PROSPECTIVE MODELLING TO MONITOR ARTISANAL GOLD MINING ACTIVITY

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Introduction and objectives

Exploitation of mineral resources in artisanal mines makes use of rudimentary tools, unlike industrial mines, which are worked with heavy mechanized equipment. Artisanal mining is then far more labour intensive. However, it may be considered as a job creating activity. As an illustration, the active population involved in this activity is estimated at 40 million throughout the world and 5 million in Africa alone (ILO, 1999). Nevertheless, the said population remains poor in economic terms since the income generated by artisanal mining is not enough to live normally. Moreover, a problem of governance exists because of a "non-official" aspect of the activity. Typically, in the case of gold purchase, whereas the authorities attempt to control the market, one finds clandestine buyer networks that are willing to pay a higher price than the official price for the produced resources.

By taking the artisanal gold mining of the Alga site (noted AGMAS) in Burkina Faso (BF) as a case study, the objective of this work was to carry out *prospective modelling research* on answers to the following questions (q_1 and q_2) that the BF State may pose: q1)- "With regard to *development*, to what extent is it possible to improve the income of the AGMAS population by a given b %?" and q2)- "With regard to *governance*, to what extent is it possible to reduce the importance of clandestine gold buyers in the AGMAS network to a given a %?".

This work is particular in the sense that, although in the geosciences field, modelling often aims at analyzing the dynamics of ore resources themselves (e.g. Mbandezi & al., 2001) according to industrial exploitation, we here apply it for a complementary purpose: the prospective study of the society (artisan communities) exploiting these ore resources.

Methodology

In carrying out our prospective research, we adopted the following steps:

Step 1: Setting the main policy hypothesis: we assumed in this work that the BF State, in seeking answers to q1 and q2, has decided to play only on the variation of the official gold price.

Step 2: Data collection for the model: we made use of the real field data (rea_d) collected by Jaques & al. (2004) relating to the analysis of dynamic artisanal gold mining in BF. The Alga site was chosen since it is considered as a reference for carrying out such work.

Step 3: Choice of the modelling approach: we considered that the Multi-Agent System (MAS)

approach (Ferber, 1999) was appropriate for the work. Indeed, MAS is often used to model complex socioeconomic systems (such as AGMAS) where it is impossible to obtain all output data from a purely numerical transformation of input data (e.g. Andriamasinoro and Angel, 2005).

Step 4: Elaboration of the model: We modelled the organisation of actors in the AGMAS network, by setting and following up (1) the *exploitation* of ores containing gold, from its extraction by miners to its treatment by labourers (*crushers*, *washers*, *winnowers*, etc.); (2) the *selling* of the gold to buyers, or more accurately between clandestine buyers (who obtain, according to rea_d, around 84% of the production) and official buyers (who obtain the remainder); (3) the *distribution* of the resulting income by the mine owners, based on the (commonly accepted) rule that the income of miners depends on what remains after the payment of the labourers and the cost of the exploitation.

Step 5: Simulation and collection of results: we then carried out simulations, aiming at:

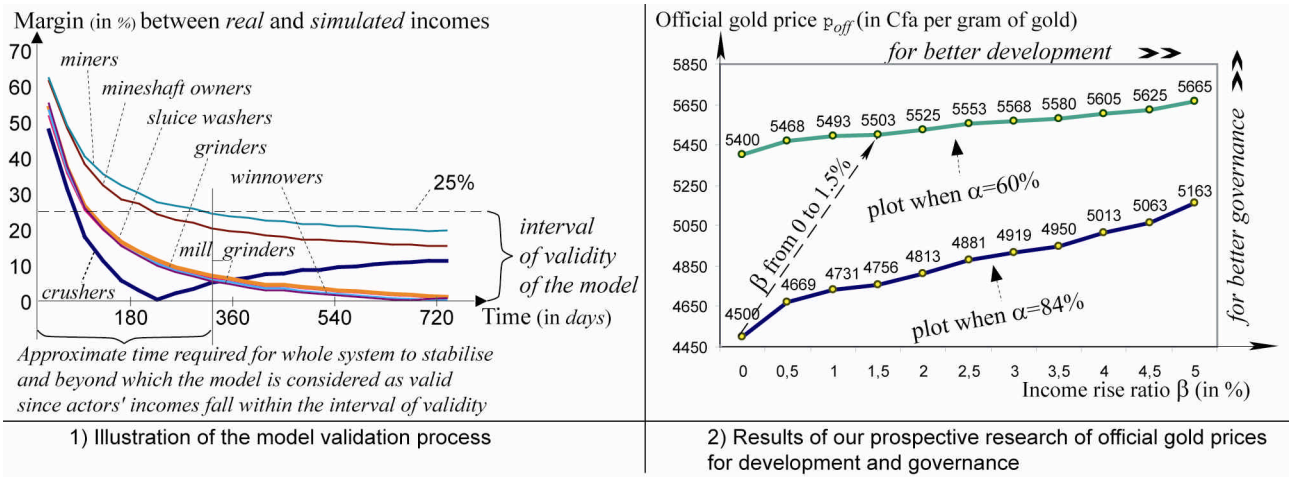
(a) *validating* the model: we considered that the model had been validated from the simulation point where the difference between the real and the simulated income of *all* actors was < 25%.

(b) in seeking answers to q1 and q2, *carrying out the prospective research*, as follows:

1. We took the current official gold price poff (=4500 *Cfa per gram of gold*, according to rea_d)
2. We set a given value of the income rise ratio b % (for better development) as well as the extent of the reduction ratio a % of the clandestine channel (for better governance).
3. And we iteratively increased poff and made simulations until we had the approximate value of poff, which showed that the income of *all* actors effectively increased by b % and, at the same time, the gold sold to the clandestine network decreased from 84% to a %.

   Each simulation was repeated several times to ensure that the result trends were similar.

Simulation results and technical analysis



1) Illustration of the model validation process

2) Results of our prospective research of official gold prices for development and governance

Figure 1) illustrates the model validation process (cf. Step 5(a)). Although we agree that, in modelling research, validation is open to discussion (and falls outside the scope of this study), we believe that what we have achieved so far is promising: we have constructed a simulation mechanism that has been validated and has allowed us to carry out initial prospective research.

Figure 2) presents the possible values of poff that result from our prospective research, as explained in Step 5(b). According to the results in this figure, the authorities may, for example, take the following decision: "*if we want to raise the actors' income by b =1.5% (for better development) while decreasing the proportion of clandestine buyers from a =84% to 60% (for better governance), we should raise the official gold price to at least 5500 Cfa per gram of gold*".

Conclusions

Notwithstanding the values of the different numbers we obtained during our simulations (although interesting for illustration purposes), we particularly wanted to demonstrate here the possibility of building a model and tool to follow up the possible dynamic evolution of artisanal mining activity.

In actual fact, this follow up is not an easy task compared to, for example, that of industrial mining activity. Indeed, in the latter case, the activity has greater transparency because the dynamic results, driven by economical indicators are periodically displayed, allowing decision makers to have a better idea about what to do in the future. On the contrary, the artisanal mine dynamic, as stated in the Introduction, is based on the *socioeconomic* situation of the population, i.e. related to human behaviour. The study of the future of such a system is then more difficult. To deal with this case, prospective modelling by MAS, as carried out in this work, seems to be a promising approach.

In the longer term, this work should lead to a tool that (1) is as reliable as possible, (2) may be used as an aid for authorities to answer questions other than q1 and q2 and (3) could act as a decision aid tool for the long term, in short, a decision aid tool for sustainable development.

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