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Reconsidering royalty and resource rent taxes for Australian mining*

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It is argued that a comparative assessment of a royalty and a resource rent tax as a special tax on the Australian mining industry should recognise the following: the importance of quasi-rents earned on investments which shift out the mining supply curve over time, the dominance of nonresidents as buyers and as shareholders, and available data on relative costs for mines with more and less favourable natural resource endowments. Comparable tax rates for the two special taxes to generate similar government revenue are derived. For approximate revenue neutral taxes, the efficiency and distributional effects of the royalty and resource rent tax options are assessed and compared. In terms of efficiency, the superiority of one over the other is ambiguous because of imperfect knowledge about key parameters. In terms of returns to Australia, and in particular the aggregate of transfers from nonresident shareholders and export buyers, both provide similar outcomes.

Key words: mining taxation, resource rent tax, royalty.

1. Introduction

Special taxes are levied on the extraction of minerals and energy,[1] in addition to the general income and other taxes levied across all industries. The special taxes include state royalties, most ad valorem, commonwealth resource rent taxes on off-shore oil and gas, and between 2012 and 2014 a hybrid of both for iron ore and coal before repeal of the minerals resource rent tax. In 2012–2013, royalties are estimated to have generated $8.6 billion, the petroleum resource rent tax $1.5 billion and the minerals resource rent tax $0.3 billion.[2]

Several overlapping arguments justify special taxes on the extraction of minerals and energy in addition to income and other taxes levied on all industries. Foremost, they are a charge for, or income in exchange for, the transfer of community owned natural resource deposits for use by private sector investors. The income argument is augmented by two further considerations. First, sustainable consumption over time when exploiting nonrenewable inputs requires reinvestment of the economic rent in other

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[1] For the rest of the article, the extraction of minerals and energy is summarised as the mining industry.

[2] Data from State and Federal Budget Papers.

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capital (Hartwick 1977). Second, with about 80 per cent of the Australian mining industry owned by nonresident shareholders (Connolly and Orsmond 2011), and a similar share of sales as exports (Bureau of Resources and Energy Economics (BREE) 2014), most of the special taxation revenue is a transfer from nonresidents, and the transfer provides a large net gain for Australia (Ergas and Pincus 2014). To the extent that the special taxation falls on Ricardian rent generated by the geographically immobile natural resources, they involve minimal efficiency costs, and certainly lower costs than alternative income and other taxes.

An extensive literature has investigated the case for special taxation of the mining industry and evaluates the effects of, and the relative merits of, different options (for example, Daniel *et al.* 2010; and specifically for Australia, Henry *et al.* 2010; Garnaut 2010; Hogan 2012; Mayo 2013; Ergas and Pincus 2014, and references therein). Special taxation options considered include production taxes or royalties, economic rent taxes, including the Brown or cash flow tax, a resource rent tax, upfront auction bidding and the corporate profit tax.

In comparing a royalty and a resource rent tax, most authors, including Boadway and Keen (2010), Land (2010) and Hogan (2012), assume most of the economic rent measured as receipts less expenses represents a Ricardian rent. Ricardian rent is interpreted as a residual return on a fixed and known quantity of natural resource deposits, with larger rents for higher quality deposits. Only a passing reference is given to exploration and new technology changing the quantity of the natural resource input. In this context, the resource rent tax option has clear efficiency advantages. On the other hand, a royalty has advantages of stability of government revenue and lower administration and compliance costs. This mix of advantages leads these authors to suggest a package of both a royalty and a resource rent tax.

This article focuses on three specific issues that are important to an assessment of the relative merits of a royalty versus a resource rent tax as special taxes on the Australian mining industry. First, and contrary to Boadway and Keen (2010), Land (2010), Hogan (2012) and many others, the paper suggests a more nuanced consideration of the meaning of measured economic rent using the cash flow or Brown tax, and its applied variant the resource rent tax.[3] In the realistic context of substantial investment in exploration, and investment in technology and management skills to lower mining costs, the known natural resource deposit input is not fixed in supply over the long run. At least some of the resources invested in exploration and increased productivity are both scarce and geographically mobile in the long

[3] Other authors have raised potential costs of resource rent taxation and distortions to investment decisions. Kemp (1987) focuses on the importance of some long-run supply elasticity for resources invested in exploration. Ergas *et al.* (2010) note that a resource rent tax likely will result in higher production costs shifting the supply curve upwards. This study explores in more detail potential effects of the measured economic rent where some of the measure includes above normal returns to investment inputs which have a positive elasticity of supply to the Australian mining industry, at least over the medium and longer term.

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run. However, some are immobile in the short run, with successful investments earning quasi-rents.

Economic rent for the resource rent tax is measured as a residual of revenue less payments representing the opportunity costs of mobile labour, capital, materials, services and other inputs drawn from other parts of the economy. The cash flow economic rent includes three components: Ricardian rent on the known fixed in supply natural resource deposits; quasi-rents earned on short-term immobile inputs invested in exploration and lower production costs; and monopoly profits. Given the dominance of international trade and the volatility of mineral prices, sustained monopoly profits are considered to be zero.[4] A key point of this study is the importance of quasi-rents in the resource rent tax base.

Second, the study draws on industry data about the relative costs of different mines at a particular point in time as the basis of the observed supply curve. This information implies a very elastic supply curve. This data also allows estimation of approximate aggregate revenue neutral tax rates for the royalty and resource rent taxes. The revenue neutral tax rates are sensitive to the mix of mines by relative costs.

Third, explicit recognition is given to the dominant roles of nonresident investment and of export sales in the Australian industry as they influence from an Australian perspective the efficiency and distributional effects of the royalty and resource rent tax. The analysis by Ergas and Pincus (2014) for royalties is extended to the resource rent tax.

2. Nonrenewable resources and economic rent

A general model of the production function for mineral products for period t has the form

$$Q_t = f(N_t, K_t, L_t, T_t), \tag{1}$$

where Q is mineral output per unit period, N is the known natural resource deposits, K is the capital inputs, L is the labour inputs, and T represents an amalgam of technology, management expertise and other intangible capital inputs. The production function is an important ingredient to the cost and supply functions and to measures of economic rent.

A strict interpretation of a nonrenewable input means there is a known fixed quantity of a mineral, that is, $N_t = N$ for all t time periods, and consumption today reduces future consumption. There are many deposits. Favoured deposits have relatively low costs in terms of required L and K inputs associated with a combination of, for example, smaller overburdens, deeper, richer and more extensive mineral ores, more accessible transport,

[4] This is not to ignore important exceptions, including the OPEC cartel for oil, and short-run lived mineral commodity 'stabilisation' schemes.

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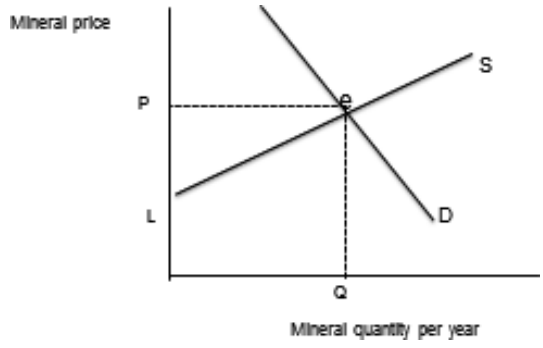

Figure 1 Mineral market.

and the area has low opportunity costs for alternative agriculture, environment, heritage and other uses. Less favoured deposits require more K and L inputs per unit Q output and higher costs. Ranking deposits by L and K costs per unit of Q generates a rising supply curve, such as S in Figure 1. The supply curve can be interpreted as the opportunity costs of reallocating L, K and other economy-wide mobile inputs from the rest of the economy to mining. The upward slope of the supply curve can reflect both changes at the extensive margin associated with investment in new mines with less favoured natural resource deposits, or at the intensive margin associated with extracting a larger quantity per existing mine from extending the mine to less favoured portions of the particular deposit.

The mining industry and associated financial analysts maintain cost curves ranking mines across the world by average costs (Daley and Edis 2010). Data for Australia indicate the more favoured mines have extraction costs given by L in Figure 1 from 20 per cent (for LNG) to up to 50 per cent (for steaming coal) lower than marginal mines given by the market price P at a specific point in time. Note that the supply curve is elastic, and more so the smaller the difference between the cost of the marginal mine relative to the lowest cost mine, $P - L$.[5]

In this static constant technology world, the area PeL between the cost curve for the inputs purchased from the general economy and the price line P represents a Ricardian rent to the limited and fixed supply natural resource deposits. The more favoured deposits generate larger rents. Special taxation of the Ricardian rent as shown in Figure 1 to a rate as high as 100 per cent is a nondistorting tax.

In practice, much lower resource rent tax rates are set. The reasons include the following: practical measurement problems, distortions with the resource rent tax base, and the tax base includes returns to investments which have a nonzero supply elasticity over the medium and long term.

[5] Formally, if the supply curve is linear as shown, the average supply elasticity, Es, can be expressed as $(P + L)/(P - L)$. Then, for example, with $L = 0.8P$, Es = 9 and for $L = 0.5P$, Es = 3.

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For many mines, the theoretical ideal of being able to accurately measure the price at the mine-head, and so focus only on economic rents from mining are dubious in practice (Mayo 2013). The majority of mining operations involve a firm with an integrated supply chain, including exploration, mining, processing and transport, before a market price is revealed. Many of the costs along the supply chain are joint costs, including management, marketing, development of technology, negotiating finance, and improved management and work practices. There is an important element of arbitrariness and of game playing in the allocation of joint costs to the mining activity and other parts of the supply chain.[6] Often, businesses control a number of mines, and some a number of different products from each mine, which add to the challenges of allocating joint costs to different mines and minerals. As a result, almost certainly, too many or too few joint costs will be allocated to the mine, resulting in an under-estimate or an over-estimate, respectively, of the economic rents associated with mining relative to the down-stream activities.

Application of the cash flow tax base in an ideal efficient way would require symmetry of taxation of wins and losses, with government writing cheques to miners in the event of a negative cash flow. To avoid government payments, the resource rent tax carries forward losses, with carry forward losses indexed by the long-term bond rate plus a risk premium (under the PRRT of 10 per cent for exploration and 5 per cent for production, and of 7 per cent with the MRRT), and no payout for accumulated losses. The arbitrary carry forward rate and no government contribution to an accumulated loss represents ex ante a subsidy for assessed favoured deposits and an additional tax for marginal mines.

A key implication of a strict interpretation of a nonrenewable resource that is known and in fixed supply over time so that in Equation (1) $N_t = N$ for all t is the Hotelling rule (Hotelling 1931). The rule says that to maximise social welfare, the price of minerals will rise over time,[7] with a declining path of production (and consumption).

Practical experience of mineral markets does not confirm the predictions of the Hotelling model. Over the twentieth century, quantity increased and real prices trended downward. With a dynamic or multiperiod model of the mining industry, this realised outcome reflects that while the demand curve shifted outwards with the growth of population and income per capita, at the same time, the supply curve shifted out even further with exploration and new discoveries and with cost-reducing technology in the extraction of minerals. Investment in the term T in Equation (1) has increased the known natural resources input N, and it has reduced the quantities of K and L required per

[6] From an economic perspective, the allocation of joint costs across $i = 1, 2, \ldots, n$ activities to a particular i activity can vary from zero to all of the joint cost.

[7] If mines are of similar attributes, the price rises at the rate of interest. For the realistic case of mines with different attributes and cash costs, the rate of price rise will be less than the rate of interest.

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unit output Q, to shift outwards over time the mineral supply curve. An example is investment in technology supported expansion of oil and gas production with the discovery and development of off-shore reserves and fracking technology.

While the commodity price boom of the 2000s decade resulted in sharp price increases up to 2011, quantity also increased, and the induced investment boom means further increases in production and significant price falls in 2014 and beyond (BREE 2014; and Bullen *et al.* 2014). This set of market outcomes represents primarily an unexpected large shift in demand which in time stimulated another round of investment and subsequent supply curve shift.

Unlike the example of land, the simplifying assumption of a fixed supply of nonrenewable minerals reserves N is inappropriate. Then, some of, and likely a large share of, the measured economic rent based on a Figure 1 type model represents the benefits of outward shifts of the supply curve. Some of the returns for investment in exploration and discovery, intellectual property in geology, engineering and other extraction technology, processing and transport activities, managerial expertise, work practices, and other drivers of outwards shifts of the minerals supply curve over time represent quasi-rents. Available resources for investment in the new technology and its adaptation for application to particular mines are limited in supply in the short run. In a temporary monopoly situation, they generate a short-run return above production cost. Further, for some T, intellectual property rights, including patents, support the short-run monopoly position. But, over the medium and longer term, the forces of competition, and of adaptation and further development, work to attract additional resources for T and to spread the new exploration and cost-reducing technology across more and more mines. In time, these processes drive down above normal returns so that just opportunity costs are covered. That is, with the progress of time, the supply of many of the T inputs to the Australian mining industry become more elastic, and in some cases approximately infinitely elastic. The rapid spread of improved machinery for extraction and transport, and fracking technology illustrate.

Taking a medium- to long-term view, some of the investments in T in Equation (1) are mobile in location between Australian mining and other uses, and their actual location is sensitive to relative tax burdens. Mobility can refer to location with Australian mines or with mines in other countries. The importance of multinational companies in the mining industry, including Australia, provides many operators with discretion as to the country of location of their investment in exploration and in mining technology. Mobility of inputs into T can refer to investment in the mining industry or investment in other industries, again within Australia or in other countries.

Also, multinational companies have the opportunity to shift revenues via transfer pricing to countries with relatively low tax rates and to shift overhead expenses, including those associated with investment in T, to relatively high

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tax rate countries. Alternatively, companies may have the option of locating investment in T in either (a) the registered mining company which faces special taxes or (b) purchasing the technology and equipment from other service businesses at a price. In the latter case, where the service provider is not registered as a mining company, it can avoid special mining taxes on quasi-rents.

Estimation of the relative importance of Ricardian economic rent on N and quasi-rents to investments in T by mining companies is challenging. Certainly, shifts over time of the mining supply curve have been large. But not all of the area between a current period and a future period supply curve can be regarded as a quasi-rent. Only in the extreme case where the T is mine specific and there is zero mobility of the investment inputs could all of the area be regarded as Ricardian rent. Often new technology can be acquired as a purchased input or service from another mining company, or from nonmining registered business, and perhaps with a small mine-specific investment for adaptation. In time, successful investment in T by a specific mining business spreads to other firms and/or competition drives down short-term quasi-rents to a normal rate of return.

3. Comparative market effects

This section compares the long-run static equilibrium effects of a royalty and a resource rent tax on market prices and quantities. These market outcomes are used to assess comparable revenue raising rates for the two special taxes, and their effects on global economic efficiency and distribution of the tax burden. Figure 1 represents the base case before the special taxes. The demand curve is an aggregate of domestic plus export demand for Australian product,[8] and the supply curve includes the effects of economy-wide income and other taxes, but before the special mining taxes. Figure 2 adds the royalty and resource rent tax.

In Figure 2a, a fixed royalty of R, or ad valorem royalty rate of $r = R/P$, shifts down the demand curve[9] from D to $D' = D - R$. A new long-run market equilibrium means a smaller quantity at Q', a lower market price to producers of P' and a higher buyer price of $P' + R$. The relative magnitudes of the price changes from P, and the share of the tax borne by buyers and producers, depend on the relative elasticities of demand and supply. Royalty revenue, RR, is given by

$$\mathrm{RR} = \text{rectangle}\,\mathrm{RQ}' = rP'Q' = rP'Q(1 - (Q - Q')/Q). \tag{2}$$

[8] For most minerals, export demand represents from about 80 per cent of production in the case of steaming coal through to 100 per cent for uranium. Most CGE models, including MONASH (Dixon and Rimmer 2002) and GTAP (Hertel 1997), use export demand elasticities for Australian minerals of between −4 and −8.

[9] Alternatively, the royalty often is modelled as a shift up of the supply curve by R. Both give the same market outcomes.

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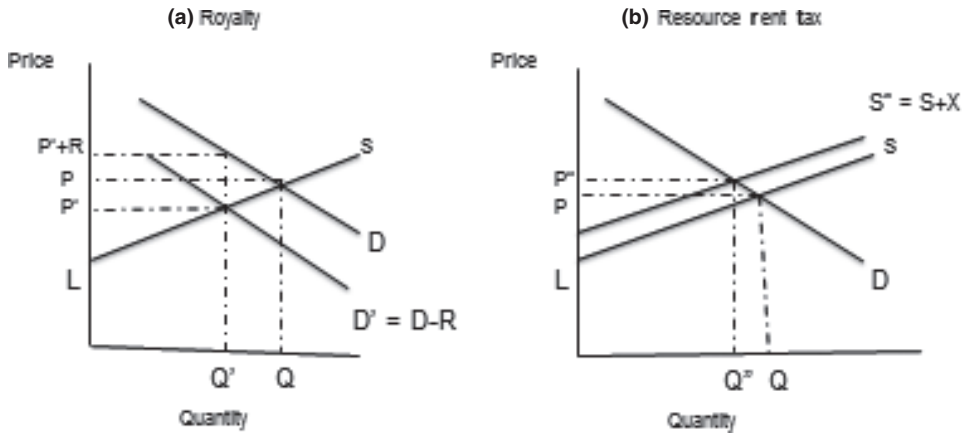

Figure 2 Market effects of special taxes (a) Royalty (b) Resource rent tax.

Figure 2b considers a resource rent tax. A tax rate of trr captures a share of both the Ricardian rent earned on the immobile natural resource inputs N and of the quasi-rents earned on the partly mobile inputs T.

In contrast to the royalty which does not alter the incentives to invest in T and the rewards from these investments, the resource rent tax falls on the quasi-rents and reduces the return on the partly mobile T inputs located in the Australian mining industry. In response, some of the T inputs may relocate to other industries in Australia or to mines in other countries where there is no special taxation of the quasi-rents. Specifically, the resource rent tax on mobile resources allocated to investment in T in Australian mining, but not applied to alternative locations, increases the required pretax return on the Australian mining location, namely

$$\mathrm{RA} = \frac{R^*}{1 - \mathrm{trr}}, \tag{3}$$

where RA is the required pretax Australian mining return and R^* is the alternative overseas mine or other Australian industry return, and trr is the resource rent tax rate peculiar to Australian mining investment. Equilibrium with a higher RA means less investment of T in Australian mining. As a consequence, the resource rent tax leads to a smaller rate of outward shift over time of the Australian mining supply curve. Or, the tax causes a lag in the outward shift, and in the extreme Australian mining becomes a technology follower rather than a leader. In the context of the static model of Figure 2, a resource rent tax on quasi-rents received from investment of mobile inputs T shift the supply curve upwards from S to $S'' = S + X$.

In most cases, for an approximate revenue neutral royalty and resource rent tax (as below), the upward supply curve shift X of a resource rent tax will be less than the downward demand curve shift R of a royalty. Given the

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magnitude of cost differences between the more favoured and marginal mines, Ricardian rents on the immobile natural resource deposit are an important component of the resource rent tax base. Only some of the T inputs are closely tied to the peculiarities of a particular mine. In many cases, the technology can be acquired by: purchase from the market from non-mining firms not subject to the resource rent tax as technology embedded in equipment and machinery, payment to a third party for intellectual property or payments for business support services. Multinational firms often will have the option of transferring technology from mines in other countries to Australian mines. These options for outsourcing the investment in T on the geographically mobile T investments may be second best, but with relatively small additional costs, including short delays in the transfer of effective T to the specific circumstances of each Australian mine.

The new market equilibrium with the resource rent tax shown in Figure 2b is a fall in quantity to Q'' and a rise in market price to P''. For a linear supply curve, revenue collected by the resource rent tax, RRT, is given by

$$\begin{aligned} \mathrm{RRT} &= \mathrm{trr\,triangle}(P'' - L)Q = 0.5\mathrm{trr}((P'' - \mathrm{L})/P'')P''Q'' \\ &= 0.5\mathrm{trr}((P'' - L)/P'')Q(1 - (Q - Q'')/Q), \end{aligned} \tag{4}$$

where trr is the resource rent tax rate and L is the cost of the lowest cost mine and P'' the cost of the marginal mine.

Comparable royalty and resource rent tax rates to derive, on average and over the long run, similar government revenue equate Equation (2) for the royalty rate with Equation (4) for the resource rent tax rate. To simplify, assume a perfectly elastic demand so that $P = P' = P''$. Then, the resource rent tax rate trr to generate the same revenue as the royalty rate r is

$$\mathrm{trr} = 2r((P - L)/P)\{[1 - (P/(P - L)r]/(1 - (P/(P - L)x]\}, \tag{5}$$

where $x = X/P$ and the other terms are defined as above. The term $(P–L)/P$ describes the cost advantage of the least cost mine relative to the marginal mine. The numerator and denominator of the {} term are the effects of (a) the royalty rate shifting downwards the demand curve from D to D' and a lower output from Q to Q', and (b) the resource rent tax on quasi-rents shifting upwards the supply curve from S to S" and output down from Q to Q'', in Figure 2.

Using Equation (5), Table 1 illustrates comparable rates of the resource rent tax, trr, for: different royalty tax rates, r, of 5, 7 and 10 per cent, which span most state royalty rates; more favoured mines having costs, $(P - L)/P$, of 20, 33.3 and 50 per cent lower than marginal mines drawing on data summarised in Daley and Edis (2010), and the resource rent tax induced upward shift of the supply curve by X being zero, 25 and 50 per cent of the royalty rate downward demand curve shift R.

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Table 1 Approximate similar aggregate government revenue resource rent tax rates, trr; for different royalty rates, r; ratio of lowest cost mine to marginal mine, $(P–L)/P$; and the ratio of the resource rent tax shift of supply curve to the royalty shift of demand curve, X/R (% rate)

Cost advantage $(P\text{-}L)/P$	RRT supply shift, X/R	Royalty rate, r (%)		
		5	7	10
0.2	0	37.5	45.5	50.0
	0.25	40.0	49.9	57.1
	0.5	42.9	55.2	66.7
0.33	0	25.5	33.2	42.0
	0.25	26.5	35.0	45.4
	0.5	27.6	37.1	49.4
0.5	0	22.2	24.1	32.0
	0.25	22.8	25.0	33.7
	0.5	23.4	25.9	35.6

Given current royalty rates over the 5–10 per cent range, and the resource rent tax rates of 40 per cent for the PRRT and 22.5 per cent for the MRRT, a notable observation from Table 1 is the likely small differences in government revenue to be collected in replacing royalties with a resource rent tax at around current rates. The required resource rent tax rate to replace a royalty in an approximate revenue neutral swap increases more than proportionately with the royalty rate, and it needs to increase significantly the smaller the difference between the lowest cost and marginal mine as this determines the Ricardian rent plus quasi-rent tax base, even after accounting for the effect of the more elastic supply curve causing a larger reduction in output. The magnitude of the upward shift of the supply curve driven by a resource rent tax increases the required resource rent tax rate, but with a lesser magnitude of effect when compared with the other two parameters.

4. Relative efficiency effects

Efficiency costs of the royalty and the resource rent tax from a global perspective can be assessed from the Figure 2 market outcomes. For simplicity, the initial pre-special tax market outcome with demand curve D and supply curve S is taken to be the nondistorting outcome.[10]

For the royalty, the downward shift of the demand curve to $D' = D - R$, with R the specific royalty and $r = R/P$ the ad valorem royalty, and associated fall in quantity from Q to Q', generates a triangle of efficiency loss, RL,

[10] For simplicity, global distortions associated with very different tax treatments of mining across different countries are ignored. In reality, very large differences are found in both corporate income tax, including base definition, and in particular depreciation, and corporate tax rates, in special mining tax systems and tax rates, and in interactions of the general and special taxes.

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$$\mathrm{RL} = 0.5R(Q - Q') = 0.5r^2((\mathrm{Ed} + \mathrm{Es})/\mathrm{EdEs})\mathrm{QP}, \tag{6}$$

where the far right hand term shows the loss as a share of total revenue, QP, depending on the square of the royalty rate, r^2, and increasing with one or both of the elasticities of demand and supply, Ed and Es.

Apart from the reduction in the net price received, the royalty does not impose additional taxes on quasi-rents earned on the T inputs of Equation (1). That is, the royalty does not reduce the incentives or the rewards from investment in exploration, technology and management skills to shift outwards the supply curve.

By contrast with the royalty, and unlike the theory for a Ricardian rent tax received for an input in perfectly inelastic supply over time, a resource rent tax which falls also on quasi-rents earned by the partially mobile T inputs shifts upwards the supply curve, shown as X in Figure 2b. If $X = 0$, as assumed in Henry *et al.* (2010) and some others, the resource rent tax is a nondistorting tax and more efficient than a royalty. At a minimum, given the asymmetry of tax treatment of negative and positive cash flows with the resource rent tax (as compared with the pure cash flow tax), $X > 0$, even for Ricardian rent.

Including quasi-rents earned on investments in T in the resource rent tax base results in a further upward shift of the X term. This shift will be larger: the larger the share of quasi-rent earned on T relative to the Ricardian rent earned on N; the more mobile the inputs invested in T and their supply sensitivity to additional taxation in the Australian mining industry; the higher the resource rent tax rate, trr, which, for revenue neutrality, as shown in Equation (5) and illustrated in Table 1, increases with the royalty rate, r, and the smaller the cost advantage of the least cost mine, $(P - L)/P$; and the more difficult and costly it is to acquire the new technology via purchased inputs and services from firms not subject to the resource rent tax. Each of the factors affecting the magnitude of X will vary from one mine to another, and over time for each mine.

There are two elements to the efficiency costs of a resource rent tax. First, similar to a royalty, the smaller quantity $Q - Q''$ involves a triangle of efficiency loss. Second, a portion z, with $0 \leq z \leq 1$, of the additional costs to the Australian mining industry due to less investment in the T inputs given by the rectangle[11] between the supply curves S and S'' represents a net efficiency cost of reallocating some T inputs from their pre-resource rent tax most productive use in the Australian mining industry to alternative lower productivity uses in other Australian industries or to mining in other

[11] For simplicity, and in the absence of compelling a priori or empirical evidence to the contrary, Figure 2 and the formula of (6) assume a parallel shift of the supply curve. Convergent or divergent supply curve shifts clearly would result in larger and smaller losses, respectively, than the assumed parallel shift. In the case of exploration, a referee suggested a divergent shift is more likely.

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countries. The extreme assumption by Ergas *et al.* (2010) of $z = 1$, even if the focus is narrowed to Australia rather than the global economy, seems too strong and unrealistic. The reallocated inputs will generate value in their alternative uses, and often close to their first best Australian mine location. Adding the two elements, the efficiency cost of the resource rent tax, RRTL, is given by

$$\mathrm{RRTL} = 0.5\,\mathrm{X}\,(Q - Q'') + z\,\mathrm{X}\,Q = 0.5x^2((\mathrm{Ed} + \mathrm{Es})/\mathrm{EdEs})\mathrm{QP} + z \times \mathrm{QP}, \tag{7}$$

where $x = X/P$ is the ad valorem equivalent upward cost effect of withdrawal of some mobile T inputs which earn quasi-rents shifting the supply curve upwards, and all other terms are as defined above.

The resource rent tax involves less distortion costs than a royalty system if Equation (7) < Equation (6). A necessary condition for superiority of the resource rent tax is that $x < r$. That is, the disincentive caused by the additional taxation of quasi-rents earned on mobile T inputs cause a smaller upward shift of the supply curve than a royalty downward shift of the demand curve. As argued above, it is likely that this condition will hold. With this necessary condition, the break-even value of the share, z, of the rectangle between the S'' and S supply curves measuring the distortion costs associated with the relocation of some T inputs from Australian mining to alternative less productive uses is given by rearranging Equation (6) and Equation (7) to yield

$$z = \frac{(r^2 - x^2)\theta}{2x}, \tag{8}$$

where $\theta = (\mathrm{Ed} + \mathrm{Es})/\mathrm{EdEs}$ and the other terms are as before.

Using Equation (8), Table 2 provides indicative estimates of z. Sensitivity of the breakeven z is provided for royalty rates, r, of 5, 7 and 10 per cent; the ratio of the resource rent tax induced upward shift of the supply curve to the royalty rate reduction of the demand curve, $X/R = x/r$, of 0.1, 0.3 and 0.5; and elasticities of demand and supply of 4 and 3 to give $\theta = 1.71$. To illustrate, for a royalty rate of 5 per cent and for an upward shift of the supply curve with a resource rent tax equal to 0.1 of the downward shift of the demand curve, the resource rent tax is more globally efficient if less than 42 per cent of the supply shift represents a net efficiency loss of investment by Australian mines in T reallocated to investment in mines in other countries or to other industries.

Interpretation of Equation (8) in conjunction with the illustrative numbers in Table 2 highlights that the global efficiency ranking of the resource rent tax and the royalty is very sensitive to key parameters. For a given royalty rate, the larger the cost increase effect of the resource rent tax on investment in T inputs earning quasi-rents, the smaller is the permissible global distortions to

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Table 2 Minimum values for the global resource allocation distortion cost as a share of additional costs to australian mining, z; for different royalty rates, r; and different ratios of supply shift to demand shift, x/r (proportion)

Resource rent tax supply shift relative to royalty demand shift (x/r)	Royalty rate (%)		
	5	7	10
0.1	0.42	0.59	0.85
0.3	0.13	0.18	0.26
0.5	0.06	0.09	0.13

the investments in T, and the more likely a royalty will be more efficient. In part, this effect is modified for higher royalty rates and for more elastic supply and demand.

Unfortunately, there are no compelling estimates of the key z and x/r parameters. Further, almost certainly they will vary from one mine to another, and also over time for each mine.

5. Distribution effects: producers and buyers

There are similarities, but also important differences, in the redistribution effects of an approximate revenue neutral royalty and a resource rent tax between buyers and miners (shareholders) and then between different mines.

A portion of the burden of both special taxes is passed onto buyers as higher prices if the elasticity of demand is less than infinite. When the royalty demand shift R exceeds the resource rent supply shift X, as argued above, producers bear more of a resource rent tax than a royalty. The larger the royalty impost relative to the resource rent tax induced increase of the supply curve, that is R/X, the larger is the share of the special tax passed forward to buyers as a higher price by a royalty relative to a resource rent tax. For both of the special taxes, the less elastic is demand relative to supply, the larger the share passed forward to buyers.

Distribution of the special tax burden on producers and their shareholders within the industry will be different between the two special taxes. Lower cost mines which earn relatively larger economic rents will face a doubling of the special tax burden of a royalty under a resource rent tax; marginal mines earning minimal economic rents will have their special tax burden reduced to near zero.

Under conventional asset price models, most of the resource rent tax falling on Ricardian rents on N, and on quasi-rents on T inputs in short-run inelastic supply to the Australian mining industry, will be born as a one-off windfall fall in the share price of existing shareholders. This model assumes the following: the asset value component of the share price is given by the present value of the expected future stream of after-tax economic rents; and new shareholders in allocating their savings across different investment options

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arbitrage to achieve comparable after-tax returns (adjusting for relative risks which are assumed to be little affected by the alternative special taxes). Then, replacing a royalty with a revenue neutral resource rent tax would result in a one-off windfall capital loss for shareholders of relatively low cost mines and a one-off windfall capital gain for shares in marginal mines.

6. Distribution effects: residents and nonresidents

As argued by Ergas and Pincus (2014), in assessing the implications of a royalty for Australian welfare, it is important to recognise the substantial roles of nonresidents to the industry. Similar implications are relevant for a resource rent tax. With the exception of crude oil, most Australian mineral and energy production is exported, and in aggregate more than 80 per cent (BREE 2014). The long-run export demand for Australian minerals is elastic but less than perfectly elastic (Hertel 1997; and Dixon and Rimmer 2002). Nonresident shareholders represent about 80 per cent of the mining industry (Connolly and Orsmond 2011). Shareholders bear most of the special taxes passed back to producers as a combination of lower dividends and lower retained earnings flowing into reduced capital gains.

All of the revenue collected from a royalty and from a resource rent tax, as measured in Equation (2) and Equation (4), go to the federal and states governments. Governments then use these funds for the benefit of Australian citizens as a combination of reductions in other taxes (and higher private effective disposable incomes) and increases in government expenditures on valued goods and services. Mining industry producers and buyers initially bear the tax transfer cost plus the efficiency losses, as measured in Equation (6) and Equation (7), with the share between producers and buyers described in the preceding section. The global efficiency losses expressed as a share of the revenue collected would be below 5 per cent for relatively low long-run elasticities of demand and supply (of 3 and less) and a royalty of 5 per cent or an resource rent tax of 25 per cent; and up to 20 per cent for a 10 per cent royalty rate or a 40 per cent resource rent tax and very high elasticities of demand and supply (of 8 and more). Then, subtracting the transfers from resident shareholders and domestic buyers, up to 75 per cent of government revenue from a royalty or a resource rent tax is a net transfer from overseas buyers and nonresident shareholders to Australian citizens.[12]

Importantly, the magnitude of the net transfer from nonresidents to Australia from either a royalty or a resource rent tax is much larger than differences in the global efficiency costs of the two special tax options over the likely ranges of values for the key parameters discussed in Equation (6) through Equation (8). Also, given that nonresidents have similar shares of purchases and of shareholding in the Australian industry, the different

[12] For an average royalty of 7 per cent, and using a much lower supply elasticity of Es = 1, Ergas and Pincus (2014) estimate a larger net gain of from 76 to 81 per cent.

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distributions of the royalty and resource rent tax burden between buyers and shareholders discussed in Section 5 above is of second order importance.

The significant transfer of revenue from nonresidents to Australians from the production and consumption of nonrenewable natural deposits can be justified as a fee for nonresident access to Australian community owned deposits, and as a way of channelling some of the derived economic rent into other productive investments which is required for a long-run sustainable consumption path for Australians when exploiting nonrenewable resources.

7. Conclusions

A key outcome of the more nuanced distinction between Ricardian rent and quasi-rent included in the measured resource rent tax, use of data on relative mine costs as the basis of the contemporary supply curve, and explicit recognition of nonresident shareholders and export sales, is a less clear-cut superiority of the resource rent tax relative to the royalty than recommended by some, including Henry *et al*. (2010).

In the context of the Australian mining industry with majority nonresident ownership of mining business shares, and the high proportion of product exported, Australia as an economy gains a significant transfer of revenue from nonresidents from both the royalty and the resource rent tax options. The net gain for either special tax likely exceeds 75 per cent of the tax revenue. Importantly, the magnitude of this transfer dominates differences in both the distortion costs and the distribution effects of similar aggregate revenue royalty and resource rent tax options.

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