Technological Innovation Studies Program

Research Report

DEVELOPMENT OF NEW INDUSTRIAL PRODUCTS: Sensitivity of Risk to Incentives

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The University of Western Ontario

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Rapport de recherche

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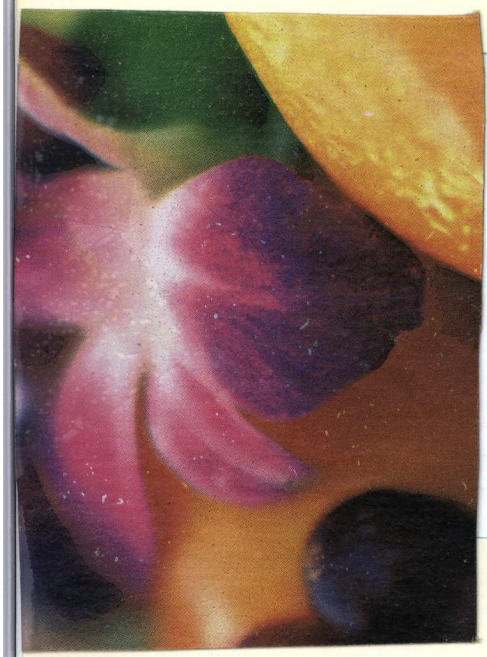

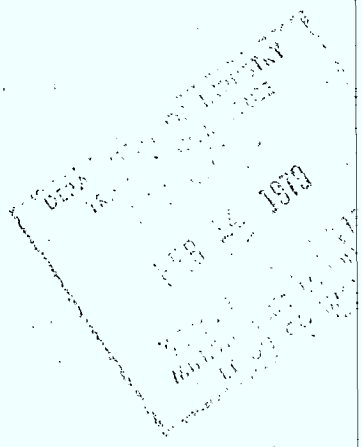

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Roger A. More

INTRODUCTION

A complex and serious problem facing the majority of industrial product firms is the allocation of scarce resources to competing projects for product innovations. The majority of firms have more potential projects at any given time than they do resources to pursue them. The outcome is that some potential projects are selected for further development and some are rejected.

The select/reject decision process is commonly referred to as screening, and represents a critical decision process in most firms. Normatively, the decision faced by managers can be viewed as a trade-off between the potential payoffs of the projects and the risks it represents. Managers will tend to select projects where the payoff is maximized at acceptable levels of risk, and reject other projects. The role of incentives for

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innovation can be related to this management decision process. Incentives can be viewed as risk-reducers for managers; they enable managers to select projects with acceptable payoffs but with levels of risk managers may be unwilling or unable to handle.

This exploratory research was directed at probing the nature of the risks that influence manager's decisions to select or reject new product opportunities and the sensitivity of the manager's decisions to different types of incentives. The questions asked by the research were the following:

1) Are there differences in the types of risks in the projects that are selected and those rejected by managers?
2) If there are differences, what types of risks tend to dominate the select/reject decision?
3) Are the decisions to reject new project ideas sensitive to different types of incentives?
4) Is the sensitivity of the reject decision different for different types of risks in the decision?

The study is directed at improving the understanding of how managers deal with different risks in the project selection process and how incentives might better relate to this risk-handling process.

BACKGROUND OF THE RESEARCH

The real-world management decision process to select innovation projects for development is complex and evasive, and as a result not well understood. There are a large number of normative approaches to project selection, yet most evidence indicates that few Canadian firms use formal normative approaches to screening. The screening decision process emerges as informal and complex largely determined by the unique circumstances of the company and its particular mix of managers facing a particular new product situation.

In attempts to conceptually define the decision process better, a commonly used approach is the payoff-risk view of project selection. Managers seek to maximize the payoffs and minimize the risk of project ventures. Many authors have extended and explored this view of project evaluation, but with one common problem; operationalizing the concept of risk. While commonly used as a concept, its dimensionality is diverse and

confused. This presents a major problem for both the formulation of normative models for project selection and planning of incentive programs for innovations. In order to be effective in helping managers in the project selection decision, normative models must enable him to operationally structure, dimensionalize and evaluate risk.

To be effective, incentive programs must be structured to enable managers to handle specific types of risk. Therefore, to plan programs, the dimensionality of risk must be understood, and the sensitivity of managers selection decisions to specific elements of risks must be evaluated.

THE RESEARCH MODELS

The overall model for the research consists of two basic conceptual models which ultimately form the basis for the definition of variables and the research hypotheses. The models are the following:

- A view of the management decision process for selection of innovation projects
- A view of the dimensionality of risk in the decision process

THE MANAGEMENT DECISION PROCESS

The decision process to be described is normative in nature, yet descriptive in the sense that most managers faced with the selection decision likely consider most of the factors in some form. The basic decision process is outlined schematically in Figure 1.

THE DIMENSIONALITY OF RISK

The concept of risk used in this study is outlined schematically in Figure 2. As shown, the decision to accept or reject a new product possibility can be seen as a tradeoff between the expected payoffs and the perceived risk in the situation.

The four basic components of risk in Figure 2 are defined as follows;

Payoffs: The estimated set of positive cash flow outcomes in the new product venture, generally realized only if the product is introduced, made up of profit contribution from the product. The components of profit contribution may be broken out as unit sales, unit price, and unit costs.

Amounts at Stake: The estimated set of negative cash flow outcomes in the new product venture, usually made up of development costs, and investments.

FIGURE 1

An Example of a Normative Screening Approach

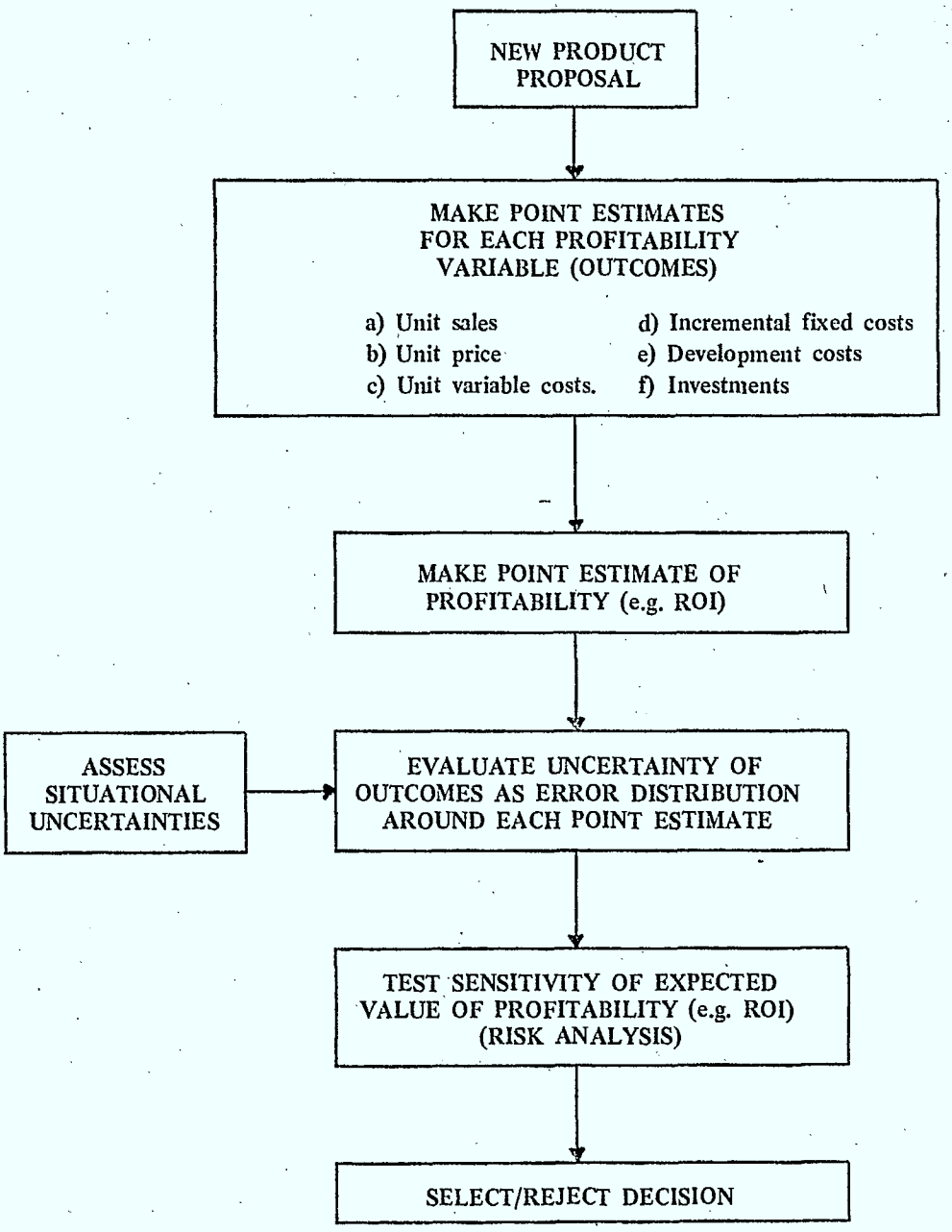
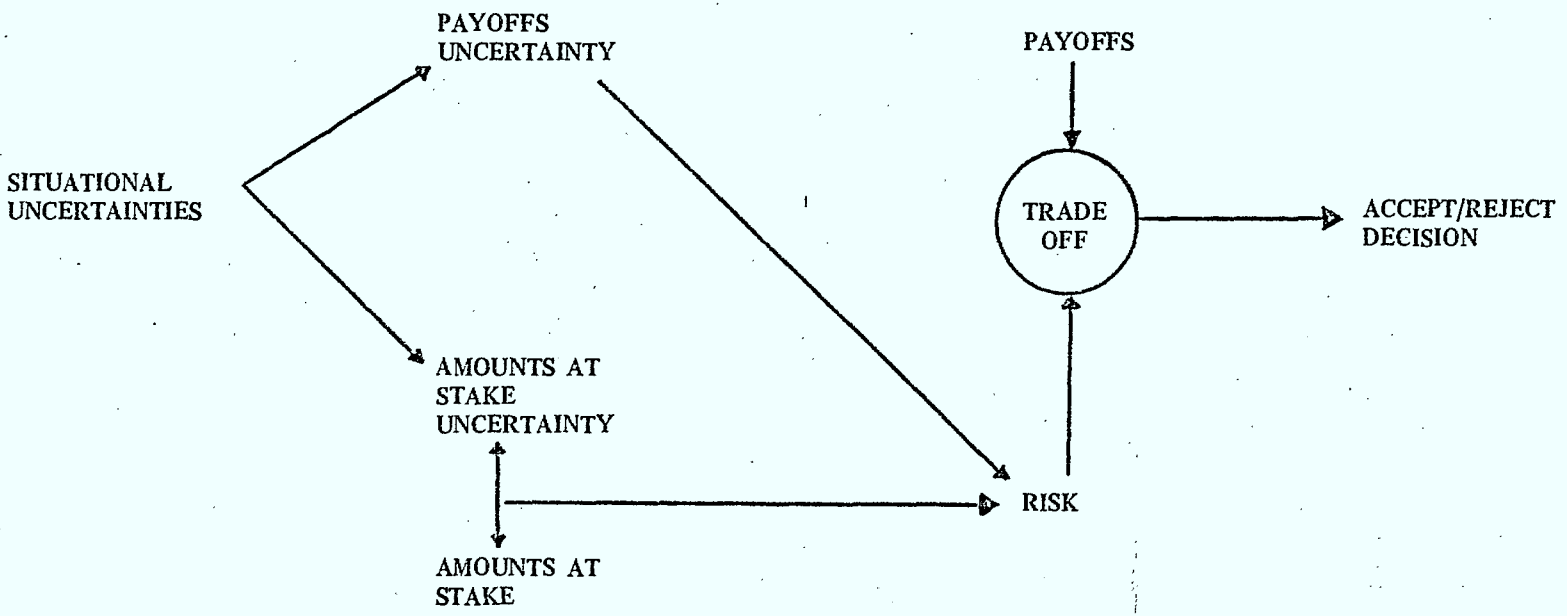


FIGURE 2

The Components of Risk in The New Product Screening Process



Payoffs Uncertainty: The uncertainty attached to each estimate of the payoffs, generally represented by a probability distribution on profit contribution around the expected value over some time frame. In the context of discounted cash flows, each discounted payoff estimate may have a separate distribution with potentially higher variance to reflect greater uncertainty in future payoffs farther removed in time.

Amounts at Stake Uncertainty: The uncertainty attached to each estimate of the amounts at stake, represented as outlined above.

Situational Uncertainties: All those factors in a particular new product situation that introduce uncertainty into the estimates of the payoffs and amounts at stake; that is introduce greater variance into the probability distributions of each estimate. For example, situational uncertainties include uncertainty about what strategic approach will be used to develop and market the new product, uncertainty about potential buyers, distributors, competitive reaction, and the myriad factors that influence the outcomes in a particular new product venture. In general, these factors tend to be qualitative and highly subjective in nature,

usually expressed for measurement on some form of ordinal scale.

VARIABLES IN THE STUDY

The variables used to measure the different constructs in the model are shown in Table 1. The expanded descriptive model for the research is shown in Figure 3.

RESEARCH METHODOLOGY

Data on 43 new product ventures was gathered by personal interview in the summer of 1974 to form the basis of the study. Managers of 15 electronics product firms active in new product development were interviewed. Most interviews were with one person only, although in some instances other management personnel were brought into the discussion, in all cases the interviewers attempted to deal with persons most familiar with the firm's overall new product development activities. The interviews lasted from two to four hours and were based on two questionnaires, one used in the interview and one left with the respondant and returned by mail. Much of the information on the specific new products was drawn from written company data files to improve the reliability of the data.

Table 1

The Study Variables

1. Variables Measuring Amounts at Stake (AS_i)

AS1	Development cost
AS2	Maximum downside loss

2. Variables Measuring Situational Uncertainties

a. Marketing Task Similarity (MT_i)

MT1	Product newness to company
MT2	Similarity of after-sale service
MT3	Fit with existing products
MT4	Similarity of buyers
MT5	Similarity of distributors
MT6	Suitability of sales force
MT7	Similarity of selling task
MT8	Product appeal to sales force
MT9	Similarity of service task
MT10	Similarity of competitors

b. Distribution Difficulty (DD_i)

DD1	Buyer industry diversity
DD2	Number of distributor levels
DD3	Importance of distributor support
DD4	Expected distributor support
DD5	Extent of distributor power

c. Market Stability (MS_i)

MS1	Time to product obsolescence
MS2	Stability of primary demand
MS3	Trend in primary demand
MS4	Rate of change in buyer needs
MS5	Trend in competing products

d. Production complexity (PE_i)

PE1 Similarity of manufacturing process
PE2 Ability of manufacturing personnel
PE3 Difficulty of manufacturing process
PE4 Reliability of manufacturing process
PE5 Complexity of manufacturing technology

e. Development complexity (DV_i)

DV1 Similarity of technology to company
DV2 Extent of prior technology use
DV3 Ability of company technical personnel
DV4 Complexity of technology to company
DV5 Number of technical product alternatives

f. Competitive Advantage (CA_i)

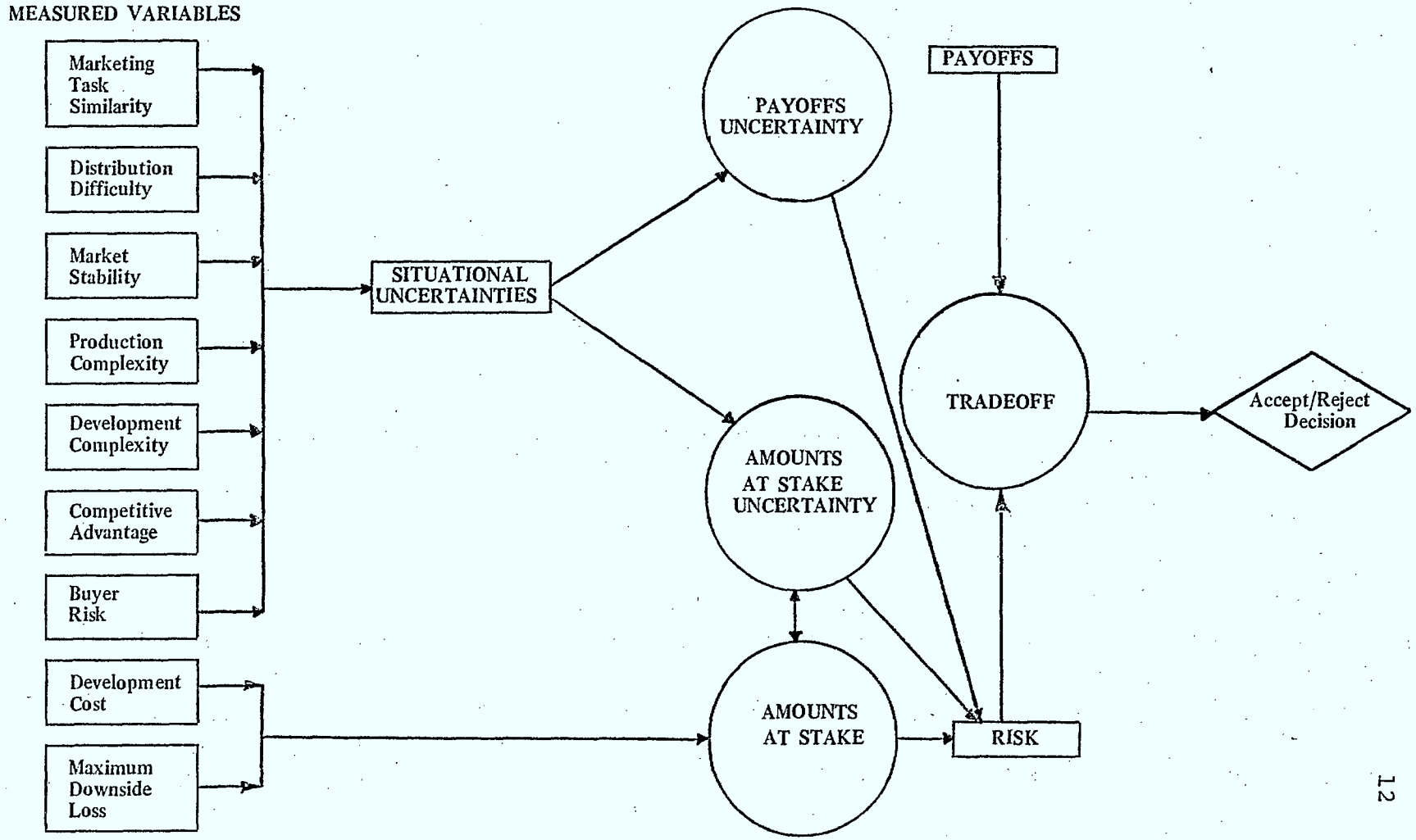
CA1 Extent of patent protection
CA2 Extent of license protection
CA3 Competitive product improvement
CA4 Product Uniqueness
CA5 Similarity to competing products
CA6 Ease of competitive duplication
CA7 Product price position

g. Buyer Risk (BR_i)

BR1 Extent of after-sales service
BR2 Importance to buyer operation
BR3 Technical complexity to buyers
BR4 Product newness to buyers
BR5 Buyer purchase experience
BR6 Effect on customer profitability
BR7 Familiarity of purchase task to buyers
BR8 Buyer time commitment
BR9 Purchase size to buyers
BR10 Extent of buyer adaptation

FIGURE 3

The Descriptive Model for the Research



In each case, the manager or managers most involved in the new product venture were interviewed. The manager was requested to select three example of fairly recent new product ventures with which he was intimately familiar, some which were selected for further development and some which were rejected.

In the interview itself, the particular new product and its development were outlined. For the rejected products, the manager was presented with different types of incentives and asked to estimate the conditional probability of the product being accepted if the particular incentive had been taken into the decision process.

After the interviews, managers were left with an extensive mail return questionnaire to measure the situational uncertainty variables.

Measures of the potential payoffs for rejected new product ventures were not taken for a number of reasons. Firstly, all the data was measured at the screening stage of the new product when estimates of future payoffs are extremely uncertain and subject to large errors. Secondly, the study focuses on risk, and since the payoffs are so uncertain makes the assumption that their effects on the select/reject decisions are randomly distributed across the 43 situations studied.

FINDINGS

Differences in Risks Between Selected and Rejected Projects

Discriminant analysis was used to relate the nominal dependent variable, select or reject to the hypothesized predictor variables. The discriminant function is of the form;

$$z_i = b_o + b_1 z_{1i} + b_2 z_{2i} + \ldots\ldots b_n X_{ni}$$

where:

z_i = the discriminant score for the i^{th} new product situation

x_{ji} = the value of the j^{th} predictor variable for the i^{th} new product situation

b_j = the discriminant coefficient for the j^{th} predictor variable.

Given the values of the predictor variables for a particular new product situation, the discriminant function generates a discriminant score z. This score can be used to classify the particular new product situation as having the greatest likelihood of being selected or rejected. Summary findings of the analysis are shown in Table 2.

Of the three variables measuring amounts at stake, two were significant in discriminating between selected and rejected products ($\alpha \leq 0.10$), both in the hypothesized

TABLE 2

Summary Findings: Risk Differences Between Rejected/Selected New Products

Results of Two-Way Multiple Discriminant Analyais (N = 43)
Group 1: Rejected Product (N = 18)
Group 2: Selected Products (N = 25)

Construct	Variable	Variable Name	Mean Rejected	Mean Selected	Expected Direction	Discriminant Significance Level
Amounts at Stake	AS1	Development Cost ('000)	135.55	73.77	✓	.025
	AS2	Maximum Loss ('000)	1,622.08	509.98	✓	.01
Marketing Task Similarity	MT1	Product Newness to Company	3.61	3.36	✓	0.10
	MT2	Similarity of after-sale Service	2.17	2.48	x	.025
	MT4	Similarity of buyers	2.44	3.12	✓	.10
	MT6	Suitability of sales force	2.33	2.12	✓	.05
	MT9	Similarity of service task	2.50	2.40	✓	.05
	MT10	Similarity of competitors	2.61	2.76	x	.025
Market Stability	MS1	Time to product obsolescence	8.94	16.40	✓	.025
	MS2	Stability of primary demand	2.50	3.00	✓	.05
	MS3	Trend in primary demand	3.83	3.80	x	.025
Production Complexity	PE3	Difficulty of manufacturing Process	1.89	2.21	x	.025
	PE5	Complexity of manufacturing Technology	3.00	3.21	x	.05
Development Complexity	DV1	Similarity of technology to Company	2.00	1.84	✓	.025
	DV2	Extent of prior technology Use	2.67	2.52	✓	.10
	DV3	Ability of company technical Personnel	1.94	1.52	✓	.025
	DV4	Complexity of technology to Company	2.05	2.72	x	.025
	DV5	Numbers of technical product alternatives	3.44	3.20	x	.05
Competitive Advantage	CA1	Extent of patent protection	1.72	1.80	✓	.01
	CA2	Extent of license protection	1.44	1.48	✓	.025
	CA3	Competitive product improvement	3.28	3.32	✓	.025
	CA4	Product uniqueness	2.39	2.56	✓	.05
	CA6	Ease of competitive duplication	1.94	2.44	✓	.025
	CA7	Product price position	2.89	2.84	✓	.10
Buyer Risk	BR4	Product newness to buyers	2.44	2.48	x	.05
	BR5	Buyer purchase experience	47.94	51.76	✓	.05
	BR7	Familiarity of purchase task to buyers	1.94	1.68	✓	.10
	BR8	Buyer time commitment	39.50	50.25	✓	.10
	BR9	Purchase size to buyers	2.72	2.52	x	.05
	BR10	Extent of buyer adaptation	2.00	1.80	✓	.025

Percent correctly classified = 100%
Overall F on discrimination = 8.68×10^3
Significance of $F \propto \leq 0.001$

directions. Rejected products tended to have significantly greater amounts at stake than selected products.

Of the ten variables measuring marketing task similarity, six were significant in discrimination, and of these four were in the direction hypothesized. Rejected products tended to have greater product newness to the company, lower similarity of buyers, lower similarity of the sales force, and lower similarity of the service task. However, rejected products tended to have greater similarity of after-sales service, and greater similarity of competitors.

Of the five variables measuring distribution complexity, none emerged as significant in the discrimination between selected and rejected products.

Of the five variables measuring market stability, three emerged as significant in the discrimination, two in the directions hypothesized. Rejected products tended to have lower time to product obsolescence and lower stability of primary demand. However, rejected products tended to have a slightly higher growth in primary demand.

Of the five variables measuring production complexity, two were significant in the discrimination, neither in the direction hypothesized. Rejected products tended to have lower difficulty of the manufacturing

process and lower complexity of the manufacturing technology.

Of the five variables measuring development complexity, all five were significant in the discrimination. Rejected projects tended to have lower similarity of the technology to the company, lower extent of prior technology use, and lower ability of company technical personnel. However, rejected products tended to have lower complexity of the technology to the company and a smaller number of technical product alternatives.

Of the seven variables measuring competitive advantage, six were significant in the discrimination, all in the direction hypothesized. Rejected products tended to have lower extent of patent protection, lower extent of license protection, lower competitive product improvement, lower product uniqueness, greater ease of competitive duplication, and a higher product price position.

Of the ten variables measuring buyer risk, six emerged as significant in the discrimination, four in the directions hypothesized. Rejected products tended to have lower buyer purchase experience, lower familiarity of the purchase task to buyers, greater purchase size to buyers, and greater extent of buyer adaptation. However,

rejected products tended to have lower product newness to buyers and lower buyer time commitment.

In summary, the hypothesis that rejected products tend to have greater amounts at stake and situational uncertainties, and therefore risk on this dimension than selected products was well supported.

The differences in the amounts at stake were striking, with rejected products having a mean development cost of approximately $135,000 compared to $74,000 for accepted products, and having a mean maximum loss of approximately $1.6 million compared to $0.5 million for accepted products.

The most significant sets of situational uncertainties that differentiated the projects selected and rejected were the development complexity and competitive advantage. Broadly speaking, projects where the product involved a new development technology to the company in a situation that seemed to have limited competitive advantage represented major risks to the managers involved. In terms of a scenario, the new product scenario that tended to represent the highest situational uncertainty to managers, and therefore risk was the following;

- a newer technology to the company
- a newer group of potential buyers

- a newer selling and sales service task to be performed
- a product likely to be obsolete sooner, with a shorter life cycle
- a market with greater fluctuation in demand
- greater competitive advantage on all dimensions
- greater risk to the potential buyers

Sensitivity of Risks to Incentives

The sensitivity of risks in the rejected new product ventures to different types of incentives was examined by measuring the mean scale sensitivies on the five-point scales and derived measures of the conditional probabilities of the rejected project being selected, given the particular incentive. The findings are shown in Table 3.

Sensitivity to development cost incentives was moderate. As shown, repayable development cost incentives raised the conditional probability of selection to 0.33 at the 100% level. Changing the basis of the incentive to non-repayable did not appreciably improve the probability up to a 50% incentive (probability of selection = 0.38).

Table 3

Sensitivity of Rejected Products to Incentives

Incentive	Mean Scale Sensitivity	Conditional Probability of Project Selection
Development Costs		
25% Repayable	1.25	0.25
50% Repayable	1.46	0.29
100% Repayable	1.63	0.33
25% Non-repayable	1.33	0.27
50% Non-repayable	1.92	0.38
Capital Investment		
25% Repayable	1.13	0.23
50% Repayable	1.21	0.24
100% Repayable	1.50	0.30
25% Non-repayable	1.46	0.29
50% Non-repayable	1.88	0.38
Market Research Assistance		
25% Non-repayable	1.12	0.22
50% Non-repayable	1.54	0.31
100% Non-repayable	2.63	0.53

Market research assistance sensitivity was not significant until the 100% non-repayable level, at which the conditional probability of selection was 0.53, which is reasonably high. It demonstrates clearly manager's recognition of the impact of situational uncertainties on risk and their desire to reduce these uncertainties through information-gathering.

Incentive Sensitivity and the Level of Risk

Correlation analysis was used to test the sensitivity of development cost incentives to different levels of development costs. As shown in Table 4, there was no significant relationship between sensitivity to development cost incentives and the magnitude of development costs, at any incentive level.

Correlation analysis was also used to test the sensitivity of capital investment incentives to different levels of required investment. Similar to development cost incentives, there was no significant relationship between sensitivity to investment incentives and required capital investment.

Multiple discriminant analysis was then used to test which uncertainties were related to sensitivity to marketing research incentives. Summary results of the

Table 4

Sensitivity of Project Development Costs to Different Development Cost Incentives

Correlation Coefficients: Development Cost vs. Conditional Probabilities

Incentive Level	Correlation Coefficient
25% Repayable	0.71
50% Repayable	- .028
100% Repayable	- .08
25% Non-repayable	- .10
50% Non-repayable	.03

analysis are presented in Table 5. As shown, a total of ten variables were significant in the discrimination ($\alpha \geq 0.10$). Rejected projects which were sensitive to market research incentives tended to have greater product newness to the company, greater buyer industry diversity, an increasing number of competing products, a lower ability of manufacturing personnel, greater difficulty of the manufacturing process, lower extent of patent protection, lower extent of license protection, greater ease of competitive duplication, greater product newness to buyers, and lower buyer purchase experience.

IMPLICATIONS OF THE FINDINGS

The research has some potentially useful implications for government policy in the area of incentives for innovation.

1. Managers are very sensitive to the amounts at stake in new product ventures. They will tend to reject ventures with higher development costs and high potential downside losses in the possible event of a product failure. However, their sensitivity to development cost incentives is relatively low, and apparently insensitive to the size of the development cost. Similarly, their sensitivity to investment

Table 5

Sensitivity of Different Project Risks to Market Research Incentives for Rejected Projects

Results of Two-Way Disciminant Analysis (N = 18) based on low sensitivity to 100% market research assistance (conditional probability of selection $\leq$ 0.20) vs. high sensitivity to 100% market research assistance (conditional probability $>$ 0.20)

Construct	Variable	Variable Name	Significance Level
Marketing Task Similarity	MTI	Product newness to company	.025
Distribution Ease	DE1	Buyer industry diversity	.025
Market Stability	MSS	Trend in competing products	.05
Production Ease	PE2	Ability of manufacturing personnel	.05
	PE5	Difficulty of manufacturing process	.05
Competitive Advantage	CA1	Extent of patent protection	.025
	CA2	Extent of license protection	.05
	CA6	Ease of Competitive duplication	.025
Buyer Risk	BR4	Product newness to buyers	.025
	BR5	Buyer purchase experience	.10

Overall % correctly classified 100%
Overall F 3.46×10^{8}
Significance level of F = .0005

incentives is relatively low, with parallel insensitivity to the size of the investment. These findings suggest that incentives designed to reduce managers risk on the dimension of downside risk may not be particularly effective.

2. Managers are sensitive to particular types of situational uncertainties in new product ventures, most particularly the complexity of the development technology and the expected degree of competitive advantage expected. This fact coupled with the relatively high sensitivity to market research incentives points to the potential value of greater incentives for companies to carry out more effective market research to attempt to reduce the uncertainties.

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