Resources Policy 38 (2013) 490–495

Contents lists available at ScienceDirect

Resources Policy

journal homepage: www.elsevier.com/locate/resourpol

Influence of the time factor on the availability of deposits of nonferrous metals

M. Kharitonova*, A. Mikhailov, N. Matsko

Laboratory of Mineral Resources, Institute of Chemistry and Chemical Technology, Siberian Branch of the Russian Academy of Sciences, Karl Marx Street 42, Krasnoyarsk 660036, Russia

A R T I C L E I N F O

Article history:
Received 6 June 2013
Accepted 19 June 2013
Available online 16 August 2013

JEL classification:
P28

Keywords:
Mineral resources
The availability of deposits
Probability involvement in the development
The time factor

A B S T R A C T

This study presents a probabilistic approach to the assessment of mineral deposits availability. This approach takes into account the joint influence of decision making involving deposits in development and the difficulty in formalizing socio-economic factors. Using this approach, we designed a model for estimating the availability of deposits with regard to the influence of the length of time elapsed prior to beginning development; values for copper deposits in Russia, the USA and Canada were calculated. The characteristics of mineral resources are determined by an experimental method for these countries. These characteristics are defined by periods when the time factor has a positive influence on deposit availability.

© 2013 Elsevier Ltd. All rights reserved.

Introduction

In the realm of mineral resources, the word "availability" denotes the difficulties connected with ore extraction that are caused by adverse geographical conditions and geological developmental factors. The term "minerals availability" is defined by the United States Bureau of Mines (Bureau of Mines, 1987), which we applied based on Peshkov and Matsko (2004: page): "Availability of mineral resources is the characteristic of a system 'society–mineral resources', which describes the possibility of efficiently and safely implementing their use on the basis of the achieved technological level."

The probability of developing minerals is a convenient quantitative measure of minerals availability. Many factors influence development probability, with the main factors being the volume, quality, and properties of rocks, as well as the level of development of technologies such as extraction and raw materials processing. These factors are used to determine the cost level for the resources.

Minerals availability is also influenced by the price of mineral resources, which reflects the level of demand for the given raw material. For example, a mineral's presence in a region surrounded by competitive businesses promotes the investment climate, institutional factors, etc.

In general practice, the decision to commence mining is made using an engineering-and-economical evaluation of the project, which is based not on current or long-term average prices, but on market research and predicted prices.

There are various approaches for mitigating risk associated with forecasting prices. One common practice uses a method of trends and applies various wave development theories, including N.D. Kondratiev's theory of long waves, J. Shumpeter's theory of innovation, U. Rostou's price theory, and others. Hotelling's (1931) fundamental model predicts a general rise in commodity prices over time. As stated by Krautkraemer (1998, p. 2065), "Hotelling's formal analysis of nonrenewable resource depletion generates some basic implications for how the finite availability of a nonrenewable resource affects the resource price and extraction paths." Hotelling's rule states that the most socially and economically profitable extraction path of a non-renewable resource is the one in which the price of the resource increases at a constant rate equal to the rate of interest. In known publications of Harold and Morse (1963), the results of studying the costs associated with extraction of a unit of a resource are defined for the period from 1870 to 1957. The authors conclude that the costs of extraction of nonrenewable resources have not grown; rather, the prices of nearly all natural resources, corrected for inflation, have decreased during past decades and, in most cases, during past centuries. The price of mineral raw materials tends to decrease over long intervals of time (Sullivan et al., 2000). It is

* Corresponding author. Tel.: +7 391 2124813; fax: +7 391 2494108.
E-mail address: ritau@icct.ru (M. Kharitonova).

0301-4207/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.resourpol.2013.06.006

interesting to note that for the last 100 years, the decrease in price level in constant dollars occurred simultaneously with the decrease in the average contents of useful components in ores of extracted minerals for practically all kinds of mineral raw materials, with the exception of gold. According to Crowson (1998), from 1973 to 1993, prices on the London Metal Exchange fluctuated around the highest expenses of the mining enterprises, making up 10% of the general number of mining enterprises. It has been noted by Pindyck that over long-term intervals, the change in price of metals is connected with marginal costs and has a U-shaped form, unlike the monotonous increase predicted by Hotelling's basic model (Pindyck and Rubinfeld, 1997; Pindyck, 1978). There are many theoretical models that establish a U-shaped form for the price of resources and numerous proofs of these hypotheses. U-shaped trends for the price of 11 kinds of natural raw materials have been identified in previous studies (e.g., Slade and Thille, 1997). The prices for practically all resources during this period were already on curves' upward trajectories. Nordhaus (1973) has developed studies on the optimal control of extraction of exhaustible resources in connection with power branches. His so-called “backstop technologies” limit the market price of natural resources.

Studies conducted under the auspices of the USGS (US Geological Survey) estimate mineral resources based on SME models of mineral deposits, which are based on the representation of SME in the form of GT diagrams (grade-tonnage) (Cox and Singer, 1986). In the United States Bureau of Mines, which performed a global assessment of resource potential for both the USA and the world, models of normative costs for both mining and processing of mineral resources were developed. A simplified model of value indicators, which was developed by Camm (1991), was used to predict costs. The results given in Singer et al. (1998) show that the simplified model, adjusted for inflation, provides the necessary accuracy in preliminary cost estimates and may be used at the present time. Unfortunately, without significant adjustments, these models are not useful to assess Russian mining enterprises due to significant differences in the cost and price structures of the Russian and U.S. economies.

However, despite of big number of new researches in this field, the results obtained cannot be considered completed, and there are significant difficulties in forecasting the prices and costs for nonrenewable resources. It is also difficult to predict whether the trends observed now will be similar in the future.

In fact, in certain situations, available deposits that meet all the criteria for immediate development are in fact left undeveloped for many years, as in the case of the Udokan deposit. This is one of the largest copper reserves in the world, but its development may only be possible with preferential tax treatment. This is mainly due to the deposit's technological complexity, as it contains three types of ore sulfide, oxidized and mixed. In addition, Russia lacks the technological capacity to develop rock in a zone of high seismicity at an altitude of 2400 m. A lack of positive scientific and technological solutions hinders the development of the Udokan deposit. Deposits may also remain undeveloped if the owner is not satisfied with the value of current prices for mineral products, the investment climate, the currency exchange rate, bank interest rates and/or inflation. Development may be further delayed due to official incompetence, corruption, etc. The influence of these kinds of factors is difficult to formalize and quantify. These factors are considered for individual deposits in varying degrees in the most representative Russian techniques using the method of correcting coefficients. However, in estimating the mineral resources in a country or region, it is challenging to consider the numerous influences derived from the difficulty in formalizing socio-economic factors.

Why can new effective deposits remain undeveloped for significant lengths of time?

To answer this and other questions, the authors have drawn the conclusion that it is necessary to study a parameter that affect the availability of deposits of nonferrous metals: development delays, which are defined as the time interval from deposit discovery to the initiation of development. In our opinion, the main reasons for delays in development of effective deposits are reflected implicitly in the parameter, namely, the time period from the discovery of a deposit to its development.

In this study, the results are derived by applying a probabilistic approach to estimate the time factor influence on deposits availability for selected regions.

The problem was solved using a special approach in which we consider influences related to the difficulty of formalizing socio-economic factors, as well as features of the decision-making process surrounding deposits development in a select region.

The theoretical model

The essence of the method is as follows (Peshkov et al., 2010). Information on ore reserves and average content mineral components is applied to the chart and developed and undeveloped deposits are marked. Using logit-regressions, the function of objects belonging to the classes developed and undeveloped is determined. The probability of involving deposits in development (P) depends on ore resources, grade of ore and the strip ratio. The equation for estimating the probability of development is as follows:

$$P = \exp(b_0 + b_1\alpha + b_2S + b_3K\text{в})/(1 + \exp(b_0 + b_1\alpha + b_2S + b_3K\text{в})) \quad (1)$$

where b_0, b_1, b_2, and b_3 are the model coefficients, a is the content of useful components, g/m^3, S represents ore reserves, and m^3, $K\text{в}$ indicates strip ratio. We then build a model for a concrete regional raw material base, define factors b_0, b_1, b_2, and b_3 statistically, estimate unknown variables and predict the value of dependent variable P. In model (1), the values of P will have the mathematical meaning of the probability that a deposit with the characteristics of S, α, $K\text{в}$ belongs to an area under development.

For studying time factor influence on the availability of deposits, we constructed an economic-mathematical model, model (2). The parameter of time from deposit discovery to its development was introduced into this model. This model calculates the probability of deposit development, taking into account the time lapse, using the following logit-regression equation:

$$P_T = \frac{\exp(b_{0T} + b_{1T}\lg\alpha + b_{2T}\lg S + b_{3T}\lg T)}{1 + \exp(b_{0T} + b_{1T}\lg\alpha + b_{2T}\lg S + b_{3T}\lg T)}, \quad (2)$$

where b_{iT} represents the model coefficients and T the time interval from discovery to initiation of development.

Indicators P and P_T are defined by models (1) and (2), respectively, and change in the interval [0,1]. The period from the deposit discovery to development, during which the time factor positively affects the probability of development, corresponds to the maximum period of delay in development without decreasing efficiency. This is calculated for each deposit by

$$T_{max} = \left[\frac{e^{b_0}\alpha^{b_1}S^{b_2}}{e^{b_{0T}}\alpha^{b_{1T}}S^{b_{2T}}}\right]^{1/b_{3T}} \quad (3)$$

We find the rate of change in the probability of development over time by differentiating the equation $P_T = qT^{b_{3T}}/(1 + qT^{b_{3T}})$ where $q = e^{b_{0T}}\alpha^{b_{1T}}S^{b_{2T}}$ (P'_T):

$$P'_T = \frac{dP_T}{dt} = \frac{qT^{b_{3T}}/(1 + qT^{b_{3T}})}{dt} = -\frac{qb_{3T}T^{b_{3T}-1}}{(1 + qT^{b_{3T}})^2} = -P_T\frac{b_{3T}}{T(1 + qT^{b_{3T}})} \quad (4)$$

Download English Version:

https://daneshyari.com/en/article/10484041

Download Persian Version:

https://daneshyari.com/article/10484041

Daneshyari.com