Modelling the Skinner Thesis: Consequences of a Lognormal or a Bimodal Resource Base Distribution

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Abstract

The copper case is often used as an example in resource depletion studies. Despite these studies, several profound uncertainties remain in the system. One of these uncertainties is the distribution of copper grades in the lithosphere. The Skinner thesis promotes the idea that copper grades may be distributed with a bimodal distribution instead of a lognormal distribution. This paper presents a System Dynamics implementation of both the lognormal and the bimodal distributions. By simulating this model for different demand scenarios, it was demonstrated that in case of a bimodal distribution, a slower degradation of copper grades is to be expected. This is in contrast with the common believe that the bimodal distribution, and the 'mineralogical barrier' between the two modes, limit the availability of affordable copper.

Keywords: Resource base, Skinner thesis, Resource depletion, Copper, Uncertainty

1 Introduction

[…]

The Skinner (Skinner 1976) thesis argues that the available copper ore in the lithosphere, or the resource base (*i.e.*, the total amount of conventional resource plus unconventional resource, after McKelvey (1973)) may be distributed with a bimodal distribution, rather than the alternative lognormal distribution. This distribution may be expected for all metals with less than 0.1% crustal abundance. If the Skinner thesis is confirmed, the copper ore grade is expected to drop quickly after depleting the first, relatively high ore grade mode containing sulphide ores. As energy costs are heavily dependent on the ore grade, this would lead to a quick rise in production costs. The second, lower ore grade

mode would consist of copper in common rocks and was estimated by Skinner to have production costs approximately ten times as high with the same ore grade. The shift between two modes was called the ‘mineralogical barrier’, a moment when copper extraction would stop as we know today and copper prices (Skinner 1976). More recent, Gerst (2008) used production – ore grade figures to analyse whether either of the two hypotheses was plausible. He found evidence of lognormal distribution of resources, but indicated the impossibility of presently assessing whether this distribution was part of a singular lognormal distribution, or a bimodal distribution.

[…]

In this paper, I present an SD model which simulates the ore grade development of copper resources under sixteen plausible demand scenarios. As such, this model forms a simple copper supply model with a top down approach for the demand development (Auping, Pruyt, and Kwakkel 2012) in the fixed stock paradigm (Tilton 1996). This approach allows to see to what extend the depletion will cause the ore grades to decline in both the lognormal and bimodal distribution. This simulation will generate insight in the consequences of either ore grade distribution in combination with the potential development.

The setup of this paper is as follows. First, I will explain how a lognormal distribution and a bimodal distribution can be modelled, as well as the rest of . In the next section, I will present the results for the ore grades of conventional and unconventional sources of copper. After this, I will discuss the policy implications of the copper ore grade developments and draw conclusions about this approach of modelling the ore grade development of metals.

FOR THE FULL VERSION OF THIS ARTICLE, PLEASE CONTACT THE AUTHOR

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