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Perceiving and managing business risks: differences between entrepreneurs and bankers

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Abstract

We compared entrepreneurs with bankers in their perception and management of a variety of risks. Problems included financial risk, risk to human life and health, and risk of a natural disaster. Cluster analysis and content analysis of think-aloud protocols revealed surprising details. Entrepreneurs accept risk as given and focus on controlling the outcomes at any given level of risk; they also frame their problem spaces with personal values and assume greater personal responsibility for the outcomes. Bankers focus on target outcomes – attempting to control risk within structured problem spaces and avoiding situations where they risk higher levels of personal responsibility. Published by Elsevier Science B.V.

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1. Introduction

Entrepreneurship is inherently risky compared with operating an existing business. But whether entrepreneurs are risk takers by nature is another matter altogether. In fact Palich and Bagby (1992) found support for the hypothesis, "*there is no difference in risk propensity between entrepreneurs and non-entrepreneurs*". Yet the success of entrepreneurs is closely tied to the way they perceive and manage risk. Although the perception and management of risks have been studied extensively, this study breaks new

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ground – using verbal protocol analyses to compare entrepreneurs with bankers in their cognitive approaches for solving problems involving a variety of risks.

The whole question of 'risk propensity' seems to be a confusing one in the light of the following fact: People perceive risks differently because they draw different cognitive problem spaces where they search for solutions – not because risk is an objective attribute of decisions and events. Therefore, to say "Entrepreneurs are risk-averse" is almost a meaningless statement. This study essentially looks a level deeper into the subjects' risk perception and finds that it is not risk propensity that is relevant to understanding risk perception, but feelings of control and responsibility and personal values.

2. Method

This study is exploratory in nature; it uses a quasi-experimental design, Campbell and Stanley (1963) in the sense that selection of subjects is non-random. Subjects were four entrepreneurs and four bankers each with over five years of experience. The entrepreneurs are founders of their companies that range in size (measured by annual sales) from $ 5M to $ 30M. They participated in a continuing education program at Carnegie Mellon University (CMU), Pittsburgh and volunteered for the study upon request by the authors. Though the bankers included both investment bankers and loan officers (Vice-President level), they have been involved in loans to small business at one time or another. They are CMU alumni and were selected based on geographical accessibility and convenience of scheduling.

All subjects were given the same set of problems; verbal think-aloud protocols were used to analyze the responses and thought processes of the subjects as they solved the problems Ericsson and Simon (1993). Each subject spent approximately one hour on solving the problems. They took the tasks seriously and seemed to enjoy thinking through them. For example, B1 finished solving Problem 1 as a textbook problem of financial decision making and then went back and looked at the problem again as a real world problem, asking himself if he would really make the investment decision this way using calculations alone.

3. The problems

Five problems were used – two involving financial risk only, two involving risk to human life and health and the last one involving risk of a natural disaster (The problems are fully specified in Appendix A).

The problems were designed to keep the parameters simple while at the same time offering a rich texture of risks for the subjects to think about:

- Problem 1 consists of choosing between two projects with differing probability distributions of returns – Project 1 has a much smaller variance than Project 2. Part two of the problem is the same except that the variance of Project 2 has been decreased even more than in part one.

- Problem 2 involves choosing between two products with differing probability distributions of demand. Here the focus is on break-even rather than on returns.
- Problem 3 involves the possibility of a pipe burst and two options of safety with differing expenses. Also, the product manufactured is essential to human life; and suggestions are requested from the subjects for possible actions in case the firm cannot afford the expensive but safe option.
- Problem 4 is similar to Problem 3, except that the product is synthetic rubber – not exactly essential to human life – and involves risk of causing cancer in workers.
- Problem 5 is a choice between two plots of land for building a factory – one costs only $ 100 000 but is situated in a flood plain and the other is safe but costs $ 5M.

The encoded protocols are available on request.

4. Cluster analysis

Encoding the verbal protocols and analyzing their content identified five variables on which similarity/dissimilarity between subjects could be identified:

- *CONTRET*: Statements indicating the subject's perception of his/her ability to control the possible returns to the decision.
- *CONTRISK*: Statements indicating the subject's perception of his/her ability to control the risks involved in the problem.
- *INTRESP*: Suggestions given by the subjects that involve factors internal to the firm only (Ex: safety masks, more frequent maintenance, etc.).
- *EXTRESP*: Suggestions given by the subjects that involve factors external to the firm (Ex: convincing regulatory agencies to subsidize safety expense, price increase through cooperation with competitors, etc.).
- *PERSCOND*: Statements involving personal considerations in making the decision (Ex: considerations of age, bequeathing to children, net worth, peace of mind, etc.).

A data matrix was developed based on these variables and the actual decisions made by the subjects, and a cluster analysis was carried out. The dimensions for the cluster analysis were developed by analyzing the contents of the verbal protocols (See Table 1 for example phrases for each cluster dimension). The data matrix is presented in Table 2. Also, summarized details about the decisions, quotes from the protocols, and some explanations are given in Appendix A.

5. Decisions

In each problem the subjects were asked to choose between two options. Each decision is encoded as either 1 or 2 depending on which project (problems 1a and 1b), product (problem 2), option (problems 3 and 4), or plot (problem 5) was chosen. For example, E1 chose Project 1 in Problem 1A, Project 2 in Problem 1B, Product 1 in Problem 3 and so on.

Table 1
Example phrases from the protocols for each cluster dimension

CONTRET:	What appears to me to be a certainty of.. of at least 300 000 and perhaps cap out at 500 000 (E1 – Problem 1)
	I would mainly be looking at.. where the greatest percentage.. of.. of a favorable result would be... what I can do.. (E2 – Problem 1)
	That will cover our..$ 800 000 investment as well as looking further down here.. what I can do... (E2 – Problem 2)
	If you wanna sell the business which I think you'll have to keep in mind.. you have a much better salable operation.. (E2 – Problem 5)
	We may be we may take great risk as viewed by others but maybe not so great from our own perspective.. where we have some control over making it happen (E3 – Problem 1)
	And then I push.. at least as hard as I can.. ah.. to get higher volumes and move towards 400 000... (E4 – Problem 2)
CONTRISK:	You ran out of money or something and needed more money so I think one would be safer.. (B1 – Problem 1)
	And enclose the area so that there's a much lower chance of pipeburst.. (B1 – Problem 3)
	But floods don't happen very often..... but it just looks like its such a.. better buy... that I would take the risk and try to protect myself every way I could.. (B1 – Problem 5)
	If I can't afford option 2.. well.. how much at all would my insurance go down or not go up not increase by taking option 2 ahm... (B2 – Problem 3)
	I don't know what insurance would cover and I assume it would cover.. something.. ahm.. (B2 – Problem 4)
	I would look at.. ahm.. possible current suits in these areas and at the type of.. suit levels that you know.. suit amounts that they are going for.... maybe you could defend yourself better because you have lowered the leakage.. (B3 – Problem 4)
	But probably if you.. if you.. had the flood insurance and you had the flood you could probably get the factory updated (B3 – Problem 5)
	I'll also look at.. trying to.. produce more.. stuff and warehouse it somewhere outside of the factory..... if there'd be a flood (B4 – Problem 5)
INTRESP:	I wonder if.. replacing the pipes would be another option..... or how about wearing special.. having special masks in the area (B1 – Problem 3)
	In general.. what does my insurance cover.. what is my deductible (B2 – Problem 3)
	How much would it cost.. to.. replace the pipes.. ahm.. maybe sooner than every ten years.. (B3 – Problem 3)
	And if I can't afford option 2, I would also consider.....consider discontinuing this product (B4 – Problem 3)
EXTRESP:	I would attempt to go out and find the financing for the $ 10M option and we'd go with that (E1 – Problem 3)
	Go back to the previous owners.. help get some type of.. some type of settlement for covering these $ 10M(E2 – Problem 4)
	I assume that I have competitors who are faced with similar types of problems.. and can we raise the price.. of the product.. to support the investment of $ 10M or.. (E3 – Problem 3)
	If we couldn't afford option 2.. probably no one else in the business could afford option 2 and we ought all to get.. get in together in understanding how one another protecting our workforce from the hazard.. (E4 – Problem 3)
	I would also seek out the (government) agencies proactively ah..... and we would work with them cooperatively to.. to find a solution that was satisfactory to both the workforce the regulatory agencies and the company (E4 – Problem 4)
PERSCOND:	I would prefer not to give up the equity but as a socially conscious human being I want to save human lives.. perhaps it is worth..ah..ahm.. giving up equity (E1 – Problem 3)
	I'm going to spend $ 5M for a plant.. that I can live with easily.. (E1 – Problem 5)

Table 1 (Continued)

	Also look at.. if it was my business.. how.. is my business.. how old I was... how long I plan to work.. (are) children coming along..who was going to continue the business on... (E2 – Problem 3)
	And it's a beautiful location which means a lot when you.. go to work everyday.. (E2 – Problem 5)
	Now if I were.. maybe in my thirties I would have.. taken project 2 ah.. and go for the home run and... (E3 – Problem 1)
	So really.. it gets into a personal issue here.. (E3 Problem 3)
	I certainly would feel a hell of a lot better.. going to bed every night knowing that.. I don't wake up and read the paper the next morning or get a phone call that night saying.. it's all gone.. (E3 – Problem 5)
	This is plain and simple an ethics and.. a safety decision and.. and those tend to be simpler for me.. (E4 – Problem 3)

Table 2
Data matrix for cluster analysis

Subjects	*DECN1A*	*DECN1B*	*DECN2*	*DECN3*	*DECN4*	*DECN5*
	ROI	ROI (less σ)	Demand	Pipe burst	Cancer	Flood plain
E1	1	2	1	2	1	1
E2	1	2	1	2	1	1
E3	1	1	1	2	1	1
E4	1	1	1	2	1	2
Comparison	0/4	2/4	0/4	4/4	0/4	3/4
Metric	2/4	2/4	4/4	0/4	4/4	1/4
B1	1	1	2	1	2	2
B2	1	1	2	1	2	1
B3	2	2	2	1	2	2
B4	2	2	2	1	2	2
Subjects	*CONTRET*	*CONTRISK*	*INTRESP*	*EXTRESP*	*PERSCOND*	
E1	1	0	1	1	1	
E2	1	0	1	1	1	
E3	1	0	1	1	1	
E4	1	1	1	1	1	
Comparison	0/4	3/4	0/4	0/4	0/4	
Metric	4/4	0/4	0/4	4/4	4/4	
B1	0	1	1	0	0	
B2	0	1	1	0	0	
B3	0	1	1	0	0	
B4	0	1	1	0	0	

6. Problem space variables

The problem space variables (CONTRET, CONTRISK, INTRESP, EXTRESP and PERSCOND) were encoded in binary fashion with 1 representing *at least* one

statement expressing the attribute and 0 representing no statements whatsoever. For example, E1 made *at least* one statement expressing perceived control over the returns to the decisions, but said nothing whatsoever about controlling the risk involved.

7. Results of cluster analysis

Complete results are given in Appendix B.

A simple cluster analysis using *k means*, the most widely applied nonhierarchical clustering technique MacQueen (1967), found two distinct groups in the data – it perfectly separated the entrepreneurs from the bankers.

Using a comparison metric based simply on counting the choices, we found the following: on three of the six decision variables *DECN2*, *DECN3*, and *DECN4*, there is perfect separation and *DECN5* has a 75 : 25 separation. *DECN1A* has 50% separation, and *DECN1B* appears completely unseparated. Yet if we look at the protocols for details, we find that there is at least a 50% separation here too. That is because 1A and 1B are part of the same problem and when the variance was changed in the second half of the problem, two of the four entrepreneurs changed their minds, but the bankers did not. The two entrepreneurs who changed their minds appear to be reacting to higher cumulative probabilities in Project 2 in Problem 1B while the bankers went by the expected value each time and did not change their choices.

The problem space variables are very clear. There is perfect separation in *CONTRET*, *EXTRESP* and *PERSCOND* and a 75% separation on *CONTRISK*. In *INTRESP* there is no separation whatsoever, as expected.

8. Protocol analysis

A detailed problem-by-problem summary of the contents of the protocols is given in Appendix A.

8.1. Results of the protocol analysis:(A)

8.1.1. Hypothesized problem spaces – financial risk (problems 1, 2 and 5): Risk as defined by issues of control

In the problems that involved purely financial issues, the entrepreneurs and bankers appear to have reasoned from different perspectives of control. Entrepreneurs expressed more perceived control over returns and appeared to accept risks as irreducible. They did not consider any options for controlling the risks involved. In contrast, bankers mentioned additional methods of controlling risk and practically no measures to increase returns. The entrepreneurs used the worst case scenario as a focal point. Their approach is to pick some acceptable level of risk and then push for larger profits. They seemed to select the project with the best worst case scenario – reasons were expressed in comments such as "if anything can go wrong, it will" (E1), "the market is never as good as we think it will

Using a detailed conte ancial risk problems (1, 2, and 5) within the tradi stinct representations of the problems:

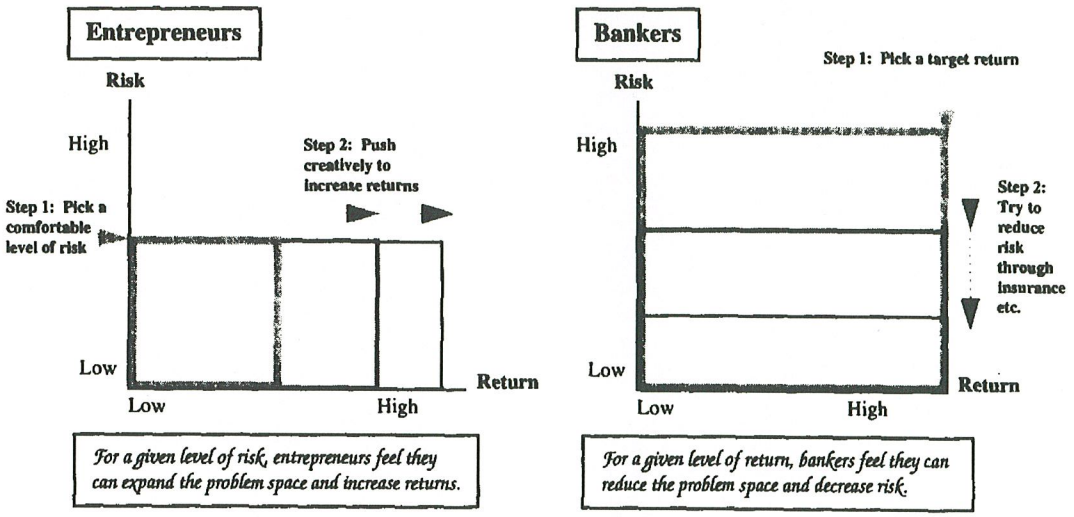

Fig. 1. Entrepreneurs feel control over returns while bankers feel control over risk.

(be)" (*E3*). They also expressed confidence that they could make the reality better than the worst case probability calculated ex-ante. "Then I push, at least as hard as I can, to get higher volumes and move towards 400 000 units" (E4).

The bankers seem to believe that they can go for the highest possible returns and somehow work on minimizing the risks. In Problem 5, suggestions include:

- Warehouse 6 months inventory to supply customers in case of flood;
- get business interruption insurance (B1);
- damage control (B3);
- invest $ 4.9M saved from buying Plot B (B4).

Using a detailed content analysis of the protocols we can study the financial risk problems (1, 2, and 5) within the traditional risk-return space. We can identify two distinct representations of the problems:

In Fig. 1(a), the light gray square represents the initial problem space of the entrepreneur – they seemed to pick a relatively low level of risk that they felt comfortable with – and then came up with suggestions as to how they would increase returns *at the same given level of risk*. They expressed ways to expand the original problem space (the light gray square) into the darker rectangles along the X-axis.

Fig. 1(b) shows how the bankers used their problem spaces. They picked a level of return that they aspired to (the light gray square) and came up with ideas to reduce the risk involved at that level. So they proceeded to collapse the original problem space (the light gray square) into the darker rectangles along the Y-axis.

8.2. Results of the protocol analysis: (B)

8.2.1. Hypothesized problem spaces – risk to human life and health (problems 3 and 4): Risk as a function of values and personal responsibility

Blomkvist (1987) wrote that one cannot risk what one does not value. Problems 3 and 4 touched some rather complex issues of values and responsibilities. In these problems, the differences in reasoning between entrepreneurs and bankers were glaring. But the explanations for the differences are not so obvious. So our representation of the problem spaces captures only the literal contents of the protocols.

In problem 3, where the trade-off was between a $ 3M option that only reduced the risk to the workers' lives due to a pipe burst but did not eliminate it, and a $ 10M option that eliminated it but could not be afforded by the firm, all entrepreneurs *rejected* the $ 3M option outright (we suggest referring to the detailed comments in Appendix A because they give a richer texture to this decision and further illuminate the differences in reasoning) and came up with creative suggestions to pay for the $ 10M option. Besides possible technical suggestions to be implemented within the firm, their suggestions included: *asking for volunteers and giving up equity* (E1); *selling to a larger company* (E3); *cooperating with competitors to increase price* (E4).

All bankers said they would go for the $ 3M option because it is better than doing nothing. They did *not* make any creative suggestions for raising the $ 10M – and considered delaying the decision (B1); being unable to make a decision given the limited information (B2); "I don't know" (B3); and "I hope I wouldn't have to make this decision" (B4). (Please refer to Appendix A for detailed comments).

In problem 4, the protocols paint a similar picture. Please refer to Appendix A for detailed comments. In this problem involving risk of cancer due to the exposure to chemicals, even though the $ 10M option was affordable, the bankers were reluctant to implement it because of its effects on profit.

The contents of the protocols do not provide detailed explanations for these choices. What is clear, however, is the fact that the bankers are extremely uncomfortable with these two problems and would do all they could to avoid finding themselves in such situations. Their discomfort is evident not only in explicitly wishing not having to make the decision, but also in several flippant comments about the loss of workers' lives: "I don't want any workers in my plant to die because I don't think it is very good PR" (B1); "I think it would probably be worth the extra $ 7M to save the other four workers, especially if he expects this is gonna happen once every ten years because over a long term we are killing a lot of people" (B4).

Thus we hypothesize that bankers do not feel compelled to solve problems such as these and perceive their sphere of control as limited to the confines of the firms whereas entrepreneurs fully accept these problems as their responsibility and seek solutions proactively both internally and externally. It appears that entrepreneurs take personal values into account while making their decisions in all the five problems (even in the relatively mundane one of choosing a plot of land to build their factory); bankers, on the other hand, seem to have given up any personal considerations at all in any of these decisions. Even the references to the risk of human life and health were in the third person – general statements like *of course one would like to save all lives ideally*, etc.

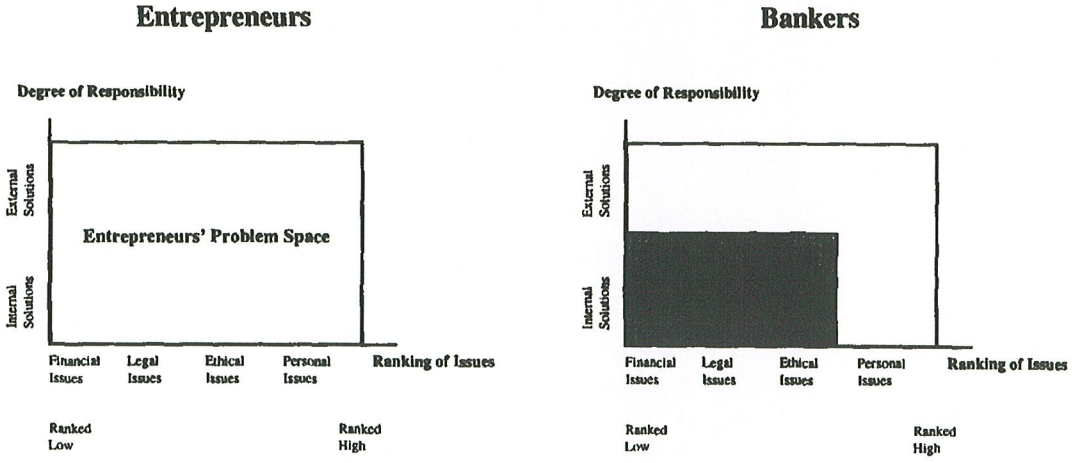

Fig. 2. Entrepreneurs use a much larger problem space than bankers.

Examples where entrepreneurs gave very clear importance to personal issues and standpoints:

- How old I was and how long I plan to work (E2 Problem 3).
- It gets into a personal issue here and this is not an investment issue now (E3 Problem 3).
- This is for me not a financial decision but plain and simple an ethics and safety decision and those tend to be simpler for me (E4 Problem 4).
- Several personal issues were mentioned in Problem 5. For example, the entrepreneurs who chose Plot A had personal reasons like sleeping peacefully at night, enjoying going to work there every day, it being a much better legacy for their children, etc.

We hypothesize the problem spaces as follows: We assume that both entrepreneurs and bankers rank the various issues involved in the same direction – i.e. financial issues are subordinated to legal and ethical considerations, and in the case of entrepreneurs personal values are overarching in their implications for every decision. Thus we can see that the entrepreneurs operate in a much larger problem space than the bankers(see Fig. 2).

9. Discussion: links with previous research

9.1. In general, how do managers make decisions involving financial risk?

Conrath (1973) intensively studied the decision-making of a certain corporation's executive committee and its staff over a long period of time. The decisions under consideration concerned whether the corporation should invest in the development of specific new products. The decision making rule predominantly used by the committee consisted of regarding any return $r<C$ (a pre-specified critical return) as a loss. Yates (1990) terms this a conjunctive decision procedure. The bankers in our study also seemed

to follow this pattern of decision-making in the problems involving financial risk. They picked a target outcome first and then considered alternatives to reduce the risk involved. In contrast, entrepreneurs picked a comfortable risk level first and then considered alternatives to increase the level of return achievable.

9.2. In general, are internal representations/problem spaces important in decision making?

For some time now, researchers in decision theory have become increasingly aware that personal representations of the decision/problem are extremely important in understanding how decisions are made and how judgments are formed. In his book "*Judgment and Decision-making*", Yates (1990) clarifies:

A broad view of virtually all real-world decision problems suggests that they evolve as indicated here:

Stage I: Discovery or generation of alternatives
Stage II: Evaluation or choice

In most scholarship on decision making, the focus has been on Stage 2 almost exclusively.... The discovery and generation of alternatives can be viewed as a representation issue.

Presented with identical decision problems, entrepreneurs and bankers use very different representations of those problems. Representations in general become particularly important in decision problems involving risks.

9.3. In general, are internal representations important to the psychology of risk perception?

Brehmer (1987) has this to say about the psychology of risk perception:

The term "perception of risk" is somewhat of a misnomer. The term perception carries the implication that there is some risk "out there" to be picked up. But the "objective risks" that are supposed to be perceived are of course not real objects, but only numbers that have been computed according to this or that formula. We do not perceive risks, we perceive various features of decision problems and this, in turn, leads to feelings of risk.

It is very clear from the present study that internal representations are crucial to understand not only how risks are perceived, but also how they are managed. In the case of problems involving risks to human life and health, bankers are unable to generate as many alternatives as entrepreneurs because their internal representation limits the space they search.

9.4. The role of moderators in internal representations of risk

We still need to understand *why* the entrepreneurs and bankers used different problem spaces (or used the problem spaces differently). Several moderators have been suggested in the literature to explain subjective representations of risk. A partial list includes experience (Hale, 1987 and Fischhof et al, 1978a), personal responsibility (Guttinger, 1984), and control (Perusse, 1980).

In our study we find that a perception of control over returns or risk, and the degree of personal responsibility and personal values moderate the representations that subjects use in constructing and manipulating problem spaces. Can experience be a moderator of these differences? It seems obvious that entrepreneurs and bankers differ markedly in their work experience and that might explain why they construct different problem spaces. But causality is not so easily determined. The evident reluctance and discomfort that bankers expressed over the problems involving risk to human life and health suggests that causality might be in fact be in the other direction. To put it differently, the differences in cognitive representation might have led entrepreneurs and bankers to choose different careers in the first place.

9.5. *Alternatives generation and creative problem solving:*

Further arguments in favor of this direction of causality (differences in thinking leading to experience rather than the other way around) can be found in the literature on alternatives generation and creative problem solving. The limited number of alternatives that the bankers considered while solving problems involving risk to human life and health, could be interpreted by studies in the alternative generation. A study by Gettys et al. (1987) illustrates that a typical individual generates only about 50% of the possible total number of alternatives in solving a problem and misses about 70 to 80% of the actual high-quality alternatives. In his book "*Value-Focused Thinking*" Keeney (1992) differentiates between *Alternative-focused thinking* and *Value-focused thinking:*

Value-focused thinking and alternative-focused thinking are not merely two different approaches for "solving" decision problems. Solving decision problems is the sole aim of alternative-focused thinking. Value-focused thinking is much broader. One of its aims is to solve decision problems, but value-focused thinking is also concerned with the identification of decision opportunities – a process sometimes called problem finding.

The entrepreneurs in our study are clearly using value-focused thinking. This also seems to be in line with the Silver (1985) thesis in *Entrepreneurial Megabucks* that entrepreneurship is more a *problem-finding* process than merely a *problem-solving* one.

10. Conclusion

All economic actors including entrepreneurs and bankers have to deal with risk and uncertainty. To that extent the question of whether entrepreneurs are risk takers or not is irrelevant. What is interesting, however, is the fact that they appear to have a discernibly distinct cognitive approach for managing various types of risk.

Entrepreneurs accept risk as given and focus on controlling outcomes at any given level of risk; they also frame their problem spaces with personal values and consequently assume greater personal responsibility for influencing outcomes.

Bankers use target outcomes as reference points and operate by attempting to control risk within the existing structured problem spaces, avoiding situations where they risk higher levels of personal responsibility.

The key for understanding how entrepreneurs perceive and manage risk lies in the problem spaces that they construct and operate upon.

Acknowledgements

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Appendix A

A.1. Problem 1 – choosing between two investment opportunities

Part One

You have some extra cash which you want to invest in projects with positive net present values (NPV). Your accountants/financial managers have calculated the cash flows of each project. After consulting with them, you have arrived at the conclusion that the projects have the following NPV's with specific probabilities for each NPV:

Project 1		Project 2	
Probability	NPV$	Probability	NPV$
30%	$ 300 000	30%	$ 10 000
40%	400 000	40%	400 000
30%	500 000	30%	800 000

Which project would you invest in? Why?

Part Two

What if the NPV's and probabilities were as follows?

Project 1		Project 2	
Probability	NPV$	Probability	NPV$
30%	$ 300 000	20%	$ 10 000
40%	400 000	60%	400 000
30%	500 000	20%	800 000

Which project would you invest in? Why?

A.1.1. Problem 1 – summary of verbal protocols

Subject	Part 1	Part 2	Reason
E1	Project 1	Project 2	Play it a little bit safer (for Part 1). Cumulative probabilities of between 4 and 800 000 are 80% (for Part 2).
E2	Project 1	Project 2	Higher consistency (for Part 1). Higher probability for 400 000 (for Part 2).
E3	Project 1	Project 1	A more conservative stance.
E4	Project 1	Project 1	How much downside I'm willing to take.
B1	Project 1	Project 1	Somebody else's money.
B2	Project 2 - Project 1	Project 1	Higher expected value of Project 2. Worst case it is 300 000 vs. 10 000.
B3	Project 2	Project 2	Higher expected value of Project 2.
B4	Project 2	Project 2	Higher expected value of Project 2.

All the E's selected Project 1 in Part 1. All B's except B1 chose Project 2 (though B2 went back and changed his mind to Project 1). B1 made a difference between investing on her own behalf and investing on behalf of her customer. She stated that personally she would select Project 2 but assuming she was investing someone else's money, she would go for Project 1. Also, E1 and E2 changed from Project 1 to Project 2 in Part 2 of the problem – none of the B's changed their preferences.

A.2. Problem 2 – introducing a new product

You want to introduce a new product. This product need not pay for any of your existing fixed expenses – it has to only take care of new fixed investment worth $ 800 000 per year. You can choose from two products A and B. Each product will sell at $ 20 a piece and will cost you $ 16 in variable costs.

After analysis by your marketing people you have used your experience and intuition to come up with the following probable demands for the two products:

Units demanded	Project 1 Probability	Project 2 Probability
50 000	0.0	0.1
100 000	0.1	0.1
200 000	0.2	0.1
300 000	0.4	0.2
400 000	0.2	0.4
500 000	0.1	0.1

Which product would you choose to introduce? Why?

A.2.1. Problem 2 – summary of verbal protocols

Subject	Decision	Reason
E1	Project 1	Combined probabilities for 300 and 400 and I'm still fairly safe if I only do 200 000.
E2	Project 1	20% probability of 200 000 units.
E3	Project 1	Higher probability of 300 000 units.
E4	Project 1	Twice the chance that I can get to my breakeven point with Project 1.
B1	Project 2	Higher probability that I get up to 400 000 and that would be a bigger profit.
B2	Project 2	Higher expected value of Project 2 and % chance of not breaking even not much greater than Project 1.
B3	Project 2	Higher expected value of Project 2.
B4	Project 2	Higher expected value of Project 2.

There is a clear dichotomy here. All the E's focused on breakeven – while the B's decided the increase in the chance of not breaking even was not high enough to give up the possible higher expected return.

A.3. Problem 3: pipe burst

Assumption 1: The product you manufacture is essential to human life.

Your industrial hygiene consultant has recommended you spend $ 3M to put a hood and special ventilation apparatus over your production area. He says that a rupture of one pipe could spill an extremely toxic chemical endangering your workers. When you question him closely, you learn that he expects the pipe would rupture less often than once every ten years, that a rupture could cause the death of 8 workers and that putting up the hood and ventilation system would mean that only 4 workers would die in the event of a pipe rupture.

A second option is that for $ 10M you could put on special pipes and enclose the area so that there is a much lower chance of a pipe burst and there would be no worker exposure if the pipe did rupture.

Should you reject both options, go with Option 1, or Option 2? What if you cannot afford Option 2? Can you suggest other options? (List any questions that you might want to ask the hygiene consultant)

A.3.1. Problem 3 – summary of verbal protocols

All the E's chose Option 2 unequivocally – they rejected doing Option 1 because it was just simply not enough and came up with proactive suggestions for what they would do if they could not afford Option 2.

None of the B's made a decision – their suggestions were doubtful and evasive. All B's said they would do Option 1 because that is better than doing nothing.

Comments on ten million dollars vs workforce safety

E1 Eliminate the possibility of death to absolute zero.
I would feel very uncomfortable, even with a process that was essential to human life, of placing workers at risk.

E2 No question – you cannot go into this project knowing that someone could die as a result of this.

E3 I can only go with Option 2. I couldn't feel comfortable internally knowing that I'm exposing workers to death because of the lack of something that I could have installed and didn't install.

E4 Not only is this a catastrophic risk to the individuals who work here but it is to the business as well because you can almost guarantee you are going to end up with some legal liability which in fact will cost you much more than $ 10M. It wouldn't make any sense to be in a business where you couldn't afford to protect your workforce.

B1 I don't want any workers in my plant to die because I don't think it is very good PR.

B2 You can't put a value on human life – I'd probably contradict myself in a couple of sentences.

B3 If you're going to spend $ 3M for 4 workers, you're certainly not getting your money's worth by spending the $ 10M for Option 2.
I mean, of course you'd love, ideally you wanna save all workers but it just seems to me that the second option brings you double the cautiousness for more than double the cost.

B4 I think it would probably be worth the extra $ 7M to save the other four workers, especially if he expects this is gonna happen once every ten years because over a long term we are killing a lot of people.

Suggestions if you could not afford Option 2

E1 Ask for volunteers.
Make a cheaper mechanism for protection.
Give up equity to raise money.

E2 Exit the business?
Sell to a larger company who can afford to build protection.
Verify the consultant's data – has this occurred anywhere else? When?
Did they have similar equipment – how old was their equipment, etc.

E3 Reduce the cost of the product and increase the price to raise funds for Option 2.
This should be doable because competitors will also be in a similar situation.

E4 Replace pipes of tener – preventive maintenance.
Exit the business.
Get together with others in the industry and raise the money.

B1 Separate the toxins from the chemicals.
Replace pipes more often.
Special masks.
I wouldn't make a decision yet.

B2 Check whether there is a payback in insurance.
If I can't borrow to afford it I don't know.
Mentioned 'limited information' 5 times.

B3 I might go for Option 1 or I might go for replacing the pipes.
"I don't know" – thrice.
"That's a strange one" – twice.

B4 Definitely do the first (Option 1).
I hope I wouldn't have to make a decision like this.

A.4. Problem 4: risk of causing cancer

You have just purchased a plant that makes synthetic rubber. Your partner is an industrial hygienist and does a complete survey of the facility. He discovers that production process leaks small amounts of benzene (a cancer causing chemical) into the air. Of the 500 workers in the plant, he estimates that one will get cancer from breathing benzene for every five years of production. It would cost $ 10M to lower the leaks of benzene to a level where there would be one cancer for every 20 years of production. He also tells you that if the regulators inspect for benzene levels, they will fine you $ 50 000 and shut down the plant until you have completed repairs. If this happens, any worker with cancer might sue you; even workers who don't have cancer might be able to collect money from you. However, he thinks it is unlikely that the plant would be inspected during the five years you expect to own the plant. He also tells you that if you put workers in the production area for no longer than one year, there is a much lower chance that any would get cancer from the exposure.

Should you:

1. Pay $ 10M to lower the amount of benzene leaks?
2. Rotate workers through the production process?
3. Ignore the problem until the regulators find you and shut down the plant?

A.4.1. Problem 4 – summary of verbal protocols

All subjects (both E's and B's) rejected Option 3 of ignoring the problem till the regulators found out.

All the E's decided they would implement Option 1 *and* rotate the workers. All of them expressed concern about the residual exposure of one worker getting cancer in twenty years. Except E1 they came up with additional courses of action such as:

E1 None.

E2 Check purchase contract of the plant and see if the seller is liable for the benzene leaks and can be made to pay the $ 10M.

E3 Make workers aware of the risk.

E4 Talk to the agencies proactively to find better solutions.

The B's felt the $ 10M option was too expensive – some comments were:

B1 I'm not real crazy about putting $ 10M out (Twice). Rotate workers every couple of months – in the mean time see if we can't find some cheaper way of getting rid of the benzene.

B2 Do Option 1 in stages (did not specify how).

B3 People suing and fines could add up to a substantial amount. So I guess I'd have to look seriously at number 1. That's kinda another touchy-feely one. I probably could talk about this forever.

B4 Today you would want to fix these things because, at least from my understanding of them people will come back to you. Rotate workers first. If that didn't work, then the ten million bucks (did not specify how to decide rotating doesn't work)

A.5. Problem 5: flood plain

You are searching for land to build your factory. Your expected sales per month are around $ 1M. Plot A is in a beautiful location and sells for $ 5M. Plot B is located in the flood plain near the river; it sells for $ 100 000. Plot B is just as good a location as Plot A, but about 1 year in 100 it will be flooded, stopping production for 6 months and costing you $ 10M to repair the damages. If you buy Plot B, you can purchase flood insurance that will pay $ 9M if the plant is flooded. The insurance will cost you $ 200 000 per year. You figure that having the plant shut for 6 months would cost you a great deal of customer good will and that some sophisticated customers might not want to order from you knowing that their supply was vulnerable to a flood. The last floods occurred about 50 years ago.

Should you buy Plot A or Plot B? If you buy Plot B, should you buy flood insurance?

A.5.1. Problem 5 – summary of verbal protocols

Subject	**Decision**	**Reason**
E1	Plot A	Customer goodwill+personal reasons.
E2	Plot A	Resale value+personal reasons.
E3	Plot A	Customer goodwill+personal reasons.
E4	Plot B	Debt/Equity Ratio – assumed did not have the cash.
B1	Plot B	Looks like its such a good buy.
B2	Plot A	Assumed it costs $ 1M instead of $ 5M.
B3	Plot B	The numbers probably say you should buy Plot B.
B4	Plot B	Only one is a 100 chance its gonna flood.

E4 assumed that he did not have the cash, felt there was not enough information about the profit margins and decided to buy Plot B till the business grew to a point when he could move out of the flood plain. B2 assumed Plot A cost $ 1M instead of the 5 M mentioned in the problem (apparently he was given the copy of the problems used by the

Table 3

Variable	Between SS	DF	Within SS	DF	F-ratio	Prob
DECN1A	0.50	1	1.00	6	3.00	0.13
DECN1B	0.00	1	2.00	6	0.00	1.00
DECN2	2.00	1	0.00	6	..	..
DECN3	2.00	1	0.00	6	..	..
DECN4	2.00	1	0.00	6	..	..
DECN5	0.50	1	1.50	6	2.00	0.21
CONTRET	2.00	1	0.00	6	..	..
CONTRISK	1.13	1	0.75	6	9.00	0.02
INTRESP	0.00	1	0.00	6	..	..
EXTRESP	2.00	1	0.00	6	..	
PERSCOND	2.00	1	0.00	6	..	.

Table 4

Cluster number: 1

Members			Statistics				
Case	Distance	|	Variable	Min.	Mean	Max.	Std. Dev.
E1	0.18	|	*DECN1A*	1.00	1.00	1.00	0.00
E2	0.18	|	*DECN1B*	1.00	1.50	2.00	0.50
E3	0.18	|	*DECN2*	1.00	1.00	1.00	0.00
E4	0.35	|	*DECN3*	2.00	2.00	2.00	0.00
		|	*DECN4*	1.00	1.00	1.00	0.00
		|	*DECN5*	1.00	1.25	2.00	0.43
		|	*CONTRET*	1.00	1.00	1.00	0.00
		|	*CONTRISK*	0.00	0.25	1.00	0.43
		|	*INTRESP*	1.00	1.00	1.00	0.00
		|	*EXTRESP*	1.00	1.00	1.00	0.00
		|	*PERSCOND*	1.00	1.00	1.00	0.00

Cluster number 2

Members			Statistics				
Case	Distance	|	Variable	Min.	Mean	Max.	Std. Dev.
B1	0.23	|	*DECN1A*	1.00	1.50	2.00	0.50
B2	0.31	|	*DECN1B*	1.00	1.50	2.00	0.50
B3	0.23	|	*DECN2*	2.00	2.00	2.00	0.00
B4	0.23	|	*DECN3*	1.00	1.00	1.00	0.00
		|	*DECN4*	2.00	2.00	2.00	0.00
		|	*DECN5*	1.00	1.75	2.00	0.43
		|	*CONTRET*	0.00	0.00	0.00	0.00
		|	*CONTRISK*	1.00	1.00	1.00	0.00
		|	*INTRESP*	1.00	1.00	1.00	0.00
		|	*EXTRESP*	0.00	0.00	0.00	0.00
		|	*PERSCOND*	0.00	0.00	0.00	0.00

previous subject who, after completing the protocol, had discussed the possibility of making it one million and had changed the number 5 to number 1). All subjects who decided to buy Plot B decided to buy flood insurance. The E's who chose Plot A had personal reasons like sleeping peacefully at night, enjoying going to work there every day, it being a much better legacy, etc.

Appendix B

Results of Cluster Analysis

Summary statistics for 2 clusters – Tables 3 and 4

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