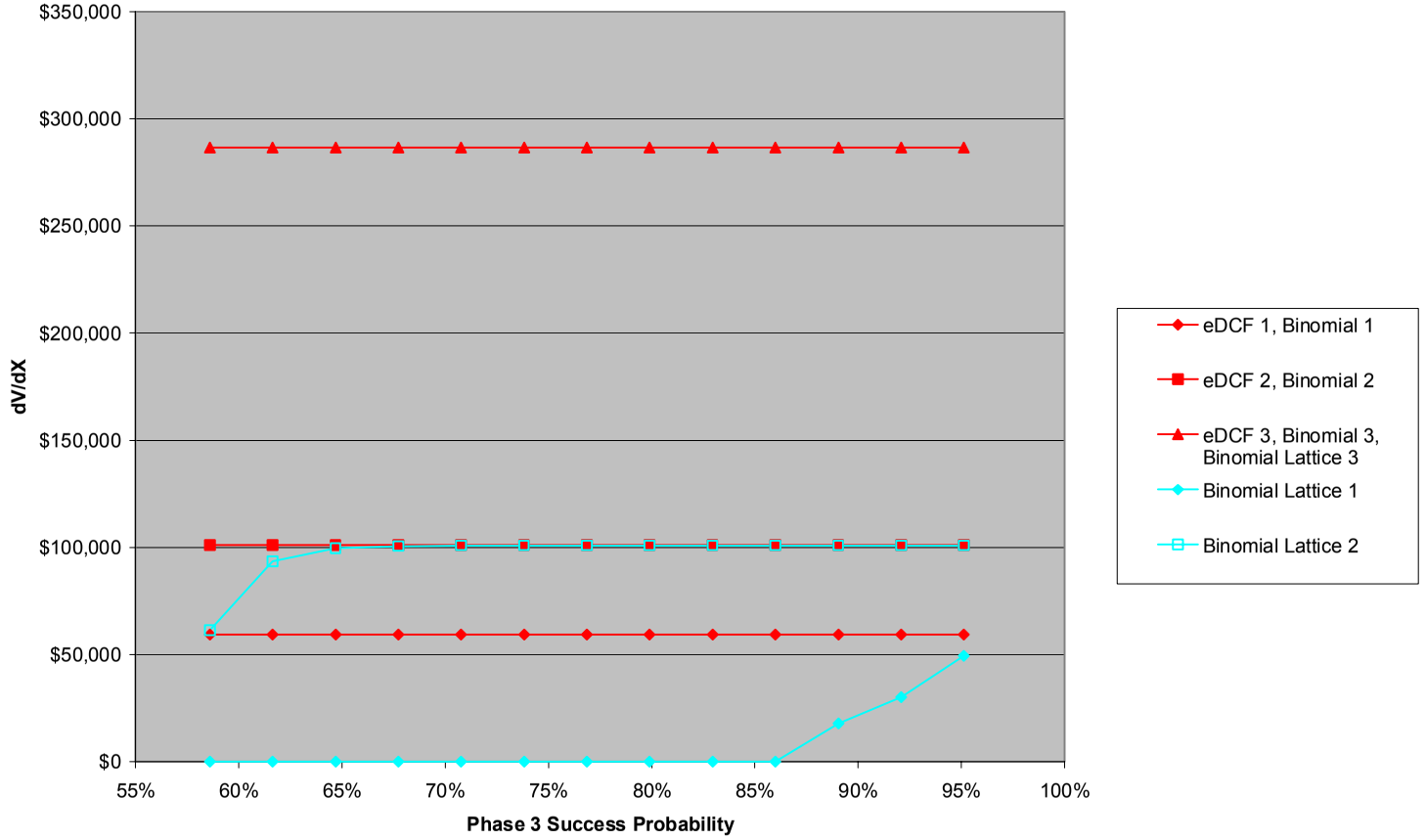
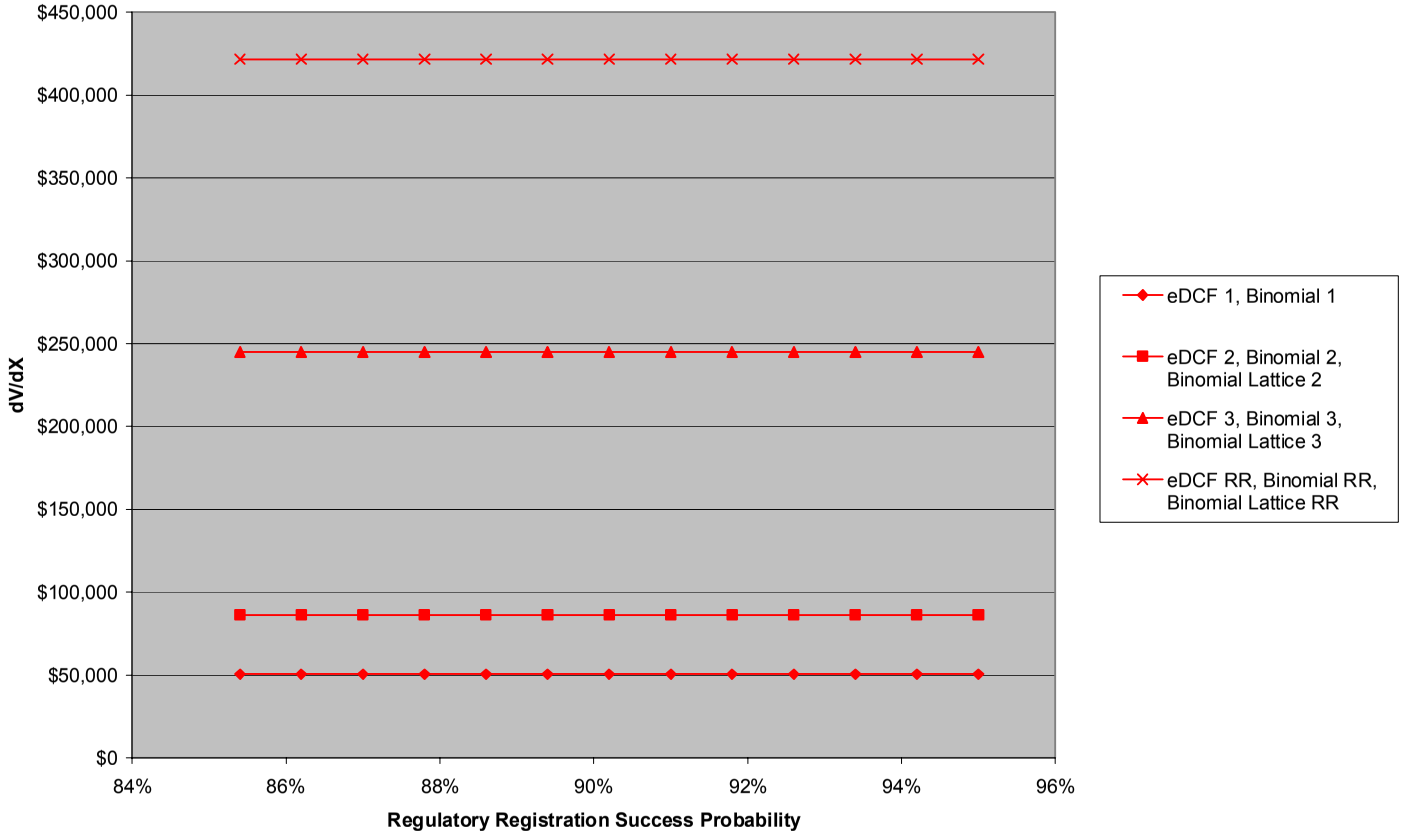


**Figure 6-41 δV/δX for X = Regulatory Registration Success Probability**

This figure shows estimates for δV/δX (in $,000) where X equals the probability of successful registration with the regulator for marketing approval (in %). These estimates are calculated by holding all inputs fixed at their expected mode and systematically varying the success probability through the range of possible values defined in Table 6-1. The resultant changes in value estimates were then used to calculate δV/δX for each X. For simplicity, where δV/δX = 0 for all X, the data is not shown on the chart. The chart represents results for each of DCF, eDCF, binomial, and binomial lattice valuation methods immediately prior to the commencement of stage 1, 2, 3 clinical trials and regulatory registration (represented by suffixes 1, 2, 3 and RR respectively).



## 6.6 VALUATION METHODOLOGY CHOICE IMPLICATIONS

Reducing valuation uncertainty improves management's ability to efficiently allocate resources and ensure shareholder returns are maximised. Similarly, reduced valuation uncertainty reduces a potential investor's risk exposure, and with improving risk-return characteristics the amount of money being invested in drug development projects should increase.

### 6.6.1 Management

The reduced variation in the value estimates produced by the decision tree models offers management the opportunity to more effectively manage existing projects and assess potential new projects. With greater valuation certainty, management is less likely to misjudge the value of a potential project and miss an attractive investment opportunity.

The eDCF model is easily constructed using commonly understood and applied DCF principles. The eDCF model produces value estimates with reduced uncertainty, and which equitably incorporates a wide variety of potential outcomes. Simple DCF analysis offers a useful tool for valuing opportunities, however, the benefits derived from incorporating a greater level of detail in to an eDCF model appear to more than outweigh the slight increase in workload required to construct this model.

For early stage products, the option to abandon the project if unfavourable conditions eventuate may increase the expected value of the project. The option pricing models are able to incorporate the value benefits from abandonment and these tools may enable management to more effectively manage their product portfolio.

The cash flows generated by the final product were the major driver of value for biotechnology products in all stages of development based on the results for four valuation methods included in this analysis. Thus management considering investment in biotechnology products need to carefully assess the commercial viability of the end product. Similarly, managers of a product under development need to carefully monitor the commercialisation landscape as a change in conditions may mean that value maximisation is achieved through project abandonment. This is particularly important

given that the sensitivity of value estimates to commercialisation cash flows increased as the product moved through the development process.

Through the development process, management are able to directly influence value most through cost containment. However rather than embarking on substantial cost reduction strategies, management needs to be aware of the influence that development time also had on value estimates. Whilst cost had a greater impact on value, a reduction in expenditure may place the product at risk of increased time spent in development, offsetting the impact of reduced cost on value.

For projects entering the regulatory registration, value estimates were significantly more influenced by the time under assessment than the cost of assessment. Thus it is important that firms have open communication with the regulator throughout development to ensure that the submission meets the regulators expectations. During the assessment period, firms should place a high priority on assisting the regulator, ensuring that any queries are addressed in a timely manner.

The probability of successful development had less influence on value than commercial viability, development cost and development time. Thus when comparing two potential projects with similar commercial opportunities, management should focus their attention on the speed with which the product could be developed and at what cost rather than the probability of success. Whilst the probability of success may not be the most important driver of value, for cash strapped Australian biotechnology firms, the success of the firm often depends on the success of one or two lead products in their portfolio, thus, probability of successful development is of greater significance.

### 6.6.2 Investors

Improved value assessments by investors will allow investors to more accurately assess potential biotechnology investments and should facilitate a more efficient allocation of investment money. By shifting capital away from underperforming firms towards relatively undervalued higher potential firms, an increase in capital should be made available to those firms best able to apply those funds, successfully develop their portfolios and generate shareholder returns.

Considering the value of a biotechnology firm as the sum value of its portfolio of products allows investors to value a firm using "sum-of-parts" valuation. The eDCF model offers investors a simple mechanism to reduce the level of uncertainty in their investments compared with those assessed using simple DCF analysis.

The value benefit from the incorporation of abandonment options into a valuation depends on management's ability to identify those projects which would have their value maximised by abandoning or halting development. Investors should be wary of including the value benefits of abandonment options in their models as management may not possess the tools to allow continuous and efficient identification of those underperforming projects. This being the case, investors may overvalue abandonment options, thus investors should be wary of including abandonment value in their assessments without knowledge of management's project evaluation and implementation practice.

For investors analysing a biotechnology firm for potential investment, the ability of the management team to influence the primary value drivers should be assessed. If the final product is deemed to have strong commercial opportunities then investors should assess the likelihood that management will be able to cost effectively meet regulatory requirements in a timely manner. The majority of Australian firms do not have access to sufficient capital to fully develop a product, thus investors should also assess the potential development partners as part of their assessment. The major pharmaceutical companies likely to partner an Australian biotechnology firm have a track record of product development, providing investors with some insight into the ability of those firms to manage the development process.

Throughout the development process the discount rate applied to the commercialisation cash flows had a greater impact on value than the development stage discount rate. It is important that investors test valuation models for sensitivity to discount rate assumptions prior to deciding on a choice of action.

## 6.7 CONCLUSION

The DCF valuation model is the simplest model to construct and is widely understood and applied by practitioners today. A simple DCF valuation can be expanded into an

eDCF model by incorporating alternative potential outcomes into the cash flow estimates. This process is relatively simple and does not require significant additional financial expertise. For biotechnology projects this has the potential to reduce investment uncertainty and, depending on the outcomes included in the model, can increase the estimated value of the project.

The difference in standard deviations (see Figure 6-12) of the value estimates produced by the four unrestricted valuation models described in section 6.2 implies that the there is greater uncertainty in valuations produced by the traditional DCF model. By using alternative valuation methodologies, projects can be valued with greater precision, particularly in the early stages of development when Australian biotechnology firms battle for sufficient capital to fund necessary research and development costs.

Through utilisation of the risk neutral valuation concept, the option pricing models were expected to estimate values consistently higher than those predicted by the eDCF model. The increase was expected due to the apparent "double counting" of risk in the eDCF model whereby project success rates were specifically modeled, whilst the discount rate was the same as those used for the DCF model which were based on CAPM analysis of drug development firms. The similarities between value estimates of the option models and the eDCF model suggest that the project success rates represent diversifiable risk which is not captured by the CAPM risk quantification.

Whilst the option pricing models analysed in this thesis were not significantly more complex than the eDCF model, these models are less understood and applied by financial practitioners (Hartmann and Hassan 2006). These models require a greater understanding of financial instruments than the eDCF model however they may not produce valuation estimates providing any greater insight than the more recognised alternatives.

By incorporating management ability to flexibly manage a project throughout its life, specifically the option to abort a project, value estimates for early stage projects are greater than would otherwise be the case. In later stage projects the abandonment option is less significant because the product is closer to market launch and the option to abandon is less likely to be of greater value than the option to continue development.

Value in biotechnology firms is driven by the commercial viability of the products under development. Managers and investors should be continuously focused on the likely commercial outcomes from the products in development. Development costs and times are also key drivers of value and the ability of management to control these elements with consideration of the relationship between these two elements is an important driver of value.

# CHAPTER 7 CONCLUSION

## 7.1 INTRODUCTION

The Australian biotechnology industry must overcome significant challenges in order to fully capitalise on the competitive advantages of the local industry and successfully compete in a global market. Whilst biotechnology research and development is typified by long lead times and significant capital requirements, significant uncertainty also exists around investment returns. The underlying uncertainty of investment in biotechnology assets has acted as a deterrent to biotechnology investment in Australia, restricting our ability to compete with larger more mature markets.

The three components of this research combine to describe the challenges and opportunities surrounding the Australian biotechnology industry. Insight into the drivers of value in biotechnology investments is provided through quantitative investigations into biotechnology value drivers at the firm and project level.

## 7.2 SUMMARY OF THESIS

The central focus of this investigation was an investigation into the value drivers for Australian biotechnology firms. This focus formed the nexus between the multiple research methods. The primary research question addressed in this thesis is:

- What are the appropriate valuation models for Australian biotechnology firms?

The focus of each of the discussion chapters addresses the following key secondary research questions:

- What are the challenges and opportunities for Australian biotechnology firms? (Chapter 4)
- What factors internal and external to the firm impact the amount of capital raised by Australian biotechnology companies through IPOs? (Chapter 5)
- What is the appropriate methodology for valuation of biotechnology investments? And, what are the key drivers of value for Australian biotechnology companies? (Chapter 6)

First Chapter 2 introduces the Australian biotechnology industry in the context of a global competitive market via a review of the existing literature. One of the key barriers to success in the Australian industry is the inability of Australian firms to raise commercialisation capital, particularly when compared to our international competitors. As a result of the funding shortfall, Australian biotechnology firms have historically turned to the public markets for capital at an earlier stage than in other countries, particularly the US, whose biotechnology industry is the most successful in the world. For any company, an IPO is one of the most important capital raisings in that company's life, however, for a biotechnology company, this is exacerbated by the capital intensive nature of biotechnology R&D and the difficulty in raising additional funds after IPO.

The research methodology is discussed in Chapter 3 which describes a multi-method approach to investigate the multi-faceted aspects of the valuation challenges facing Australian biotechnology companies. A qualitative investigation of the issues facing Australian biotechnology companies formed a broad foundation, providing context for the two focused quantitative research components. The two quantitative components of this research delve into the issue of biotechnology valuation at the firm and project level. An analysis of biotechnology initial public offerings provides insights into the key value drivers for firms during this critical capital raising period. Additionally, Monte Carlo simulation of contemporary valuation models provides insight into the key value drivers for a biotechnology project with implications for both managers and investors.

The first of three results and discussion chapters is presented in Chapter 4 which presents a broad qualitative investigation into challenges and opportunities facing the Australian biotechnology sector. The overwhelming theme to emerge from this analysis was the funding challenge that the Australian sector faces compared to larger international competitors. The structure of the industry was found to encourage creation of small firms with narrow pipelines, exacerbating the risk of company failure and acting as an impediment to sustainability and investment in the sector. Despite the challenges facing the Australian biotechnology industry, the nation possesses a competitive advantage in the strength of local science which, if fully leveraged, should see the development of an internationally competitive industry. Through improved funding mechanisms which encourage the creation of sustainable business models,

increased investor participation in the industry should see a greater portion of the value generated through biotechnology retained by local participants.

An IPO is likely the largest single capital raising in a company's history. Chapter 5 provided a quantitative investigation into the factors which influence the amount of underpricing and money left on the table for Australian biotechnology IPOs and found that the amount of money left on the table was more critical than the level of underpricing. Additionally the impact of market sentiment on biotechnology IPOs was investigated and increased media coverage in the lead up to IPO was found to be positively related to the amount of money left on the table.

Chapter 6 provided an additional exploration into the factors influencing biotechnology value. Using project valuation models the drivers of value over the life of a typical biotechnology project were identified. Value in biotechnology firms is driven by the commercial viability of the products under development. Managers and investors should be continuously focused on the likely commercial outcomes from the products in development. Development costs and times are key drivers of value and the ability of management to control these elements is crucial.

Using alternative valuation methodologies for a typical biotechnology project, Chapter 6 provided insight into the issue of value estimation and uncertainty. A traditional DCF model generated value estimates for a typical biotechnology project with a greater level of uncertainty than the more contemporary methods of decision trees analysis (eDCF and binomial real options) and binomial lattices. Additionally, DCF models are not able to quantify the benefits of management flexibility. Incorporation of management flexibility into the valuation assessment using real options techniques increased the perceived value of biotechnology projects, particularly for early stage projects where the option to abandon was found to greatly influence values generated.

## 7.3 KEY CONTRIBUTIONS OF THESIS

This thesis provides a clearer understanding of the challenges and opportunities facing the local industry and investigates the issue of valuation uncertainty in a quantitative framework. Biotechnology valuation is an issue that has been discussed at length in the literature however significant uncertainty continues to exist surrounding the most

appropriate valuation models and value drivers for biotechnology products. The major contribution of this thesis is the investigation into the value drivers for biotechnology products and those factors which significantly influence the valuation of biotechnology IPOs in an Australian context.

Some of the specific findings presented in this thesis include:

- The current structure of funding mechanisms in Australia encourages smaller firms with narrower product pipelines.
- Australian biotechnology firms are often forced to raise capital via an IPO due to a lack of alternative funding sources.
- Due to funding challenges Australian firms often sell a portion of their IP prior to development to a point that would allow an optimal risk return payoff.
- Merger and acquisition activity between existing firms should be encouraged to improve firm survival prospects and reduce the risk of firm failure.
- An excess of "uneducated" investment money in biotechnology exposes the industry to greater sentiment driven fluctuations in value and allows poorer performing firms to retain capital that would otherwise flow to higher potential firms.
- Increased investor interest in the sector will drive improved analyst coverage leading to more efficient allocation of capital
- Money left on the table at IPO is more critical than underpricing for Australian biotechnology companies
- Australian biotechnology companies with a developed product leave less money on the table at IPO
- Australian biotechnology companies who engage a reputable accountant to audit their prospectus financials leave less money on the table at IPO
- Australian biotechnology companies with a larger number of patents and patent applications leave more money on the table at IPO
- The more times Australian biotechnology company staff publications were cited, the greater the amount of money on the table at IPO
- In times of rising investor sentiment more money is left on the table by Australian biotechnology IPOs
- Media exposure is a superior proxy for sentiment for Australian biotechnology IPOs

- Valuation estimates incorporating decision tree analysis have lower levels of uncertainty for assessment of biotechnology project value than standard DCF models.
- Real option analysis captures the value of management flexibility and increases perceived project value, particularly for early stage biotechnology projects.
- Commercialisation cash flows are the major driver of value for a biotechnology project.
- The sensitivity of valuation estimates to commercialisation cash flows increases as the project moves through the development process
- Development time, costs and project success are important drivers of value which should be considered by biotechnology project investors and managers alike.

## 7.4 DIRECTIONS FOR FUTURE RESEARCH

By definition the biotechnology sector covers a diverse range of business sectors. Due to the breadth of this definition and the relatively small size of the Australian biotechnology industry this study focuses on the drug development sub-sector which comprises the majority of Australian biotechnology companies. Despite the size of the drug discovery sub-sector, other sub-sectors within the biotechnology definition such as agbio and biomechanics provide an important contribution to the Australian economy and warrant further study into their specific challenges, opportunities and value drivers.

To control costs, interview participants for the qualitative component of this study were chosen from biotechnology firms based in Victoria, home to the greatest number of biotechnology firms in Australia. Additional interviews with biotechnology firms based in alternative locations would provide a broader sample set and enable a comparison of the difference (if any) commercial environments for biotechnology across Australia.

The quantitative analysis of Australian biotechnology company IPOs gathered data for all the reasonably available biotechnology listing data up to 2004 which gave a total of 34 companies. Additional data points to include recently listed biotechnology firms would add to the robustness of conclusions drawn from this stage of the research.

The quantitative analysis of contemporary valuation techniques relies on publicly available data relating to the probability of successfully negotiating the clinical trials and regulatory approval. This information is predominantly US based due to the lack of Australian data available. A useful extension to this study would be collection of Australian drug development data for comparison with the international figures. Currently the Australian biotechnology industry has not generated a sufficient volume of data for consideration in isolation however this will change as the industry evolves.

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# APPENDIX A – CORRELATION MATRIX

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | MTUM | 1.0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | AGE | 0.0 | 1.0 | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | LOC_METRO | -0.1 | 0.0 | 1.0 | | | | | | | | | | | | | | | | | | | | | | |
| 4 | RES_PROJ | -0.1 | 0.1 | 0.1 | 1.0 | | | | | | | | | | | | | | | | | | | | | |
| 5 | PROD_DEV | -0.1 | 0.1 | 0.1 | -0.2 | 1.0 | | | | | | | | | | | | | | | | | | | | |
| 6 | PROD | 0.0 | 0.6 | 0.1 | 0.4 | 0.1 | 1.0 | | | | | | | | | | | | | | | | | | | |
| 7 | SERV | 0.4 | -0.1 | -0.3 | -0.1 | -0.1 | 0.1 | 1.0 | | | | | | | | | | | | | | | | | | |
| 8 | PAT_FAM | -0.1 | -0.1 | 0.1 | 0.1 | 0.2 | 0.0 | 0.0 | 1.0 | | | | | | | | | | | | | | | | | |
| 9 | TOT_PAT | -0.1 | 0.1 | 0.0 | 0.0 | 0.3 | 0.3 | 0.1 | 0.5 | 1.0 | | | | | | | | | | | | | | | | |
| 10 | TOT_APP | 0.0 | 0.0 | 0.0 | -0.1 | 0.1 | 0.1 | 0.1 | 0.5 | 0.6 | 1.0 | | | | | | | | | | | | | | | |
| 11 | RD_HIST | 0.2 | 0.8 | 0.1 | 0.3 | 0.1 | 0.9 | 0.0 | -0.1 | 0.1 | 0.0 | 1.0 | | | | | | | | | | | | | | |
| 12 | RD_FORC | 0.1 | 0.6 | 0.1 | 0.3 | 0.1 | 0.5 | -0.1 | -0.2 | -0.1 | -0.1 | 0.7 | 1.0 | | | | | | | | | | | | | |
| 13 | CIT | 0.4 | -0.1 | 0.1 | 0.0 | -0.2 | -0.1 | 0.2 | 0.2 | 0.0 | 0.1 | -0.1 | -0.1 | 1.0 | | | | | | | | | | | | |
| 14 | PRICE | 0.1 | 0.6 | 0.2 | 0.3 | 0.2 | 0.6 | -0.1 | 0.2 | 0.2 | 0.0 | 0.8 | 0.6 | -0.1 | 1.0 | | | | | | | | | | | |
| 15 | SENT_AO | 0.3 | -0.3 | -0.1 | -0.1 | 0.1 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 1.0 | | | | | | | | | | |
| 16 | SENT_HB | 0.2 | -0.1 | 0.0 | -0.3 | 0.2 | -0.3 | 0.1 | 0.2 | 0.0 | 0.2 | -0.2 | -0.2 | 0.1 | -0.1 | 0.6 | 1.0 | | | | | | | | | |
| 17 | UPRICE | -0.2 | 0.1 | -0.3 | 0.0 | -0.2 | -0.1 | 0.4 | 0.0 | -0.1 | 0.0 | -0.1 | 0.0 | 0.0 | -0.1 | -0.2 | -0.2 | 1.0 | | | | | | | | |
| 18 | MON_TAB | -0.1 | 0.2 | -0.2 | 0.0 | 0.0 | 0.0 | 0.4 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.2 | -0.2 | -0.1 | 0.9 | 1.0 | | | | | | | |
| 19 | LN_CAPRAIS | 0.1 | 0.6 | 0.1 | 0.3 | 0.1 | 0.7 | -0.1 | 0.1 | 0.0 | 0.1 | 0.8 | 0.7 | 0.0 | 0.9 | -0.1 | -0.3 | -0.2 | 0.1 | 1.0 | | | | | | |
| 20 | UWRIT | -0.5 | -0.1 | 0.2 | 0.2 | 0.1 | -0.1 | 0.0 | 0.2 | 0.0 | 0.0 | -0.2 | -0.2 | 0.0 | 0.0 | -0.3 | -0.1 | 0.2 | 0.1 | -0.1 | 1.0 | | | | | |
| 21 | INDACC | 0.2 | 0.2 | 0.2 | 0.2 | 0.0 | 0.2 | -0.1 | 0.0 | 0.1 | 0.2 | 0.4 | 0.3 | 0.2 | 0.4 | 0.3 | 0.2 | -0.3 | -0.1 | 0.5 | 0.0 | 1.0 | | | | |
| 22 | SUBOPT | 0.2 | -0.3 | 0.1 | -0.2 | 0.0 | -0.2 | 0.3 | -0.1 | -0.1 | 0.0 | -0.3 | 0.0 | 0.4 | -0.4 | 0.2 | 0.1 | 0.3 | 0.2 | -0.3 | -0.2 | -0.1 | 1.0 | | | |
| 23 | UNDOPT | -0.1 | 0.0 | 0.1 | 0.1 | -0.2 | -0.1 | -0.1 | -0.2 | -0.2 | -0.2 | -0.1 | -0.1 | 0.1 | -0.2 | -0.1 | -0.1 | 0.4 | 0.2 | -0.2 | 0.2 | -0.1 | 0.2 | 1.0 | | |
| 24 | CAPRET | -0.3 | -0.6 | -0.1 | -0.1 | 0.0 | -0.5 | 0.1 | 0.3 | 0.2 | 0.2 | -0.8 | -0.8 | 0.1 | -0.7 | -0.1 | 0.2 | 0.1 | -0.2 | -0.7 | 0.4 | -0.2 | 0.2 | 0.1 | 1.0 | |
| 25 | RDPERCENT | -0.1 | -0.2 | 0.0 | 0.5 | -0.1 | 0.0 | 0.3 | 0.3 | 0.0 | -0.1 | -0.2 | -0.1 | 0.0 | 0.1 | -0.4 | -0.2 | 0.3 | 0.3 | 0.0 | 0.4 | -0.2 | -0.1 | 0.1 | 0.3 | 1.0 |

+/- 0.5 < Correlation < +/- 1

+/- 0 < Correlation < +/- 0.5