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Direct economic return to government of public geoscience information investments in Chile

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A B S T R A C T

This article presents the first attempt to evaluate the direct economic return of the provision of public geoscience information in Chile. To achieve this goal the study uses multiplier effect ratios through the value chain of PGI and a probabilistic discounted cash flow model to evaluate the economic returns of different scenarios for the ongoing governmental program mandated to generate country-scale geological information, named the National Geological Program.

The study shows that, in average, every dollar invested in PGI in Chile during the past three decades could have generated 11.5 dollars of government tax revenues from the mining industry (in terms of its NPV), with an IRR of around 21%. These results are in accordance with comparable studies abroad, but they should be taken carefully due to methodological restrictions of the study. These indicators are positive in almost all the scenarios considered in the study, despite that they show a wide range of results. Similar outcomes are obtained for the National Geological Program when different scenarios are evaluated.

1. Introduction

Despite the size of the Chilean mining industry and its relevance for the local economy, the available public geoscience information (PGI) is deficient in terms of coverage and updating. By 2012 only 30% of the country has modern and detailed geological maps at a scale of 1:100,000 (Schwarz et al., 2012). According to Jara and Cantallopts (2008), the main problems related to this topic in the country are: a) deficiency in coverage and updating of information; b) limitations to access and use of the available information; c) the need for new tools to acquire and analyze data; and d) the lack of new/advanced types of information.

To remedy this situation, in 2011 the Ministry of Mining through the National Geological and Mining Service (Sernageomin, by its Spanish acronym) started a National Geological Program (NGP). This program is aimed to reduce the gap between supply and demand for geoscience information in the country. An original ambitious goal was to achieve a basic geology, geochemistry and geophysics cartographic coverage for most of the territory, over a period of 10 years (2011–2020) (Espinoza, 2015; Sernageomin, 2017). Currently the agency is provided with 6 million dollars per year for its execution, which corresponds to about half of what was initially requested to the central government by the service. The reduction of available resources, combined with other difficulties such as a shortage of experienced professionals at the time the program started, have generated a significant delay in the original plan. Therefore, currently it is estimated that the NGP will take at least 50–100% more time than initially estimated (Muñoz, 2013; Espinoza, 2016).

The aim of this study is to determine the direct economic return of PGI provided by the Chilean state, in terms of the tax revenues collected from the mining industry. To do so, the study applies a methodology based on multiplier effect (benefit-cost) ratios through the steps of the PGI value chain (structured stages of development modelling) and a probabilistic discounted cash flow model (Monte Carlo simulations) to evaluate the direct economic impacts of different scenarios for the NGP that is underway in the country.

Quantifying the benefits associated to PGI should contribute to the public debate, to the promotion of policies that could foster the country's geological potential and its mining competitiveness and to support the decisions of the competent authorities in Chile (Jara et al., 2008). Finally, it should open opportunities for future research with focus on the allocation of public funds related to geological programs.

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The article is structured as follows. Section 2 addresses the role of PGI in enhancing mineral exploration and mining, reviewing the economic effect that this kind of initiatives could generate. Section 3 presents the main aspects of the methodology and the databases to evaluate the Chilean case. In Section 4 the main results for historical analysis and the National Geological Program are presented. The discussion of the outcomes and some recommendations from the research are found in Section 5.

2. Public geoscience information and its stimulus to mineral exploration and mining activities

Several studies (Herfindahl and Kneese, 1974; Bernknopf et al., 1997; Hogan, 2003) notes that PGI meets some of the main characteristics of a public good[1] (quasi-public good), since its use is not rival nor exclusive. It can advance useful information in areas of public interest such as land management, infrastructure planning and development and natural resources assessments (Ovadia, 2007; Castelein et al., 2010; Häggquist and Söderholm, 2015).

Regarding the mineral exploration and mining industry, PGI is valuable because it reduces the risk of greenfield activities (and in some cases in brownfield exploration), cuts expensive re-acquisition of data, catalyzes refinement of geological knowledge and decreases environmental impacts of exploration programs. Thus, it improves the efficacy and efficiency of mineral exploration and maintains the competitive edge of mining jurisdictions (The Parliament of the Commonwealth of Australia, 2003). As a result, PGI mitigates the three main challenges which differentiate this activity from other economic sectors: specific locations, long-term returns and high-risk investment levels (Eggert, 1987; Tilton et al., 1988).

There are three main factors that make it difficult to assess the effects of PGI (Duke, 2010; Häggquist and Söderholm, 2015): it is virtually impossible to identify all users of the information; impacts are long-lived as it can influence exploration decisions for more than 20 years (in addition, mining development can last from 10 to 20 years, or even more); and it is difficult to evaluate the exact contribution of PGI, since in the decision-making process it is combined with other factors that influence mineral exploration success (Fogarty and Sagerer, 2016).[2]

Given these limitations, a useful approach to measure the effects of government PGI programs is to run a step-by-step/benefit-cost evaluation process (Input-based assessment; Häggquist and Söderholm, 2015), which shows progress from the initial activities of PGI to the achievement of government plan objectives (Fig. 1).

According to this method, the initial effect of PGI is the stimulus of private efforts in exploration. Geoscience Australia estimates that every dollar invested by the state in PGI generate five dollars in private exploration expenditures (The Parliament of the Commonwealth of Australia, 2003). The same source indicates that the Government of South Australia considers that this factor has a multiplier effect from three to five times the public investment in basic information. The Queensland Government raises this factor up to 15, according to the experiences in its territory. In the case of Canada, the Government of Ontario estimates that every dollar invested in PGI generates between two to five dollars in terms of exploration by private entities (Fyon et al., 2002). Based on 13 case studies in Australia and Canada, a work commissioned by the Canadian government concluded that every million-dollar invested by these governments in such basic information stimulated private exploration expenditures for roughly five million dollars (Boulton, 1999).

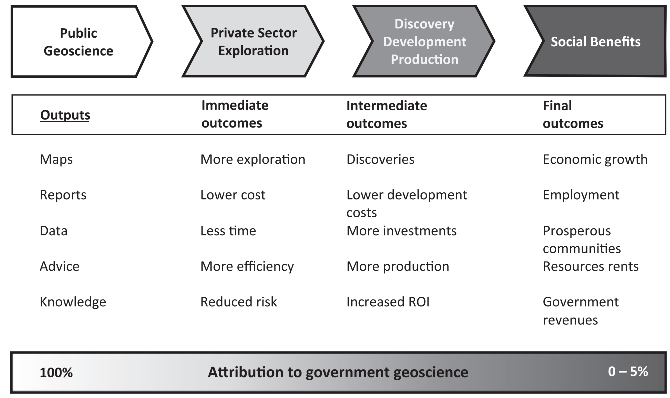

Fig. 1. PGI value chain and its intermediate and final outcomes.
Modified from Duke (2010).

In a report commissioned by the Prospectors and Developers Association of Canada (PDAC) the multiplier ratios vary greatly, from a minimum of 0.83 to a maximum of 19 (Duke, 2010).[3] However, the conclusion of the author is that it is reasonable to use a factor of five as a rule of thumb. Nevertheless, the evaluators should understand the limitations and specific aspects of the case to be analyzed, such as the period and scope of the PGI plans. An alternative to these ex-post analysis is the approach of Bernknopf et al. (2007), based on mineral prospectivity evaluations and economic modelling. Using these tools, they evaluate the future impact of a second generation PGI program in the Baffin Islands, showing a multiplier effect between 1.2 and 8.2, consistent with other retrospective assessments.

Regarding intermediate results, mineral exploration identifies deposits that may become attractive to be developed and exploited in the future. While data on the direct impact of PGI on the discovery and development of projects is scarce, there is enough information about the effects of private exploration on mining development stages. A study on copper exploration in the Central Andes of Argentina, Chile and Peru (Cabello, 2004) shows that between 1969 and 2001 every dollar spent on exploration generated 6.1 dollars associated to mining development and an additional 7.8 dollars in future investments (4.5 and 5 dollars in the case of Chile; Cabello, 2006). Similarly, every dollar spent on exploration caused, at the time of the study, 14.9 dollars in mineral production and 226 dollars on in-situ resources (23 and 125 dollars in the case of Chile; Cabello, 2006).

Closing these series of results are the so called final effects of PGI, related to its contribution to economic development and society's welfare. Duke (2010) indicates that a value commonly attributable to PGI on this matter is between one and five percent of mineral production, but it easily could be more than that. Swan (1997) proposes to assess the results of state programs in terms of their contribution to the value of mineral production. Therefore, PGI is considered as a production factor whose contribution is proportional to its cost. Alternatively, Scott et al. (2002) run an economic model to evaluate royalty and tax increments due to PGI improvement plans (which leads to higher discovery rates, based on mineral potential assessments), incorporating uncertainty and risk. They conclude that the increase in royalties and taxes is equivalent to a benefit-cost ratio of 4.7–6.2:1 (in terms of net present value) with an IRR of 23–78%, depending on the reinvestment scenario considered. Finally, in a recent study Fogarty and Sagerer (2016) assess the government returns from PGI and other exploration subsidies in Western Australia. Through a structured stages of development modelling approach, time-series analysis and Monte Carlo

[1] They are goods that their use is not rival nor exclusive; i.e., it is not possible to prevent a person uses a public good, and its use by one does not reduce its use by others (Samuelson, 1954; Mankiw, 2015).

[2] As noted by Fogarty and Sagerer (2016), other factors such as new deposit discoveries, economic cycles, metal price variations, tax incentives and mining and general regulation changes cannot be completely isolated when evaluating PGI contribution to mineral exploration success.

[3] It includes some of the previous references plus others mainly from Australia, Canada and a couple of PGI plans in countries such as Bolivia and Zimbabwe.