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Analysis

A behavioral model of collective action in artisanal and small-scale gold mining

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ABSTRACT

There is a rising global concern about mercury use in small-scale gold mining because of its harmful effects on ecosystems and human health. Associative entrepreneurship has been promoted as a way of accessing alternative techniques to address this concern. By associative entrepreneurship, in this paper we mean the creation of local associations between small-scale gold miners in order to acquire more environmentally-friendly technologies. We built a behavioral simulation model to assess the feasibility of associative entrepreneurship in the context of the public-good dilemma that gold mining communities face. The model construction is based on results from field economic experiments, and properly replicates the observed behavioral patterns; thus, it reveals that sustained collective action is possible when miners completely understand the social dilemma they face, but that self-organization is not possible. Features such as reciprocity and temptation to free ride partially explain why self-organization fails. In such a case, external intervention has a key role in promoting programs that improve the understanding of the social dilemma faced by artisanal and small-scale gold miners.

1. Introduction

In the design and implementation of support policies for communities involved in artisanal and small-scale gold mining (ASGM), several scholars have stressed the importance of having a good understanding of the social dynamics of these communities (Hilson, 2006; Sinding, 2005; Spiegel, 2009). Poor performance of some projects aimed at regularizing and providing assistance to ASGM has been said to be, in part, due to an insufficient understanding of the dynamics of target communities (Hilson, 2007).

Communities involved in ASGM face a social dilemma that is found in the way gold is recovered. In the gold recovery (ore beneficiation) process, a miner usually employs the apparently cheapest and traditionally available technique – mercury amalgamation – to gain the maximum short-run benefit for himself. However, the entire community is worse off than if a cleaner and more productive technology were used. This social dilemma can be classified as a public-good dilemma and it concerns the control of pollution resulting from this process.[1]

In a public-good dilemma people find it costly to contribute to the provision of the public good and prefer others to pay for its provision instead (Ostrom, 1998). When everybody in the community follows this type of strategy, the public good is underprovided or not provided at all, while pollution increases. However, the entire community might be better off if everyone contributes to the provision of the public good (Ostrom, 1998). In an ASGM context, cleaner technologies for gold recovery could be accessed under an association scheme that involves entrepreneurial activities (associative entrepreneurship); i.e., through collective action. Nevertheless, some incentives and personality traits might hinder the emergence of such pro-social behavior.

There is a kind of policy aiming to reduce mercury pollution in ASGM, which is the promotion of miners' organization via entrepreneurship (Saldarriaga-Isaza et al., 2013). By associative entrepreneurship it is meant the creation of local associations between small-scale gold miners in order to acquire more environmentally-friendly technologies, in order to overcome the social dilemma that is present in the gold recovery process. In addition, it is also expected to improve the relationship with the state, and thus associative entrepreneurship would enable miners to accumulate the financial capital required to obtain cleaner and more productive technologies that are beyond the budget of most miner families (Hinton et al., 2003; Ghose and Roy, 2007; Spiegel, 2009). This financial capital is difficult to obtain from the financial system, which perceives small-scale mining as a risky activity (Chaparro, 2003). This fact, added to the low tendency of miners to save money for investing (Saldarriaga-Isaza et al., 2013), makes associative entrepreneurship an option for small-scale miners to increase the financial capabilities.

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[1] Public-good and common-pool resource dilemmas are similar in that there is no exclusion in the access to the resource or good. They differ in the degree of rivalry; in public-goods this is much lower or simply do not exist.

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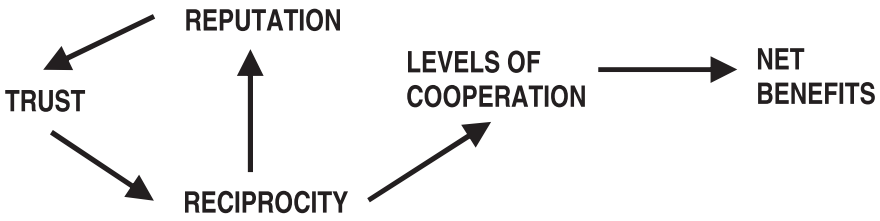

Fig. 1. The core relationships of collective action.
Source: Reproduced from Ostrom (1998).

In an effort to assess the feasibility of associative entrepreneurship and collective action in the context of this public-good dilemma, in this paper we propose a behavioral simulation model. This approach goes beyond the analysis done so far by some scholars who, through visual models, have integrated, for instance, the most relevant factors that explain poverty-traps in ASGM (see Heemskerk, 2001; Hilson and Pardie, 2006; Spiegel, 2009). Even though these models represent the core relationships that drive poverty-traps in ASGM, it is still not clear from these visual models, for instance, which are the attributes that would prevent the use of cleaner technologies, in a way that allows the design of strategies for overcoming resistance to technological change.

Modeling, in general, has been established as a useful tool in the process of creating scientific explanations of how systems work, and also in assessing alternatives for transforming systems (Morecroft, 2007). Modeling by simulation has become an important methodology for theory development in the literature about organizations, and for explaining social phenomena (Vázquez et al., 1996; Bowles, 2004; Davis et al., 2007). The use of simulation has been previously employed in the analysis of situations that imply a social dilemma. Using the *System Dynamics* simulation method, Castillo and Saysel (2005) explained the behavior arising from individual decision rules of communities whose livelihood depends upon the extraction of common-pool fisheries, and where a common-pool resource dilemma is implied. The model that we propose builds on the mode and analysis created in Castillo and Saysel (2005) which is modified in its structure for the public-good dilemma that we study in this paper.

The paper is organized as follows. In the next section, we provide a brief discussion of the theory of collective action and our approach to modeling individual decision rules of artisanal gold miners, considering the aforementioned public-good dilemma. Thereafter, the behavioral simulation model and some issues on model validity are presented, followed by the simulation results and policy analysis. We use simulation methods to explain the endogenous causes of behavior of individuals involved in ASGM, in situations that involve a public-good dilemma and in which collective action is a challenge. In the final section, we conclude with a discussion of this model and provide some insights for future work.

2. Collective Action in Social Dilemmas

Extensive fieldwork has established that under some circumstances individuals do voluntarily organize themselves to, for example, protect natural resources (see, e.g., Ostrom, 2000, 2010; Anderies et al., 2011). Ostrom (1998) pointed out that some of the structural variables that affect individuals' decisions in situations involving social dilemmas are the size and heterogeneity of the group of participants, discount rates, and the level of information available to participants. Besides these variables, face-to-face communication (cheap-talk) is another factor that affects the individual attributes that finally shape behavior in a social dilemma situation (Ledyard, 1995; Ostrom, 1998; Anderies et al., 2011). Such individual attributes are trust, reciprocity and reputation (Ostrom, 1998, 2000), which positively reinforce each other and affect the level of cooperation (extraction effort in a common-pool resource, or contributions to a public good). Such a level of cooperation finally determines the benefits that individuals earn from their social interactions (see Fig. 1).

Table 1
Number of subjects by treatment.

Treatment	Students	Miners
Baseline (control)	50	10
Exclusion	45	30
Co-management	45	20
Exclusion & co-management	45	25

Laboratory experiments concerning public-goods provide empirical evidence of Ostrom's theory. For instance, Czap and Czap (2010) show that the level of trust in others that someone has may positively determine the concern the subject has for the provision of the public good, and therefore his levels of donations to the provision of the good. Ostrom (2000) and Fischbacher et al. (2001) report that a certain type of player, a "conditional cooperator," may lead to relatively high levels of contributions in public-good games. A conditional cooperator is someone who is willing to initiate cooperative action when he estimates that others will reciprocate, and to repeat these actions as long as a sufficient proportion of the others involved do reciprocate (Ostrom, 2000). However, Fischbacher and Gächter (2010) found that players in a public-good game are not complete, but rather imperfect conditional cooperators, and this feature explains the decline in contributions to finitely repeated linear public-good games.

When cooperators reciprocate in their decisions, there is "an incentive to acquire a reputation for keeping promises and performing actions with short-term costs but long-term net benefits" (Ostrom, 1998, p. 12). Additionally, in cases where the relation between individuals is recurrent, and they have the opportunity of retaliation against those who defect, cooperation is more likely to occur (Bowles, 2004).

In addition to the effect of the structural variables on collective action mentioned by Ostrom (1998), a key ingredient for explaining the success or failure of a community in solving a social dilemma is the context. Different kinds of broader contextual variables, such as the resource system (Ostrom, 2007), market conditions (Castillo et al., 2011), and historical and ecological settings (Prediger et al., 2011) generate differences in the behavioral patterns and decision-making processes of resource users.

Finally, another driver of decision-making in social dilemmas is the *homo-economicus* or rational profit maximizer from neoclassical economics. In this regard, Castillo and Saysel (2005) pointed out that some aspects of human behavior, such as temptation to free-ride and profit maximization, are important drivers of individual decision-making in situations involving a common-pool resource dilemma.

In the next section we propose a model of individual decision rules of artisanal gold miners, which considers the aforementioned aspects of collective action in social dilemmas. The model is expected to improve the understanding of the societal dynamics of ASGM communities. Although there are certainly other mechanisms that would explain the poverty-trap in this sector (see, e.g., Hilson and Pardie, 2006), we focus our attention on the social (public-good) dilemma as it relates to the technology trap that causes pollution from the gold recovery process to persist.

3. Modeling Approach for Decision Making in ASGM

The behavioral simulation model that we develop is based on the methods of System Dynamics. These methods allow the description