LECTURE NOTES: EMGT 234

HOW SAFE IS SAFE ENOUGH?

SOURCE:

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1. INTRODUCTION

Common Headlines:

1. "Are Nuclear Power Plants Really Safe?";
2. "11,000 Industrial Waste Disposal Sites a Hazard to U.S. Citizens" ;
3. "Saccharin May Cause Cancer"

Examples lead to the question: **"How safe is safe enough?"**

Aim :
Provide characterization of the problem,
realizing that no universal agreement may exist.

Explain the problem by:

- defining the essential ingredients
- discussing generic features complicating these problems,
- discussing types of "solutions" that are appropriate.
- identifying types of "solutions" that are not appropriate.
- Discussing complicating characteristics, such as;

1. complicating social, political, and ethical features that limit the usefulness of analysis;

2. the role of regulatory agencies in determining acceptable risk.

2. WHAT IS ACCEPTABLE RISK?

- Determining "How safe is safe enough?",per se, is not a problem. Therefore, it does not have an answer.

- Rather "How safe is safe enough?" is a catchy phrase to identify a component in many complex socio-technical decision problems.

The answer in **any particular problem** depends **on many things**.

Definition of Risk:

The possibility of consequences involving mortality, morbidity, or injury to members of the public.

"How safe is safe enough?":

- Addresses the acceptability of risks from using technology that may endanger the safety of the public.

- Needs to address both technical and social aspects in the answer.

Acceptable Risk is defined by a decision among alternatives i.e. by choosing the best combination of advantages and disadvantages among several alternatives.

Explanation:

1. The particular decision problems have at least one disadvantage: safety risks to the public.

2. Less risk is always better than to more risk if all other consequences were held fixed. However, this is never the case.

3. In selecting the alternative, the various pros and cons should be weighed in some responsible manner.

4. The level of risk associated with the chosen alternative is then, by definition, acceptable.

5. In a situation with no alternatives, the level of safety associated with the only course of action is by definition acceptable, no matter how disagreeable the situation.

"The risk associated with the best alternative is safe enough."

Possible source of confusion:

Acceptable risk is not necessarily the level of risk with which we are happy.

3. SOME NOTIONS RELATED TO ACCEPTABLE RISK PROBLEM

- One Alternative = No-go option

Example: Nuclear Power or not?

- Public safety may be threatened through direct or indirect effects of the alternatives.

Example:

Close nuclear power plants and all coal power plants

↓

Direct safety risk = 0

However, what is the indirect risk of **no energy?**

- Acceptable Risk problem domain may include governmental and institutional activities.

Example:
Acceptable Risk Problems addressed by the FDA may need to include the nation's transportation systems, medical facilities, and work places (factories and office buildings).

- Most large-scale problems involve both technological and social concerns, a choice of alternatives, and the possibility of risk to the safety of the public.

Special case of General Problem:

Advantages of each of the alternatives are equal

Alternatives differ only by their disadvantages e.g. costs and risk.

Best Alternative = Best Combination of costs and safety.

Example:

After decision to build nuclear plant, the major questions are where to build it and how to design its safety features.

4. ADDRESSING THE ACCEPTABLE-RISK DECISION PROBLEM

- "Acceptable Risk Analysis" should be prescriptive analysis i.e. the analysis helps identify how safe the chosen alternative should be.

- "How safe is safe enough?" is not the same as determining how safe various alternatives are.

5 Interdependent Steps in complete analysis process of any decision problem:

1. Define the alternatives.

2. Specify the objectives and measures of effectiveness to indicate the degree to which they are achieved.

3. Identify the possible consequences of each alternative.

4. Quantify the values for the various consequences.

5. Analyze the alternatives to select the best choice.

Conclusion:
Thus only Step 3 analyses the safety of the various alternatives. Step 3 also analyses benefits and other costs.

5. THE ANSWER TO THE PROBLEM

"How safe is safe enough?" depends on the 5 steps above.

↓

Will show that Acceptable Risk is determined by:

1. What alternatives are available,
2. What objectives must be achieved,
3. The possible consequences of the alternatives,
4. The values (tradeoffs) to be used.

Assumption Figure 1:
Benefits are identical for all alternatives. The differences among alternatives are in cost & risk .

Figure 1A:

1. Alternatives :

- K=High Cost, Low Risk
- L=Low Cost, High Risk

2. Acceptable Risk :
The Risk associated with best alternative, K or L.

3. Add Alternative M :
M lower in both Risk and Cost compared to both K and L

↓

Acceptable Risk Level is now level associated with M.

Conclusion:
Acceptable Risk Level depends on available alternatives.

Figure 1B:

1. Alternatives :

- K=High Cost, Low Risk
- L=Low Cost, High Risk

2. Objectives:

Minimize Risk

↓

Alternative K = Best Alternative

↓

Acceptable Risk is K level.

Minimize Cost

↓

Alternative L = Best Alternative

↓

Acceptable Risk is L level.

Conclusion:

Acceptable Risk Level depends on chosen objectives.

Figure 1C:

1. Alternatives :

- K=High Cost, Low Risk, L=Low Cost, High Risk
- M with new consequence levels due to new information

2. Acceptable Risk :

The Risk associated with alternative K or L.

Conclusion:

Acceptable Risk Level may change depending on the consequences.

Figure 1D:

1. Alternatives :

- K=High Cost, Low Risk, L=Low Cost, High Risk

2. Tradeoffs :

- Case 1: Indifference Curve: Incur large costs to reduce risk by small amounts.
- Case 2, Incur less costs to reduce risk by small amounts Alternative L Acceptable Risk is L level.

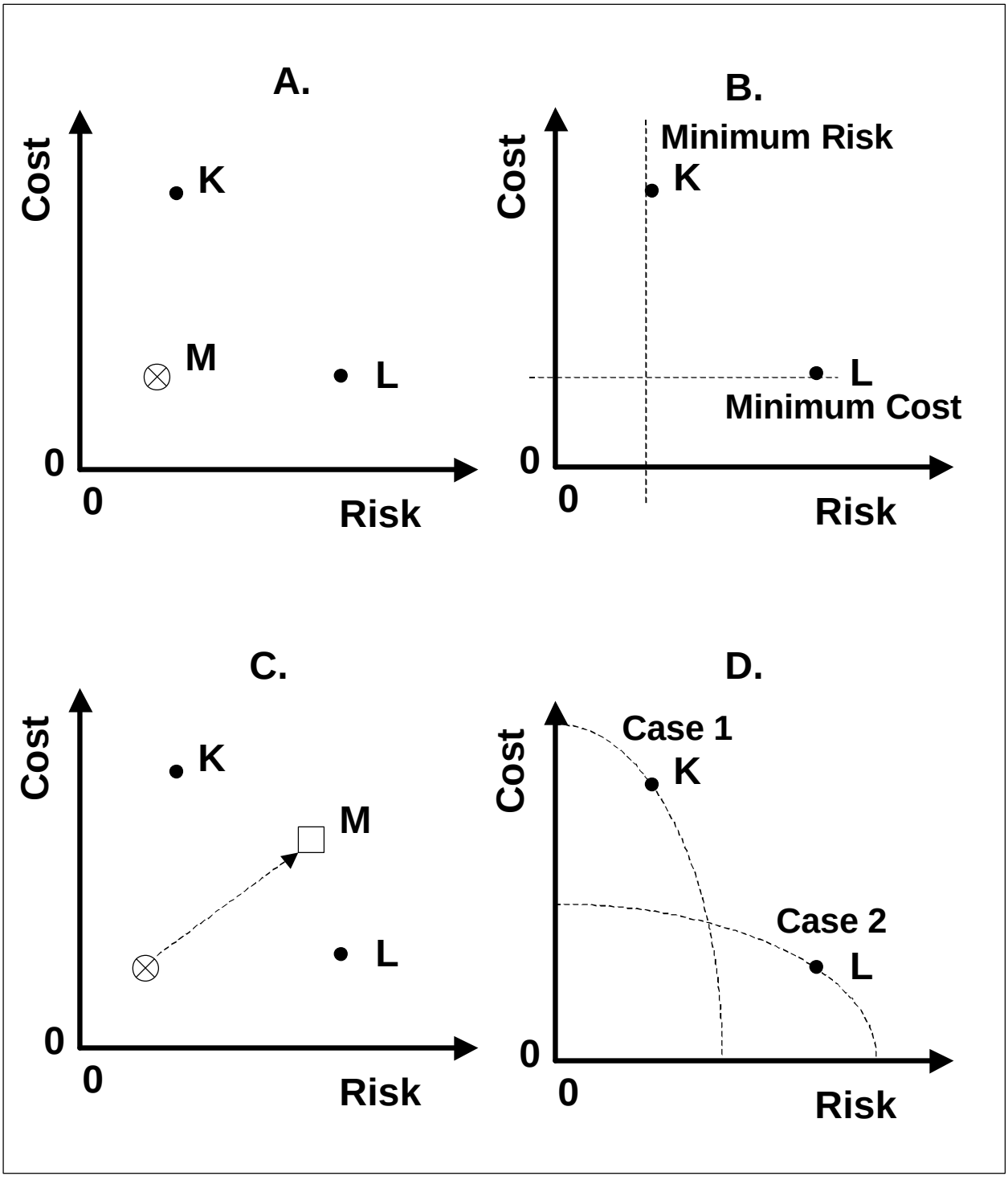
3. Acceptable Risk:

- Case 1: Risk associated with K, Alternative K is best alternative.
- Case 2: Risk associated with L, Alternative L is best alternative.

Conclusion:

Acceptable Risk Level changes with Values and Preferences.

Figure 1. Acceptable Risk depends on Many Factors



6. WHAT THE ANSWER IS NOT

- Many oversimplified "solutions" have been suggested due to complexity of the problem and the "confusion" that "How safe is safe enough" in itself is not a problem, e.g.

"no risk to safety should be tolerated"

- There are no Alternatives are not available that have no risks.

Example:
Laboratory testing gave regulators justification to ban saccharin. However,

Saccharin ⟶ Causes cancer.
No saccharin ⟶ Causes Risk to diabetes patients.

Figure 2a: "no risk to safety should be tolerated"

Alternatives :

- A = High Cost, Zero Risk
- B = Low Cost, A + epsilon =Very Small Risk

Conclusion :
The minute ↑ risk may be worth the large ↓ in cost.

Figure 2b:"As safe as possible"

Alternatives :

- C = High Cost, Certain level of Risk
- D = Low Cost, Risk of C +epsilon

Conclusion :
The minute ↑ risk may be worth the large ↓ in cost.

Figure 2c:"Risk is acceptable when below a threshold level of e.g 10^{-7} per year"

Alternatives :

- E = High Cost, Certain level of Risk
- F = Low Cost, Risk of E +epsilon

Conclusion :
The minute ↑ risk may be worth the large ↓ in cost.

Other Reason:

Chance of 1 in 10000 when 10000 people are exposed
Chance of 1 in 10 when 10 people are exposed

- Both Instance have same frequency of annual mortality but may be viewed differently by society.
- In other words, you can not establish a threshold on annual frequency of mortality to answer "how safe is safe enough".

Figure 2d:"One tradeoff weight for risk to cost"

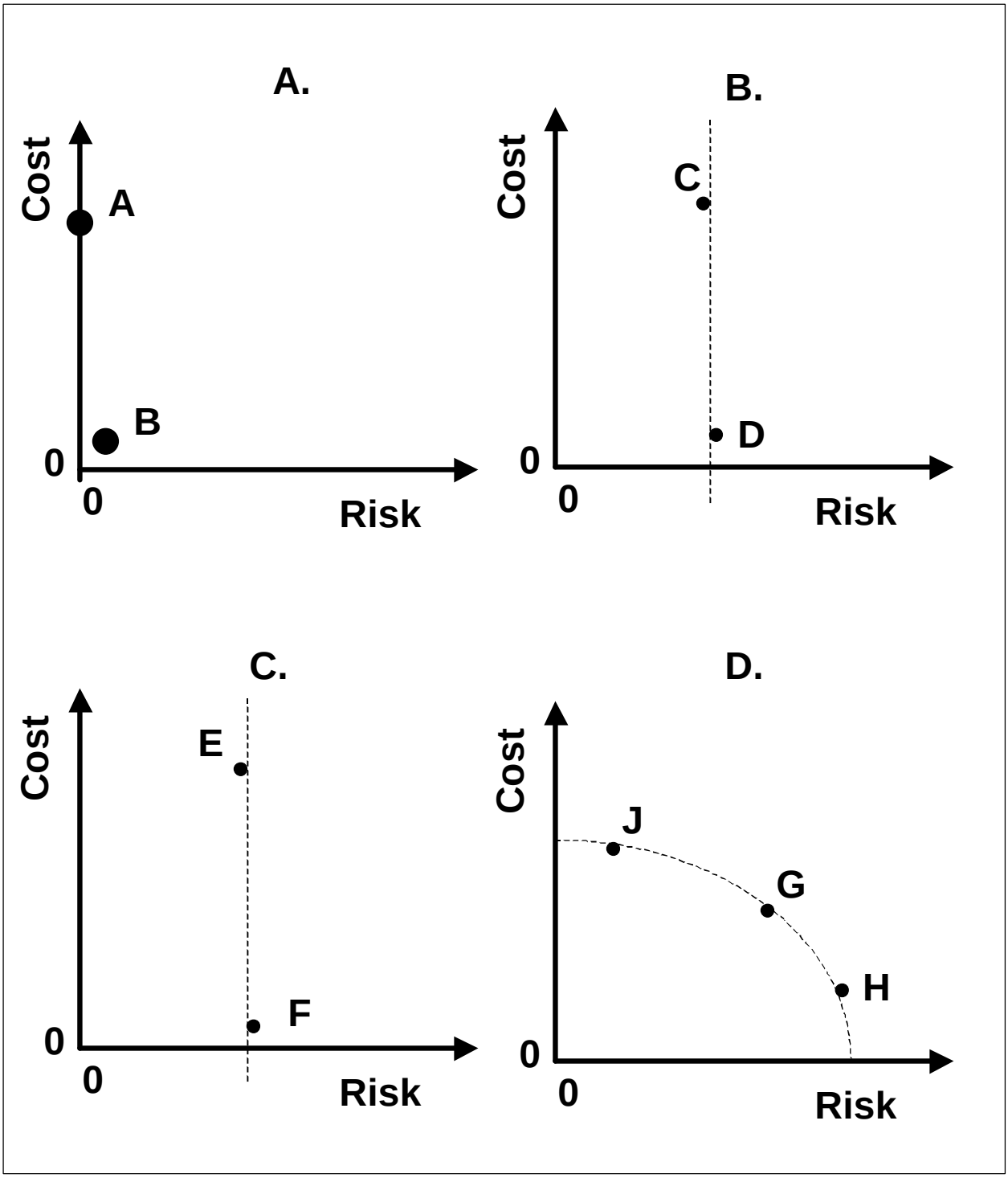
Alternatives: H, G, J

Trade-offs:
Case 1: G could be preferred over H, even though
H → G: Reduce Risk by 1/4 and double the cost.

Case 2: J could be preferred over G:
G → J Reduce Risk by 2/3 and Increase cost by 1/4.

Conclusion:
Tradeoff weight may vary over the range of risk.

Figure 2. Inappropriate procedures to determine acceptable risk.



7. COMPLICATING TECHNICAL FEATURES OF THE PROBLEM

1. Not clear what all alternative courses of action are.

- Is there another better alternative?
- To seek such an alternative is itself could be an alternative.

2. The objectives and their measures are not clear.

- Maximize benefits, minimize costs often too general
- When the question becomes more specific, the problem becomes much more or too difficult.

Example: Ban nuclear power?

Objectives may concern:
1. The defense of the country;
2. Increased jobs and employment;
3. Obtaining energy independence;
4. The implications of foreign control of government policy to consideration of concerns for environmental, social, safety, and economic issues.

3. Any complex problem contains many uncertainties.

- Consequences may by no means well known.
- Large array of possible consequences → # of disciplines with relevant information relevant is large.
- Collecting and meaningfully using all the data from these disciplines is a formidable task.

4. Constructing Values for measuring consequences is very involved.

- **Whose values should be used?**

1. Elected officials representing the public,
2. Regulatory authorities charged with various responsibilities to control safety hazards,
3. The public themselves,
4. A combination of the above?

- **How should these values be determined?**

1. Major conflicts in values among various people.

- **How should these conflicting values be reconciled?**

1. Values and preferences not well formed for many people.
2. Having a person or group understand their own values is as much of a challenge as identifying whose values should be used.

No prescribed course of action
for addressing these complexities.

- Requires ingenuity and creativity.
- Complications need to be addressed systematically and openly for those problems critical to our society.

"Risk Analysis\Risk Management is an ART"

8. COMPLICATING SOCIAL, POLITICAL, AND ETHICAL FEATURES OF DETERMINING ACCEPTABLE RISK

Collective Action must be taken on Risk Management Alternatives:

- "What process will be used for making the decision""
- "Who or what organization should make the decision?"

Answers determined in the political process, not by scientific analysis.

Factors complicating political process in determining acceptable Risk Alternative:

- The collective acceptable risk decision is meant to reflect both judgments, perceptions and values of each person.

- Collective decisions cannot please everyone.

- High level of technical details are involved in most acceptable-risk decisions not known or understood by the general public.

1. One must be a specialist to understand many of the technicalities.
2. Number of technical details so high that no one individual can be a specialist in all aspects of an acceptable-risk decision.

- **An acceptable risk decision should consider both the technological details but also social realities.**

1. Ethical constraints imply that certain alternatives and certain decision processes cannot be followed.

Example:
A decision process that excluded the participation of the people who would bear the risk from technological hazards is unethical.

2. The collective decision process must be representative and consistent with our political ethics and social values and must acceptable to the public.

To determine acceptable risk with collective decisions, the decision process itself must be acceptable.

9. THE ROLE OF A REGULATORY AGENCY IN DETERMINING ACCEPTABLE RISK

Responsibility for making acceptable risk decisions often rests with regulatory agencies.

However:

1. The legislative charters often state general, vague objectives for what the agency should do.
2. These never clearly state how to measure the achievement of regulatory objectives.

Example: U.S. Coast Guard.

Captain of the Port is responsible for maintain an safe level of risk. No guidelines on how to achieve it.

Current typical process of Regulatory agencies:

- Identify technical alternatives for managing the risk
- Gather information on alternatives.
- Recommendation or ruling is made. This ruling has the effect of either choosing the alternative or specifying guidelines.

Observations:

- Rarely are the technical complications in section 7 explicitly addressed in a level of detail which can be useful.
- Focus is on classifying possible consequences of identified alternatives.

- Formal analysis to identify different objectives, to explain the uncertain consequences, and to evaluate value trade-off are only implicitly considered.

Primary role of a Regulatory Agency:
Bridge the gap between its general charter objectives
and
the specific regulations and rules that the agency uses.

- Systematic, scientific analysis has many appealing features for aiding (not for replacing) the regulatory agency in its decision process.

- To exploit this potential value from analysis requires that the technical features (Section 7) and the social, political, and ethical aspects complicating the problem (Section 8) be **explicitly recognized** and addressed-in those analyses.

10. CONCLUSION

There is no single "How safe is safe enough?" problem

The search for its answer is fruitless.

- The problem appears in many different contexts and solutions for each case are context and problem specific.

- Complexity suggest that formal analysis has a significant potential to aid our society in selecting responsible courses of action concerning risks.