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The economic value of geological information: Synthesis and directions for future research

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ABSTRACT

Geological information can play a key role in addressing challenges of sustainable development such as land degradation and groundwater protection, and contribute to improved decision-making processes. In this paper we: (a) provide a review of previous research on the economic value of geological information and other earth observations as well as related products, services and infrastructure; and (b) identify important lessons from this work as well as methodological challenges that require increased attention in future research. The review of prior research shows significant economic benefits attached to the generation of this type of public information. The value of geological information has typically been measured in terms of avoided costs. Still, it is difficult to compare results across studies since they differ in scope and make alternative assumptions concerning which sectors to cover. Furthermore, previous research is not uniform in their treatment of potential (rather than only existing) users, and employ varying conceptions of avoided costs. The paper concludes that future research should devote more attention to the public and experience good characteristics of this type of information, thus highlighting the preconditions for information adoption as well as addressing the role of potential users. A number of specific methodological challenges also deserve further scrutiny in future research, such as the use of discount rates and benefit-transfer approaches. We also provide some thoughts on how to proceed with such research.

Introduction

Background and motivation

Earth observations (e.g., of a geological, meteorological or topological nature) may have profound impacts on our everyday lives, but most people are generally not well informed about the economic values attached to this type of information. In this review paper we address the ways in which such values can be comprehended and measured, report results from previous studies, and identify important issues and challenges for future research.

Natural processes and human activities often cause stress to the environmental system's capacity. Having reliable information about such impacts is therefore a critical input into a large number of decision-making processes involving potentially significant environmental impacts (Bernknopf et al., 1993; Swedish Geological Survey, 2012). When natural phenomena, such as landslides or earthquakes, are better understood important societal costs can be avoided (Berg, 2005). For this reason, geological information and other types of earth observations are important for addressing the challenges of sustainable development (Grant and Williamson, 1999; Ting, 2002; Rodriguez-Pabon, 2005).

In brief, geological information could be – and is often – useful for decision-making in a wide range of societal activities, such as: (a) the development, sustainable use and protection of groundwater; (b) environmental impact assessments; (c) the exploration and development of minerals and fuels; (d) understanding and managing the causes of geologic hazards; (e) the construction of infrastructure projects; (f) city planning including zoning and landscaping; and (g) regional planning such as siting and permitting industrial facilities (Bhagwat and Ipe, 2000; Swedish Geological Survey, 2011).

A noteworthy example of a product containing geological information is the geological map. It describes the physical world by linking spatially based information, geological materials and geologic structures. Geological maps also add time and space interpretations on how these materials and structures interact. Improved geological information in terms of novelty and resolution, e.g., communicated through a geological map, may generate several benefits. It could influence mineral exploration and investment by reducing the risks at the early stages of the exploration process (Bernknopf et al., 2007; Scott et al., 2002). Moreover,

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excavations are dependent on accurate knowledge concerning soil conditions.

The costs of providing geological information are connected to the collection of the information and subsequently to the compilation, database construction, publication and distribution. The bulk of the costs are borne up front, in part since the gathering of new geological information such as maps is labor intensive, and requires field work and a highly skilled staff. The distribution costs are instead relatively low, and the costs of serving an additional customer are therefore also low. Moreover, the costs of providing geological information can be accessed via existing market prices, such as wages for skilled workers (Cressman and Noger, 1981) and the market prices of other inputs (Castelein et al., 2010).

However, whereas the costs of providing geological information are fairly straightforward to assess, this is typically not true for the economic benefits of such provision. First, the costs occur in the present while the benefits are allocated over time, thus motivating the use of appropriate social discount rates. Second, several users can appropriate the benefits of the information at the same time (i.e., non-rivalry in consumption), and the information is in part non-exclusive in use. Due to these public good characteristics geological information is typically not effectively priced in existing economic markets.

Since public goods typically are underprovided in the free market, this sets the stage for the government's interest in the provision of geological information. Geological information is mainly collected and analyzed by national government-funded geological survey agencies. Bhagwat and Ipe (2000) suggest that in the absence of government funding very little geological information would be provided.

In addition to this, critique has been expressed concerning the amount of government funding towards the generation of geological information and the existing distribution trends of such information. Reedman et al. (2002) argue that the provision of geological information often is inadequately funded and as a result poorly informed decisions may lead to substantial economic losses for society. A related critique has been directed towards the use of earth observations in general. For instance, Booz Allen Hamilton (2013) estimates that earth observation data saved USD 24–72 million in avoided revenue losses and avoided aircraft damages after the Eyjafjallajökull volcano eruption in 2010. Still, the authors conclude that if the ash cloud data had been implemented and used directly from the time of the eruption (and not with a one-week lag), the total avoided costs could have been as high as USD 200 million.[1]

A comprehensive assessment of the value of geological information and other earth observations is not only important for judging the viability of investments in information collection and provision (Borzacchiello and Craglia, 2011), but also for identifying the sectors of society that would benefit the most from such efforts (Castelein et al., 2010). Craglia and Nowak (2006) remark that since many countries have established new spatial data infrastructures[2] increased attention needs to be devoted to assessing the social and economic impacts of such infrastructure. In addition, Craglia et al. (2012) note that there has not yet been any convergence of the reference methodology, and there is therefore a need for more consistent methodologies aiming at valuing earth observations.

The potential societal and environmental importance of geological information motivates a closer scrutiny of how the associated economic values have been defined and assessed in previous work. Such a review of existing research in terms of theoretical foundations, and methodological and empirical scope is important for identifying gaps in the academic literature as well as unresolved challenges that ought to be addressed in future research.

Objectives, scope and approach

The objectives of this paper are to: (a) provide a review of previous empirical research on the economic value of geological information (including any related products, services and infrastructure); and (b) identify important lessons from this work as well as issues and challenges that deserve increased attention in future research.

The paper focuses on previous research that has assessed the economic values of either geological information or other earth observations. The literature on earth observations is broad and fragmented into different fields, including geological, meteorological and topological research. The inclusion in this paper of studies assessing also non-geological information based on other types of earth observations is motivated by the similarities in the qualities – and economic characteristics – of such information. The methodological challenges involved in the valuation of information are also very similar across these research fields.

Previous work ranges from analyzing the value to many users of a marginal increase in the overall quality of the information to assessing the economic value of information in the context of specific decision-making situations (e.g., monitoring water quality with the help of satellite information or for mineral exploration decisions). Moreover, a number of studies explicitly address the value of spatial data infrastructure, including technological standards or policies that enable the use of, for instance, geological information in society. This latter work therefore provides a more complex picture of any associated information products and services.

In our search for previous research on the value of geological information, we employed a combination of different keywords. Specifically, we carried out searches on combinations of terms such as "societal value" or "economic value" on the one hand, and "geological information", "earth observations", "geodata" or "spatial data infrastructure" on the other in key bibliographic databases such as Web of Science, Science Direct, Wiley Online Library and Google Scholar. In order to find recently published literature, we forward-followed quotations on the articles identified by this keyword search. In addition, since the economics literature on assessing the economic value of geological information is relatively narrow a keyword search was also conducted on a wide range of national geological surveys in order to identify additional relevant work on the topic. In total about 25 reports and 11 peer-reviewed articles involving the economic assessment of geological information and/or closely related earth observations have been reviewed. Most of the reports are – even if not all are peer-reviewed in line with academic standards – well described (and cited) in the scientific literature.

Outline of paper

The paper proceeds as follows. In the next section we discuss geological information as an economic good, as well as the theoretical foundations for valuing such information. Most

[1] The London Volcanic Ash Advisory Center (VAAC) had not previously used the so-called Aura data. Hence, after the volcano eruption the VAAC had to work against the clock to develop, and deliver the requested data products. The data products were intended for the VAAC warnings and for European officials to assess which airspace to open. The VAAC first presented and used the Aura products on April 19, 2010, that is a week after the eruption began. By that time some flights had already resumed.

[2] Such infrastructure includes technology and information standards that are necessary in order to acquire, process, distribute, use, maintain, and preserve data. Geospatial standards are technical documents containing detail interfaces or encodings.