The impacts of potential iron ore supply restrictions on producer country welfare

Authors

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Abstract

Rapid changes in commodity prices often lead to calls for government intervention in markets. The large fall in global iron ore prices in 2015 from the highs during the 'China boom' led to demands for an inquiry in Australia into pricing and claims that restrictions on Australian supply were in Australia's national interest. This paper uses a spatial equilibrium model to examine the impact of various iron ore supply restriction scenarios on the commodity price and trade flow outcomes for a range of key iron ore suppliers. The results show that restricting Australian iron ore supply will result in loss of Australian income, to the benefit of Australia's main competitor Brazil. A reduction in mining income would also reduce government royalty revenues, output and employment, and is therefore not in the national interest.

Keywords

Iron ore; spatial equilibrium model; supply restrictions; trade flows; Australian iron ore inquiry

Introduction

Australia is a critical supplier of strategic raw materials into Asia, and currently supplies over 45 per cent of Asia's externally sourced iron ore. As such, the Australian mining industry is an important component in the economic security of regional partners including China, Japan and India. Key aspects of the trade relationships with these counties are reliability and competitiveness of supply.

Brazil is Australia's largest competitor in the seaborne iron ore market, and its flagship miner Vale is the world's single largest iron ore producer with annual production of over 350 million tonnes of ore and pellets. Brazil also boasts extensive iron ore reserves and its S11D project is the largest iron ore mining project in the world, set to produce 90 million tonnes of high quality low cost ore by 2018. While Brazil is projected to add 120 million tonnes of capacity to the market over that timeframe, in Australia, Rio Tinto and BHP will each bring on an additional 20 million tonnes, and Hancock Prospecting's Roy Hill development will add a further 55Mt per year at full production.

China has for some time been the world's largest consumer of iron ore, demanding over one billion tonnes of the commodity from domestic and international sources in 2014. As economic growth and construction has slowed in China in recent times, growth in the demand for iron ore has also eased.

Correspondingly, iron ore prices have fallen dramatically from their historic highs in 2011 when the commodity traded at over three times current levels.

It is in the context of moderating demand growth, strong supply side prospects, and falling iron ore prices that attempts were recently made at the highest levels of Australian government to initiate a public inquiry into whether constraining Australian iron ore supplies might be in the national interest. The notion of such an inquiry has for now been set aside. However, debate is ongoing about the rationality of the large iron ore producers' expansion strategies, and the national consequences of a regulated restriction on exports of iron ore.

This paper uses a spatial equilibrium modelling framework to quantify the potential impacts on global iron ore trade flows and the revenues of major producers resulting from imposing supply restriction scenarios on one or more key producers. It does not seek to consider the legal or competition aspects of such restrictions.

Method

Spatial equilibrium models take into account trade flows and transport costs when predicting firm or regional level supplies, regional demands and prices. More specifically, these models allow for price arbitrage between regions connected through trade so that regional differences in prices and production costs are less than the cost of transport. Large differentials in transport costs can lead to the isolation of markets and regional trading blocks. The modelling approach is suited to the problem of examining voluntary or regulatory supply controls on the supply of iron ore because the outcomes are highly dependent on market shares in iron ore markets that are linked or isolated due to transport costs.

The Model

Takayama and Judge (1964) initially developed the spatial equilibrium model to represent regional trade in a competitive market. Since then the models have been generalised in a mathematical sense to allow for more flexible representations of supply, demand and the costs of transport. However, the model put forward by Takayama and Judge remains the basic conceptual framework and requires the fewest number of assumptions with regard to the model parameters.

The model is set out as a mathematical optimisation problem with an objective function to be maximised subject to a set of constraints. The specification of the spatial equilibrium model is based on:

- the theoretical assertion that competitive markets maximise the sum of producer returns and consumer welfare, which defines the objective function;
- arbitrage conditions on marginal production costs and prices between trading partners that take the form of constraints;
- the specification of demand and supply as a linear function of price, where price is a function of quantity; and
- constant per unit transport costs.

This gives a quadratic objective function with linear cost and price arbitrage constraints that can be solved numerically (Goldfarb and Idnani 1982 and 1983). The problem is well behaved in that it has a unique solution, given a feasible solution exists, and a numerically stable solution algorithm. As a consequence, the model will generate consistent results under alterative scenarios in which supply controls are imposed or removed.

The model has been implemented in R, open source code, available online from the Comprehensive R Archive Network.

The objective function to be maximised is the sum of producer and consumer surplus less transport costs across all firms and regions:

$$Max \sum_{i \in I} \int_{s=0}^{qd_i} \left(\beta_{0i} + \beta_{1i} qd_i\right) ds - \sum_{k \in K} \int_{t=0}^{qs_{ik}} \left(\alpha_{0ik} + \alpha_{1ik} qs_{ik}\right) dt - \sum_{k \in K} \sum_{j \in J} c_{ijk} q_{ij}$$

$$\equiv Max \sum_{i \in I} \beta_{0i} qd_i + \frac{1}{2} \beta_{1i} qd_i^2 - \alpha_{0ik} qs_{ik} + \frac{1}{2} \alpha_{1ik} qs_{ik}^2 - \sum_{k \in K} \sum_{j \in J} c_{ijk} q_{ij}$$

where:

- β_i is a demand parameter;
- qd_i is the quantity demanded by region i;
- α_i is a supply parameter;
- qs_{ik} is the quantity supplied by firm k in region i;
- c_{ijk} is the cost of transport from firm k in region i to region j; and
- q_{ijk} is the quantity transported from firm k in region i to region j.

There are four sets of constraints that must be met. First, the sum of quantity transferred from firm or region i to region j, including that transferred internally (where i= j) must equal the quantity supplied by region i:

$$qs_{ik} - \sum_{k \in K} \sum_{j \in J} q_{ijk} = 0$$

Second the sum of the quantity demanded by region i must equal the sum of all imports into the region including internal imports:

$$qd_i - \sum_{k \in} \sum_{j \in J} q_{ijk}$$

The third set of constraints are the arbitrage constraints on prices and marginal production costs:

$$\left|\beta_{0i} + \beta_{1i} qd_i - \beta_{0j} + \beta_{1j} qd_j\right| \leq c_{ij}$$
$$\left|\alpha_{0ik} + \alpha_{1ik} qd_{ik} - \alpha_{0jk} + \alpha_{1jk} qd_{jk}\right| \leq c_{ij}$$

where the vertical bars denote absolute value. It is important to note that these constraints are imposed when:

- there is the potential for trade between regions i and j; and
- there are not any additional binding constraints on regional supply or demand.

These additional constraints are used to limit supplies by the firms and regions to simulate voluntary or regulatory restraints:

$$qs_{ik} \leq qs_{ik}^{*}$$

The final set of constraints requires that all quantities are non-negative:

$$qd_i, qs_{ij}, q_{ijk} \geq 0$$

Model Calibration

The model is specified for 13 iron ore supply firms/regions and 10 demand regions. The model is calibrated to align with the most recently available international iron ore production and trade data for these regions. The information required to calibrate the model is on a standardised 62 per cent iron content basis:

- production, consumption and net exports (exports less imports);
- transport costs; and
- a domestic price for each region.

Production, consumption and trade data were sourced from the Steel Statistical Yearbook 2014, using the most recently reported year 2013 (see Table 1). Transport costs were sourced from industry contacts (see Table 2). Prices were derived from a reference price of $US55 per dry metric tonne free on board Dampier, Australia. This price is adjusted for transport costs across all markets with the exception of the rest of world category, which is restricted to trade within itself (see Table 1) for the purposes of the present analysis.

In addition, demand and supply elasticities are needed to calculate the firm/regional supply and regional demand functions. Elasticities are measures of how responsive demand and supply are to price, expressed in percentage change terms. These are key assumptions as demand and supply elasticities will determine how the model will respond to voluntary or regulated reductions in supply. A reduction in supply in one key region will increase prices, thereby leading to expanded production from other suppliers and a downward readjustment of prices. In general terms, the effect on producer revenue of a reduction in supply will be greater the more price inelastic is demand.

Information on which to base these elasticities has been drawn from a consideration of the demand for iron ore as an input into steel production, a limited number of empirical studies of iron ore and steel markets, and mine industry cost curves. The most consistent empirical finding is that the demand elasticity for iron ore is lower (in absolute terms) than the supply elasticity for iron ore. That is, a one per cent change in price will have a greater effect on supply, in percentage change terms, than on demand. Demand and supply elasticity assumptions are set out in Table 1.

The demand for iron ore is likely to be price inelastic (relatively non responsive to changes in price):

- Empirical studies of the steel market have found that steel demand is price inelastic and this will be passed through to the demand for iron ore. Malanichev and Vorobyev (2011) report a range of demand elasticities between -0.2 and -0.3.
- Iron ore demand in developed markets should be more price responsive given the greater availability of scrap iron as a substitute for iron ore.
- Priovolos (1982) reported country level iron ore demand elasticities ranging from 0.04 to 0.64. Considine and Zheng (2012) in a study of iron ore demand in China estimated an own price elasticity of around -0.25.

The supply of iron ore may range from being price inelastic to price elastic:

- Priovolos (1982) reported country level iron ore supply elasticities ranging between 0.5 and 2.2.
- The shape of the industry cost curve is relatively steep at high prices and flat at low prices, so supply should be more price responsive at lower prices.
- Chinese iron ore mines tend to have high cost structures due to low ore grades, among other factors, so the elasticity of supply should be relatively low in China.
- Ore grades are high in Australia and Brazil and both Australia's and Brazil's major producers sit at the bottom of the cost curve so the elasticity of supply should be relatively high.

Table 1 Assumed iron ore market calibration data

Firm/region	Market Data, 2013				Elasticities	
	Supply (Mt)	Demand (Mt)	Net Trade (Mt)	Price US$/t	Supply	Demand
Rio Tinto	262,195	0	263,753	55.00	0.65	0.00
BHP	195,017	0	196,281	55.00	0.65	0.00
FMG	91,409	0	92,007	55.00	0.55	0.00
Rest of Australia	61,135	447	57,267	55.00	0.50	-0.30
China	269,200	1,089,375	-820,175	64.34	0.20	-0.25
North Asia	3,052	224,807	-221,755	64.34	0.25	-0.30
India	136,100	122,789	13,311	53.00	0.50	-0.30
North America	109,141	63,305	45,836	55.00	0.50	-0.30
Brazil/Vale	364,030	34,391	329,639	43.70	0.65	-0.30
Rest of South America	37,480	17,786	19,694	43.70	0.50	-0.30
Africa	86,900	618	86,282	49.84	0.50	-0.30
EU	41,038	154,177	-113,139	61.00	0.50	-0.30
ROW	277,689	277,689	0	55.00	0.50	-0.30

Table 2 Assumed transport costs, $US/t, 2013

Region	Australia	China	North Asia	India	North America	South America	Africa	EU
Australia	0	9.34	9.34	-	-	-	-	-
China	9.34	0	-	11.34	-	20.64	14.5	-
North Asia	9.34	-	0	11.34	-	20.64	14.5	-
India	-	11.34	11.34	0	-	-	-	-
North America	-	-	-	-	0	-	-	6
South America	-	20.64	20.64	-	-	0	-	12
Africa	-	14.5	14.5	-	-	-	0	11
EU	-	-			6	12	11	0

Elasticity Assumptions

The base case is the near to medium term of three to five years with the assumed elasticities shown in Table 1. Given the importance of the elasticities in determining how the model will respond there is a need to test the robustness of model results to these assumptions.

The most important theoretical consideration for price elasticities is that demand and supply will become more price elastic over time, as firms are able to adjust their investments and operating costs. In the immediate to near term these elasticities can be expected to be considerably lower in absolute terms. In the medium to longer term these elasticities can be expect to be considerably higher in absolute terms.

The calibration of the supply and demand functions is straightforward:

$$\alpha_1 = \varepsilon s \frac{p}{qs}$$

$$\alpha_0 = p - \alpha_1 qs$$

$$\beta_1 = \varepsilon d \frac{p}{qs}$$

$$\beta_0 = p - \beta_1 qs$$

Where p is the reference price and εs is the elasticity of supply and εd is the elasticity of demand.

Results

Market Baseline and Supply Restraint Simulations

The baseline solution of the model for the iron ore market with unconstrained trade is summarised in the following two tables. Supply, fob supply prices, demand and cif prices for each firm/region are shown in Table 3. These can be compared with the market values given in Table 1. The solution is not an exact fit as the model optimises trade flows under the simple assumption that transport costs are constant rather than exactly duplicating the base case trade flows. Trade volumes are shown in Table 4.

In constructing the baseline a nominal transport cost of $2.50 was added between the Australian and Bazilian supply nodes and the Australian and rest of South America demand nodes respectively. This was done to retain production in the rest of Australia and South America given that production was excluded from these regions in the initial optimal model solution.

Table 3 Calibrated iron ore market supplies, demand and prices: baseline elasticity assumptions

Firm/Region	Supply		Firm/Region	Demand	
	Quantity '000 tonnes	fob price USD/dmt		Quantity '000 tonnes	cfr price USD/dmt
Rio Tinto	267,976	57	Australia	438	60
BHP	200,039	57	China	1,073,434	68
FMG	94,346	58	North Asia	221,838	67
Rest of Australia	63,129	58	India	119,405	58
China	270,194	66	North America	64,207	52
North Asia	3,075	66	Brazil	33,502	47
India	140,819	57	Rest of South America	17,326	49
North America	105,913	52	Africa	604	54
Brazil/Vale	373,719	46	EU	156,327	58
Rest of South America	38,446	46	ROW	275,085	57
Africa	89,516	53			
EU	39,907	58			
ROW	275,085	54			

Table 4 Calibrated iron ore market trade flow: baseline elasticity assumptions

From	To	Volume (Mt)	From	To	Volume (Mt)
Rio Tinto	China	186,840	Rio Tinto	North Asia	81,136
BHP	China	152,872	BHP	North Asia	47,168
FMG	China	94,346	Brazil	North Asia	90,459
Rest of Australia	China	62,692	North America	EU	41,707
China	China	270,194	Brazil	EU	53,594
India	China	21,415	Rest of South America	EU	21,120
Brazil	China	196,164	Africa	EU	0
Africa	China	88,912			

Supply Restraints and Sensitivity Analysis

In the supply restraint scenario, a 15 per cent reduction in supply was imposed on four different sets of suppliers:

- Rio Tinto and BHP;

- All of Australia;
- All of Australia and Brazil; and
- Rio Tinto, BHP and Brazil (Vale).

In addition to the elasticity assumptions used to generate the market baseline, the following alternative elasticity assumptions were evaluated:

- A more inelastic Chinese demand elasticity of -0.10;
- Less elastic supply elasticities from all exporters of 0.30;
- A reduction in all elasticities, in absolute terms, of 50 per cent; and
- An increase in all elasticities, in absolute terms, of 100 per cent.

The first two alternative elasticity assumptions are intended to test the robustness of the quantitative conclusions regarding the effectiveness of supply controls in the near to medium term. These conditions should favour the restriction of supplies, relative to the baseline results.

The third alternative set of elasticity assumptions is intended to reflect an iron ore market that is largely non-responsive to prices and might characterise the immediate to near term.

The last set of alternative elasticity assumptions is intended to reflect the medium to long term in which the iron ore market is price responsive.

For each simulation the percentage change in supply, price and revenue is presented. The results are presented in Tables 5 through 10. In making comparisons it is important to note that a 15 per cent decrease in supply is not fully offset by 15 per cent increase in supply. This is easily verified as 0.85*1.15 = 0.98.

Discussion

Overall, the results tell a consistent story. Neither Rio Tinto nor BHP nor Australia as a whole has sufficient iron ore market share to gain from voluntary or regulatory supply controls in terms of export revenue. This result is not particularly sensitive to alternative supply and demand elasticity assumptions or the length of the time horizon under consideration. Conversely, suppliers in other countries would gain substantially in terms of revenue from these restrictions.

Focusing on Australia as a whole and the near to medium term base case elasticities, a 15 per cent reduction in Australian supply would:

- Increase prices received by Australian exporters by about 9 per cent but lead to a reduction in Australian export revenue of about 7 per cent.
- Increase prices received in Brazil by over 11 per cent along with increased exports to fill the gap left by Australia. Vale's revenue increases

by 20 per cent and other countries' suppliers also benefit to a lesser extent.

The larger percentage increase in prices in Brazil versus Australia is due largely to the higher base price in Australia. However, due to the supply constraints on Australia, prices are no longer arbitraged between Australia and Brazil through the Chinese and North Asian markets. As a consequence it is possible for prices to diverge by more than the difference in transport costs. Detailed results for this scenario are presented in Table 5.

Table 5 Percentage change in supply, prices and revenue: base case supply and demand elasticities

Firm/Region	Rio Tinto and BHP			Australia			Australia and Brazil		
	Supply	Price	Revenue	Supply	Price	Revenue	Supply	Price	Revenue
Rio Tinto	-15	6.38	-9.58	-15	9.28	-7.11	-15	21.1	2.94
BHP	-15	6.38	-9.58	-15	9.28	-7.11	-15	21.1	2.94
FMG	3.63	6.38	10.24	-15	9.28	-7.11	-15	21.1	2.94
Rest of Australia	3.3	6.38	9.89	-15	9.28	-7.11	-15	21.1	2.94
China	1.15	5.51	6.72	1.68	8.01	9.83	3.81	18.21	22.71
North Asia	1.41	5.75	7.23	2.03	8.22	10.42	4.81	18.71	24.42
India	3.36	6.33	9.91	4.9	9.22	14.56	11.08	20.87	34.27
North America	3.29	6.66	10.18	4.75	9.62	14.82	11.31	22.92	36.83
Brazil	5.27	7.9	13.59	7.61	11.5	19.99	-15	26.13	7.21
Rest of South America	3.94	7.9	12.15	5.68	11.5	17.83	13.57	26.13	43.24
Africa	3.63	7	10.88	5.29	10.18	16	12.02	23.14	37.94
EU	3.06	6.1	9.35	4.37	8.81	13.56	10.27	20.99	33.42

Turning to the sensitivity analysis on the elasticity assumptions, if Chinese demand is more inelastic, the price received by Australian exporters when supplies are constrained is higher, and hence Australia's revenue losses are lower - less than 6 per cent. However, Vale benefits even more from the price increase that results from curtailing supplies in Australia, because China's demand falls less in response to the market price increase. Brazilian exports increase from an 8 per cent rise under baseline elasticities to over 13 per cent, and revenue rises by 23 per cent. All results from this sensitivity are shown in Table 6.

Table 6 Percentage change in supply, prices and revenue: Chinese demand elasticity -0.10

Firm/Region	Rio Tinto and BHP			Australia			Australia and Brazil		
	Supply	Price	Revenue	Supply	Price	Revenue	Supply	Price	Revenue
Rio Tinto	-15	7.37	-8.74	-15	10.86	-5.77	-15	26.77	7.75
BHP	-15	7.37	-8.74	-15	10.86	-5.77	-15	26.77	7.75
FMG	4.2	7.37	11.88	-15	10.86	-5.77	-15	26.77	7.75
Rest of Australia	3.83	7.37	11.48	-15	10.86	-5.77	-15	26.77	7.75
China	1.34	6.36	7.79	1.98	9.38	11.55	4.85	23.11	29.09
North Asia	1.63	6.61	8.35	2.39	9.6	12.21	6.05	23.6	31.07
India	3.9	7.32	11.52	5.76	10.81	17.2	14.09	26.44	44.26
North America	3.81	7.68	11.78	5.58	11.24	17.45	14.28	28.86	47.27
Brazil	6.09	9.11	15.76	8.92	13.43	23.55	-15	33.11	13.14
Rest of South America	4.55	9.11	14.08	6.66	13.43	20.99	17.11	33.11	55.88
Africa	4.21	8.07	12.63	6.22	11.9	18.86	15.25	29.33	49.05
EU	3.51	7.04	10.8	5.1	10.31	15.93	12.93	26.39	42.73

With less elastic supplies from exporting countries, revenue losses to Australia when supplies are constrained are less than 5 per cent, since prices received by Australian exporters are higher than in the base case (Table 7). Exports from Brazil fall relative to the baseline, offsetting the higher prices. Vale's exports rise by only 4.5 per cent compared to the baseline increase of 7.5 per cent, and the increase in Vale's revenue is about the same as in the base case, 20 per cent.

Under the immediate to near term elasticity assumptions (where elasticities are reduced 50 per cent), the increase in prices received by Australian exporters is almost enough to offset the decline in export volumes, with revenue falling by a little over 1.5 per cent. Vale is still the largest beneficiary. However, the lower supply elasticity in Brazil implies a more rapid increase in marginal costs as production expands. Growth in Brazilian exports thus decline relative to the baseline elasticity assumptions, and limit the increase in revenue to 19 per cent, slightly less than the base case (see Table 8).

Under the medium to long-term elasticity assumptions (where elasticities are increased by 100 per cent) prices received by Australian exporters increase by less than 5 per cent and revenue falls by almost 11 per cent. Vale's revenue increases by less than 15 per cent, as the smaller price increase is offset, in part, by the expansion of production and exports in the longer term (Table 9).

Table 7 Percentage change in supply: supply elasticity in all exporting regions of 0.30

Firm/Region	Rio Tinto and BHP			Australia			Australia and Brazil		
	Supply	Price	Revenue	Supply	Price	Revenue	Supply	Price	Revenue
Rio Tinto	-15	8.44	-7.83	-15	12.02	-4.78	-15	22.68	4.28
BHP	-15	8.44	-7.83	-15	12.02	-4.78	-15	22.68	4.28
FMG	2.68	8.44	11.35	-15	12.02	-4.78	-15	22.68	4.28
Rest of Australia	2.68	8.44	11.35	-15	12.02	-4.78	-15	22.68	4.28
China	1.54	7.3	8.95	2.2	10.4	12.83	6.16	19.61	26.98
North Asia	1.91	7.57	9.63	2.71	10.66	13.65	6.3	20.13	27.7
India	2.74	8.4	11.38	3.91	11.98	16.35	7.35	22.53	31.53
North America	2.67	9.03	11.94	3.78	12.78	17.05	7.36	24.9	34.09
Brazil	3.35	10.41	14.11	4.74	14.84	20.28	-15	27.99	8.79
Rest of South America	3.26	10.41	14.01	4.61	14.84	20.13	9.01	27.99	39.52
Africa	2.95	9.24	12.46	4.21	13.16	17.92	7.93	24.83	34.73
EU	2.43	8.24	10.88	3.44	11.68	15.51	6.66	22.74	30.91

Table 8 Percentage change in supply, prices and revenue: all elasticities reduced in absolute magnitude by 50 per cent

Firm/Region	Rio Tinto and BHP			Australia			Australia and Brazil		
	Supply	Price	Revenue	Supply	Price	Revenue	Supply	Price	Revenue
Rio Tinto	-15	10.98	-5.67	-15	15.77	-1.59	-15	34.4	14.24
BHP	-15	10.98	-5.67	-15	15.77	-1.59	-15	34.4	14.24
FMG	3.24	10.98	14.57	-15	15.77	-1.59	-15	34.4	14.24
Rest of Australia	2.95	10.98	14.25	-15	15.77	-1.59	-15	34.4	14.24
China	1.03	9.51	10.63	1.48	13.67	15.34	3.21	29.8	33.97
North Asia	2.51	9.81	12.57	3.59	13.96	18.05	7.99	30.47	40.89
India	5.88	10.94	17.47	8.45	15.73	25.52	18.4	34.24	58.93
North America	5.87	11.73	18.29	8.4	16.78	26.58	18.79	37.65	63.52
Brazil	4.74	13.49	18.88	6.79	19.39	27.49	-15	42.28	20.94
Rest of South America	3.59	13.49	17.56	5.13	19.39	25.51	11.52	42.28	58.67
Africa	3.25	12	15.64	4.67	17.24	22.72	10.18	37.6	51.61
EU	2.64	10.74	13.66	3.77	15.35	19.71	8.42	34.33	45.64

Table 9 Percentage change in supply, prices and revenue: all elasticities increased in absolute term by 100 per cent

Firm/Region	Rio Tinto and BHP			Australia			Australia and Brazil		
	Supply	Price	Revenue	Supply	Price	Revenue	Supply	Price	Revenue
Rio Tinto	-15	3.29	-12.2	-15	4.84	-10.88	-15	10.84	-5.79
BHP	-15	3.29	-12.2	-15	4.84	-10.88	-15	10.84	-5.79
FMG	3.98	3.29	7.4	-15	4.84	-10.88	-15	10.84	-5.79
Rest of Australia	3.3	3.29	6.7	-15	4.84	-10.88	-15	10.84	-5.79
China	1.17	2.83	4.03	1.72	4.17	5.96	3.82	9.33	13.5
North Asia	1.38	3.02	4.45	2.01	4.33	6.42	4.96	9.69	15.13
India	3.31	3.2	6.61	4.87	4.71	9.81	10.83	10.46	22.42
North America	3.25	3.19	6.55	4.73	4.63	9.58	11.63	11.36	24.32
Brazil	5.2	4.09	9.51	7.55	6.02	14.03	-15	13.48	-3.54
Rest of South America	3.73	4.09	7.98	5.42	6.02	11.77	13.35	13.48	28.63
Africa	3.63	3.61	7.37	5.35	5.32	10.95	12.01	11.9	25.34
EU	3.17	2.97	6.24	4.6	4.31	9.12	10.96	10.58	22.7

The results when only Rio Tinto and BHP reduce supplies follow the same pattern as for the supply constraint on Australian exports. However, because prices increase less with the smaller supply restriction, this leads to a greater reduction in their revenue, a reduction in export revenue of 9.5 per cent as opposed to 7 per cent with the base case elasticity assumptions.

Overall, West Australian export revenues increase as FMG expands supplies but this increase is limited to around 3.5 per cent of a smaller base than that applying for Rio Tinto or BHP. Despite a comparative swing in FMG production of 18.5 per cent, West Australian export revenues still fall by 12 as opposed to 15 per cent when only Rio Tinto an BHP constrain exports.

Gains to Vale are also less, owing to the smaller price increase, however they benefit from cannibalising Australian market share. Once a competing region commits to an expansion in response to a price increase generated by a supply restriction elsewhere the capital associated with the expansion is sunk and therefore large price adjustments are required to cause a short term reduction in this new supply. The consequence is that it is difficult for the region that reduced supply in the first instance to regain market share.

Brazil/Vale Supply Reduction

A supply reduction arrangement that includes Brazil gives different market outcomes that are sensitive to the time horizon under consideration. Under the base case elasticity assumptions for the near to medium term a 15 per cent reduction in supplies by Australia and Brazil results in:

- a price increase in over 20 per cent, with the price rise in Brazil exceeding 25 per cent;
- revenues to Australian producers increasing by almost three per cent; and
- Vale revenues increasing by more than 7 per cent.

Under the immediate to very near term elasticity assumptions there are quite substantial benefits to Australia and Vale with revenue increasing by more than 14 per cent for Australia and almost 21 per cent for Vale.

However, under the medium to long-term elasticities the combined market share of Australia and Brazil is not sufficient for a reduction in output to increase price to the point where export revenue rises.

- Prices rise by almost 11 per cent in Australia leading to nearly a 6 per cent decline in revenue.
- Price rise by 13.5 per cent in Brazil leading to a 3.5 per cent decline in Vale revenue.

This result does have the caveat that other suppliers have sufficient iron ore reserves to expand long run supplies.

Rio Tinto, BHP and Vale

The incentives for a cooperative arrangement between Rio Tinto, BHP and Vale are not strong. Under the baseline near to medium term elasticity assumptions a 15 per cent reduction in supplies by Rio Tinto, BHP and Vale (Brazil):

- Prices rise by around 16 per cent in Australia and 19.5 per cent in Brazil.
- Rio Tinto and BHP revenue falls by 1.5 per cent.
- Vale revenue increases by only about 1.5 per cent.

Under the immediate to short term elasticity assumptions Rio Tinto and BHP revenues increase by over 7 per cent and Vale revenue by over 12 per cent. However, under the medium to long-term elasticity assumptions Rio Tinto and BHP revenues fall by over 8 per cent and Vale revenue fall by over 6 per cent (Table 10).

Table 10 Percentage change in supply, prices and revenue given a 15 reduction in reduction in Rio Tinto, BHP and Vale (Brazilian) supply under various elasticity assumptions

Firm/Region	Immediate to Near Term			Near to Medium Term			Medium to Long Term		
	Supply	Price	Revenue	Supply	Price	Revenue	Supply	Price	Revenue
Rio Tinto	-15	26.29	7.35	-15	15.83	-1.54	-15	8.05	-8.16
BHP	-15	26.29	7.35	-15	15.83	-1.54	-15	8.05	-8.16
FMG	7.77	26.29	36.11	9.02	15.83	26.28	9.72	8.05	18.55
Rest of Australia	7.05	26.29	35.2	8.16	15.83	25.29	8.02	8.05	16.71
China	2.45	22.78	25.79	2.85	13.66	16.9	2.83	6.93	9.95
North Asia	6.17	23.36	30.96	3.67	14.11	18.3	3.83	7.25	11.36
India	14.05	26.16	43.89	8.31	15.65	25.26	8.03	7.75	16.41
North America	14.44	28.88	47.49	8.57	17.36	27.41	8.79	8.59	18.13
Brazil	-15	32.32	12.47	-15	19.61	1.67	-15	10.01	-6.49
Rest of South America	8.85	32.32	44.03	10.28	19.61	31.9	10.09	10.01	21.12
Africa	7.78	28.74	38.76	9.02	17.36	27.94	8.91	8.84	18.54
EU	6.48	26.4	34.59	7.8	15.9	24.94	8.4	8	17.07

A Western Australian perspective

With an estimate of the average state government royalty of 6.44 per cent, government revenues are projected to fall with supply restrictions where price increases fail to offset the reduction in export volumes.[1] Under the base case elasticity assumptions estimates of government royalty revenues fall by:

- Seven per cent or about $US143 million ($A184 million) with a 15 per cent reduction in West Australian exports; and
- Six per cent or about $US126 million ($A161 million) with a 15 per cent reduction in only Rio Tinto and BHP exports.

From a West Australian perspective the break-even point for restricting exports is not where increased prices just offset the reduction in export volumes. Levy revenues on iron ore exports may be unchanged but the reduction in production

[1] The estimate is based on the amount of iron ore royalties paid in Western Australia in 2013-14 of $A5450m on production of 632Mt sold at an average price of $US122.8/t at an exchange rate of 91.8 (Western Australian Treasury 2014). This gives an average royalty rate of 6.44 per cent. Actual royalties paid in any one year will depend, among other factors, on the composition of grades exported and any concessions that are in place.

has further implications for GSP, driven, for the most part, through the direct and flow on effects of reduced employment.

According to the 2013 ABS input output tables, wages and salaries account for 8.6 per cent of the value of mining industry output. A 15 per cent reduction in output across all producers would, on this basis, correspond to about a $A250 million fall in wages and salaries. With only Rio Tinto and BHP constraining supplies the fall in wages would be about $A215 million.

The total output multiplier for Australian mining industry based on the ABS input output tables is 1.67 (Productivity Commission 2013). This would be an overestimate for Western Australia as some mining inputs would be all or partially sourced from other States. Taking a more modest multiplier of 1.5, the flow on reduction in Western Australia output would be:

- $A1.4 billion with a 15 per reduction in supplies across West Australian exports; and
- $A1.2 billion with a 15 per cent reduction in Rio Tinto and BHP exports only.

While these are only crude order of magnitude estimates of the costs to the West Australian economy from constraining iron ore production, they strongly reinforce the conclusion that the probability of finding a set of conditions in the iron ore market that would lead to a net economic gain to West Australia as a result of a policy induced constraint on exports is negligible.

Conclusions

Across scenarios, the results tell a consistent story. While supply restrictions in a country such as Australia, which produces a significant proportion of global seaborne iron ore, do result in higher near term prices for iron ore, this effect is more than offset by smaller export volumes resulting in lower revenues overall. Lower mining revenues are associated not only with lower royalty receipts, but lower national output and employment, and hence such restrictions are neither commercial nor in the national interest. Moreover, any supplies that exit the market from one country are filled primarily by Brazilian supply, which is incentivised to come onto the market because many Brazilian projects sit low on the global iron ore cost curve. As such, Australian iron ore restrictions reduce Australian mining income, to the benefit of Brazil.

Neither Rio Tinto nor BHP nor Australia as whole has sufficient iron ore market share to gain from voluntary or regulatory supply controls in terms of export revenue. This result is not particularly sensitive to alternative supply and demand elasticity assumptions or the length of the time horizon under consideration. Conversely, suppliers in other countries, notably Brazil, would gain substantially in terms of revenue from any such restrictions imposed in Australia.

The only circumstance in which Australia could gain from supply restrictions in the short run is one in which all Australian and Brazilian suppliers acted cooperatively to restrict iron ore supply. Aside from the serious legal and competition issues this would raise, the incentives to enter into such an arrangement are not strong given that any short run revenue gains by the major suppliers fall away over the medium to long run as alternative sources of supply are brought into the market.

Iron ore is abundant in the earth's crust across many countries, and in a global commodity market, supply side competition is strong. High prices experienced during the recent commodities boom associated with China's rapid growth and industrialisation represented once in a lifetime market conditions and prices are now returning to more normal levels. This will ultimately cause consolidation in the supply chain as higher cost producers are unable to compete with those suppliers lower down the cost curve.

It is important to note that as consolidation occurs and market share is lost, it is extremely difficult to regain. The modelled impacts may underestimate this effect of potential supply restrictions given the capital flexibility built into the model. The primary reason market share is difficult to regain is that expansions by producers in other countries are incentivised if sufficient capacity is restricted by regulated controls, and once expansion costs are sunk and productivity enhancements consolidated at those new higher levels of production, the hurdle to regain market share is very high if not impossible to surmount. To a lesser extent, market share may be difficult to regain if buyers lock in specific products or particular blends, and optimise their steelmaking processes around these. If use of these new blends requires capital investment, buyers will be disincentivised to switch suppliers unless the price differential is large enough to support a change. Further, regulated supply restrictions would likely be viewed by buyers as uncompetitive and shatter perceptions around reliability of supply that would take time to overcome.

It is therefore commercially rational to see producers that are able to generate a margin through expanded production of low cost supplies do so, even where prices are at relatively low levels.

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