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THE OPTIONAL VALUE OF IS PROJECTS – A STUDY OF AN IS PORTFOLIO AT A MULTINATIONAL MANUFACTURER

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ABSTRACT

The IS research literature has tested the applicability of option pricing models to IS projects mostly through detailed case studies. The current study complements this literature by considering a wide set of IS projects and assessing, albeit crudely, their optional value. We test the literature's assumption that IS projects embed significant optional value. Our research site is a European plant of a leading multinational manufacturer of sophisticated products. The portfolio of current and recent IS projects is studied through a questionnaire administered to all project managers. Seventeen project managers were interviewed concerning thirty-one projects with median cost of $325k and median benefit of $1.2m.

We find strong support to the prediction that IS projects include considerable optional value. The thirty one projects we studied embed forty seven options, many of them with benefits comparable to the value of the original projects. Only four projects had no optional value. A comparison between a subset of the portfolio and the corresponding scale-up options shows that the exercise price of the options is 20% of the original projects' cost, and that the value of these options is about 70% of the original projects' value. This data also demonstrates the large return, of scale-up options – the median return is 1500%, five fold the median return of projects.

The main practical implication of this study is that real option evaluation is useful for IS projects in general, and should not be confined to special cases. A further implication is that real option thinking may be of particular value in recognising reduction and deferral options. The project managers in our study found such options difficult to identify and considered their time to expiration as relatively short. Proactive management of reduction and deferral options should thus increase the flexibility and value of IS projects.

1. INTRODUCTION

Careful evaluation of IS investment is of particular importance nowadays after a period characterised by over-investment. The application of option pricing models to IS projects has been advocated for a number of reasons, including the inherent flexibility in such projects [Kumar, 1997], the infrastructure development and wait-and-see deployment-opportunities typical of many projects [Benaroch and Kauffman, 1999] [Taudes et al., 2000], the strategic value of IS investment [Benaroch and Kauffman, 1999], and the fact that opportunities in the digital economy are not obvious and by the time they become apparent, the window for investment has closed [Kulatilaka and Venkatraman, 1999]. Indeed, the applicability of option pricing models to IS projects has been discussed and tested in the research literature. The empirical tests consist of case studies, each illustrating a specific evaluation technique. These include a calculation of the optimal timing for deploying a point-of-sale debit

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services network [Benaroch and Kauffman, 1999 and 2000], an evaluation of an upgrade for a SAP package at a car parts manufacturer [Taudes, 1998] [Taudes et al., 2000], and an analysis of a two-stage investment in an imaging system by a mortgage bank [Kulatilaka et al., 2000].

The current study aims to complement this literature by considering a wide set of IS projects and by assessing, albeit crudely, their optional value. Our aim is to test the prediction (or assumption) of the literature that IS projects embed significant optional value. Although this prediction is intuitively appealing, it has not been tested empirically. We have studied 31 projects at a multinational manufacturer through structured interviews with all of its IS project managers. These respondents identified 47 options, many of them with benefits comparable to the value of the original projects. We have found that project managers more readily identify scale-up options over reduction and deferral options and that the exercise time for the later is relatively short. A strong correlation between scale-up cost, benefit and timing and the parameters of the original projects have been found; however, no correlation with uncertainty score has been measured.

This paper continues in Section 2 with a brief and abstract introduction to real options. Section 3 describes the research method and instruments and Section 4 depict the project portfolio. The main findings, the options, are presented in three sub-sections: scale-ups (§5.1), reductions (§5.2), and deferrals (§5.3). Section 6 is an analysis and discussion, and a brief conclusions-section ends the paper.

2. REAL OPTIONS

The concept of real options is based upon the fact that managers have the flexibility to alter decisions as further information becomes available. If conditions are favourable, a project may be expanded to take advantage of these conditions. On the other hand, if circumstances become unfavourable, a project may be curtailed or even cancelled as the conditions warrant. These discretionary actions can be referred to as *real options*, made available to the management as part of a project, and allow to expand or contract investment according to changing environmental conditions [Brealey and Myers, 2000].

Traditional investment appraisal techniques, such as net present value, have been criticised because of their inadequacy in modelling uncertainty and management flexibility. A negative net present value of a project is usually taken as a signal that the investment should not take place. However, that same investment could still generate valuable options, which in favourable circumstances could make the initial investment worthwhile.

Real option evaluation corrects this deficiency by using financial option pricing to evaluate investment under uncertainty. *Financial options* refer to the right, but not the obligation, to buy or sell a financial asset at a predetermined exercise price on, or before, a given expiration date. Pricing models of such options use the ability to trade and replicate assets and assumptions of risk neutrality and known probability distributions to derive pricing formulae. For example, the Black-Scholes formula shows that the value of an option to buy a stock is positively related to the price of the stock itself, the time before the option expires, the standard deviation per period of the rate of return on the stock, and the risk free interest rate; the option value is negatively related to the exercise price.

There is a large body of literature about the application of option pricing to project evaluation, including an annual international conference (see: realoptions.org). Most work to-date is in the oil and mining industries and both the large consulting firms and specialist consultancies (ROgroup.com, real-options.com) promote this method. A recent panel at ICIS concluded that although assumptions of option pricing are mostly untrue for IS projects, the insights gained from using these methods are useful [Kauffman et al., 2001].

3. METHOD

The current study considers a wide set of IS projects and assesses their optional value. Our aim is to complement the existing literature that evaluates single projects and to test the prediction that IS projects embed significant optional value. In order to prevent bias in the selection of projects, we study a complete portfolio at a single research site. However, we limit our investigation to the optional value of each project separately, and do not consider either the interaction between projects or a detailed portfolio risk profile [McFarlan, 1981].

Our research site is a European plant of a leading multinational manufacturer of sophisticated products; we denote this plant by 'Déan', which is the Irish word for 'to make'. The portfolio of current and recent IS projects within Déan has been studied through a questionnaire administered to all Déan's project managers. Our initial plan to delineate the portfolio by the annual budgetary documents failed, as there are no central lists of projects within Déan. Instead, we were given access to all software development project managers, and we asked each to identify his or her three most recent projects. These included any project from initial concept investigation to fully implemented ones. Interviews were conducted face to face and typically lasted thirty minutes per project; in most cases we had an introductory interview, which covered one project, and a secondary interview, after a few days, to cover the additional one or two projects.

The study of a wide set of projects necessitated a simple and short questionnaire. We chose as our guiding perspective the option application chapter of Brealey and Myers [2000], because of its simplicity and clarity. The chapter classifies three common and important real options found in capital investment projects:

- An *expansion*, or *scale-up*, is the option to make a follow-on investments if the immediate investment project succeeds.
- A *reduction*, or *scale-down*, is the option to abandon planned investments in a project.
- A *deferral* is the option to wait and learn before investing.

The chapter discusses the cost, benefits and timing of options, and the volatility of the underlying assets – we used these simple issues to form our questionnaire. Because of the difficulties in assessing future costs and benefits, we allowed answers in terms relative to the original project parameters. In particular, we asked whether the costs and benefits of the option are much smaller, smaller, similar, larger, or much larger than the original costs and benefits. Furthermore, the conceptual and practical difficulties in estimating volatility [Benaroch and Kauffman, 2000], convinced us to ask only for a rough assessment of the overall degree of uncertainty. These compromises were possible because we did not attempt on calculating the option value and we concentrated on the identification of options and their basic parameters. An initial questionnaire was tested by two pilot interviews and was discussed with the senior IT manager at Déan; the final research questionnaire is given in the appendix.

We present the data about the 31 projects using qualitative and quantitative tables; we use frequency tables to prevent the few large projects from distorting the analysis. When actual costs and benefits are not known, the relative values are transformed into quantities by multiplying them with the original project parameters. For example, when the benefits of a scale-up are related to the benefits of the original project, much smaller benefits are considered as 20% of the original ones, smaller as 50%, similar as equal to the original, larger as 200% and much larger as 1,000%.

4. THE PORTFOLIO

Seventeen project managers were interviewed about 31 projects, 14 of these projects were on-going and 17 already completed. The newest project in the portfolio was in the definition phase and the oldest project was completed 18 months before the interview. Although we interviewed 17 managers and asked for 3 recent projects from each, the final number of projects is smaller than expected, mainly because larger projects involved several managers. The senior IT manager at Déan reviewed this set of projects and confirmed that it was typical of Déan and involved all IT disciplines at the site. Table 1, on the next page, presents the projects, sorted by cost; an item that is not available is marked by N/A; k denotes thousands of dollars and m denotes millions of dollars.

Proj. No.	Functionality	Duration (months)	Cost ($)	Benefit ($)	Uncertainty (1-7)
1	Automating fault logging for building facilities	4	3k	40k	2
2	Automated time-logging by automation engineers	7	25k	300k	4
3	Remote and central monitoring of servers	4	25k	300k	3
4	Logistical DSS – delivery scheduling	6	28k	N/A	7
5	Human Resource DSS – employee turnover analysis	6	30k	25k	4
6	Report generation for production work-in-process; used for passing information between shifts	12	40k	1.8m	6
7	Electronic purchasing for facilities materials	18	50k	75k	7
8	System integration of call centre support services; will allow outsourcing	4	78k	N/A	5
9	Marketing DSS – identifies and compensates distributors who achieve sales targets	16	90k	190k	5
10	A depository of firm training resources; facilitates internal training rather than external courses	12	100k	1.2m	5
11	Production floor quality testing; expected to increase productivity	3	135k	2.3m	2
12	Logging service history of tooling machines; will aid repair technicians	16	160k	1m	6
13	Office IT Infrastructure set-up; will allow marketing tele-workers to work in a new location	7	200k	200k	2
14	Cost control application for project management	15	300k	300k	7
15	Data back up facility for laptops	4	300k	300k	4
16	Quality Control DSS –removes defective products early during the production to save production costs	7	325k	30m	4
17	Knowledge management tool for corporate intranet	12	350k	3.5m	7
18	System integration with Déan's IT infrastructure of a newly acquired company 1	8	390k	N/A	6
19	System integration with Déan's IT infrastructure of a newly acquired company 2	16	500k	N/A	7
20	Network solution to capacity overload	12	500k	22m	6
21	Disaster recovery central system	12	800k	1.7m	5
22	Migrating legacy infrastructure to new non-propriety IT infrastructure; will reduce support costs	32	1.1m	3m	3
23	Move to non proprietary database system	6	1.1m	2.5m	6
24	System integration with Déan's IT infrastructure of a newly acquired company 3	6	1.5m	3m	6
25	Software upgrade for production process tools	15	5m	1.2m	2
26	Worldwide firm Y2K system upgrade and audit	25	10m	N/A	4
27	Integration of the production process tools	33	10.5m	30m	6.5
28	Marketing and sales office IT infrastructure	12	13m	20m	7
29	Increase processing capacity for shop floor systems	13	30m	N/A	4
30	IT infrastructure for a new production floor	16	60m	N/A	5
31	IT infrastructure for the next generation production	32	95m	N/A	5.5

Table 1: Projects

Porter's [1985] value chain is utilised to demonstrate where our projects fall within Déan's operations. As can be seen from Figure 1, projects are spread throughout the value chain with a concentration in Operations/Technology-Development; this seems reasonable for a manufacturing company.

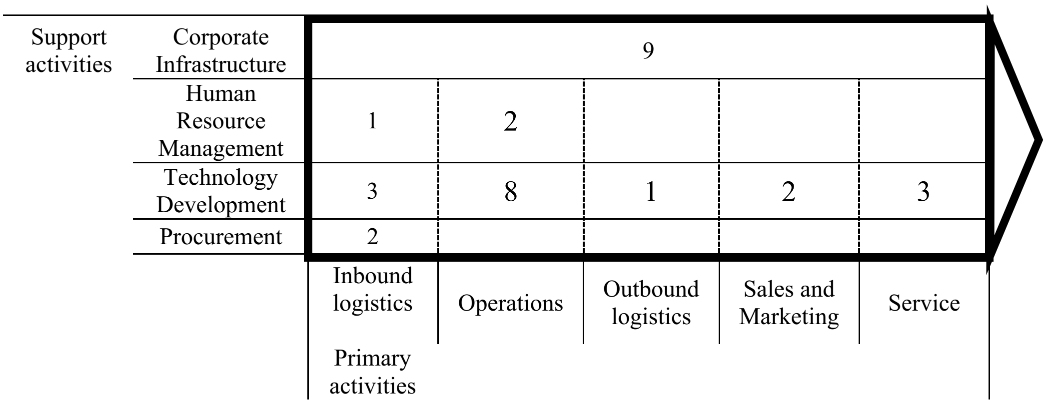

Figure 1: Number of projects for value chain classes

Table 2 presents the project cost and benefit frequencies; for example, seven projects had costs below $50K, three projects above $50K and below $100K, and so on. The benefits for eight projects are not available, as project managers could not estimate them with confidence.

Projects below this sum ($)	50k	100k	1m	10m	100m
Cost	7	3	11	5	5
	23%	10%	35%	16%	16%
Benefit	2	1	7	8	5
	9%	4%	30%	35%	22%

Table 2: Cost/Benefit frequencies

The cost of most projects is between $100k and $1m and five are 'mega-projects' with costs above $10m. The frequency of high benefit is relatively higher (57% above $1m) than the frequency high cost (32%). Indeed, the median project cost is $325k and the median project benefit is $1.2m; similarly, the median return – benefit on cost - for the 23 projects with both cost and benefit data is 290%. Managers were asked for their agreement with the statement that "the overall degree of uncertainty in this project is much higher than in Déan's typical IS projects". The answers were on a Likert scale from with 1 - strongly disagree, 2 – disagree, 3 – somewhat disagree 4 – neutral, 5 – somewhat agree, 6 – agree, and 7 - strongly agree. The frequencies of responses are presented in Table 3. The median value is 5 (some agreement) which we interpret as consistent with Déan's culture of risk taking in order to be first to market.

Uncertainty	1	2	3	4	5	6	7
Number of Projects	0	4	2	6	5	7	7

Table 3: Frequency of project uncertainty

There is no significant correlation between the project uncertainty scores and other project parameters. We tried to further assess the underlying volatility of the projects by asking the project managers for either a market sector or a publicly traded company that are similar to the project. Only for eight of the projects managers were able to identify a sector or company which fits well the project; for example, a specific production tooling company. For most projects, the sector or company suggested did not fit well the project; for example, the software services sector and SAP were mentioned for several projects.

5. THE OPTIONS

Most projects, twenty-seven in number, included options, typically either one or two options per project. Only four projects had no options – these are projects 4, 7, 8, and 20; three of these are relatively small with cost below $100k. The frequency of embedded options in the portfolio is represented in Table 4; the next sub-sections describe the three classes of options in some detail.

Number of options per project	0	1	2	3	4
Number of Projects	4	12	14	1	1

Table 4: Frequency of options

4.1. Scale-Up

A scale-up option is defined as the ability to make any additional investment, which becomes beneficial as a direct result of the initial project investment. Table 5, on the next page, presents data about the 30 scale-up options: the first column gives the original project number, and the exercise time column represents the time (after project start) when the scale-up could have been exercised until.

The table is sorted by the option cost. However, the column of the original project numbers (representing their cost ranking in the portfolio) is also in ascending order demonstrating the correlation between costs. Indeed, the scale-up cost is correlated with the project cost ($r=0.95$; $p<1\%$), the scale-up benefit is correlated with the project benefit ($r=0.48$; $p<1\%$), and the exercise time is correlated with the project duration ($r=0.60$; $p<1\%$). Cross correlations (project-cost/scale-up benefit, etc.) are also positive and significant; there is no significant correlation between the project risk scores and the scale up parameters. The reasons for the scale-up options are presented in Table 6. They include new functionality, addition of capacity, users, departments, and sites, and commercialisation of a project.

Reason	Projects	Number of options
Additional functionality	1, 2 (twice), 9, 12, 16, 21, 23, 27	9
Capacity expansion	13, 18, 19, 24, 29, 30, 31	7
Increase in the number of users	2 (twice), 10	3
Application in more departments	3, 9, 14, 21, 22, 26, 27	7
Implementation in other sites	5, 6, 11, 12, 15, 28	6
External sale of the project	17	1

Table 6: Scale-up reasons

Table 7 presents the frequencies of scale-ups by cost and benefit; data about the benefit of six scale-ups is not available.

Number of options below this sum ($)	50k	100k	1m	10m	100m
Scale-up Cost	11	2	10	6	1
	37%	7%	33%	20%	3%
Scale-up Benefit	1	2	10	6	5
	4%	8%	42%	25%	21%

Table 7: Scale-up cost/benefit frequencies

Proj No.	Option functionality	Exercise Time (months)	Cost ($)	Benefit ($)
1	Replace administration personnel with additional functionality to the fault logging system	5	8k	80k
2	Expand functionality of the time tracking system; will allow to add new users	12	10k	750k
2	Yet more functionality and users to the time tracking system	10	12.5k	675k
3	Monitor additional departmental servers by the remote monitoring system	24	25k	3m
5	Install the employee turnover DSS in other sites	16	19k	250k
6	Install the work-in-process reporting in other manufacturing sites	24	40k	1.8m
9	Analyse the data collected by the distributor target-achievement system	12	4k	95k
9	Addition of marketing channel programs to the distributor target-achievement system	12	4.5k	190k
10	Add users to the depository of internal training resources	3.5	10k	2.4m
11	Install the production floor quality testing system in additional sites	4	20k	2.3m
12	Install the service history logging system in additional sites	16	32k	10m
12	Capture more information about certain tooling processes into the logging of service history	16	80k	500k
13	Expand capacity of the office IT infrastructure	12	400k	400k
14	Add departments as users of the project cost control system	4	150k	300k
15	Install the laptop backup system in other sites	8	600k	600k
16	Capture more information about certain tooling processes; will allow better quality control	16	325k	30k
17	Sell externally the intranet knowledge management tool	14	2m	100m
18	Add IT infrastructure to the newly integrated WAN	8	78k	N/A
19	Add IT infrastructure to the newly integrated WAN	15	250k	N/A
21	Add data archiving to the disaster recovery system	12	160k	875k
21	Add departments to the disaster recovery system	24	200k	3.5m
22	Migrate more legacy databases to the new non-propriety system	24	220k	50k
23	Add DSS capability to the non-proprietary database	4	150k	40m
24	Add IT infrastructure to the newly integrated WAN	5	187k	600k
26	Upgrade additional systems as part of the 2000 compatible upgrade and audit	6	2m	N/A
27	Expand functionality and deploy in another part of the production process	36	5m	65m
28	Install the marketing and sale IT infrastructure in other sites	9	5m	40m
29	Further processing capacity increase in the shop floor systems	24	7m	N/A
30	Increase processing capacity of the new production floor	28	6m	N/A
31	Increase processing capacity of the next generation production floor	24	19m	N/A

Table 5: Scale-ups

The scale-ups cost is lower than the original projects – 37% of them are below $50K. The frequency of high benefit is higher (46% above $1m). Stated differently, the median scale-up cost is $155k, and the median scale-up benefit is $713k. The median values for the original projects are – cost $325, benefit $1.2m. When returns, benefit on cost, are calculated for the 24 scale-ups with both cost and benefit data, the median value is 1500%; the median return for the original projects is 290%. It seems that scale-up options are able to leverage the original investment making them very attractive.

4.2. Reductions

A reduction option is defined as the ability to scale down the initial investment or abandon planned investments, should conditions prove unfavourable. Twelve projects were identified as having reduction options. The ability to execute reductions expires relatively early in the project duration when compared to scale-ups. Table 8 presents the data about reductions; data about the cost of one option is unavailable and data about the benefit reduction of one option is not included. Table 9 presents the relevant frequencies.

Proj. No.	Reduction description	Exercise time (months)	Cost savings ($)	Benefit reduction ($)
5	Reduce the employee turnover DSS functionality if resources are needed elsewhere in the department	4	N/A	9k
10	Keep the depository of training resources only at Déan and not in other of the firm sites	2	20k	240k
13	Reduce capacity of the office IT infrastructure	1	100k	100k
14	Keep the project cost control system only at Déan and not in other of the firm sites	4	75k	240k
17	Do not complete the knowledge management tool as a commercial product	14	2m	100m
21	Limit functionality and scale of the disaster recovery system	4	300k	800k
23	Reduce processing power of the non-proprietary database	3	100k	100k extra benefit
24	Eliminate duplicate systems between Déan and the newly acquired company	2	525k	750k
25	Remove functionality of the software for process tools	1	250k	3.6m
27	Reduce functionality of the process tools	12	5m	20m
28	Reduce marketing office IT infrastructure to 'must haves'	6	3.5m	2m
31	Reduce processing capacity of the next generation production floor	12	9.5m	N/A

Table 8: Reductions

Number of options below this sum ($)	50k	100k	1m	10m	100m
Cost savings	1	3	3	4	0
Benefit reduction	1	1	4	3	2

Table 9: Reduction frequencies

Reasons for why a reduction could be necessary are both internal and external:

- External reasons offered by project managers were mainly change in market demand and legal compliance.

- Internal reasons related to internal political risk, budget over-run, technical risk, limited resources and project management difficulties.

While the internal reasons are more varied, external reasons were cited for eight out of the twelve reductions. This corresponds with Keil et al.'s [1998] observation regarding the significance of uncontrollable external risk in IS projects. In comparison, the exercise time for reductions is relatively short, with median of 4.0 months. The exercise time for the scale-up options has a median of 12.0 months, which is the same as the median project duration.

4.3. Deferrals

A deferral option is defined as the opportunity to postpone the original investment in the project in order to wait and learn about the environmental conditions. Table 10 presents the five deferral options identified.

Proj. No.	Description	Exercise Time (months)	Cost reduction ($)	Benefit Increase ($)
14	Re-analyze and design the cost control system	4	22	0
21	Wait for stability of the technical standards for the disaster recovery system	10	0	0
25	Wait for new release of the process tools software	6	2.5m	0
29	Wait for data about market demand before increasing processing capacity for shop floor systems	6	6m	0
30	Wait for the next generation of the relevant IT infrastructure before investing in the new shop floor	6	35m extra cost	N/A

Table 9: Deferrals

All deferred projects were considered to be potentially beneficial because of the opportunity to reduce investment costs during the deferral period. One project (number 30) would have increased its costs as deferral meant waiting for the release of the next generation of a product. The exercise time for deferrals is short with median of 6.0 months.

Deferral options were rejected by many project managers due to contractual obligations with vendors and Déan's culture of being first to market; some managers reported that it is difficult to be critical of your own project. Where deferral options existed, they were primarily viewed as an opportunity to reduce project cost during the deferral period.

6. ANALYSIS AND DISCUSSION

We have found strong support to the assumption, or prediction, that IS projects include considerable optional value. The 31 projects we studied included 47 options, many of them with benefits comparable to the value of the original projects. Only four projects had no optional value. A full comparison between portfolio value and optional value is not possible because we do not have detailed enough data for option value calculation. However, comparisons are possible between projects and scale-up options because their costs and benefits are conceptually similar. In particular, the portfolio total cost is about $245m, the total cost, or exercise price, of the scale-up options is $50m, or about 20% of the portfolio cost. For the 20 projects where data about benefits (for both project and scale ups) is available, the total benefit is about $96m; the total benefit of the scale-up options for these projects is about $68m, or 70% of the original benefit. These simple comparisons demonstrate that not only there are many options, but their costs and values are considerable. This data also demonstrates the large return, benefit on cost, of scale-up options – the median return for scale-ups is 1500%, five fold of the median return for projects.

The reasons for the existence of options in information systems, as described in the literature, are indeed relevant in our portfolio:

- The inherent flexibility in such projects [Kumar, 1997]: nine scale-ups consist of additional functionality and six reductions consist of not developing some functionality.
- The infrastructure development and wait-and-see deployment-opportunities typical of many projects [Benaroch and Kauffman, 1999] [Taudes et al., 2000]: twenty-three scale-up options consisted of addition of capacity, users, departments, or sites. Several of these were related to IT infrastructure.
- The strategic value of IS investment [Benaroch and Kauffman, 1999]: many of the expansions allow relatively fast and inexpensive scale-up of production capacity that is of strategic importance for the multinational manufacturer. Similarly, some of the reductions and deferrals allow fast scale-down in production capacity.
- Opportunities in the digital economy are not obvious and by the time they become apparent, the window for investment has closed [Kulatilaka and Venkatraman, 1999]: one option consisted of commercialisation of a project into a software package.

An additional finding is that project managers more readily identified scale-up options over reduction and deferral. The exercise time for reductions and deferrals was relatively short. This may be a general phenomenon related to the flexibility and infrastructural nature of IS. However, the characteristics of our research site may have enhanced it: Déan is a large multinational manufacturer that regularly transfers successful systems to additional sites and has a culture of gradual improvement in productivity. Also, for the time span of many of the projects in the portfolio, Déan operated in a growing market and emphasised new products, growth in production capacity, and aggressive IS investment. A third reason for the relative lack of reductions and deferrals is project managers' bias. Many respondents remarked that it is difficult to be the 'devil's advocate' for a project that you are meant to be the champion of.

Another finding is the strong correlation between scale-up cost, benefit and timing and the parameters of the original projects. However, we have not found correlation between option parameters and project uncertainty. Do these results make sense? Theoretically, options are more valuable when their exercise price is low, the value of the underlying asset is high, volatility is high, and the time horizon is long. So, for example, the correlation between scale-up benefit and project benefit is expected. However, it is unclear why there is no correlation between benefit and uncertainty score. One explanation is that our uncertainty instrument is lacking: it includes only a single item, it is subjective, and we have not distinguished explicitly between uncertainty and risk. Another possibility is that the simple theoretical interpretation presented here may be inappropriate. Our portfolio consists of internal projects with flexible boundaries which may reflect reaction to risk. So, for example, high risk may result in a small initial investment and a negative correlation between project and option, making our additional findings difficult to interpret.

7. CONCLUSION

This study has found a considerable number and value of options in an IS project portfolio at a multinational manufacturer. This result supports the prediction of the real-options IS literature, and is the first empirical evidence for the optional value of an IS project portfolio.

The main practical implication of this study is that real option evaluation is useful for IS projects in general, and should not be confined to special cases. A further implication is that real option thinking may be of particular value in recognising reduction and deferral options. The project managers in our study found such options difficult to identify and considered their time to expiration to be relatively short. Proactive management of reduction and deferral options should thus increase the flexibility and value of IS projects.

Our conclusions are limited by the scope of this study: a single portfolio at a large manufacturer during a period of market growth. Although our original goal was to utilise a simple and short questionnaire, we feel that our measurement instrument is too limited. In particular, the classification of options, the reasons for exercising them, and data about uncertainty and risk are too limited. A study of additional portfolios using a more elaborate questionnaire is called for. A further limitation is the lack of analysis of interaction between projects; we feel that a careful definition of interacting options and their empirical study should be attempted in future research.

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APPENDIX: THE RESEARCH QUESTIONNAIRE (PART 2 - PROJECT OPTIONS)

The following questions investigate the potential options that may or may not have been enacted by the company. Answer the questions without using the benefit of hindsight, namely, use the managerial point of view at the time the project was started.

1. Describe briefly the possibilities to <u>expand</u> the project or to have <u>continuation</u> projects? Yes/No

a) How long after the initial project start date would such a scale-up have been possible and why would it have been useful?

b) Roughly, how much would such a scale-up have cost?
OR The <u>costs</u> from such a scale-up option in relation to the costs of the initial project would have been: (Circle one)

Much Smaller (1)	Smaller (2)	Similar (3)	Larger (4)	Much Larger (5)

c) Roughly, what would have been the quantifiable benefits of such a scale-up?
OR The benefits from such a scale-up option in relation to the benefits of the initial project would have been: (Circle one)

Much Smaller (1)	Smaller (2)	Similar (3)	Larger (4)	Much Larger (5)

d) What would have been the other benefits (if any) of such a scale-up option?

2. What would have been the possibilities to reduce (or scale down) the project? Yes/No

a) When, after the project start date, would have such a reduction been possible?
b) Why would a reduction have been necessary?
c) Roughly, how much could you have reduced the investment by?
OR "The reduction in costs arising from the option to reduce the investment, as it related to the initial project costs would have been." (Circle one)

Very Small (1)	Small (2)	Half (3)	Large (4)	Very Large (5)

d) Roughly, what would be the drop in project value or benefits?
OR "The benefits lost arising from the option to reduce the investment, as it related to the initial project benefits would have been." (Circle one)

Very Small (1)	Small (2)	Half (3)	Large (4)	Very Large (5)

3. What would have been the possibilities to defer the starting date of the project? Yes/No

a) For how long would it be possible to defer the project?
b) What would have been the quantifiable benefits been (value from learning of market conditions or new technology, etc)?
OR "The increase in benefits arising from the option to defer the investment, as it related to the initial project benefits would have been." (Circle one)

Very Small	Small	Similar	Large	Very Large

c) Roughly, would this deferral reduce project costs?
OR "The reduction in costs arising from the option to defer the investment, as it related to the initial project costs would have been." (Circle one)

Very Small (1)	Small (2)	Half (3)	Large (4)	Very Large (5)

4. What is the risk embedded in this project?

a) "The overall degree of uncertainty in this project is much higher than in our typical IS projects?"

Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Neutral (4)	Somewhat Agree (5)	Agree (6)	Strongly Agree (7)

b) Would you know off-hand, of a market sector (or a company that is publicly traded), and similar to this project in terms of its operations and business type?