Chapter 8
Mathematical Models for Optimizing the Global Mining Supply Chain

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ABSTRACT

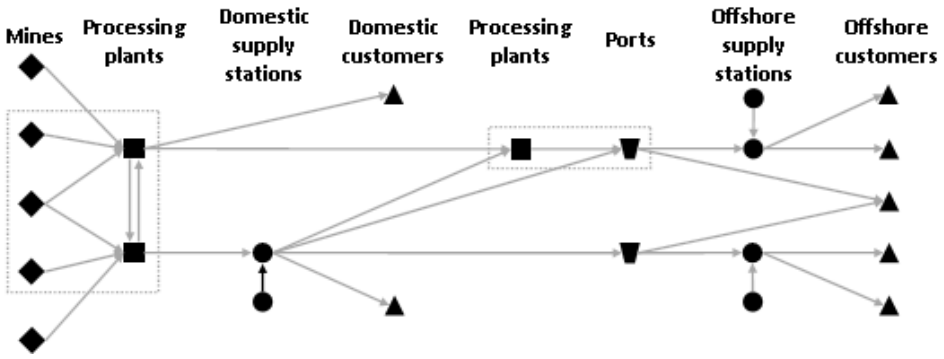
The present chapter discusses the application of intelligent decision-support systems – mathematical programming-based in particular – to operations management within the mining industry. The underlying production and distribution planning and scheduling problems have often been addressed individually, in disregard of upstream and downstream operations. A supply chain approach to mining operations, however, requires an integrated perspective which takes into account mine, railway and port operations, as well as domestic and international supply stations served by appropriate logistics channels. Three main topics are discussed here: recent operations research developments in the mining industry; integrated approaches towards the development of decision-support systems to address a global mining supply chain; and possible solution approaches to the integrated problems. The main thread is oriented to mathematical programming approaches, but relevant applications of simulation and artificial intelligence techniques are also discussed.

INTRODUCTION

The present decade has shown extreme variations in ore prices and demand. In a growing economy environment, when ore prices and demand are high, mining companies tend to invest in establishing new ventures, expanding capacity, or consolidating the market. The high ore prices improve the feasibility of lower grade operations and geographically distant ore producers, especially if product prices are significantly higher than freight costs. Customers tend to prioritize quantity over quality and there is

DOI: 10.4018/978-1-61520-605-6.ch008

Figure 1. A global mining supply chain



a high pressure on the availability of production and distribution systems. However, in an unstable or shrinking economy, the situation is quite the opposite. Demand and prices drop, thus forcing mining companies to reduce production levels and shutting down expensive or lower grade operations. Customers tend to prioritize quality over quantity and there is a high pressure on reducing production and distribution costs. Such dynamic and uncertain scenario has driven base metals mining companies to pursue higher efficiency levels in their global operations. This can be achieved by adequately modeling and planning operations in an integrated framework, such as the global supply chain.

A global mining supply chain can be defined as network of integrated facilities designed to convey ore products from mines and processing plants, through a variety of modals including roads, ducts, railways, rivers and oceans, to metal processing customers, which can be located at significant geographic distances. Figure 1 depicts a general global mining supply chain.

Although there has been significant effort in developing intelligent decision-support systems for the mining industry, these are usually focused in tasks such as mine development, hauling equipment dispatch and railway scheduling. An approach to the global mining supply chain, on the other hand, requires an integrated perspective which must take into account mine, railway and port operations, as well as domestic and international supply stations served by appropriate logistics channels. There is a whole growing stream of research aiming at the integration of strategic, tactical and operational decisions in supply chain planning (Melo et al., 2009) that could be exploited to develop intelligent systems to assist operations management in an integrated mining industry. Such developments, nevertheless, do come with an additional degree of complexity in both mathematical modeling and computational requirements.

The aim of this Chapter is thus threefold: firstly, to present recent developments of intelligent systems in the mining industry by discussing problems, models, applications and challenges to implementation; secondly, to discuss an integrated approach towards the development of decision-support systems to tackle the global mining supply chain problems; and thirdly, to discuss possible solution approaches to the problems addressed. Although the iron ore mining industry is used as a case study, there would be no significant loss of generality if different base metals industries were considered. Due to its scale and geographical range, the iron ore mining industry includes many of the operational aspects relevant to modern commodity production and distribution systems. It is important to notice, however, that the scope of this Chapter does not include an extensive analysis of supply chain theory. The most relevant