**Technological Hazards and Risk Assessments**

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The last issue we discussed in the previous section suggested a completely new and untested solution to a value conflict. Whenever we are doing this, there are always some risks associated with it. In this section, we shall be looking into how to properly analyse such hazards and risks.

Before we can dive in, we need to know a few terms.

* A hazard is any damages or other undesirable effects associated with some technology or its use.
* A risk is a quantitative specification of the phenomenon of a hazard. A single hazard could have multiple risks associated with it. For example, the hazard of radioactive materials in a nuclear powerplant has environmental risks associated with it, as well as health risks for the humans living in the area. Formally, the term risk can be defined as the product of the probability of an undesirable event occurring and the effect of that event.

We will specifically be interested in safety risks, which are the risks of events that can cause fatalities or injuries, and health risks, which are the risks of events that endanger people’s health.

* Safety could be considered the absence of risks and hazards. However, in general, safety refers to a situation in which risks have been reduced as far as it is reasonably feasible and desirable. Essentially, safety is more about acceptable risks than about the complete elimination of risks.
* Uncertainty is used to refer to situations where we know the types of consequences that might occur, but we cannot attribute probabilities to the occurrences of such consequences. For example, when we get into a vehicle, we know an accident could occur, but we do not know what the probability of an accident occurring is.

This probability concept has not been considered in any of the ethical theories, mostly because probabilistic thinking did not really exist in the field of ethics when these theories were first created. Different theories dealt with these probabilities in different ways later on. For example, deontology accepted risks if they were equally distributed amongst everyone, or if the people subject to the risk were willing to accept it. On the other hand, utilitarianism took a mathematical approach, taking the value of each possible outcome of an event, multiplying that by the likelihood of it occurring and taking the sum of all the results, essentially giving the event a value.

* It is not always possible to predict the hazards of new technology and express them reliably as risks. We simply do not know what we have to be prepared for. The term ignorance can be used here.

The final terms we see, uncertainty and ignorance, are things that lead to us having to assess the different risks that might be involved. Take the example we see about driving. Every time we decide to drive a car, we impose some risk on everyone on the street that we will injure them. Does the mere possibility of this risk mean that it is ethically wrong to drive? Why or why not? This is where risk assessment comes in.

After risk assessment has been done, we will need to essentially make a decision about whether the risk is acceptable from an ethical point of view or not. This will involve some issues, whether or not the people subject to the risk are aware of it, whether the benefits of the risk outweigh the disadvantages, whether there are available alternatives that have a lower risk and whether the risk and advantages is justly distributed, in that everyone faces a fair share (fair, not equal) of the risks and the advantages.

## Risk Assessment

1. Release Assessment - Releases are any physical effects that can lead to harm, which originated due to some technical installation. For example, if we are working on a gas field, a blast could occur. This is a release.
2. Exposure Assessment - The risk of exposure is the risk that vulnerable subjects, like human beings, will be exposed to one of the releases. Exposure assessment usually includes information about what vulnerable subjects are exposed to a certain release, and through what mechanism, the intensity, frequency and duration of the exposure.
3. Consequence Assessment - The focus of consequence assessment is the relationship between exposure and harmful consequences. In some cases, this only includes direct fatalities, while in others, long-term effects on peoples’ health and the environment are included.

An important part of consequence assessment is determining the dose-response relationship via tests on animals and models.

1. Risk Estimation - From the results of all the above steps, the risk is determined. We need to determine in what measure the risk is expressed. For example, we could present the risk in terms of the number of fatalities expected, or the reduction in the lifespan of workers and locals.

### Errors in Risk Assessment

For any given test, there are four possible outcomes.

* True Positive – The results show a positive outcome and they are correct.
* False Positive – The results show a positive outcome, but they are incorrect.
* True Negative – The results show a negative outcome and they are correct.
* False Negative – The results show a negative outcome, but they are incorrect.

These four possibilities are outlined in something called a confusion matrix, which contains the number of outcomes of each type in the corresponding cells.

|  |  |  |
| --- | --- | --- |
| Reality/Result | Positive | Negative |
| Positive | True Positive | False Negative |
| Negative | False Positive | True Negative |

The accuracy of the test can be determined by

For example, say we perform a test on people, of whom are genuinely sick. The test results give positive results, of which are correct.

From the confusion matrix, we can see that there are two types of errors, false positives and false negatives.

False positives are called type-I errors. Type-I errors are less of a problem, since they declare the existence of a risk when in reality there is none. The problem here is that we will end up taking preventive measures when we did not need to. This is still a better outcome than type-II errors.

False negatives are called type-II errors. These are extremely problematic, since they fail to identify the existence of actual risks. As a result of false negatives, we could end up ignoring precautions that should have been taken, which lead to harmful consequences.

### Risk Acceptability

From an ethical point of view, there are a few factors that make a risk more acceptable:

* Degree of Informed Consent – Risks are more acceptable if the people who will be affected by the consequences of the risk are aware of it and consent to working despite the risk.
* Benefits Versus Disadvantages – Risky activities can also be advantageous. If the potential benefits outweigh the costs of the risk, the risk is more acceptable.
* Unavailability of Alternatives – A risk is not acceptable if there are alternatives that are less risky and are able to achieve the same results.
* Just Distribution of Risks and Advantages – Risks are not acceptable if only one group faces the actual risks while another reaps the benefits. Everyone involved in the system should have an equal amount of risks and advantages.

Equal treatment can be achieved by setting standards. This does not mean that everyone will necessarily face the same risks, but that the maximum permissible risk is equal for everyone.

Keep in mind that equal treatment is not justice. Justice is giving everyone what they deserve, no more, no less.

This last point is especially important. It is essentially related to the Universality Principle of the Kantian Theory. Further, there are a few objections to the process of standardization, which we shall look into next.

#### Ethical Objections to Standards

The first objection is that the standards are not set by the people who are actually faced with the risks and advantages, but rather by a separate body. People are unable to choose the risks that they deem to be acceptable. This is a paternalistic approach.

Another objection is that standards allow companies to take more risks when less risky alternatives are available. For example, if the standards allow for a certain level of risk, companies might forgo alternatives that are even less risk but would increase costs.

Alternatively, if there is a significant drop in costs by crossing the limits for risk set by the standards just a little, the existence of the standards may not allow it even if everyone involved were to consent to it.

The final objection has already been covered. Standards attempt to equally distribute risks. This may not always be the just thing to do. For example, if a specific group has more benefits to gain, they should also be facing the larger portion of the risks.

## Mathematical Models in Risk Assessments

### Risk Matrices

Risk matrices help us calculate the risk of an event.

#### 3 x 3 Risk Matrices

In risk matrices, the likelihood of an event is measured from to , with being the most likely, while consequences are measured from to as well, with being the most severe consequences. The cells of the matrix show the product of these values.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Likelihood |  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  | Consequence | | |

Low risk cells are marked in green, medium risk ones in yellow and high-risk ones in red.

For example, if we consider a situation where we are claiming health insurance, the likelihood would be the chances that we make a claim this year, while the consequence will be the amount we claim. Thus, if we have a huge claim but are unlikely to make the claim, we would be perhaps in the yellow zone, but if we are also very likely to make the claim, we would shift into the red zone.

#### 5 x 5 Risk Matrices

risk matrices work the same way in principle.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Likelihood |  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  | Consequence | | | | |

### Probabilistic Model

Just attaching a number to a risk is not enough. We need to use these results to make real life decisions. For example, if we want to register for health insurance, the insurance company will base the premium we have to pay based on the risk factor, how likely we are to fall sick, how severe the sickness may be, etc. This is where expected values come in.

Take the results of a dice throw as an analogy.

Using this analogy to go back to the example of health insurance, the face values of the dice could be the costs associated with different health insurance claims and the probabilities are just the probabilities of those claims actually being made. An example should make this clearer.

Say we have a number of possible claims, each with a certain probability of being made.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Number of Claims |  |  |  |  |
| Probability |  |  |  |  |

Thus, the expected number of claims is

Similarly, we could have some data about the cost of a single claim.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Cost of Claim |  |  |  |  |
| Probability |  |  |  |  |

Thus, the expected cost of a single claim is

Based on these two values, we can say that the likelihood of the insurance company having the face the consequence is and the severity of the consequence is . Thus, the expected risk is .

Say the calculations have been done for a period of months for a particular person, meaning the probabilities of the claims were for the number of claims this person was likely to make over a month period. Thus, that person would have to pay a premium of every months.

The higher the risk of a particular person, the higher the premium they will be charged. Thus, people who have a lot of conditions like heart issues or cancer will have higher premiums. This is called conservatism. Sometimes, the insurance company may even agree to only pay a part of the claim, especially for people they consider to be extremely risky.