ESTPC

Emerging Science & Technology Policy Centre

ESTPC Analytical Tools Series Paper No. 1:
The Simple Emerging Technologies Reward/Risk (SETR^2) Model

About the Series

The ESTPC Analytical Tools Series publishes papers that explore knowledge-sharing tools and decision-support models which strengthen the ability of policymakers, experts, media, and researchers to effectively respond to the challenges introduced by emerging technologies. The series specifically targets analytical tools that can improve the precision and accuracy of technology assessments while at the same time strengthen the capacity of policymakers in the area of emerging technologies.

About ESTPC

The Emerging Science and Technology Policy Centre (ESTPC) is an international non-governmental organization committed to the highest caliber of policy recommendations and analyses on emerging science and technology issues. ESTPC is also dedicated to increasing the influence of Track II actors and next generation leaders on national and international science and technology policy.

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Background

The world is witnessing an unprecedented period of technological innovation being spurred by the synergistic combination of converging technologies, including nanotechnology, biotechnology, robotics, information technology, and cognitive sciences (the so-called NBRICs).

Such convergence is producing a wide range of disruptive innovations that may contribute to a "tremendous improvement in human abilities, societal outcomes, the nation's productivity, and the quality of life." At the same time, these emerging technologies are introducing new challenges that threaten to undermine all levels of security and inequitably transform the world we live in.

The question then is how should policymakers tackle these challenges. The best response would be to develop effective policy approaches that maximize the potential benefits of the adoption of emerging technologies while at the same time minimize the detrimental effects. This requires that policymakers properly understand the absolute risk/reward trade-offs imparted by the various policy approaches under consideration.

Six months ago, ESTPC launched the Analytical Tools Project to help policymakers in this endeavor. Through this project, we have sought to identify technology risk assessment approaches that can provide policymakers and policy experts with the fidelity needed to make better decisions.

Unfortunately, we found that the dominant technology risk assessment approaches tend to focus on the mitigation of risks rather than the realization of rewards. As a result, these analytical tools are designed to assess the detrimental effects of emerging technologies independent of the benefits. This of course biases the technology risk assessments provided to policymakers, undermining their ability to make optimal risk/reward tradeoff decisions.

In search of an alternative approach, we turned to the Simple Emerging Technologies Risk/Reward ($SETR^2$) Model developed by Pacific Islands Council LLC[1] As the name suggests, this model was designed to provide a better understanding of how specific research populations evaluate the risks and rewards imparted by emerging technologies.

With the permission of Pacific Islands Council LLC, we have provided an overview of their $SETR^2$ Model in the paper below. We believe that this simple analytical model can be used by researchers around the world to increase our collective understanding of risk/reward trade-offs imparted by specific policy approaches.

[1] All copyrights for this work are reserved by the Pacific Islands Council LLC.

Core Model

The $SETR^2$ Model is composed of three main variables. These include the impact, likelihood, and time. Each of these variables represents a separate axis for analysis.

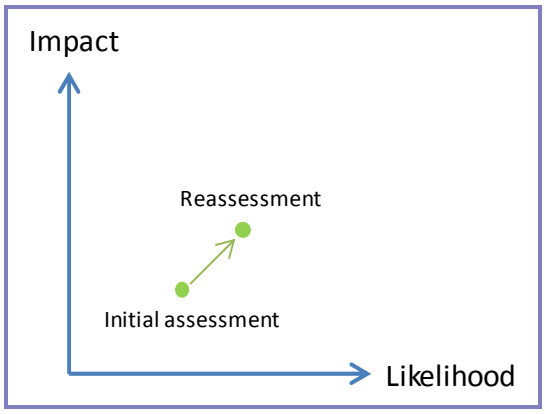

Figure 1 - SETR2 Model with Impact along the Y-Axis, Likelihood along the X-Axis, and Time along the Z-Axis (not shown)

At first glance, the $SETR^2$ Model may resemble standard risk analysis models. This includes models associated with the Probabilistic Risk Assessment (PRA) that are often characterized by "two qualities: (1) the magnitude (or severity) of the adverse consequence(s) that can potentially result, and (2) by the likelihood of occurrence of the given adverse consequence(s)."

Like PRA models, the $SETR^2$ Model is designed to provide "a systematic and comprehensive methodology to evaluate risks associated with every life-cycle aspect of a complex engineered technological entity" where "risk is defined as a feasible detrimental outcome of an activity or action."

However, there are a number of important differences between the $SETR^2$ Model and standard PRA models.

The most important is that the SETR[2] Model distinguishes between Rewards (i.e. benefits that make a positive impact) and Risks (i.e. detrimental outcomes that make a negative impact). As a consequence, the SETR[2] Model is divided into two separate and symmetrical positive and negative zones about the X-axis.

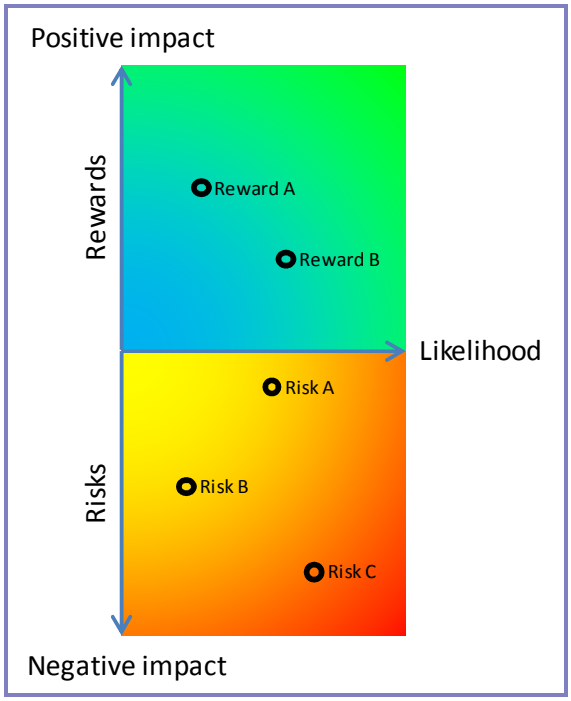

Figure 2 – The Risks and Rewards zones

The SETR[2] Model therefore requires the collection of at least[2] three values at the individual level of analysis:

- Risk Measurement: Detrimental effects of the emerging technology;
- Reward Measurement: Positive benefits of the emerging technology;
- Net Measurement: Final measurement of impact and likelihood once all of the positive benefits and detrimental effects have been taken into consideration.

These values can be obtained using a variety of methods. In studies where an exhaustive list of risks and rewards have been assessed in a preliminary step, the Risk and Reward Measurements can be calculated using an appropriate mathematical approach (ex. mean, median, etc.). With these values established, the Net Measurement can then be calculated from these values using a similar approach.

Alternatively, researchers can take an independent, subjective measurement of the three values at the individual level of analysis. This approach presumes that individuals tend to value and weight specific detrimental effects and benefits differently. This assumes that Risk, Reward, and Net Measurements will seldom represent exact mathematical averages of the underlying individual risks and rewards.

The SETR[2] Model can accommodate either approach. Either way, the resulting values will fall within one of the two previously described zones in the model:

- The Risk Measurement will always fall within the negative zone;
- The Reward Measurement will always fall within the positive zone;
- The Net Measurement can fall in either zone depending upon the given context.

[2] The SETR[2] Model can accommodate a more exhaustive data set that includes measurements of the full list of detrimental effects and benefits associated with an individual technology. This could be useful in thought listing exercises that force individuals to think critically about a specific emerging technology prior to providing general assessments. But, this step in the SETR[2] process is certainly not required. Nor is it typically useful in larger studies that seek to assess more than one emerging technology.

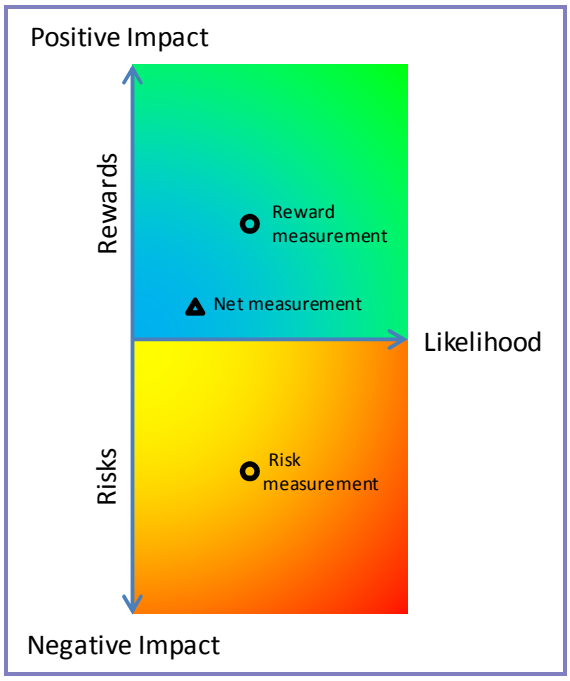

Figure 3 - Independent Measurements Plotted in Reward and Risk Zones of SETR2 Model

These values are expected to vary over time:

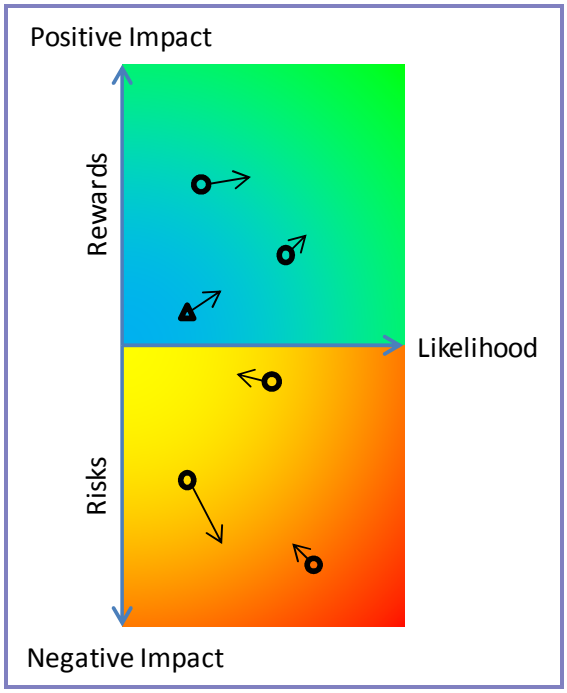

Figure 4 - Change over Time with Arrows Depicting Movement Along Z-Axis (Time)

Separately, the SETR^2 Model recognizes that certain rewards will be pursued at any cost and certain risks will be mitigated at any cost in specific contexts. At the individual level, the SETR^2 Model provides a means of modeling those values, which it terms “Enticers” and “Blockers.”

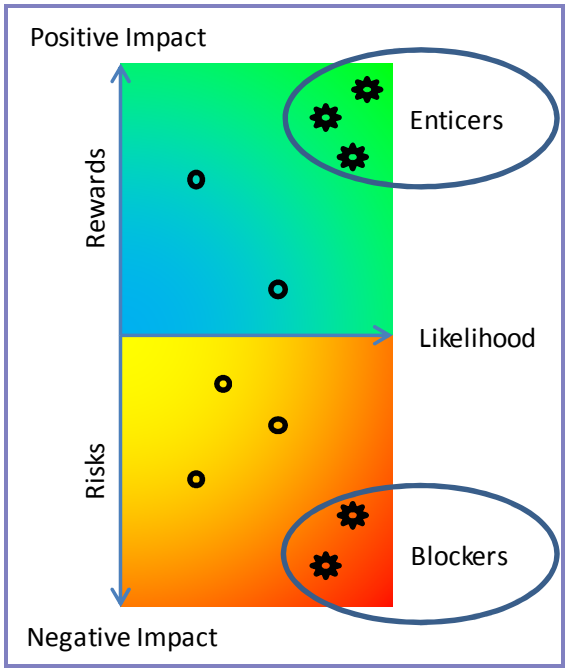

Figure 5 - Depiction of Hypothetical "Enticer" and "Blocker" Values on SETR2 Model

These five values measured provide the core data set for the SETR^2 Model. Once the Risk, Reward, Net, Blocker, Enticer measurements have been collected at the individual level of analysis, aggregated data sets can be calculated which provide mean, median, and range (standard deviation) values for each of these measurements for specific research populations or audience segmentations. These values in turn provide a statistical and modeling means of describing and comparing how research populations and audience segmentations perceive the risks and rewards imparted by emerging technologies.

Data Visualizations

A variety of data visualizations can be applied to the core model to improve researchers' understanding of how research populations and audience segmentations perceive the risks and rewards provided by emerging technologies.

These include:

- Bar charts, unordered bubble charts, tree charts, histograms, dependency graph, and bubble charts of individual benefits and detrimental effects;
- Hive plots of risk, reward, and net measurements over time;
- Box and whisker plots of risk, reward, and net measurement ranges;
- Time series of risk, reward, and net measurements by audience segmentations;
- Choropleth, cartograph, dasymetric maps, proportional symbol maps, and dot distribution maps of geo-located audience segmentation values;
- Self-organizing graphs;
- Node-link analysis (if relationships between individuals is known);
- 2D and 3D color intensity maps of risks and rewards.

Of these, one of the most useful is simple visualization using independent color intensity visualizations for the Risk and Reward zones that are symmetric about the X-Axis.

Examples of this can be found in all the graphs used throughout this document.

Use in Policy Analysis

The data, models, and visualization derived from the SETR^2 Model provide valuable inputs for further analysis of the dynamic conditions surrounding emerging technology policy decision-making. A variety of means of analysis are described below. But, this does not purport to serve as an exhaustive list. Other means of analysis will be discussed in future research briefs.

Segmentation

The SETR^2 Model provides a mechanism for segmenting research populations by a variety of data elements, including demographic information, network relationships, and like-minded assessments. A variety of statistical tools, including cluster analysis, can be used to mathematically identify audience segmentations. This is especially useful for identifying non-obvious audience segmentations.

Statistical Analysis

The SETR^2 Model can be used in statistical analysis to provide a more complete understanding of the perceived risks and rewards imparted by a specific emerging technology. This includes determining the relationship between the dependent variables (impact, likelihood) and the independent variable (time) for a specific research population or audience segmentation. The data also enables comparative statistical analysis within and between research populations or audience segmentations.

Furthermore, it provides a means of calculating the accuracy and precision of specific research populations or audience segmentations.

And, it provides a means of conducting boundary analysis to account for any enticer/blocker zones in which technology adoption should be pursued/prohibited at any expense.

Modeling

The SETR^2 Model can be used in modeling to illustrate how the dependent variables (impact, likelihood) vary as the independent variable (time). Modeling also enables researchers to visualize the effect of intervening variables (ex. new applications of the technology) on the dependent variable measurements. These can be enhanced with optional data visualizations. Furthermore, SETR^2 aggregated data can provide a means for producing more advanced models, including geospatial maps and global models across broad categories of emerging technologies (i.e. all emerging technologies categorized as nanotechnology). These can travel across specific research populations or audience segmentations. Specific models can even be developed for particular policy alternatives, which can help identify the range of detrimental effects that will be mitigated and/or benefits that will be sacrificed as a result of a particular policy approach.

Simulation

The SETR^2 Model can be used in simulations to project how the dependent variables (impact, likelihood) would vary in the event of hypothesized intervening variables.

Predictive Analysis

The SETR^2 Model can be paired with a variety of techniques, including statistical analysis, modeling, and data mining, to provide a tool for predicting future conditions based upon current and historical data. For example, statistical analysis might reveal that specific research populations or audience segments are particularly accurate and precise in their impact/likelihood assessments for a specific emerging technology. Armed with this insight, the SETR^2 Model can be used to develop new predictive, descriptive, and decision models.

About the Authors of this Paper

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