

# ***The Influence of Cognitive Bias on Risk Decision-making under Uncertain Conditions: A Case Study of 1986 Challenger***

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**Abstract:** Decision-making is full of our lives, but any decision is risky. Every single decision-making mistake may bring losses that are unpredictable. How to make rational decisions and reduce the decision loss is the hot topic in discussion. Although the cognitive biases have been widely studied in many fields, the mechanism of each cognitive bias's impact on risk decision-making has not been fully researched. In addition, the relevant risk decision research is mainly focused on the financial management, and the relevant theories have not been applied to the risk decision in daily life. Therefore, this paper will focus on 3 types of cognitive biases including confirmation bias, overconfidence and frame effect. After researching related theories, expected return and risk perception are considered as two main intermediates between cognitive biases and risk decision-making. And then the paper will apply relative theories and analyze 1986 Challenger launch decision case to explain the way cognitive biases acting on risk-decision making behaviors. Finally, the paper will give reasonable suggestions for both individuals and groups to make better risk decision and reduce decision errors.

**Keywords:** risk decision-making, cognitive bias, 1986 challenger launch decision

## **1. Introduction**

Decision-making usually refers to making choices and decisions in many possibilities. The school of decision theory represented by Herbert Simon first systematically explains the principle of decision-making, puts forward the key opinion that "decision-making runs through the whole process of management, and management is decision-making", and came up with bounded rationality model [1]. But the fact is decision not only exists in management, daily decision always contains a variety of uncertain factors and leads to risk decision-making. Under uncertain conditions and incomplete information, after making decision we should always bear the risk of loss the decision may bring. Therefore, how to reduce decision error as far as possible, improve individual or group risk decision-making ability is crucial.

According to Simon's limited rationality theory and related literature research, the cognitive psychology of decision-makers will exert influence on the risk decision-making behavior [1]. Since each individual's cognitive ability for information is limited, actions of decision-making will be

affected by their knowledge, experience, thinking patterns and other factors. Decision makers are very prone to cognitive bias [2]. However, there are few studies about risk decision behavior from the perspective of cognitive bias. And the risk decision-making behavior mostly focuses on the financial and management. The purpose is to improve the decision-making ability of managers and optimize decision-making systems of enterprises to deal with risks instead of focusing on non-managers. Therefore, this paper will take the 1986 Challenger launch decision as an example exploring the link between cognitive biases in the case (confirmation bias, overconfidence and frame effects) and risk decision-making behavior from the perspective of cognitive psychology. Try to propose reasonable suggestions to to improve individual and group risk decision-making ability and reduce unnecessary losses.

## 2. Literature Review

### 2.1. Cognitive Bias

Cognitive bias refers to the deviation in people's understanding of information and things due to each person's different experience, thinking and emotion. This phenomenon is called cognitive bias due to personal cognition. However, people often do not make a perfect decision from a rational perspective [3]. Meng summarized that when making decision individuals are difficult to be completely rational, it is easy to produce cognitive bias [4]. Zheng Yuming et al. divided cognitive bias into heuristic bias, attribution bias and reasoning bias according to the research field and direction [5]; And then, Kahneman & Tversky summarizes three typical heuristic biases, namely representational bias, availability bias and anchoring effect [6] Domestic researchers extended the field of cognitive deviation to psychology, behavioral economics, management and even engineering. For example, Zhang Zhihui, He Yi and Li Yang made a thorough study on the formation of public risk cognition deviation in the Three Gorges Project and put forward a series of strategies to eliminate cognitive biases [7]; Tan Congmin applied cognitive deviation to automobile sales and analyzed consumers' purchasing psychology to improve car sales [8].

It can be seen that the field of cognitive bias continues to extend and has important guiding significance for improving the quality of decision-making. Whereas, there are few studies related to cognitive bias and risk decision-making which is still at early stage, so the study has certain practical value.

### 2.2. Confirmation Bias, Over Confidence and Frame Effect

The school of decision theory represented by Herbert Simon systematically explains the decision principle and proposes bounded rationality theory. He points out that people may choose a basically reasonable "satisfactory" decision instead of "optimal" one [1]; The research of Zhu Huagui, Zeng Xiangdong shows that frame effect, representative bias and overconfidence play an important role in behavior decision under crisis [9].

Therefore, this paper mainly selects three types of cognitive biases: confirmation bias, overconfidence, frame effect as research objects. The definition of three kinds of cognitive biases are as followed based on previous domestic and foreign literature:(1) Overconfidence refers to that decision makers often believe too much in their judgment and the accuracy of their information because of the right decisions in the past, and overestimate the correctness of their decisions. (2) confirmation bias refers to the tendency for people to search for, interpret, believe, and recall information that confirms their beliefs or upholds their values. (3) Frame effect refers to that decision makers making decisions are influenced by the way of the problem description. In the framework of benefit, people will have the tendency to avoid risk, while in the framework of loss, people will have the tendency to chase risk [10, 11].

### 2.3. Risk Decision-making

Risk decision making is a kind of decision behavior related to “risk” and “uncertainty”, namely, decision behavior under risk and uncertain conditions [11].

Yates and Stones suggest that risk consists of the following three elements: loss, the importance of loss and the uncertainty of the connection between losses. Normally, the more important loss is, the greater the risk will be. The uncertainty of the loss includes the uncertainty of risk-taking behavior, the loss category and the uncertain level [12]. From the psychological point of view, risk is the analysis and assessment of the likelihood of loss. According to the expected utility theory, in the risk situation, the decision maker evaluates various possible results and calculates their expected utility. The purpose of the decision maker is to maximize the expected utility, so the alternative scheme with the maximum expected utility value is his final choice. Bounded rational theory holds that people choose the most satisfactory decision when making decisions instead of finding the only correct answer after complex and accurate calculation [1]. And prospect theory believes that the risk decision-making process includes the editing and evaluation stages [6].

### 3. Theoretical Analysis of Cognitive Bias on Risk Decision-making

After reviewing the relevant literature, this paper will take risk-benefit model proposed by Weber et al as the theoretical basis. The formula is: risk preference = a (expected return) + b (perceived risk) + c. It indicates that the risk preference of the decision maker is influenced by two factors: expected return and risk perception [13]. Prospect theory also points out risk preference is determined by the gap between expected return and real result, which shows the close relation between expected return and risk preference [6]. At the same time, risk perception includes the evaluation of the likelihood of risk behavior occurring as well as the subjective evaluation of negative outcomes. Individuals will not choose to chase risks if they have a high perception of risk, which can prove risk perception can directly reflect people’s risk preference [14].

In conclusion, we can conclude that expected return and risk perception are the two important factors affecting individual risk decisions.

At the same time, this paper holds that confirmation bias, overconfidence and frame effect will respectively affect expected return and risk perception, and then influence the risk preference of decision makers. The main theoretical basis is as follows: Meng Tian concluded through empirical research that risk perception plays a completely intermediary role in overconfidence and risk decision making. And the frame effect affects the decision preference of decision makers [10] by influencing risk perception; Kahneman et al. argue that the framework effect is universal, Different forms of editing information by different people will affect the of decision makers’ expected earnings [15].

According to the above literature, this paper believes that overconfidence influence the decision maker’s judgment on risk perception and then influence the risk decision; the frame effect affects the risk preference of the decision maker by influencing the decision maker’s judgment on the expected return; and confirmation bias exert impact on both expected return and risk perception.

### 4. Case Study: 1986 Challenger Launch Decision

On 28th January 1986, the Challenger Space Shuttle exploded over the Atlantic Ocean just 73 seconds after taking off, killing all 7 crew members. The very low ambient temperature at launch had caused two rubber O-rings to leak, allowing hot gasses to escape from the aft field joint of the right solid rocket motor. These gasses struck the external tank, resulting in the catastrophic explosion of this 25th shuttle flight. This Shuttle Accident obviously astonished the world at that moment. [16]

Both external factors and individual cognitive biases contribute to this shuttle catastrophe. The external impact of the accident cannot be ignored. The political, social and organizational pressure

exerting pressure on individuals, which causes the individual cognitive biases, has great impact on the decision-making process. Geo-political factor often refers to the space race between USA and USSR. In early 80s, America implements “strategic defense initiatives” against the Russia’s “Buran-Energia” space shuttle and USA Challenger shuttle is the prominent program. Secondly, from the social perspective, manned spaceflight is tightly related to the national pride and symbolizes national success and progress. As for the organizational context. NASA and Morton Thiokol are the prominent stakeholders of this launch, which involved three different interest groups: NASA managers who try to avoid embarrassment and don’t want to lose image; MT managers are concerned about not disappointing its major client, and the MT engineers concerned about a technical issue, whether the O-rings can perform normally under 53F. Before the launch. The fact is, before the launch, NASA and Morton Thiokol (MT) officials had participated in a teleconference to discuss the postponement of the Challenger as the temperature is lower than 53F and O-rings probably lose its elasticity causing awful consequence [17]. The final approval of the launch fully reflected the cognitive biases among three parties. Next, the paper will analyze three cognitive biases during the teleconference and explain the mechanism on risk decision-making.

## 5. Cognitive Biases in the Case

### 5.1. Confirmation Bias

The paper believes confirmation bias will affect both the capacity of perceived risk and expected benefit. It will decrease their perception of risk and overstate the potential benefit, and then increase the probability of risk decision-making.

In the Challenger case, no matter the NASA managers, MT managers or MT engineers, they are all affected by the “Tunnel vision”. That means they always tend to search for information that suits their preexisting beliefs and normally reject to the contradictory evidence. Besides, instead of reflecting on their bad decision, they will find more evidence to support their presupposed opinion even though it was wrong until convince themselves.

Under a lot of social pressure, the teleconference becomes a “win-lose” contest, a political “battle” to convince instead of an open discussion to solve a problem. Larry Molly is the representative of NASA managers. To avoid losing face, he had decided to launch before the discussion, and during the entire teleconference he tried to find sufficient evidence to support its opinion and overrule Roger Boisjoly’s suggestion on postponement. As Roger said, “...this was a meeting where the determination was to launch, and it was up to us to prove beyond a shadow of a doubt that it was not safe to do so. This is in total reverse to what the position usually is in a preflight conversation. It is usually exactly opposite of that.” Therefore, even though Roger gave telefaxing copies of the relevant materials to support his standpoint. He questioned the quality of data and said “we should go by our experience base as limited as that is instead of collecting quantifiable data.” The confirmation bias decreases Molly’s perception of risk because he decides to ignore the probability of risks and sidestep disastrous consequences of the unsuccessful launch. As the result, Molly’s confirmation on launch leads to the horrible explosion.

Actually, not only the Molly, even the engineer who didn’t want to launch affected by the confirmation bias which also causes their failure in persuasion of the launch. When they were asked to provide evidence to support the direct relationship between O-ring performance and cold temperature. They only show the plot with incidents of O-ring thermal distress as function of temperature that illustrates the most frequent incidents happened in 75F instead of 53F. They didn’t realize that they should be looking at the data for launches when the O-rings didn’t fail because flights with no incidents concentrated around 70F. So, they were questioned by NASA managers Larry Molly, who said the charts and data they provided didn’t show the direct relationship between O-ring

performance and cold temperature. They were so confirmed their judgment based on their practical experience that ignored the incompleteness of the data and optimistically expected the NASA managers would agree with him. The engineers overrated the return of unqualified evidence and didn't prepare more credible evidence to support their opinion. Finally, they lost their voice in discussion.

## 5.2. Overconfidence

The paper believed overconfidence will affect the perception of risk. It will overlook the probability of risk and increase the probability of risk decision-making.

Tversky finds that overconfidence occurs when people tend to make a difficult decision [6]. And people are more likely to overestimate their ability to fulfill the goal if they are at stake. Plus, according to Russo and Schoemaker, people with rich experience and knowledge are less likely to be overconfidence. Instead, those lack of expertise always tend to make overoptimistic decision. [18]

NASA managers are less skilled in O-rings compared to MT engineers, but actually they all have technical degree. A certain level of professional knowledge and experience gives them the speaking right to question the expertise of MT engineers as they cannot give convincing evidence to prove the direct relationship between temperature and performance of O-rings. The more emotional MT engineers are to prove they are right, the more confidence the managers are to believe themselves. The overconfidence shows itself to a great extent.

What's more, NASA managers focus on the likely benefits of the project and tend to ignore the potential risks during the discussion. The successful launch will prove its strength and attract more investment. Since NASA is a civilian space exploration program, it faces financial constraints over time and struggles against extra costs of multiple delays. The immediate successful launch was required at the moment. More importantly, the space shuttle Challenger is the prominent project and it has launched 9 successfully on end. What's more, erosion was considered as a normalized risk which was "unavoidable" and becomes an acceptable flight risk.

All of these factors increase the managers' confidence. The disillusion of success leads them neglect pitfalls of risks. It reduces the managers' risk awareness of severe consequence leading to the tragedy.

## 5.3. Frame Effect

The paper believed framing effect will affect expected return. Kahneman et al. believe that the framework effect is universal, and different editing forms of information by different people will affect the judgment of decision makers on the expected return [6]. Therefore, in the Challenger case, different stakeholders will form different frames, which will lead to different expectation of return. And according to Tversky and Kahneman, in the frame of benefit, people will have the tendency to avoid risk, while in the framework of loss, people will have the tendency to chase risk [6].

There are three different groups at stake. It has been fully discussed the conflicts between NASA managers who try to avoid embarrassment and don't want to lose the image and the MT engineers who concerned about a technical issue. In this section, we will mainly focus on MT managers who changed their attitude from opposing to supporting. This transformation indicates the effect of loss framing on it.

At very beginning, Bob Lund, as the MT engineering manager, at first firmly said his only concern is extreme temperature tomorrow morning launch. And they will not allow the launch when the temperature was under 53F. At that moment, MT managers listen to the knowledgeable experts' suggestions and consider the probable severe aftermath. If the launch fails, it will not only damage the company's interest and reputation, but also loss of 7 lives if exploded. The loss frame casts the

shadow of the MT managers. During 5 hours' heated discussion between MT and NASA. Lawrence Mulloy, NASA solid-rocket booster manager at Marshall Space Center, was particularly angered by the prospect of postponement, which had already been made three times. Finally, NASA won the debate and decided a compulsory launch. At that moment, MT managers requested a 5-minute discussion among chief executives within the company. The discussion actually lasted for 30 minutes and MT engineers including Roger Boisjoly were excluded. "We have to make management decisions. The vice president of MT asked Lund to take off the technology hat and put on the management hat. Roger Boisjoly noticed that managers have changed their decision to cater to their major client NASA. Under the loss frame, if not launch, they will disappoint and lose NASA, if launch, there is risk of failure but still has potential to succeed. After balancing the expected return, MT managers choose to chase the risk and decide to launch Challenger [19].

## 6. Suggestion

### 6.1. Confirmation Bias

Numerous studies find that almost everyone will suffer from confirmation bias when making decisions, so the methods to counteract "confirmation bias" are meaningful and worth learning in order to reduce loss of risk decision-making. Firstly, decision makers should actively look for information that might challenge their original beliefs. Acquiring all-sided information can help escape the one-sided view of things or events, which will increase your perception of risks and reduce decision errors. Secondly, check whether all evidences are examined with equal rigor, the more strictly people check the evidence, the more likely they make the right decisions; Thirdly, ask a respected colleague to argue against the potential decision. If other people have different experience or expertise from you, you are more likely to comprehensively scrutinize the present decision from another perspective. Fourthly, avoid "yes-men" . Try to criticize every opinion no matter it is in line with yours or not. In order to make a rational and right decision, following others' opinion should be avoided, or else it is easy to get stuck in group thinking [20].

### 6.2. Overconfidence

It can be concluded that overconfidence will increase people's expected return and further influence people's risk decision-making. On the one hand, individuals should try to offset overconfidence. Firstly, fixing overconfidence requires decision makers be adept at listening. By putting yourself in others' shoes, your ignorance can be recognized when stepping out of your own cognitive box. On the other hand, acquisition of 360-degree feedback from others can also be beneficial. Other people's feedback like mirrors which can reflect individuals' shortcomings and help timely adjust biased judgement. On the other hand, individuals can increase their perception of risks by participating in group decision. An effective group will produce diverse opinions and pull overconfident individual back in the right track. Both potential benefits and risks will be incorporated into discussion, which can decrease the probabilities of bad risk-decisions.

### 6.3. Frame Effect

As frame effect will influence the expected return, the effect of frame can be fixed in two phases. Firstly, before the forming of frame decision makers should pay attention to the "input" "lock" "procession" of the information. Information should be selected and reflected truthfully during the inputting period. Next, when issues are presented before individuals, the description should not be locked in one way. That means proactively change from negative frame to positive one can help us become risk aversion. At last, it is obvious that different people will have different reactions when

processing the similar or even same information. Individuals' knowledge played the paramount role in cognition. Just try to enrich your knowledge to transform unknown unknowns into known unknowns as soon as possible. Trial-and-error learning can be the optimal method to obtain more knowledge.

Another way to avoid risk is to reduce the expected return. And most people have a high expected return because they set unreasonable goals which will make them tend to make risks. Making realizable and applicable plans is significant. There needs to be a balance between goals and reality. A prudent and challenging goal can motivate people's desire to achieve it and can also limit their ambition within reasonable bounds.

## 7. Conclusion

The research collects the related documents and studies, we come to the following conclusions:

(1) Confirmation bias will affect both the capacity of perceiving risk and expected benefit. It will decrease their perception of risk and overstate the potential benefit, and then increase the probability of risk decision-making.

(2) Overconfidence influence the decision maker's judgment on risk perception by influencing the decision maker's ability to process information, and then influence the risk decision;

(3) Frame effect affects the risk preference of the decision maker by influencing the decision maker's judgment on the expected return;

And paper further explained the mechanism how these cognitive biases work on expected return and perception of risk, and then exert impact on risk decision-making.

The paper makes up the deficiency of researches on the relationship between cognitive biases and risk decision-making. It focuses on individuals' psychological factors to improve the quality of risk decision, which will help not only companies' managers to make better strategic decision, but every ordinary people to become a more rational decision maker.

The present studies and documents about cognitive biases and risk decision-making are rare. There are limited studies focusing on the mechanism of action between cognitive biases and risk decision-making. Researches of risk decision-making mainly concentrate on financial and management. Therefore, the paper mainly draws theories and opinions from emergency management and enterprise decision-making risk behavior. The theoretical research models quoted are scattered and incomplete. Second, there are only three cognitive biases analyzed in the paper. More biases are needed to be studied carefully to explain the mechanism acting on risk decision-making. Thirdly, the reasonable relationship between cognitive biases and risk decision-making is based on the literature review of related studies. The paper lacks some empirical researches to sufficiently support these opinions.

According to the research limitations of the above analysis, subsequent studies will focus on more cognitive biases, exploring more provable factors between cognitive biases and risk decision-making. And the article will seek to adopt the empirical research method and case study to analyze the variables and consider more influencing factors to perfect theoretical research model.

Although this study has various shortcomings, we hope that this study can play an enlightening role in theoretical exploration and provide new research directions and ideas for other scholars in this field.

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