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Issues in extractive resource taxation: A review of research methods and models

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ABSTRACT

This paper provides a conceptual overview of economists' attempts to learn about the effects of taxes on extractive resources. The emphasis is on research methods and techniques, with no attempt to provide a comprehensive tabulation of previous empirical results or policy conclusions regarding preferred tax instruments or systems. We argue, in fact, that the nature of such conclusions largely depends on, and is limited by, the researcher's choice of modeling framework. Many alternative frameworks and approaches have been developed in the literature. Our goal is to describe the differences among them and to note their strengths and limitations.

Introduction

This paper provides a conceptual overview of economists' attempts to learn about the effects of taxes on extractive resources. The emphasis is on research methods and techniques, with no attempt to provide a comprehensive tabulation of previous empirical results or policy conclusions regarding preferred tax instruments or systems. We argue, in fact, that the nature of such conclusions largely depends on, and is limited by, the researcher's choice of modeling framework. Many alternative frameworks and approaches have been developed in the literature. Our goal is to describe the differences among them and to note their strengths and limitations.

The importance of resource taxation should be apparent. Mineral wealth plays a substantial role in many national economies. The International Monetary Fund (IMF) (2012) identifies 22 countries where petroleum revenues comprise at least 10% of national GDP, a fraction that rises as high as 80% (Angola) or even 90% (Timor-Leste) in certain cases. Mining revenues typically constitute a smaller share of GDP but, due to surging commodity prices, this fraction is also large and growing. And extractive resources loom especially large as a source of government revenue. Boadway and Keen (2010) list 37 petroleum-rich nations where the fraction of government revenues drawn from oil and gas operations ranges between 10% and 97%, averaging 50% overall. A separate listing of 10 mineral-rich nations shows mining's share of total government revenue ranging between 1% and 44%, averaging 11% overall.

This variation in dependence upon resource revenues stems in part from differences in national resource endowments. The fact that 79% of Kuwaiti government revenue is derived from petroleum reflects the natural abundance of oil within the region. Even where resources are abundant, however, the government's share may be large or small depending on how provisions of the fiscal regime impact extractive industries. By "fiscal regime" we refer a broad variety of tax and contractual arrangements, including signature bonus payments, royalties, income tax, production-sharing, resource-rent taxes, and state participation, among others. Historically, individual governments have adopted various and unique combinations of these instruments, leading to a diverse and potentially confusing array of distinct fiscal regimes. No two countries tax extractive resources in quite the same way—which leaves researchers to ponder which type of regime is the best.

The fiscal regime touches many aspects of an investor's plan of exploitation, including the scope of exploration and discovery, the timing and scale of initial development, the rate of production and decline, the timing and scale of enhanced recovery operations, the overall resource recovery factor, and the timing of final abandonment. The pervasive impacts of the fiscal system, on the investor as well as the government, magnify the importance of designing and implementing a sound fiscal regime. The IMF (2010a, 2010b) reports that many resource-rich developing countries have failed to realize the full development potential of their natural resources and now seek to strengthen their ability to manage their resource sectors. The fact that, during 2006–2012, IMF staff delivered 85

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technical assistance missions to advise host governments on fiscal regimes for extractive resources, with an additional 33 missions already planned for 2013, indicates both the importance and complexity of this task.[1]

As Boadway and Keen (forthcoming) point out, extractive resources provide an unusual opportunity for governments to raise revenues without distorting the efficiency of the economy. This opportunity arises only because the resources are fixed in both the supply and location. They cannot run before the tax collector. However, if any portion of value is taxed other than the economic rent associated with the resource, distortions are inevitable. Much interest has focused therefore on tax regimes that target the rent directly, the so-called "resource rent taxes". A simple proportional tax on net cash flows (Brown tax) is an example. There the government participates equally in both the positive and negative cash flows and essentially becomes an equity partner in the project without skewing project economics.[2] Other variations include the Allowance for Corporate Equity (ACE) tax in which a portion of project expenditure is carried forward with interest to offset future cash flows, and the Resource Rent Tax (RRT), as proposed by Garnaut and Clunies Ross (1975), in which all net cash flows are carried forward with interest until the investor reaches a threshold rate of return. Under either alternative, the present value of all future tax liabilities associated with the generation of a given cash flow is equivalent to what it would be under the Brown tax, and therefore non-distorting, but the government avoids the problem of making negative tax payouts in the early years of a project.

Today, in reality, most extractive resources are taxed by rather blunt instruments that fail by various degrees to allow full deduction of economic expenses. Royalties of course, make no allowance for such deductions, but even income taxes and production sharing contracts that permit deductions usually fail to allow for interest on balances carried forward, and may deny deductions for unsuccessful exploratory efforts, etc. Auctioning of mineral rights is generally free of any distortive influence since the bonus is paid up front (sunk) and therefore plays no role in subsequent decisions on how the project will be conducted. But mineral auctions are seldom used outside of the United States, and even there they are combined with production royalties.

Research naturally turns to the question of what are the relative merits of the alternative tax systems. The merits of any given fiscal regime can be measured in terms of its ability to raise revenue and effect a reasonable allocation of risk between industry and government, without inefficiently distorting private investments. However, before those merits can be judged we must factor in the potential scope and nature of tax avoidance, i.e., actions a reasonable investor would take to mitigate the burden of the tax. As Poterba (2010) emphasizes, anticipating the taxpayer's behavioral response is primarily what economic analysis adds to the accounting discussion of tax policy. The scope for tax avoidance will be determined by the structure of the fiscal regime itself, plus the degree of project flexibility relative to the physical and economic constraints that define the extractive enterprise. For this reason, one might expect the greatest insights to come from models that are designed to accommodate a rich description of the proposed fiscal regime without oversimplifying the physical process of resource identification and extraction. As we shall see, there is tremendous variation among models in terms of fiscal detail and process description. Yet, not in every case does the more detailed and nuanced model provide the more useful results.

Literature review

Any attempt to assess the impacts of extractive resource taxation must draw from two literatures: the economic theory of extractive industries and the theory of optimal taxation. This paper reviews the contributions of many previous works that have attempted to conjoin these two subjects. A comprehensive review would necessitate a separate paper (or book) in its own right.[3] In lieu of that, we provide an overview of research that, although abbreviated, is sufficiently detailed to define the contribution of the various approaches. Although there is a considerable overlap between the two fields, we have attempted to group together those studies that focus primarily on the economics of extraction, followed by a summary of applied research on tax distortions and optimal tax design as it relates to extractive enterprise.

The literature on optimal investment and extraction

The methods and models employed to study resource extraction from a known deposit cover a broad range. At one extreme are the highly detailed numerical reservoir simulation models developed by petroleum engineers. At the other extreme are applications of the generalized neoclassical theory of production set forth in graduate economics texts. Many alternative approaches lie between those two poles, and it is the intermediate methods that have tended to prove most useful and amenable for purposes of tax policy analysis. This section provides a brief overview of the various approaches.

Reservoir simulation models

Peaceman (1977) provides a comprehensive technical overview and discussion of applications of reservoir simulation in the petroleum industry. By exploiting three-dimensional geological and geophysical modeling tools to capture the heterogeneous physical properties of a given reservoir, petroleum engineers are able to simulate fluid flows within a reservoir and forecast the production of oil, gas, and water expected to result from any particular drilling program. The dynamic properties of each simulation are governed by the rules of fluid dynamics (Darcy's Law) and the principle of material balance. After assigning costs and values to the inputs and outputs, and simulating the physical and financial consequences of alternative drilling programs, this approach provides the most detailed and accurate means of valuing alternative investment plans and project designs. It also provides the most comprehensive assessment of the investor's potential behavioral response to taxes that alter the pattern of net cash flows.

Although the high level of spatial resolution (millions of grid blocks) required to attain precise projections can place prohibitive demands on computational resources, coarser simulation models (thousands of grid blocks) provide more practical forecasts of fluid flows that are quite accurate enough to be useful for reservoir management, as described by Durlofsky et al. (1996).[4] Although

[1] See IMF (2012); Appendix 2. An outline of the IMF's technical assistance program is provided in IMF (2010a).

[2] As Boadway and Keen (forthcoming) are careful to point out, tax-induced distortions of the investor's incentives may be appropriate in the presence of various forms of market failure, like asymmetric information, a difference between private and social discount rates, or a difference between public and private risk aversion. This is seen as one possible justification for a government to adopt alternative (distorting) types of tax (e.g., royalties).

[3] Lund (2009) provides an excellent and comprehensive review of the literature on resource rent taxes. The collection of papers in Daniel et al. (2010) take a more comprehensive view of fiscal design, including virtually all tax and contract provisions in current use. Peterson and Fisher (1977) and Cairns (1990) offer broad, if somewhat dated, reviews of the economics of exploration and extractive industries.

[4] The size of each block in a highly refined simulation model can be as small as 1 cubic ft.