RESOURCES *for the* FUTURE

Value of Science 104: Categorizing the Socioeconomic Benefits of Scientific Information, Part 2

Explainer by **Yusuke Kuwayama** — May 2021

As has been discussed throughout the Value of Science explainer series, measuring the value of scientific information to society is useful. In "**Value of Science 103**," we learned that categorizing the benefits of scientific information is helpful; for instance, categorizing by whether the benefits are quantifiable, whether benefits can be monetized, and whether monetization can be done using market or non-market values. However, other methods can help us categorize benefits that do not follow this hierarchical structure. The most useful way to categorize benefits varies depending on the kind of scientific information being evaluated and the audience to whom the benefits are being described.

In addition to the categories discussed in "Value of Science 103," benefits might be categorized as follows:

1. Intermediate vs. final
2. Use vs. non-use values
3. Public vs. external

This explainer reviews each of these categorization schemes.

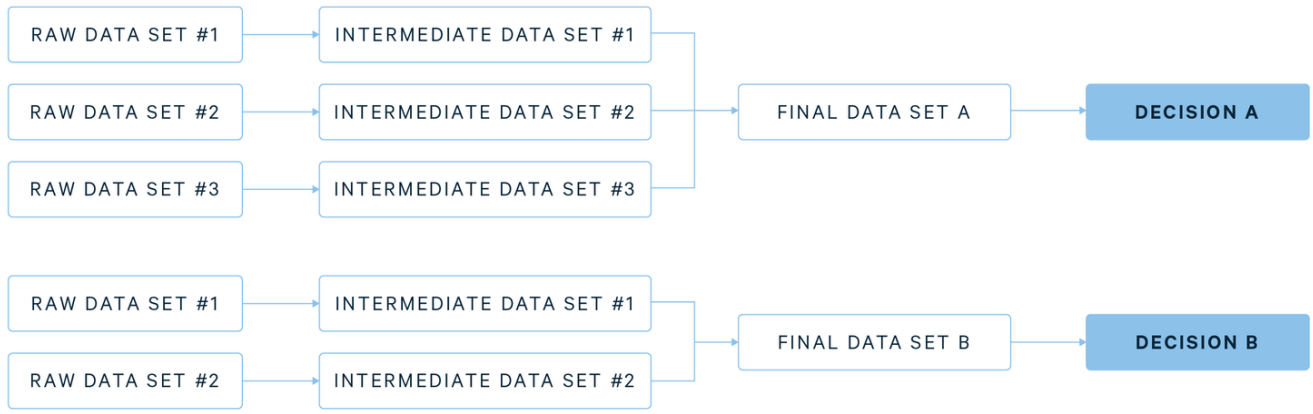
Intermediate vs. Final Benefits

When scientific information is used to make decisions, the information is almost never used in its "raw" form. Instead, it is usually processed in some way, or combined with information from other sources before it is used by the decisionmaker. For example, satellites cannot measure air pollutants (like particulate matter) directly. Instead, **researchers use algorithms** to estimate air pollutant concentrations from estimates of aerosol optical depth, which in turn is based on the satellite's measurements of how the atmosphere reflects and absorbs visible and infrared light. Similarly, the indicators of drought provided by the **US Drought Monitor** (USDM) are derived from data sets and models that first process raw data on almost every part of the water cycle.

It is relatively straightforward to conceptualize the benefits that arise from the use of scientific information in its final form, like air pollution or drought intensity measures. But how do we think about the value of scientific information that plays a less direct role in decisionmaking? The value of the information that isn't directly used by the decisionmaker—which we might call **intermediate** information—consists of the improvement in socioeconomic outcomes that results from decisions based on final information that includes the intermediate information, compared to the final information that excludes the intermediate information.

Figure 1 illustrates how one might think about the benefits of intermediate information, using a scientific data set as an example. In the upper set of boxes, three data sets containing raw data (**Raw data sets #1, #2, and #3**) are each processed by researchers to create intermediate data sets (**Intermediate data sets #1, #2, and #3**). These three intermediate data sets, in turn, are combined to form a final data set (**Final data set A**) that is used in a decision (**Decision A**). The lower set of boxes illustrates a similar process in which raw data are processed into intermediate data and then combined to

Figure 1. Examples of decisions made using intermediate forms of information



make a final data set (**Final data set B**) that is used in a decision (**Decision B**). In this final data set, **Intermediate data set #3** is excluded as an input.

Example: The US Drought Monitor

For a more concrete example, consider a decision support tool like the US Drought Monitor (USDM), which is a map that shows the location and intensity of drought across the country. The experts who produce the USDM rely on dozens of indicators that relate to variables such as temperature, soil moisture, water levels in streams and lakes, snow cover, and meltwater runoff. Suppose we want to characterize the socioeconomic benefits associated with the snow cover data as an intermediate data set. Even though USDM users don't directly use the snow cover data, those intermediate data may still be valuable if the final data set (the USDM) depends on it. This value can be described as the difference in socioeconomic outcomes between the case when decisions are made using a USDM that is informed by snow cover data, versus the case when decisions are made using a USDM that is not informed by snow cover data.

If **Intermediate data set #3** contains important information that is relevant to the decisionmaker, its exclusion in **Final data set B** may influence the decision such that the action taken in **Decision B** is different from that made in **Decision A**. If this difference in decisionmaker actions translates to a difference in socioeconomic outcomes, then the benefits associated with **Intermediate data set #3** can be described as the difference in socioeconomic outcomes between the case when the decision is made using **Final data set A** and the case when the decision is made using **Final data set B**.

Use vs. Non-use Value

Another useful distinction to make between different benefits of scientific information is whether they are based on **use value** or **non-use value**. Use value, simply put, is value that people and firms derive from the direct use of a good or service. In the context of scientific information, benefits that clearly consist of use values are improved socioeconomic outcomes like increases in crop yields, reductions in greenhouse gas emissions, and cost savings in agency activities. In each of these cases, the benefit is experienced directly by the beneficiaries (more food, reduced climate change impacts, the ability to use cost savings for other desirable activities).

A non-use value, in contrast, is a value that people assign to a good or service even if they never have, and never will, use it. Non-use value is principally composed

of **existence value**: the value placed on knowing that a resource exists, even though no one may ever use it. For example, an individual may place a value on an endangered species because they enjoy knowing that the species exists or believe that the species has a right to exist. The existence of the species is a benefit to this individual, even if they expect never to see one.

Example: Endangered Species

Boyle and Bishop (1987) estimated the socioeconomic benefits of preventing extinction of the striped shiner (a species of fish) in Wisconsin by conducting a survey that asked respondents if they would be willing to pay a membership to a private foundation that would perform the necessary activities to preserve the species. Based on the survey responses, the authors estimated that preventing the striped shiner from going extinct would be worth $12 million annually to Wisconsin taxpayers. The striped shiner, a small minnow inhabiting the Milwaukee River, has no known present or likely future uses, so the $12 million is interpreted as pure existence value.

Private vs. External Benefits

One more distinction that can be useful is whether the benefits of scientific information consist of **private benefits** or **external benefits**. The private benefits of scientific information are the benefits received by those directly involved in the use of the information. For example, if a private sector firm increases its profits by using satellite data, this is a private benefit of the information because the benefit (increased profits) is experienced exclusively by the user of the information (the firm).

However, many decision contexts that involve scientific information also generate external benefits—that is, benefits gained by individuals or firms who were not directly involved in the use of the information. Consider the example of a government agency that uses satellite data to implement a more rapid and effective emergency response after a natural disaster. In this case, most of the benefits of the satellite data are external, as they accrue to residents in the area affected by the disaster, not to the government agency itself. The sum of private and external benefits is called **social benefits**.

Note that the distinction between private and external benefits doesn't necessarily hinge on whether the decisionmaker is in the private or public sector. What matters is whether there are beneficiaries from the use of the information beyond the decisionmaker. Consider, for example, an environmental agency that needs to enforce a regulation and can do so at lower cost using monitoring data collected by satellites rather than through ground-based, local data monitoring. In this case, the regulatory cost savings are a private benefit because only the agency experiences these cost savings. In contrast, if the agency can improve environmental outcomes using the satellite data, the benefits from the improved environmental outcomes are considered to be external benefits.

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