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A Price-Based Royalty Tax?

Kimberly A. Clausing and Michael C. Durst

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Summary

This paper considers the merits of a price-based royalty, a royalty for which the rate varies with the product price, as a fiscal instrument for taxing extractive industries. In light of the literature on natural resources taxation, the case for a price-based royalty is appealing. A price-based royalty captures some of the desirable attributes of an income or resource rent tax, but in comparison to such taxes, it is easier to administer since revenue is much less sensitive to transfer price manipulation and tax avoidance efforts. In order to explore how a price-based royalty might provide some of the advantages of income- or rent-based taxation, the paper analyses the relationship between product prices and firm profits, using a dataset of the world's largest extractive firms from the Forbes Global 2000 list during the period 2003-2014. This analysis indicates that, for both oil/gas and mining firms, there is a nearly one-to-one relationship between product prices and firm profitability; prices 1 per cent higher tend to be associated with profits about 0.76 per cent higher for oil/gas firms and about 1.38 per cent higher for mining firms. The paper concludes by recommending that tax policymakers give serious consideration to increasing the use of price-based royalties.

Keywords: transfer pricing; extractive industries; natural resource taxation; royalties; resource rent tax.

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Acronyms

GEM	Global Economic Monitor
GDP	Gross Domestic Product
ICTD	International Centre for Tax and Development
IMF	International Monetary Fund

Introduction

This paper considers the merits of a price-based royalty as a tax instrument for extractive industries. Section 1 reviews the literature in this area, arguing that a price-based royalty has appealing features, given the experience with taxation in the natural resources sector. Section 2 analyses the relationship between firm profitability and underlying product prices, using a dataset that focuses on large extractive firms in the oil, gas, and mining sectors over the period 2003-2014. A final section concludes and discusses policy recommendations.

1 Literature review

This literature review is organised in three parts. First, the review addresses tax policy objectives in the natural resources sector, and, in particular, the competing concerns of government revenue and investor incentives. Second, it discusses the merits of typical tax policy choices in the natural resource sector. Finally, the review considers the idea of a price-based royalty, and surveys the limited experience with such fiscal instruments in practice.

1.1 Tax policy objectives

This section focuses on tax policy goals in the natural resource sector. The natural resource sector is an important source of tax revenue for many less developed countries, but there are also important trade-offs between revenue aims and the goal of attracting investment.

There is no doubt that natural resource industries are a key part of many less developed countries' economies, accounting for a large share of GDP and generating important impacts on economic activity and government revenue. Yet the literature shows that resource wealth is not always associated with economic growth or poverty alleviation, and there are important concerns about the capacity of less developed countries to collect appropriate levels of tax revenue from this sector.¹

As one example, the Africa Progress Panel notes:

Resource-rich countries in Africa are highly vulnerable to aggressive tax planning and tax evasion facilitated by the extensive use of offshore companies, the high levels of intra-company trade and the commercial secrecy surrounding foreign investment activity. African governments lack the human, financial and technical resources needed to secure tax compliance, and the commercial market intelligence needed to assess company tax liabilities. As a result they are losing significant revenue streams. (Africa Progress Panel 2013: 65)

Yet natural resource industries have the potential to make large contributions to both the economy and government revenue in a significant number of countries. IMF (2012) notes that there are over twenty countries where petroleum revenue exceeds 10 per cent of GDP, and that mining revenue is also an important, and growing, share of GDP in many countries, as shown in Boadway and Keen (2010).² Yet, as documented in Laporte and Rota-Graziosi (2014: 12-13), mining exports have increased a great deal in recent years, while revenue from the mining sector has not always increased proportionately; 'mining tax revenue represented around 12% of the value of exports in 1995 and less than 10% in 2010'.

¹ See African Progress Panel (2013); Humphreys et al. (2007); Smith (2012).

² See Table 1 in Boadway and Keen (2010). For example, copper accounts for 12% of government revenue in Chile, and iron ore and gold account for 8% of government revenue in Liberia.

While ensuring appropriate tax revenue is important, there are also balancing considerations, such as enabling other aspects of country tax systems to be healthy.³ There is also an inevitable trade-off between tax revenue goals and ensuring that the tax system does not provide an undue deterrent to investors. While good tax system design may mitigate the severity of this trade-off, it is still a fundamental tax policy problem.

Indeed, there are many factors to balance in the design of better tax systems for extractive industries. Natural resource industries present special tax design policy considerations due to their characteristics, including: (a) high sunk costs of exploration and early stages of production; (b) long production periods followed by eventual resource depletion or exhaustion; (c) risk and uncertainty due to variable success in exploration and initial production as well as volatility in both input and output prices; (d) asymmetric information between the government and the investor, where the latter party has greater knowledge about the investment prospects; (e) the presence of economic rents due to profits above those that would cover normal economic costs, as well as the likely market power of the investing firms; and (f) the key importance of this sector for meeting the revenue needs of many less developed countries that are abundant in natural resources, a factor which gives natural resource firms substantial political leverage. Boadway and Keen (2010) provide a thorough discussion of these features.

These factors shed light on the inevitable trade-off between investor incentives and government revenue. Consider first the large up-front costs of natural resource products, combined with their underlying risk and uncertainty. As Daniel et al. (2008) emphasise, investor incentives in natural resource projects will depend on the details of the tax system that determine effective tax rates. Given the role of risk, uncertainty, and economic rents, **a tax on profits or resource rents** may be particularly appealing, as discussed in Baunsgaard (2001). Such taxes make the government a partner in the project, thus absorbing some of the investor risk; tax revenue is then procyclical, increasing with the underlying profitability of the investor as well as product prices. Indeed, many economists are attracted by the efficiency properties of a resource rent tax that would only tax projects once initial costs had been overcome.

Yet here, as elsewhere, practical difficulties may get in the way. For instance, the administration of a resource rent tax is complex, and complexity may provide ample opportunities for tax avoidance, particularly in countries that are lacking in tax administration capacity. More generally, as noted by Laporte and de Quatrebarbes (2015), very little is known about the sharing of rent between less developed country governments and investors due to conceptual difficulties, poor data, and constantly evolving circumstances.

Further, governments also face risk: revenue streams that are stable and predictable are desirable. For this reason, **taxes that are based on output (either royalties or production sharing agreements)** are potentially attractive, since they are likely both easier to administer and less subject to tax avoidance. Yet, these revenue sources are also likely to be variable. Ahmad and Mottu (2002) emphasise the importance of revenue volatility for oil-producing developing countries, and Baunsgaard (2001) also emphasises the highly variable product prices in this sector.

One important issue that is essential to tax system design is whether tax policies should be progressive. In this literature, the term *progressive* is used to indicate taxes that automatically increase (as a share of the tax base) when profits, or product prices, are

³ Observers worry that countries can become too reliant on natural resource taxation: since the supply of natural resources is finite, the natural resource sector may be particularly volatile, and excessive reliance on natural resource revenue may undermine tax capacity, as considered by Crivelli and Gupta (2014).

higher.⁴ Several arguments speak in favour of progressive taxes on natural resource industries. As Laporte and Rota-Graziosi (2014) discuss, this may help governments earn more revenue without deterring investment, since revenue would rise automatically with the underlying project profitability, but taxes would be automatically less burdensome in times of low profits. This reduces the risk of the underlying projects, since governments share the risk with the investor through the tax revenue mechanism.

This may also help resolve the dynamic problems, sometimes referred to as *time consistency problems*, that are associated with natural resource tax design. Early in a project's development, tax concessions are tempting to governments eager to attract investment in an environment where investment is risky and where there is asymmetric information between investors and governments. Yet if a project is successful and very large profits result, governments will be tempted to raise taxes *ex post*. Indeed, Sunley et al. (2003) note that fiscal regimes tend to evolve with underlying product prices, becoming less generous to companies as prices rise.

Unfortunately, farsighted investors will anticipate this temptation and consider upcoming tax burdens to be part of the sovereign risk that deters the original investment. By committing to a progressive tax regime ahead of time, the government can both share in the investment risk and reduce the investor's uncertainty about the evolution of future tax burdens.⁵ As Boadway and Keen (2010) note, both the government and the investor may be better off than if progressivity were not possible.

Absent this consideration, progressive taxes are still desirable if governments are less risk-averse than investors, as demonstrated in Boadway and Keen (2010). However, it is not clear theoretically which group should be more risk-averse, so this is an empirical matter that likely varies based on circumstance.

1.2 Tax policy alternatives

This section focuses on the advantages and disadvantages of several tax policy options for natural resource industries, discussing corporate income taxes, resource rent taxes, royalties, and other options.

1.2.1 Corporate income taxes

Corporate income taxes are a particularly important source of revenue in many less developed countries. Abbas and Klemm (2013) describe stylised facts regarding the role of corporate tax in developing countries in more detail, showing that corporate income taxes tend to make up a larger share of total tax revenue in developing countries than in developed countries. In part, this is due to the large amount of income earned outside the formal sector, as well as tax systems that are lacking in administrative capability. These features make revenue more dependent on sources that are easier to identify and tax, such as large businesses and imports.

⁴ Note that this meaning is *not* the meaning of progressive that is used in the larger tax policy literature, where a tax is considered to be progressive if the tax rate increases with the incomes of the taxpayers, the ultimate individuals or households that pay the tax. In the natural resources tax literature, progressivity depends on the tax payments of the firms in question, without any explicit assumptions regarding the underlying taxpayers. For example, if we assume that the corporate tax on firms earning rents is borne by the shareholders of the underlying firms, and that such shareholders hold diversified portfolios, it is not clear that a progressive profits tax would be more progressive (in the ordinary meaning of the word) than a 'flat' profits tax that collected the same revenue.

⁵ Of course fiscal stability agreements can also be negotiated to limit the government's ability to raise future taxes but such agreements are *ad hoc* and raise administrative costs, while reducing the government's autonomy and tax revenue under favourable circumstances.

Profit taxes have some key advantages. They are sensitive to taxpayer 'ability to pay', since tax is only due when firms are profitable. To the extent that such taxes fall on excess profits, or rents, they avoid distortion. Effectively, the government becomes a silent partner in the project, especially if losses can be used to offset tax burdens, since corporate income tax will lower the variability of outcomes under different scenarios, reducing investment risk.

But the same administrative capacity limits that make less developed countries dependent on corporate tax also make the tax base itself more vulnerable to erosion through tax avoidance. These problems are emphasised in Africa Progress Panel:

Tax authorities in all regions struggle to prevent the erosion of their tax bases, but Africa struggles more than most. That is partly because of the restricted human, technical and financial resources available to revenue administrations. But it is also because companies involved in the extractive sector are highly integrated and make extensive use of offshore centres and tax havens with limited disclosure requirements. These are ideal conditions for tax evasion through mispricing. (Africa Progress Panel 2013: 79)

As Laporte and Rota-Graziosi (2014: 7) summarise, taxing profits in extractive industries 'is particularly exposed to the risk of profit shifting [through] thin capitalization, underestimation of turnover, transfer pricing, etc.'

1.2.2 Resource rent taxes

As Land (2010) describes, resource rent taxes can be a useful way to make the tax base more sensitive to the underlying profitability of firms. The basic mechanism is to tax *cumulatively* over the life of a project, allowing recapture of costs as well as a required rate of return, and then taxing any profit beyond that. The key features of the tax include the rate of return that is allowed before the tax is triggered, the tax rate imposed on profits beyond that, and the tax base definition itself. Land (2010) discusses these parameters in more detail, and notes that such taxes can limit distortion, making for an efficient tax. Garnaut and Clunies Ross (1975) also discuss the general issues in designing such a tax. Baunsgaard (2001) describes how resource rent taxes could be designed equivalently with either a cumulative or a cash flow method.

Indeed, some of the same features that make profit taxes desirable make resource rent taxes attractive, such as the risk-sharing features of the tax. However, there may be pragmatic drawbacks to such a tax, including the backloading of government revenue streams, the procyclical nature of revenue streams, and the administrative difficulty of implementing the tax. Further, the tax itself is not immune from the same income shifting and tax avoidance problems that plague corporate income tax.

Sunley et al. emphasise these avoidance problems, and note that resource rent taxes are difficult to administer in practice, so they rarely raise much revenue:

While the resource rent tax [RRT] has much theoretical appeal, it has not been a significant revenue raiser in practice. There may be many reasons for this. It could reflect the difficulty of designing the tax, particularly the choice of the discount (or hurdle) rate and tax rate. If the hurdle rate is set too high, chances are that the resource rent tax will never apply; if it is set too low, the tax may become a major deterrent to investment. If either the hurdle rate of return is too low or the tax rate too high, the RRT will also increase the incentives for oil companies to engage in tax avoidance, which in countries with a weak tax administration may be very difficult to detect and control. (Sunley et al. 2003: 6-7)

1.2.3 Royalties

Royalties are a very common way to tax natural resource projects, and they have key administrative advantages relative to other taxes. The tax base is easier to observe, easing administration, and thus the levy is less subject to tax avoidance pressures. There is also more revenue stability and less volatility than arises with profits taxes. Royalties can be designed in a variety of ways, as detailed in Otto et al. (2006) and Sunley et al. (2003). Specific royalties are based on units of output, and *ad valorem* royalties are based on the value of output. Sunley et al. (2003) note that *ad valorem* royalties are used most often, and a wide range of royalty rates are observed in the oil and gas sector, ranging from 2 per cent to 30 per cent.

Ad valorem royalties will be sensitive to the underlying product price of output in a way that gives the tax some of the same procyclical features of a profit tax. This could also generate some transfer pricing concerns, although regulations that specify an externally-observable price are helpful, as noted in Sunley et al. (2003). Further, transfer pricing distortions are much less problematic under royalties than under income taxes, since price manipulations have a much smaller effect on the tax base; this point is explained in more detail in the following section.

There may be other downsides to royalties. Unlike profits or rents taxes, they are not sensitive to firms' ability to pay, and thus they may discourage investment if projects are risky or yield low returns. Also, as noted in Boadway and Keen (2010), the time path of royalties will affect the time path of extraction. For example, an *ad valorem* royalty may accelerate extraction if the product price is expected to rise at a rate faster than the discount rate. Finally, royalties are typically not creditable in countries that use a foreign tax credit system of worldwide taxation, thus discouraging investment from such countries relative to similar tax burdens in the form of profit taxes.⁶

Boadway and Keen (2010) note that there may be a role for royalties in combination with other taxes, in order to reach more efficient outcomes in the presence of asymmetric information between investors and the government.⁷

1.2.4 Other tax regime options

Another approach is to rely on production sharing agreements; this is particularly common in the petroleum sector, as noted in Baunsgaard (2001). Usually, this involves a long-term contractual agreement between a national oil company and a foreign investor. The investor bears the risk, and recovers costs and profit out of production, but the oil above what is needed to cover costs is then shared with the state. As Sunley et al. (2003) detail, there are a wide range of production sharing arrangements, with somewhere between a very small and a 90 per cent share accruing to the government; typically a dominant share goes to the government. In some cases, the share itself depends on underlying product prices or rates of return. As discussed in Baunsgaard (2001), production sharing agreements raise some of the same issues as profit taxes, including transfer pricing issues involving both product pricing and related-party costs.

Baunsgaard (2001) also discusses how equity sharing may be unexpectedly difficult to administer, and can be a deterrent to investment. Auctions, while attractive in theory, also

⁶ This point is discussed in Siu et al. (2015: 12). Note that this issue is less important than in the past, as fewer countries use worldwide tax systems.

⁷ Since the government does not have as much information as investors about the underlying profitability of potential projects, they can offer investors a choice of taxes from a menu of options. By allowing firms to choose their tax instrument based on their underlying type, the government may be able to earn more revenue than they would if they had to treat all investors symmetrically. This is shown in Box 7 of Boadway and Keen (2010), and the surrounding text.

pose difficulties due to both information problems and risk, as these issues make it difficult for the state to get a fair price at auction. In theory, many of these tax instruments and tax-like arrangements can generate results that are equivalent to each other, as discussed in both Brosio (2006) and Baunsgaard (2001). Still, practical implementation issues differ substantially.

1.3 A price-based royalty?

The discussion so far has described why, in theory, the economic arguments for reliance on net income-based levies are persuasive, but, in practice, income-based levies pose difficult administrative problems. Taxes based on net income raise all the problems of base erosion and profit shifting that currently impede the effectiveness of corporate income taxes around the world; such problems are especially severe for developing country governments with limited administrative resources.⁸ The related revenue losses can have especially serious consequences in countries that rely on tax revenue from mineral extraction for substantial portions of their total national revenue. As noted by the OECD:

Revenue loss from BEPS [base erosion and profit shifting] may be particularly important for resource rich developing countries. For these countries the taxation of natural resources is possibly the single biggest make or break fiscal concern in the next decade. MNEs [multinational enterprises] dominate the extractive industries, and commonly export materials to foreign related parties, making transfer pricing a critical issue in the industry.
(OECD 2014: 11)

Of course, royalties based on gross revenue pose administrative difficulties of their own, including most prominently the need to verify the market price of the product. This problem, however, involves less risk to the tax authority under a royalty based on gross revenue than under an income-based tax.⁹ Consider, for example, an extractive company that realises a net margin of 15 per cent of sales revenue. If the taxpayer receives total sales revenue of \$1 million, its expenses will be \$850,000, yielding net income of \$150,000. Assume now that the taxpayer understates its net revenue by five per cent, or \$50,000. The taxpayer's net income will now be measured as \$100,000 instead of \$150,000; its income tax liability therefore will be understated by one-third (33.3 per cent). Under a royalty based on gross revenue, however, a 5 per cent understatement in gross income will lead only to a 5 per cent reduction in the amount of the royalty. The income-based measure is far more vulnerable, therefore, to transfer pricing non-compliance with respect to revenue than is the levy based on the taxpayer's gross revenue. And, of course, overstatements by the taxpayer of interest costs, or the costs of services and equipment purchased from related parties, do not affect the government's revenue under a royalty tax.¹⁰

While royalties thus have key administrative advantages relative to income taxes, they are still subject to the aforementioned concerns about the insensitivity of tax burdens to the profitability of the underlying natural resource projects. Thus, a *price-based royalty* may have

⁸ The problems of base erosion and profit shifting, as they particular affect developing countries, are discussed in detail in the International Monetary Fund's 2014 report, *Spillovers in International Corporate Taxation*, and in a two-part 2014 report of the OECD to the G20 Development Working Group on *The Impact of BEPS in Low Income Countries*.

⁹ A discussion of this topic, with an example similar in structure to that following in the text, is contained in Durst (2014).

¹⁰ The much greater vulnerability of income- and rent-based taxes, than royalties, to transfer pricing manipulations may not have been fully appreciated in policymaking over the years. In practice, evaluations of alternative fiscal instruments note that both royalties and income- and rent-based taxes are vulnerable to the mispricing of extracted product; and this observation might produce the impression that both kinds of instruments are essentially equivalent in their vulnerability to price manipulation. In reality, however, as illustrated in the text, income- and rent-based levies are far more vulnerable to the manipulation of product pricing than are royalties – and income- and rent-based taxation are similarly highly vulnerable to the overstatement of interest expense, management fees and other related-party costs, whereas the effectiveness of royalties is not affected at all by manipulation of these quantities.

a useful role to play. A price-based royalty is based on gross revenue, but it also varies with changes in product prices in a way that is intended to approximate the performance of a net income tax. A price-based royalty has the potential to be of substantial benefit to governments of natural resource-producing countries, since it combines favourable features of both royalties and income taxes.

In practice, some countries do attempt to implement royalties that vary with the profitability of the underlying projects, but experience in this area is quite limited. One example comes from the US state of Alaska. In 2006 and 2007, Alaska changed its oil and gas production tax in order to both raise more revenue for the state and to attract investment, as described in Dickinson and Wood (2009). The production tax was originally calculated as 15 per cent of gross value, multiplied by an 'economic limit factor' that averaged about 0.5, generating an effective tax rate closer to 8 per cent.

The reform proposed replacing the tax with a 20 per cent tax that only applied to net income, after allowing deductions for exploration, development and production costs. A progressivity feature was added, adding a fraction of a percentage to the tax rate for every dollar the per barrel net price was above \$30, subject to a maximum. This progressivity feature dramatically increased revenue relative to the pre-reform law, as shown in Dickinson and Wood (2009). Recent Alaskan revenue reports indicate that this tax raises substantial revenue. In a state with a population of about 700,000 people, corporate income tax raised about \$300-\$500 million over the period 2012-2014, whereas this production tax raised between \$2 billion and \$6 billion (Alaska Department of Revenue 2014).

Boadway and Flatters (1993) note that some countries have historically used royalties that vary based on resource prices, including Peru and Malaysia (for oil), the state of Sabah in Malaysia (for timber), Indonesia (for coal) and Malaysia (for tin). However, there is little information on these particular taxes in the literature. Presently, Ernst and Young guides suggest that Peruvian oil royalties are based in part on scale, and in part on a measure of cumulative profitability.

Indeed, much of the mention of such systems is rather dated. The Sabah timber royalty appears to have been successful in raising far more revenue from timber than other comparable regimes at the time; royalty rates were established based on type of log and average export prices. Sabah was estimated to collect between 42 per cent and 60 per cent of stumpage values between 1966 and 1985.

A 1983 book entitled the *World Tin Market* notes that royalties charged on tin by several countries are based on prices, including Malaysia, Thailand, Bolivia, Indonesia, Nigeria, and most of Australia (Baldwin 1983).

There are some examples of progressive profit taxes, or windfall taxes, that are based on underlying product prices, as noted in Land (2009, footnote 3). For example, China imposed a tax levy on oil companies in 2006 that was based on oil prices in excess of \$40/barrel, and Algeria put a windfall tax on production values exceeding \$30/barrel.

It appears that the Chinese windfall tax is still in place at present, but it has been lessened due to recent declines in oil prices, according to Bloomberg (2014). The threshold that triggers the tax has been raised to \$65/barrel. As noted in Reuters (2014), 'A 20-percent tax will kick in at \$65 a barrel, rising to 25 percent between \$70 and \$75, while the highest levy of 40 percent applies when crude prices are above \$85.'

The Algerian law is also based on product prices, but it is contingent on the overall profitability of the firms in question. This is discussed in Layachi (2013).

Two relatively recent publications – Mintz and Chen (2012) and Conrad (2014) – catalogue fiscal regimes, including both royalty regimes and those based on measurement of income or rent, in a number of national and subnational jurisdictions, in countries at different levels of economic development.

Despite the availability of these surveys of practices in different parts of the world, however, there appears to be no literature comparing the administrative success of different kinds of fiscal regimes in practice. For example, for both royalties and income- or rent-based instruments, it would be very useful to compare the actual yields of fiscal instruments, at actual production volumes and price levels, with projections that might have been made before the taxes were implemented. In addition, to evaluate the effectiveness of income- or rent-based taxes as applied to local mineral producers that are members of multinational groups, it would be useful to benchmark taxpayer ratios of both interest expense and management fees against normal business practice for independent producers, and also to determine whether the net operating margins reported by producers, for tax purposes, are consistent with what might be expected of independent producers that do not have opportunity for transfer pricing manipulation. Of course, concerns for the confidentiality of taxpayer information, as well as political reluctance to expose the effectiveness of tax administration to critical and quantitative evaluation, might make analyses of this kind infeasible. In the absence of quantitative evaluation, though, the possibility must be accepted that income- and rent-based fiscal regimes perform far less effectively than the literature sometimes appears to assume.

Also, there is very little in the literature that describes and evaluates a price-based royalty system. While such a system would combine some of the favourable attributes of income and royalty taxes, there are still some downsides and unanswered questions to consider. One key question that will be explored below is how much of the variation in natural resource firm profits is explained by variation in product prices. The more closely profitability tracks product prices, the greater the advantages of a price-based royalty system.

A factor that likely precludes a simple one-to-one correspondence between profits and product prices is cost escalation, as described in Land (2009: 164 and footnote 13): ‘In certain circumstances, cost escalation may significantly erode the advantage that high prices bring... Indeed, both the mining and petroleum sectors are affected by significant escalation of inputs into the industries, which has resulted in sharp rises in the capital costs of developing new mineral and hydrocarbon projects.’

It is also important to address some central design issues arising when royalty rates vary with product prices. To overcome time consistency problems and reduce investor uncertainty, it would be ideal to establish a formula that would not need to be changed often. It would also be ideal to have a uniform formula that applied to all firms in a given sector, rather than one that was negotiated on an ad hoc basis, since this would reduce the political pressure to negotiate special deals.

2 Data analysis

This section considers the relationship between firm profitability and product prices for firms in the extractive industry.

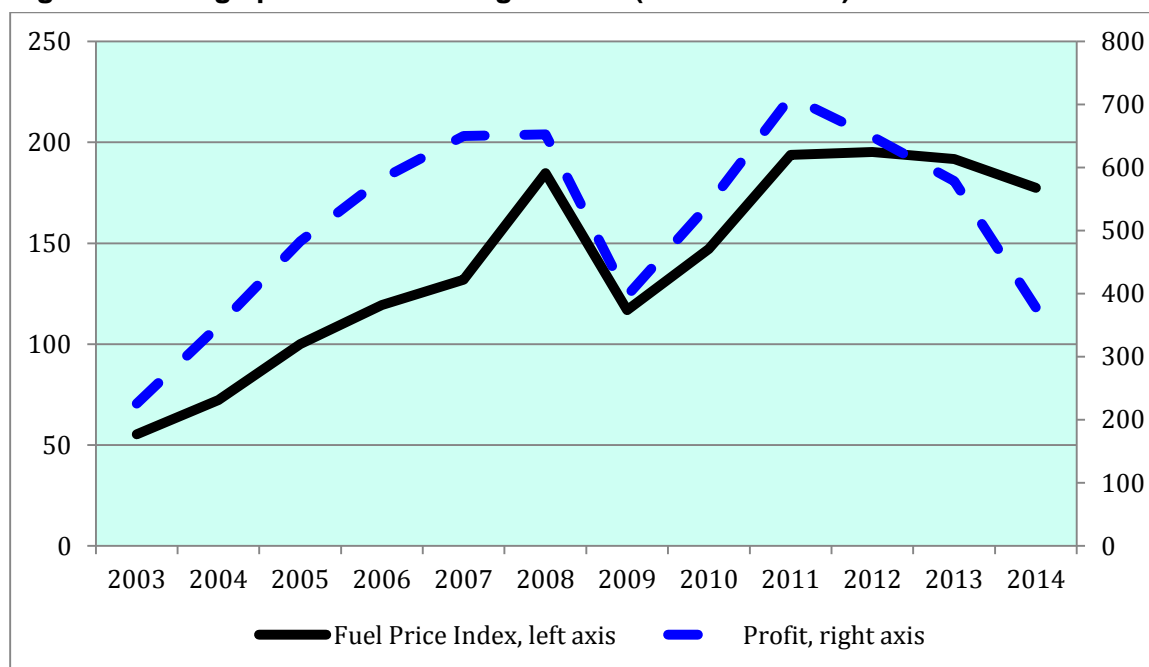
Data is gathered from several sources. For firm data, we rely on *Forbes* lists of the world’s largest 2,000 firms; these lists are published annually and include information on firms’ rank (of the 2,000 largest firms), their market valuation, and information on sales, profits, and assets. Of chief interest here is the profitability of each firm, though profits are likely

dependent on other aspects of particular firms. Indeed, firm level assets are also used as a control variable in the following analysis.¹¹

The following analysis studies the period 2003-2014. Data on commodity prices is taken from the International Monetary Fund (IMF) commodity price database.¹² They provide data on fuel price indexes, metals price indexes, particular oil price series and location-specific natural gas price series, and some particular metal price series. Some data on particular metal prices is also sourced from the World Bank's Global Economic Monitor (GEM) commodities data.¹³ The World Bank also provides data on variables that are used as controls, such as world GDP growth.

Figures 1 through 4 show that profits of firms in the extractive industry map their product prices fairly closely, on aggregate. Consider Figure 1, which shows the average profits of firms in the oil and gas sector against the IMF Fuel Price Index. It is clear that profits rose steadily as fuel prices increased from 2003 to 2008, then both profits and prices fell sharply before increasing again until 2011 and then declining until the end of the period. Firms are only included in Figure 1 if they have data for all twelve years of the sample.

Figure 1 Average profits of oil and gas firms (in million USD) and Fuel Price Index



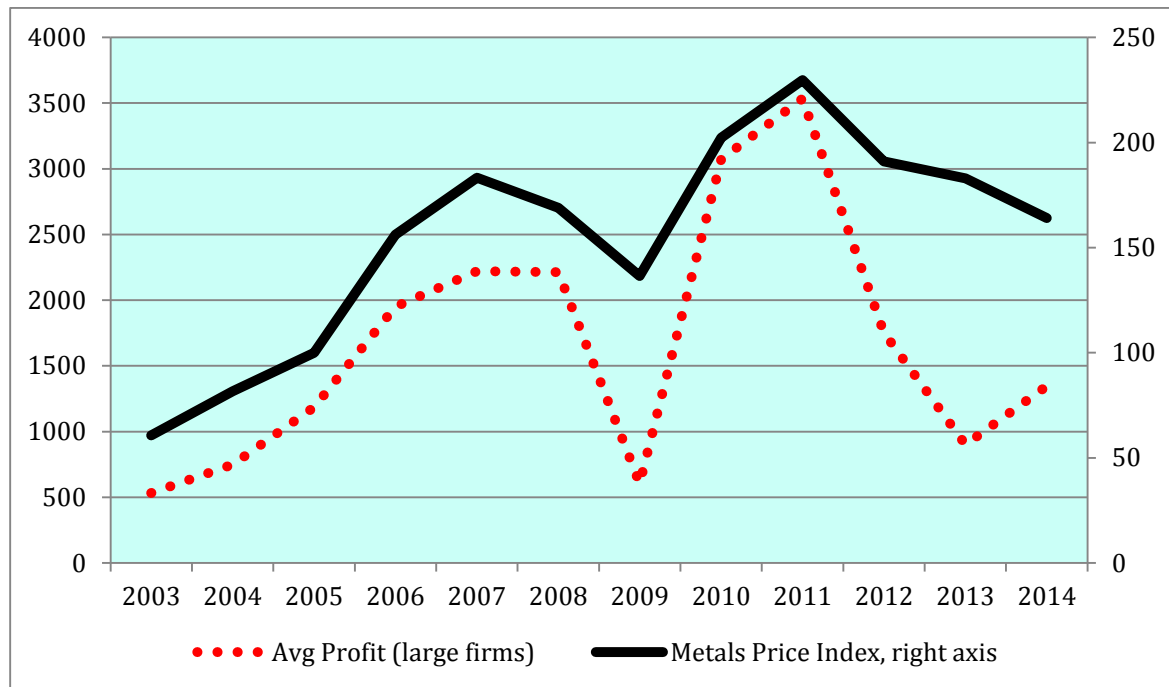
¹¹ The Forbes method is described in more detail here: <<http://www.forbes.com/2011/04/20/global-2000-11-methodology.html>> (accessed 24 July 2015). They note that: 'All figures are consolidated and in U.S. dollars. For companies in the U.S., Canada and off-shore (such as Bermuda) we use the latest-12-months' financial data (sales, profits and assets). For international companies we use the latest-fiscal-year financial data. We rely heavily on the databases for all data, as well as the latest financial period available for our rankings (the final database screen was run in mid-April). Many factors play into which financial period of data is available for the companies and used in our rankings: the timeliness of our data collection/screening and company reporting policies, country-specific reporting policies and the lag time between when a company releases its financial data and when the databases capture it for screening/ranking. We quality-check the downloaded financial data to the best of our ability using other data sources, including Bloomberg and available company financial statements.'

¹² Data is available here: <<http://www.imf.org/external/np/res/commod/index.aspx>>.

¹³ Data is available here: <<http://databank.worldbank.org/data/home.aspx>>.

Figure 2 indicates that profits of mining firms also track the Metals Price Index, in terms of the general qualitative trends. Here, firms are included if they have ten years of data.

Figure 2 Average profits of mining firms (in million USD) and Metals Price Index



Figures 3 and 4 show only firms mining gold and copper, the two most important metals in the dataset. In these figures, only firms with ten years or more of data are included, and firms are included if more than ten per cent of their revenue comes from gold or copper. A visual inspection shows that the profits of copper mining firms appear to track copper prices more closely than the profits of gold mining firms track gold prices.

Figure 3 Average profits of gold mining firms (in million USD) and Gold Price Index

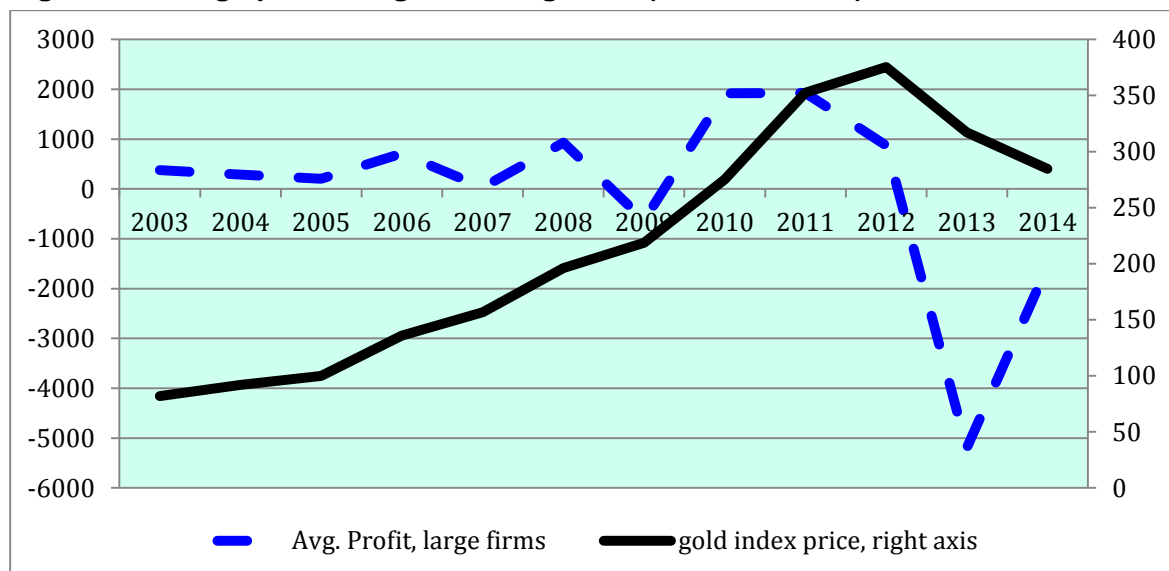
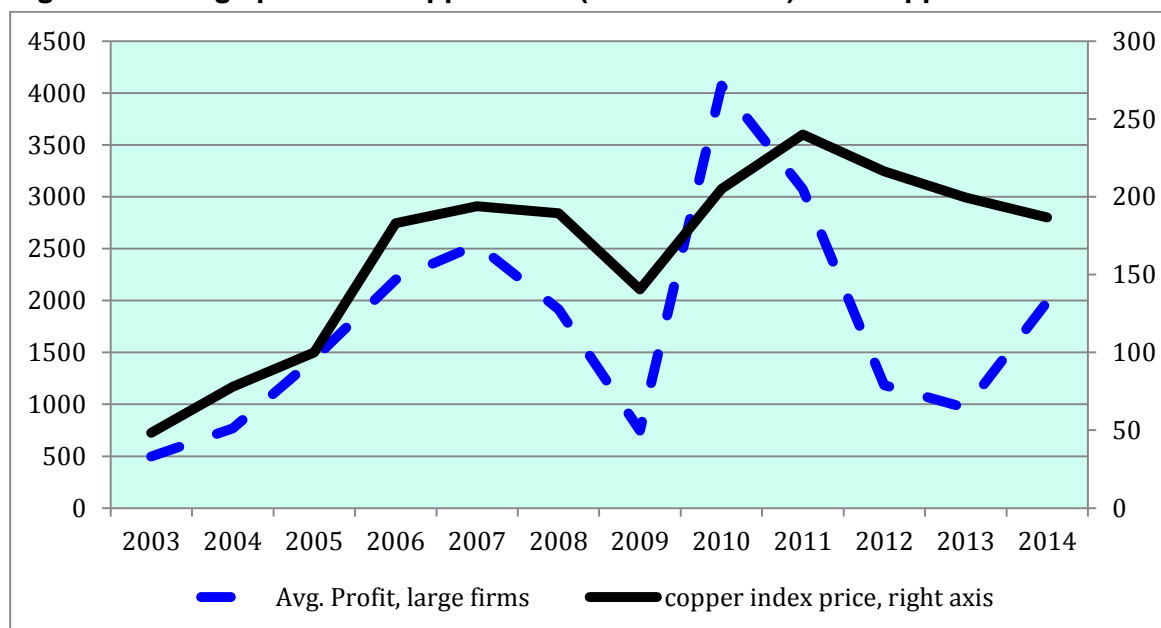


Figure 4 Average profits of copper firms (in million USD) and Copper Price Index



Of course, these simple figures do not control for other variables that affect firm profitability, nor do they indicate how closely firm profitability is related to product prices. However, regression analysis can address these considerations. Table 1 analyses the profits of oil and gas firms in the Forbes 2000 over the period 2003-2014. It is an unbalanced panel; firms are included even if data is not available for each year. There are 911 observations over twelve years; the typical firm has eight years of data.¹⁴

Table 1 Regressions explaining profits for oil/gas firms in Global 2000
(Dependent variable: natural log transformation of profits, reported in million USD)

	(1)	(2)
ln (assets)	1.038* (0.0207)	0.861* (0.0795)
ln (fuel price index)	0.686* (0.139)	0.760* (0.107)
time trend	-0.136* (0.0159)	-0.135* (0.0136)
world GDP growth	0.0248 (0.0165)	0.0315* (0.0125)
<i>N</i>	911	911
<i>Fixed Firm Effects?</i>	No	Yes
<i>R</i> ²	0.74	0.74
<i>R</i> ² <i>Within</i>		0.24
<i>R</i> ² <i>Between</i>		0.80

Standard errors in parentheses. Includes only firms with positive profits.

* $p < 0.05$

¹⁴ We also restricted each regression to balanced panels, allowing in the dataset only those firms that had observations in every year. This reduces the observations to about 55% of the total. However, the general nature of the results is unchanged; there is an increase in R^2 but point estimates of the main coefficients are similar.

Firm profits are modelled as being a function of firm assets, product prices, a time trend, and world GDP growth.¹⁵ In column (1), a pooled specification is run, including all firm observations. Data on prices, assets and profits are transformed using natural logs, so coefficients can be interpreted as elasticities.¹⁶ In column (1), a 1 per cent increase in assets is associated with an approximately 1 per cent increase in profits. A 1 per cent increase in the Fuel Price Index is associated with about a 0.7 per cent increase in profits.¹⁷ Over time, profits show a downward trend, controlling for other variables. World GDP growth is positively associated with firm profitability, but only with 85 per cent confidence, thus not meeting the typical 95 per cent threshold for statistical significance. The model performs well, explaining 74 per cent of the variation in firm profitability.

However, most of the explanatory power of the model comes from the asset variable. In all of the pooled regressions reported in this paper, a formal decomposition of the contribution to R^2 of each variable indicates the price variable accounts for less than 20 per cent of the equation's explanatory power.¹⁸

In column (2), a fixed effects specification is considered. This allows a separate intercept term for each firm in the analysis, and thus accounts for particular features of firms that might affect their underlying profitability. For example, one might think that the 'base' level of profits for Royal Dutch Shell would be different from that of Chevron, and this specification would model that difference explicitly. Indeed, statistical tests indicate that a fixed effects specification is warranted here.

Results from column (2) are largely similar to those of column (1), with a slightly higher estimate for the price elasticity (.76 instead of .69) and a slightly lower estimate of the asset elasticity (.86 instead of 1.04). The world GDP term is now statistically significant. Still, note that most coefficients are statistically indistinguishable from their values in column (1).

Table 2 considers similar regression equations for firms in the mining industry. In this dataset, there are 439 observations from mining firms over the period 2003-2014. Again, we consider all observations, even if a firm does not stay in the sample for the whole period; the average firm has six years of data.¹⁹ One issue associated with mining firms is that they each extract different metals, and of course metals prices do not move uniformly. In Table 2, all mining firms are included, and their profits are modelled as depending on the IMF Metals Price Index; subsequent tables will consider gold and copper firms separately.

¹⁵ We also tried all regressions excluding the asset variable. This did not change any of the price results substantially, although it did lower the explanatory power of the models.

¹⁶ This also restricts analysis to profitable firms. If analysis is extended to firms incurring losses, the model performs less well overall, but most of the inferences regarding individual variables are unchanged.

¹⁷ We also considered specifications that considered oil prices instead of fuel prices, without changing the coefficient on the price variable in a statistically significant way.

¹⁸ Analysis is based on Shapley/Owen decompositions. Price terms do a bit better in regressions explaining the ratio of profits/assets. In this case, in some instances, price variables account for a bit over 25% of the R^2 ; however, the R^2 are also lower. Price variables also explain more of the total variation if analysis is not restricted to profitable firms; still, the model as a whole has less explanatory power in that case.

¹⁹ As with oil/gas firms, the main results are not sensitive to this decision. If firms are only included if they have more than ten years of data, coefficient results are quite similar, although there are fewer observations and the R^2 increases.

Table 2 Regressions explaining profits for mining firms in Global 2000
(Dependent variable: natural log transformation of profits, reported in million USD)

	(1)	(2)
ln (assets)	0.735* (0.0368)	0.527* (0.0864)
ln (metals price index)	1.119* (0.188)	1.382* (0.140)
time trend	-0.101* (0.0211)	-0.0912* (0.0203)
world GDP growth	-0.00455 (0.0238)	-0.0288 (0.0173)
N	439	439
Fixed Firm Effects?	No	Yes
R²	0.51	0.48
R² Within		0.44
R² Between		0.33

Standard errors in parentheses. Includes only firms with positive profits.

* $p < 0.05$

Table 2 results are broadly similar to those of Table 1. Column (1) shows results for the pooled specification. Firm assets show an elasticity of 0.74; a 1 per cent increase in assets is associated with a 0.74 per cent increase in profits. Profits are more sensitive to product prices than in the prior table; an increase in the Metals Price Index of 1 per cent is associated with an increase in profits of 1.12 per cent. Again, profits show a negative time trend. In this table, world GDP growth is no longer statistically significantly related to firm profits.

Column (2) reports a firm fixed effects specification. This may be particularly necessary in the case of mining firms, since they specialise in different metals, and statistical tests indicate that a fixed effects specification is justified. As in Table 1, this increases the point estimate of the price elasticity and decreases the point estimate of the asset elasticity. Now a 1 per cent increase in metals prices is associated with a 1.38 per cent increase in firm profitability, accounting for separate intercept terms for each firm.

Table 3 reports results for subsets of the data: columns (1) and (2) show results for firms that earn more than 10 per cent of their revenue from gold, and columns (3) and (4) show results for firms that earn more than 10 per cent of their revenue from copper.²⁰ Columns (1) and (3) show pooled specifications, and Columns (2) and (4) include firm fixed effects. There are fewer observations, but the main results are similar in character. Assets are positively associated with profits in all specifications, with elasticities ranging from 0.46 to 0.73.

Product prices are positively related to firm profits in all cases, and statistically significant in three of four specifications, though the coefficient in column (1) is statistically indistinguishable from zero. When statistically significant, price elasticities range from 1.22 to 1.89.

²⁰ It would be ideal to include more subsets of the data for different metals, but the other metals have insufficient firm observations for this type of analysis.

Table 3 Regressions explaining profits for gold and copper firms in Global 2000
(Dependent variable: natural log transformation of profits, reported in million USD)

	(1) Gold	(2) Gold	(3) Copper	(4) Copper
ln (assets)	0.461* (0.0708)	0.673* (0.139)	0.726* (0.0642)	0.533* (0.120)
ln (gold price)	0.461 (0.524)	1.883* (0.485)		
ln (copper price)			1.222* (0.257)	1.568* (0.199)
time trend	0.0153 (0.0891)	-0.228* (0.0822)	-0.151* (0.0325)	-0.140* (0.0296)
world GDP growth	0.0894* (0.0340)	0.0696* (0.0274)	0.0213 (0.0381)	-0.0319 (0.0284)
<i>N</i>	136	136	169	169
<i>Firm fixed effects?</i>	No	Yes	No	Yes
<i>R</i> ²	0.37	0.34	0.49	0.45
<i>R</i> ² <i>Within</i>		0.57		0.49
<i>R</i> ² <i>Between</i>		0.02		0.52

Standard errors in parentheses. Firms are included if greater than 10% of their revenues result from gold or copper.
* $p < 0.05$

3 Conclusion

For practical tax policy design, a price-based royalty has appealing features. It is more sensitive to the underlying profitability of the firm than a simple royalty, and this helps the tax mimic an income- or rent-based tax, while avoiding some of the disadvantages of an income- or rent-based tax.

Income and resource rent taxes are attractive in that they enable risk sharing between the government and the investor, allowing a balance of the competing goals of revenue collection and investor incentives. In theory, since taxes are only triggered when firms are profitable, taxation need not deter less profitable investments, yet excess profits can be taxed, allowing access to important revenue for the state. In practice, however, income and excess profit taxes are vulnerable to transfer price manipulations by taxpayers, making these taxes difficult to administer due to tax avoidance and the complexity associated with collecting the tax.

Royalties, on the other hand, are far simpler to administer. As long as they are based on an externally observable price for the underlying product, it is much easier for a tax authority to collect royalties. Compared with an income tax, royalties are much harder to avoid through transfer price manipulation and other income shifting techniques. However, since royalties are not as sensitive to the profitability of the underlying projects, they may deter investment.

A price-based royalty has the potential to combine the favourable features of both an income- or rent-based tax and a royalty. However, it still raises important design issues. One essential issue is the extent to which firm profitability tracks product prices. The present investigation is a step towards understanding this relationship. Simple graphical relationships between product prices and firm profitability indicate that, for both oil/gas firms and mining firms, underlying average firm profitability tends to move in the same direction, and at the same times, as product prices.

A regression analysis confirms this relationship. For both oil/gas firms and mining firms, there is a nearly one-to-one relationship between product prices and firm profitability; prices 1 per cent higher tend to be associated with profits about 0.76 per cent higher for oil/gas firms, and about 1.38 per cent higher for mining firms.²¹

However, it is important to also note that many factors affect firm profitability. Of the explanatory variables in the regression, the assets of the firm are the largest contribution to the explanatory power of the models examined here. Product prices alone do not account for an important share of the underlying profit variation across firms. In part, this may be the result of the diverse set of firms included in the Forbes Global 2000. One might expect that the underlying profitability of the world's largest oil/gas and mining firms would depend on many factors, including the scale of the firm itself.

In sum, tax administrators should give serious consideration to increasing the use of price-based royalties as substitutes for income or rent taxes. The limited experience in Alaska and elsewhere suggests that such taxes can be successful. As is true of all taxes, careful attention should be paid to design and implementation of price-based royalties, and their performance after implementation should be monitored closely.

Finally, this paper suggests important avenues for future research regarding design and implementation issues surrounding price-based royalties. In addition, empirical research is needed to evaluate the administrative performance of current tax systems, including income- and rent-based natural resource levies in both developing and developed countries.

²¹ These are the results from the column (2) specifications of Tables 1 and 2; these are the preferred specifications.

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