Risk-adjusted Net Present Value – A New Approach to Valuing Early Stage Technologies

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joined Boston University in 1995. He has over thirteen years' experience in the biotechnology industry, having worked with both start-up companies and academic organisations, essentially from the birth of this burgeoning field, to transfer promising technologies from academic laboratories into the commercial market for practical development. He was formerly Director of the Office of Technology Transfer at the Dana-Farber Cancer Institute, a teaching affiliate of the Harvard Medical School. Previously he was cofounder and General Manager of Genmap, Inc., one of the first companies established to work on the human genome. Prior to that he was Vice President of Business Development for BioTechnica International, one of the first broad-based biotechnology companies. He started his career with the Procter and Gamble Company, where he held a number of positions in sales, marketing, strategic planning and acquisitions.

ABSTRACT

KEY WORDS: valuation, early stage, technology, drugs, biotechnology, clinical trials, success rate

This paper presents a new approach to accounting for the risk in long lead-time pharmaceutical development projects when developing a valuation model for the technology, which results in novel and non-obvious conclusions. The approach is believed to generate a more realistic valuation in the very earliest stages of development than traditional approaches which account for risk using very high discount rates. The model shows that biopharmaceutical development projects, which appear to have shorter development cycles and higher probabilities of success, have significantly higher net present values than small molecule drugs (new chemical entities or NCEs) with equivalent potential markets.

The model is in principle applicable to other technologies; however, there is

unlikely to be objective data available to quantify risk in the case of pharmaceutical projects, opening up the potential for manipulation of parameters to deliver preconceived outcomes.

The technique has a number of important applications in academic out-licensing offices – developing licensing proposals for a technology to be licensed; evaluating competing proposals that have been received for a technology; valuing a technology portfolio and measuring the change in its value over time; and evaluating the contribution to an organisation of the licensing function or of individuals within that organisation in a given time period.

INTRODUCTION

In any transaction, determining the value of the assets being transferred is often the most difficult part of the negotiation. The difficulty of determining the value is related to the uniqueness of the asset and to the risk associated with owning the asset. Thus in purchasing a bond, the price we are willing to pay will be determined by the going interest rate for instruments of similar maturity, which is instantly determinable from the markets, adjusted for the risk associated with owning the bond, and supplied by one of the rating agencies.

Despite the uncertainties of the financial markets, they are relatively low risk compared with licensing transactions, which means that we pay for them in very different ways. In buying a bond, we are prepared to pay all the cash upfront in return for a promise to pay us a string of interest payments for 5, 10 or even 30 years and to return our money at the end of the relationship. We are prepared to do this because we have a lot of information about the issuer and its ability to meet its obligations, we know exactly what we are getting and, finally, our investment is secured by a call on the issuer's assets, or, in the case of the government, its full faith, credit and, most importantly, taxing powers to repay the obligation.

Now compare a financial transaction with a licensing transaction for an early stage drug candidate. In a licensing transaction, the licensee is acquiring from the licensor the right to make and sell in the future something that does not exist today, to a market that does not exist today. Generally, the major risk of developing the product is transferred to the licensee, who should therefore reap the lion's share of the reward. The licensor surrenders his or her rights to the product in return for some consideration, normally a series of future payments. By its nature, this is an uncertain transaction. Therefore, the most equitable way to agree to pay for such a transaction is to use a conditional basis. If the licensee makes $100, the licensor will get an agreed-on percentage of the $100, the royalty. Both parties are taking a risk – the licensee is assuming the risk of investing in developing the product, while the licensor is assuming the risk that he or she has picked a poor licensee who fails in the task of development or if the market fails to materialise, he or she will receive no return.

When the licensor asks for research funding, equity investment, milestone payments or other forms of compensation in advance of product sales, the risk/reward balance is shifted in his or her favour. Is this an unreasonable thing for which to ask?

In financial terms, clearly it is not. Any future stream of payments has a value today, which can, in principle, be

calculated. It is therefore very important for both parties to a major licensing transaction to construct a financial model for the product or technology being licensed.

There are four main problems in constructing such valuation models for very early stage technologies:

- assessing the market for the product
- estimating the share of the market that will be obtained by the product
- estimating the costs of developing the product and assessing the probability that it will survive the development pitfalls and will actually enter the market and
- estimating the share of the value of the product attributable to the technology in question.

Much has been written about the first of these, technology forecasting. The second involves an attempt at expected competitive analysis, since each market entrant establishes a price/performance barrier that subsequent entrants must significantly exceed in order to gain a share from the previous entrants. The fourth point is becoming more of a factor in healthcare licensing transactions – although the product is typically protected by a single patent, licenses may be required for delivery systems, production methodologies, novel uses, and so forth, and apportionment of the value between these will be necessary. However, the third factor has been almost completely neglected and is the focus of this article.

TRADITIONAL APPROACHES TO THE PROBLEM

The traditional way of handling the high risk of early stage technology is to use a very high discount rate. For example, a study by Larry Smith of Hambrecht & Quist[1] advocates the discount rates shown in Table 1 for the various stages in drug development. It should be noted that Mr Smith was not alone in these assumptions; Mary Tanner of Lehman Brothers proposed very similar discount rates, shown in Table 2, in a 1991 paper to the Association of Biotechnology Companies.[2]

In the H&Q model, these discount rates were applied to the successful development and subsequent marketing of a hypothetical drug based on Merck's Vasotec, with the margin adjusted to be relevant to a managed care environment, in which revenues reached $1bn in the ninth year of sales. Each year's net present value (NPV) is obtained by discounting all future cash flows back to that year at the discount rate appropriate to that year. So the NPV of ($6m) for year 1 is obtained by discounting the cash outflows for years 1 through 10 and the net after-tax profits for years 11 through 29 back to year 1 using an 80 per cent discount rate, while the NPV of $437 million for year 12 is obtained by discounting the net after-tax profits for years 12 through 29 back to year 12 using a 17.5 per cent discount rate. The results are shown in Figure 1, with the full proforma shown in Table 3.

NPV starts to build as the drug enters Phase III of clinical development and peaks at $800m in the fourth year of sales. Both of these conclusions seem inherently reasonable qualitatively (though may need refinement quantitatively – drug companies have recently been acquired as multiples of sales from three to five, and an acquiror would presumably be willing to pay the NPV of future earnings). However, the

Table 1

DISCOUNT RATES USED IN HAMBRECHT & QUIST DRUG DEVELOPMENT VALUATION MODEL

Product dev. stage	*Discount rate (%)*
Discovery	80
Preclinical	60
Phase I	50
Phase II	40
Phase III	25
NDA	22.5
Launch	17.5–15
Rapid Build	12.5–10
Maturity	7.5

Source: Smith.[1]

model shows that the NPV is atually negative in the very earliest phases of the programme, so that a company which was strictly managed financially would conclude that the investment was unattractive and the project would not be funded. Since there are very few opportunities that can be confidently projected to exceed $1bn in size, if this model were valid we would see very little discovery research being carried out by the world's major pharmaceutical companies, let alone new companies being started by venture capitalists.

Table 2

DISCOUNT RATES BY DEVELOPMENT STAGE PROPOSED BY LEHMAN BROTHERS

Product dev. stage	*Discount rate (%)*
Pre-IND	>60
IND	>50
Phase I	45
Phase II	40
Phase III	35
NDA	18–20

Source: Tanner.[2]

Clearly, something is wrong with this picture. The reason is the harshness of high discount rates. After all, which of us buy even a book of stamps that will last a month if the value of the stamps is going down at 6.7 per cent a month, so that we would need to add a 2c stamp to mail something the next month? This is the implication of a discount rate of 80 per cent.

Yet drug development is extremely high risk. The attrition rate is considerable. How can we account for this risk? In this paper I propose that the risk be accounted for explicitly, and a 'cost of money' discount rate be used, rather than accounting for risk by high discount rates.

Research Corporation Technologies (RCT) applies this technique in order to determine whether it is likely to see a return on investing in a particular university invention.[3] RCT calculates an NPV and then adjusts the NPV downwards to allow for the various risk factors in commercializing the technology – patent protection, finding a licensee, development, market, product differentiation, etc. The largest of these risk factors is the development risk. However, RCT's interest is in valuing the technology at its earliest stages and it does not apply the approach to analysing how this value changes with time.

While the approach presented here is valid for all types of high-risk early stage technology, there may not be objective ways of assessing the develop-

ment risk. However, in the case of pharmaceutical development, the data to do this are available from several sources, primarily the Center for the Study of Drug Development (CSDD), founded by Dr Louis Lasagna and currently located at Tufts University, Boston, Massachusetts. While this group is best known for developing the estimate that it costs $385m to develop a drug, it has also carried out a number of studies on the duration, success rate and cost of each step in the development pathway. In addition, it has recently initiated studies of biological molecules. It works both by conducting triennial confidential surveys of major multinational pharmaceutical companies on their drug development activities and by analysing data available in public databases such as PharmaProjects.

ACCOUNTING FOR RISK

SOURCES OF DATA

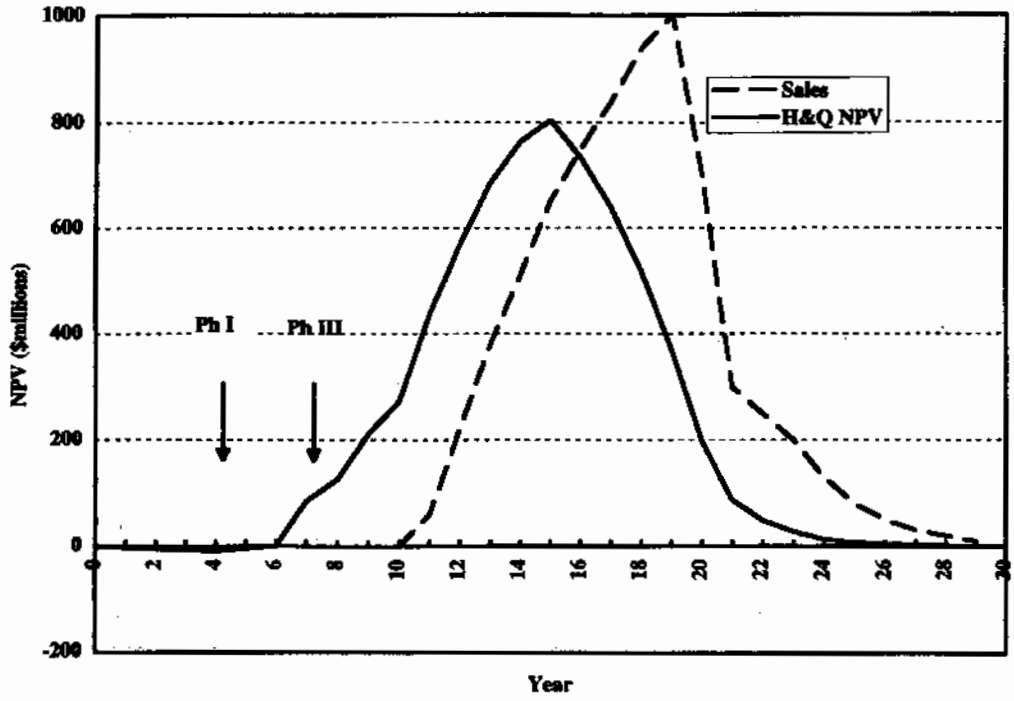
References showing the sources of the various parameters that are used in the risk-adjusted NPV model are shown in Table 4.

NEW CHEMICAL ENTITIES (NCEs)

Duration of development

The 1963–88 CSDD study analysed data from 36 US and foreign-owned companies accounting for 98.6 per cent of the 2,086 NCEs first tested in humans during this period. The authors identified the total development time, divided into three phases of

Figure 1: NPV vs time of drug using H&Q (high discount rate) model



activity: pre-Investigational New Drug (IND), IND and NDA review. As shown in Table 5, there are 5.1 years of preclinical development and nine years from the start of clinical studies. (Note that the H&Q model shortens each of these phases by one year.)

Probabilities of success

The 1991 Tufts paper studied 93 NCEs that were first tested in humans between 1970 and 1982 from 12 firms, which accounted for 40 per cent of all US pharmaceutical R&D expenditure

Table 3

HAMBRECHT & QUIST DRUG DEVELOPMENT PROFORMA

Year	*Stage*	*Disc. rate (%)*	*Costs ($m)*	*Sales ($m)*	*Gross*		*After tax*		*Cash flow ($m)*	*NPV ($m)*
					Margin (%)	*Profit ($m)*	*Margin (%)*	*Profit ($m)*		
0	Orig.	80	(1)						(1)	(2)
1		80	(1)						(1)	(3)
2	Preclinical	60	(2)						(2)	(6)
3		60	(2)						(2)	(7)
4	Phase I	50	(3)						(3)	(10)
5	Phase II	40	(7)						(7)	(5)
6		40	(10)						(10)	1
7	Phase III	25	(20)						(20)	85
8		25							(20)	126
9	NDA	22.5	(15)						(15)	210
10		22.5	(7)						(7)	272
11	Launch	17.5		60	57.5	35	10	6	6	437
12		15		220	72.5	160	15	33	33	568
13	Rap. build	12.5		380	77.5	295	20	76	76	687
14		10		510	77.5	395	20	102	102	765
15		7.5		650	77.5	504	20	130	130	804
16	Maturity	7.5		750	77.5	581	20	150	150	735
17		7.5		840	77.5	651	20	168	168	640
18		7.5		940	77.5	729	20	188	188	520
19	Patent expiry	7.5		1,000	77.5	775	20	200	200	371
20		7.5		700	72.5	508	18	126	126	198
21		7.5		300	70.0	210	15	45	45	87
22		7.5		250	65.0	163	10	25	25	49
23		7.5		200	32.5	65	8	16	16	28
24		7.5		125	30.0	38	5	6	6	14
25		7.5		75	27.5	21	5	4	4	7
26		7.5		50	25.0	13	5	3	3	5
27		7.5		25	22.5	6	5	1	1	3
28		7.5		15	20.0	3	5	1	1	1
29		7.5		6	17.5	1	5	0	0	0

NDA = New drug application.
Rap. build = Rapid Build (in sales).

in the period. The 93 NCEs accounted for 19 per cent of all NCEs tested in humans during this period. Information was provided on the duration of each phase of clinical testing. The costs and probabilties of entering each phase of testing are shown in Table 6.

From the column labelled 'Probability of entering', which shows the probability of entering a given phase from the start of clinical testing, the probability of moving from each phase to the next phase can be extracted. Table 7 compares the probability of progressing to the next phase of clinical development found in different studies, with the data from Table 6 shown in the column labelled CSDD. For example, the 36 per cent probability of entering Phase III from the initiation of clinical testing in Table 6 is obtained by multiplying the probability of initiating Phase I (100 per cent) by the probability of moving from Phase I to Phase II (75 per cent) by the probability of moving from Phase II to Phase III (48 per cent) shown in the CSDD column in Table 7.

In the model presented below, the FDA study's 50 per cent probability of moving from preclinical development to Phase I has been used, together with the CSDD probabilities of progressing through the successive steps of clinical testing. (A recent article by Dr Jürgen Drews of Hoffman-La Roche[4] quoted

Table 4

SOURCES OF DRUG DEVELOPMENT SUCCESS RATES, PHASE DURATIONS AND COSTS

Source	*Period*	*Reference*
Small molecules		
FDA	1976–78	Tucker, S. A., Blozamn, C., and Coppinger, P. (1988), *Office of Planning and Evaluation Study* 77, FDA.
CSDD	1963–89	DiMasi, J. A., Hansen, R. W., Grabowski, H. G., and Lasagna, L. (1991), *J. Health Economics*, Vol. 10, pp. 107–142.
	1976–78 and 1984–86	DiMasi, J. A., Seibring, M. A., and Lasagna, L. (1994), *Clinical Pharmacology and Therapeutics*, Vol. 55, pp. 609–622.
Pfizer		Armand, P. A., Presentation at the BioIndustry Organization Annual Meeting, San Francisco, May 1995.
Biopharmaceuticals		
CSDD	1980–88	Bienz-Radmor, B., DiCerbo, P. A., Tadmor, G., and Lasanga, L. (1992), *Bio/Technology*, Vol. 10, May, pp. 674–677.
	1982–92	Bienz-Tadmor, B. and Brown, J. S. (1994), *BioPharm*, Vol. 7, March, pp. 44–49.
	1980–88	Gosse, M. E. Personal Communication.
Struck	1983–91	Struck, M. M. (1994), *Biotechnology*, Vol. 12, July, pp. 674–677.

an industry-wide average figure of 49 per cent as the preclinical success rate.)

Table 5

TOTAL DEVELOPMENT TIME, 1988–1982 APPROVALS (YEARS)

	Priority	*Standard*
Pre-IND	5.1	5.4
IND–NDA	6.9	4.9
NDA	2.0	3.2
Total	14.0	13.5

Overall success rates

The 1963–88 CSDD study looked at different therapeutic categories and found extremely large variations in success rates between drugs in different therapeutic categories, with antineoplastics having the highest success rates, probably because so much of the early work on these drugs has typically been done by the National Cancer Institute

Table 6

PHASE TRANSITION AND DURATION SUCCESS RATES

	Mean cost ($m)	*Std dev. ($m)*	*Median cost ($m)*	*Prob. of entering (%)*	*N*
Phase I	2.1	4.5	1.0	100	87
Phase II	4.0	5.2	2.2	75	70
Phase III	12.8	14.0	7.9	36	36
Long-term animal	2.2	2.4	1.3	56	49
Other animal	0.6	1.2	0.2	16	15
NDA review				27[a]	
Approval				23[a]	

[a]From a larger study.

Table 7

COMPARISON OF PROBABILITY OF PROGRESSING TO NEXT PHASE FROM DIFFERENT STUDIES

Probability of progressing from/to	CSDD *(%)*	*Food and Drug Administration (%)*	*Pfizer (%)*
Preclinical to Phase I	—	50	—
Phase I to Phase II	75	40	52
Phase II to Phase III	48	45	66
Phase III to NDA	75	65	24
NDA to approval	85	85	80

Table 8

CLINICAL APPROVAL SUCCESS RATES (IND TO APPROVAL) BY THERAPEUTIC CATEGORY

Category	%
Analgesic/anaesthetic	15.6
Anti-infective	29.5
Antineoplastic	40.0
Cardiovascular	13.8
CNS	9.6
Endocrine	12.7
Gastrointestinal	17.5
Respiratory	16.9

(BCI), and the central nervous system (CNS) having the lowest success rate. The results are shown in Table 8.

The model presented here analyses a 'hypothetical' billion dollar drug of undetermined therapeutic category, with an average probability of reaching the market of 23 per cent after the start of clinical studies ($75 \times 48 \times 75 \times 85$ per cent). In an actual case, the overall probability of success would be factored up or down in proportion to the relationship between the success rate for that category and 23 per cent.

This same study also showed the reasons and timing that projects were cancelled. These are shown in Table 9.

The risk-adjusted NPV model

These data allow us to develop an NPV model that allows for development risk explicitly rather than implicitly. In the risk-adjusted NPV approach, a patient-based financial model is developed in the normal way. Then the probability of reaching each step in the development pathway is entered. Either the costs or the revenues from that phase are multiplied by the probability of reaching that point. The NPV is developed using the 7.5 per cent discount rate.

Figure 2 compares the results from the risk-adjusted NPV (raNPV) model with the high discount rate model, while the complete proforma is shown in Table 10. The same net pre-tax margins and profit assumptions were used as in Table 3 but are omitted for clarity. The after-tax margins and profits are the same as in Table 3 and are shown. Several conclusions may be drawn:

- the maximum raNPV is reached two years earlier and is 6 per cent higher than with the high discount rate approach
- in the later years, after market introduction, the two models give identical values
- the NPV is always positive, even in the early years
- the raNPV takes discrete steps upwards as key pass/fail points are successfully passed.

It is interesting to compare what the two models say about the return on incremental investment as the project moves through the development process. Figure 3 compares the increase in NPV between successive years divided by the investment needed to progress from the previous year. The high discount rate NPV model predicts that the greatest return on investment occurs with successful entry into Phase III. The risk-adjusted NPV model predicts that the greatest return on investment occurs with entry into Phase I, with the first year of Phase II also highly cost effective. Again, the answer predicted by the risk-adjusted NPV model has intuitive appeal.

The discount rate of 7.5 per cent used in this analysis is probably too low. Most pharmaceutical companies use a rate of 12–15 per cent in their internal analyses. The 7.5 per cent rate was used to allow direct comparison with the H&Q High Discount Rate model, which used a 7.5 per cent rate for the risk-free maturity and declining years phase. In the subsequent sections, a 12 per cent discount rate will be used. Table 11 compares the impact of changing the discount rate from 7.5 to 12 per cent on the risk-adjusted NPV model. The initial raNPV is more than halved, while the peak raNPV is reduced by 17 per cent and is reached one year later.

Table 9

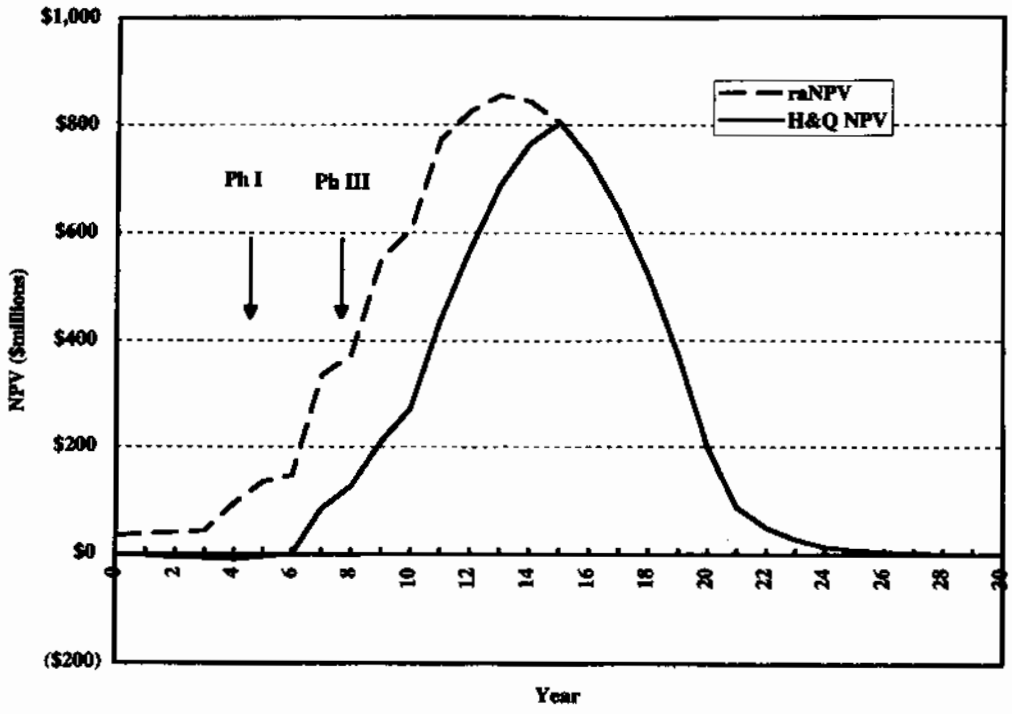
REASONS FOR AND TIMING OF DEVELOPMENT ABANDONMENT

Reason for abandonment	%	*Time (years)*
Safety	27	2.0
Efficacy	46	2.2
Economics	23	3.7
Unclassified	5	2.0

BIOTECHNOLOGY-DERIVED DRUGS

Three studies have looked at the duration and success rates of biotechnology-derived drugs.

Figure 2: Comparison of NPVs of hypothetical drug development model from risk-adjusted NPV and high discount rate models



Duration of development

The 1994 Bienz-Tadmor study[5] identified preclinical, total clinical and review phase lengths for FDA-approved non-recombinant and non-hybridoma derived products as well as recombinant proteins and antibody-based products, which are more typically regarded as 'biotechnology' products, as

Table 10

PROFORMA OF HYPOTHETICAL DRUG DEVELOPMENT PROJECT USING RISK-ADJUSTED NPV MODEL

Year	*Stage*	*Phase prob. (%)*	*Cum. prob. (%)*	*Costs ($m)*	*Sales ($m)*	*After tax*		*Cash flow*	*raNPV ($m)*
						Margin (%)	*Profit ($m)*		*($m)*
0	Orig.	100	100	(1)				(1)	34
1			100	(1)				(1)	37
2	Preclinical	100	100	(2)				(2)	40
3			100	(2)				(2)	43
4	Ph I	50	50	(3)				(3)	93
5	Ph II	75	38	(7)				(7)	135
6			38	(10)				(10)	147
7	Ph III	48	18	(20)				(20)	336
8			18	(20)				(20)	373
9	NDA	75	14	(15)				(15)	552
10			14	(7)				(7)	606
11	Launch	85	11		60	10	6	6	774
12			11		220	15	33	33	826
13	Rap. build		11		380	20	76	76	855
14			11		510	20	102	102	843
15			11		650	20	130	130	804
16	Maturity		11		750	20	150	150	735
17			11		840	20	168	168	640
18			11		940	20	188	188	520
19	Patent expiry		11		1,000	20	200	200	371
20			11		700	18	126	126	198
21			11		300	15	45	45	87
22			11		250	10	25	25	49
23			11		200	8	16	16	28
24			11		125	5	6	6	14
25			11		75	5	4	4	7
26			11		50	5	3	3	5
27			11		25	5	1	1	3
28			11		15	5	1	1	1
29			11		6	5	0	0	0

NDA = New drug application.
Rep. build = Rapid Build (in sales).

well as various comparison groups of NCEs. The data are shown in Table 12. Ongoing work by Gosse has shown results very similar to those of Bienz-Tadmor (personal communication).

Probabilities of success

The study by Mark Struck of the Swiss Serum and Vaccine Institute looked at 683 biopharmaceuticals that were in

Figure 3: Comparison of return on incremental investment predicted by two models

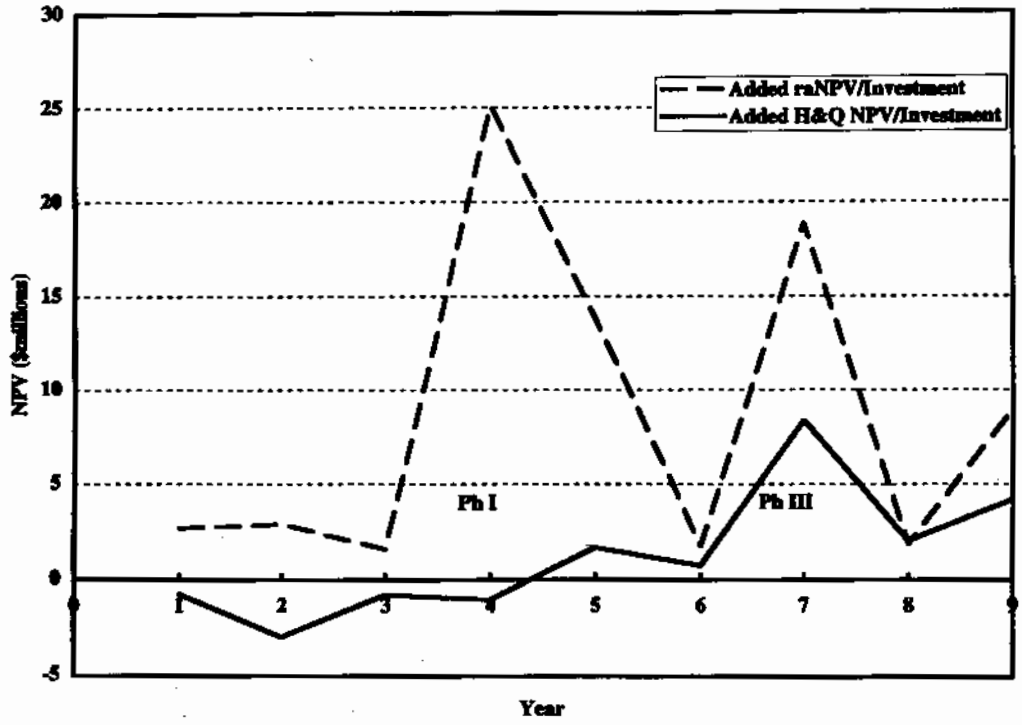


Table 11

IMPACT OF HIGHER DISCOUNT RATE ON NCE DEVELOPMENT PROJECT RISK-ADJUSTED NPV MODEL

Discount rate	*raNPV at inception ($m)*	*Peak raNPV ($m)*	*Peak year*
7.5%	34	855	13
12%	15	710	14

Table 12

DEVELOPMENT TIMES FOR BIOPHARMACEUTICALS AND BIOLOGICS (YEARS)

Stage	*Biopharmaceuticals*	*Biologics*
Preclinical phase	1.8	6.9
Clinical phase	3.4	3.3
Review phase	1.7	2.1

development between 1983 and 1991, using the PharmaProjects database. As with the other studies, this study included non-recombinant protein products. The study developed phase transition success rates and compared them with those for NCEs. These success rates are shown in Table 13.

Risk-adjusted NPV model for biopharmaceuticals

Summarising the results of these studies, biopharmaceuticals appear to have a significantly shorter development time and also a significantly higher probability of success than NCEs. Intuitively, this certainly seems to have been the case in the early days of the biotechnology industry, but may be less likely today. Indeed Gosse's study has documented the recent increase in projects which were discontinued in Phase III and Regulatory Review. This is shown in Figure 4. Additionally, there have been concerns that biotechnology Phase I and II trials are less conclusive, leading to a higher Phase III failure rate.

Table 13

PHASE TRANSITION PROBABILITIES FOR BIOTECHNOLOGY DRUGS

Phase transition	*Probability (%)*
Preclinical to Phase I	54
Phase I to Phase II	87
Phase II to Phase III	83
Phase III to registration	92
Registration to launch	100

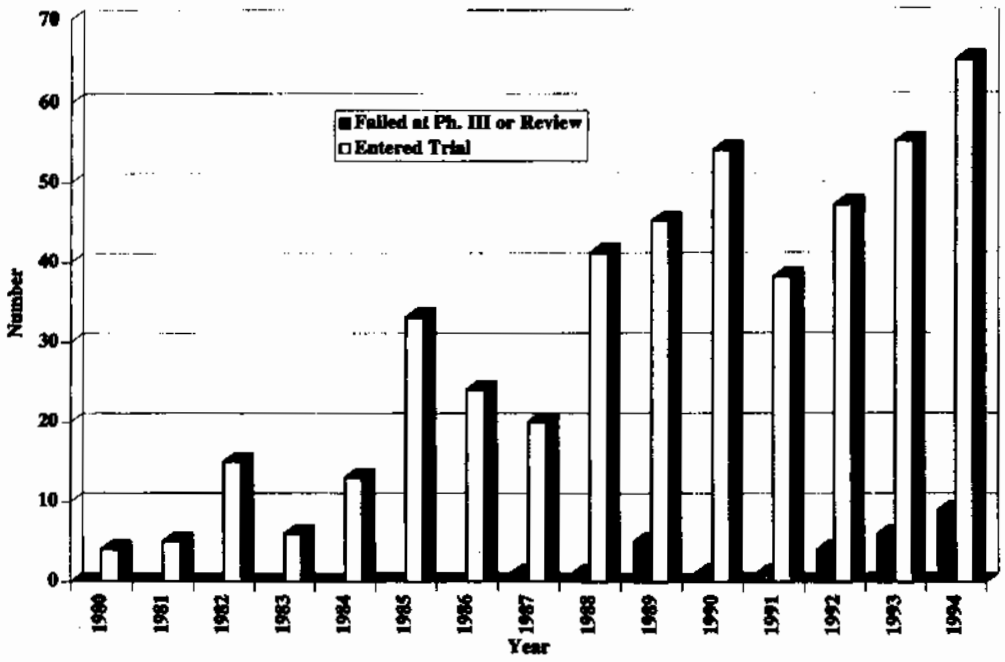
However, it is interesting to see what effect shorter development time and higher phase success rates have when incorporated in the drug development model. Throughout, patents are assumed to be issued two years after the project starts and to run for 17 years (the General Agreement on Tariffs and Trade (GATT) rules would extend this by 2 years if the original application was filed as a provisional application and subsequently converted to a full application). In the H&Q NCE model, patent expiration coincided with peak sales, and sales declined thereafter. In the biopharmaceutical models analysed here, the additional period of protected sales allowed by the shorter development time is assumed to result in additional years of peak sales at full margin. Also, note that throughout the rest of this paper, a discount rate of 12 per cent is used in the risk-adjusted NPV model.

Two biopharmaceutical scenarios were analysed:

- the same four-year preclinical duration as the NCE and
- a two-year total preclinical duration as the Bienz-Tadmor study indicated.

The results are shown in Table 14. The second of these scenarios is compared with the NCE case in Figure 5.

Figure 4: Biopharmaceutical development projects terminated in Phase III and regulatory review



Two effects can be seen:

- the greater number of years of peak sales at full margin results in a peak raNPV for the biopharmaceutical which is 40 per cent higher than the raNPV of an NCE. The peak also comes three years earlier, because sales start earlier
- the higher overall probability of ultimate success means that at the outset of the project, the raNPV is over six-fold higher for a biopharmaceutical than an NCE.

This result may explain the extraordinary jump in the value of Amgen's stock in August 1995 when it

Table 14

COMPARISON OF NCE AND BIOPHARMACEUTICAL DEVELOPMENT PROJECT RISK-ADJUSTED NPV MODELS

Scenario	*raNPV at inception ($m)*	*Peak raNPV ($m)*	*Peak year*
NCE	15	710	14
Biopharmaceutical	69	863	13
Biopharmaceutical, short preclinical	99	999	11

announced that it had licensed rights to leptin, the protein with the potential to be a treatment for obesity, from Rockefeller University. After agreeing to pay what is probably the highest upfront payment for an academic licence ever, $20m, with potential milestone payments of a further $80m, Amgen's stock climbed around $7.50, increasing the value of the company by $800m.

To determine the impact on the above conclusions of the current clinical success rates for biopharmaceuticals being artefactually high, the model was rerun using a 70 per cent Phase III success rate in place of the CSDD figure of 92 per cent. The results are shown in Table 15. Since the peak raNPV in both the above scenarios comes after Phase III, the timing and magnitude of the peak raNPV values is not impacted. The initial raNPV is reduced by about 25 per cent in both the scenarios. However, initial raNPVs are still substantially higher than for NCEs – the shorter development time and greater number of years' sales at full patent-protected margins have a significant effect on increasing the initial raNPV.

FUTURE DIRECTION

This paper has used a hypothetical model of drug development. The next step in developing the technique is to look for real world examples to which the two models can be applied in order

Figure 5: Comparison of risk-adjusted NPVs of NCE and biopharmaceutical products of equivalent market size

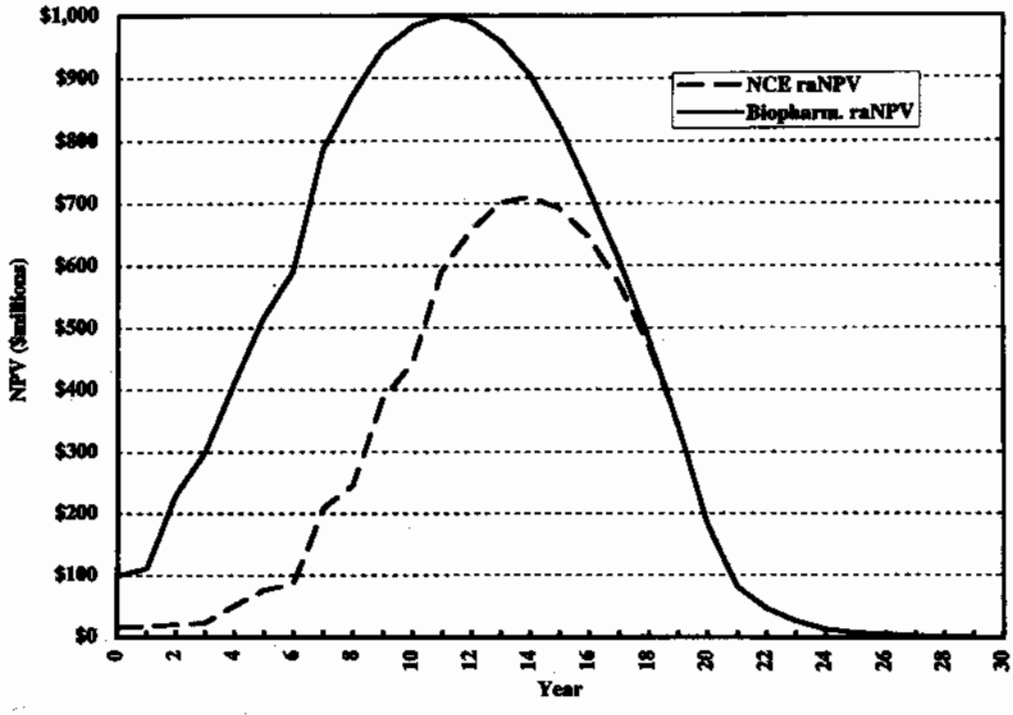


Table 15

EFFECT OF LOWER PHASE III SUCCESS RATES ON INITIAL RISK-ADJUSTED NPV OF BIOPHARMACEUTICAL DEVELOPMENT PROJECT

Scenario	*Initial raNPV with*	
	92% Phase III success rate ($m)	*70% Phase III success rate ($m)*
Biopharmaceutical	69	52
Biopharmaceutical, short preclinical	99	75

to determine which is a more realistic approach to valuation.

The approach also has considerable value in structuring licensing transaction and strategic alliances, as it allows a better comparison of the value of different deal structures involving different combinations of payments at different stages in the project, eg front-end loaded versus back-end loaded.

A number of applications are possible in academic licensing offices:

- valuing different types of technology on a common basis, so that the effort which should be devoted to each can be determined
- measuring the contribution of an individual or the entire office in a given time period
- valuing the institution's technology portfolio and tracking changes in its value over time.

CONCLUSIONS

This paper presents a new approach to accounting for the risk in long lead-time pharmaceutical development projects when valuing technology which predicts novel and non-obvious conclusions. The approach is believed to generate a more realistic valuation in the very earliest stages of development than traditional approaches which account for risk using very high discount rates. The model shows that biopharmaceutical development projects, which appear to have shorter development cycles and higher probabilities of success, have significantly higher NPVs than NCEs with equivalent potential markets.

The model is in principle applicable to other technologies; however, there are unlikely to be objective data available to quantify risk in the case of pharmaceutical projects, opening up the potential for manipulation of parameters to deliver preconceived outcomes.

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