UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

A BIBLIOGRAPHY ON THE ECONOMIC THEORY OF MINERAL RESOURCES

by

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Explanatory Note

This is a bibliography of economic *theory* as it relates to exhaustible resources, in particular, to minerals. The bibliography excludes studies of particular mineral resources or industries that do not develop or apply in an exemplary manner some aspect of the economic theory of exhaustible resources. Such studies will be the subject of a future bibliography. The bibliography is comprehensive, and includes literature outside of the English language.

In a seminal article, Hotelling (1931) demonstrated that the exhaustibility of a resource introduces unique problems to the application of economic theory to the study of optimal resource use. Principal among these is how to allocate resource production over time in order to maximize profits and/or social benefits. Hotelling's (1931) analysis concluded that profits would be maximized by reducing resource production and raising resource prices over time until the resource is exhausted. This would imply that minerals prices should be increasing in real terms over time, when in fact empirical studies (Barnett and Morse, 1963; Gordon et. al., 1987; Halvorson and Smith, 1984, Smith, 1979) show that the opposite has occured. Most of the literature cited in this bibliography can be viewed as attempts to deal with this discrepancy by generalizing Hotelling's (1931) simplistic model of resource extraction such that it better reflects the reality of resource use under conditions of uncertainty, competition from substitutes, scarcity of capital and technological innovation.

These studies have also illuminated many economic and public policy aspects of the extraction of mineral resources. These include, in particular, the economics of mineral exploration, which is not only the process by which new, profitably minable mineral deposits are found, but is also the primary means by which information on the resource base is acquired. Thus, studies of the magnitude and composition of undiscovered mineral resources must take into account the biases and omissions in mineral resource information that are the result of a competitive, profit-motivated search for new resources. The economics of exploration are, in turn, motivated by the economics of resource extraction and use, which are likewise influenced by government taxation and regulation, technological change, international competitiveness, etc. The studies listed in this bibliography address all of these issues and, taken together, comprise a sophisticated body of knowledge of mineral economics.

Unfortunately, there is no one comprehensive, non-technical guide to the issues and results addressed by these studies. Most are written at a high level of abstraction that require of a reader a strong background in economic theory and in specialized branches of mathematics such as optimal control theory. The best comprehensive study accessible to geologists is that of Gordon et. al. (1987); those geologists wishing to obtain a deeper understanding of the economics involved might consult the textbooks by Anders et. al. (1980), Fisher (1981), and Pearce and Rose (1975). Economists unfamiliar with exhaustible resources might begin with Dasgupta and Heal (1979) and Devarajan and Fisher (1981).

The bibliography is organized by subject, according to a schema that should make sense to economists unfamiliar with the literature. An attempt to acquire a comprehensive knowledge of this literature should closely follow the order in which the studies are grouped as each successive subject grouping tends to draw on previous ones. At one time it was possible to master this body of economic theory in a matter of months. That time is now past and there is a need for a synthesis and proper presentation of all that has been learned in this area in the last two decades. Hopefully, this bibliography will be a small contribution to that effort.

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