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Review of cost allocation methodology and treatment of mine specific infrastructure—report to Aurizon Network

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About the Author

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Sapere Research Group is one of the largest expert consulting firms in Australasia and a leader in provision of independent economic, forensic accounting and public policy services. Sapere provides independent expert testimony, strategic advisory services, data analytics and other advice to Australasia's private sector corporate clients, major law firms, government agencies, and regulatory bodies.

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1 Background

Aurizon Network's current rail access undertaking is due to expire in July 2013. Over the coming year, Aurizon Network will need to negotiate a new undertaking with the QCA. To assist Aurizon Network in that endeavour, this report reviews and applies economic principles to the treatment and pricing of:

- Investments in shared network infrastructure; and
- Mine-specific rail infrastructure.

In doing so, it considers:

1. The current regulatory environment and regime, especially the principles currently applied to allocate costs of new investments in (a) shared trunk network infrastructure and (b) infrastructure that is used only by or mainly by a single customer.
2. The economic principles relevant to the pricing of major network infrastructure and how these compare to the existing approach for regulated rail infrastructure in Queensland.
3. The criteria that should be applied to assess different possible cost allocation methodologies.
4. The approach for pricing new investments in shared network infrastructure: the relevant economic principles, including the objectives of financial capital maintenance and of the QCA Act, and relevant regulatory precedents.
5. The approach for pricing mine-specific infrastructure: the relevant principles and objects of the QCA Act.

In the next section I outline the main economic principles that I believe are relevant to the cost allocation questions considered in this report:

- how costs of expansion of capacity in the network core should be allocated between customers and, in a temporal sense, between Aurizon Network and customers as a group; and
- how costs of mine-specific infrastructure, such as spur lines serving a single mine, should be allocated between customers.

The two subsequent sections deal with these issues. Each section contains a brief review of the current regulatory environment, a discussion of the relevant economic principles and how they affect the criteria that should guide selection of methodology, and a review of the approach together with an assessment of options. The final section concludes.

2 Relevant economic principles

The relevant economic principles are of three types:

- Competition and efficiency objectives;
- An assumption of rationality and voluntary participation by all players; and
- Promoting dynamic efficiency through pricing incentives.

Each of these types is considered in a subsection below.

2.1 Competition and efficiency objectives

The purposes of regulation of Aurizon Network's infrastructure business are:

1. to constrain access pricing in the absence of competition from alternative infrastructure providers; and
2. to ensure that access customers who compete with each other can do so on a level playing field.

The first of these purposes is set out in section 168A (a) of the QCA Act 1997 (*expected revenue to be at least enough to meet efficient costs including a return on investment commensurate with risks*). In practice, the QCA has applied the pricing principles in such a way that the "fundamental regulatory test" is met. Under this fundamental test, the net present value of future cash flows of the regulated firm should equal the initial investment.

The second purpose is acknowledged in sections 120(1)(d) and 138(2)(d) of the QCA Act, which stipulate that the QCA must have regard, inter alia, to the public interest, including the benefit to the public in having competitive markets (whether or not in Australia). Section 100(2) also states that the access provider must not unfairly differentiate between access seekers in a way that leads to a material competitive disadvantage to any access seeker.

The desire for economic efficiency underpins both of these aspects of regulation. It gives rise to the "break-even" constraint on the infrastructure provider, which translates to a zero economic profit rule for pricing overall.

With regard to the efficiency of coal mining, it gives rise to the objective that lowest-cost sources of coal should not be disadvantaged competitively via differentially higher access prices simply because of such considerations as historical accidents of timing, past infrastructure capacity decisions, etc. This is important because the State and national economies would suffer if lowest cost suppliers of key export commodities suffered barriers to entry and expansion.

A further implication of these principles is that firms should not be protected from increased competition, and those that suffer a disadvantage because of it should not be compensated. When existing rail access customers assert incumbency rights, care must be taken not to permit these rights to prevent competitive forces from playing their efficiency-enhancing role.

2.2 Assumptions of rationality and voluntary participation

Both of the questions considered in this report concern the optimal allocation of investment costs. Where these costs are common to several customers, there is a degree of arbitrariness to allocations—there is no unique allocation that is objectively better than any other.

However, some allocations can be ruled out on objective grounds. Allocations that involve cross-subsidy between customer groups are objectionable on efficiency grounds. Cross-subsidies would not occur if all participants (that is, access seekers and the access provider) are rational and their participation in the system is voluntary.

Coalitions of customers that are asked to pay more than their own stand-alone cost would rationally wish to break away from the grand coalition of customers and build their own infrastructure network at lower cost to themselves. From this point of view, cross-subsidy requires coercion of these customers.

The other side of the coin concerns commercially unviable parts of the infrastructure network. These can be defined as those line sections that would, if abandoned by the access provider, result in a loss of access revenue smaller than the avoidable cost of keeping them open for service. The cross-subsidy implicit in the maintenance of these unviable parts of the network requires coercion of the access provider, because a rational profit maximiser would close them if possible.

When the ceiling test or the floor test is violated, prices involve cross-subsidy, which is inconsistent with the voluntary participation of rational agents—both access seekers and access providers. Price sets that meet both floor and ceiling test do not involve cross-subsidy and could therefore be considered reasonable. There may be many different such acceptable price sets.

Since the Australian Competition Tribunal's 2003 GasNet decision there is strong precedent for the principle that the regulator should not reject prices proposed by an asset owner that are reasonable. This logic suggests that a cost allocation that is not unreasonable should be protected from regulatory interference, even though there may be alternative allocations that are no less valid.

2.3 Dynamic efficiency and incentives

Efficiency matters now and in the future. Pricing rules establish patterns of incentives that may affect future behaviour by customers. Dynamic efficiency is particularly important in high-growth industries, such as Queensland coal.

Any pricing rule that discriminates between customers based on the timing of entry has the potential to create dynamic efficiency problems through perverse incentives. Two abstract examples serve to illustrate two different facets of this point.

A customer that takes on foundation risk in funding construction of a new line will be discouraged from doing so if second-movers can free-ride off that investment. This may happen whenever a second mine can use the same line but receive a more advantageous access price by waiting.

Conversely, if incremental costs of expansion are fully allocated to the last customer on board, whose usage triggers a lumpy investment in capacity, then customers will have an incentive to jostle for position in the queue. This situation is analogous to the game of "musical chairs." When the stakes are high enough and small timing differences can strongly affect access prices, quite inefficient behaviour can be promoted. Miners may rush the development of new projects in order to jump the queue, or even lobby government agencies in the attempt to get approvals first.

In order to avoid some of these perverse incentives, small timing differences should not strongly affect prices. The foundation customer issue, which may involve larger timing differences, can be managed through an explicit recognition in relative pricing of startup risks taken by foundation customers.

3 Cost allocation methodology

The addition of new customers or expansion by existing customer may necessitate capacity augmentation in the trunk or core network. Those existing customers who do not expand their output have a double-edged desire to maintain their pre-expansion access prices. First, all firms wish to avoid cost increases. Second, if new or expanding customers must pay in full the costs of capacity augmentation, this cost will be a barrier to entry, which will benefit incumbents by reducing the competitive threat to themselves. This second motivation is well recognised in competition economics and law as an invalid one.

For their part, new and expanding customers will wish to socialise the costs of expansion so that they are borne by the entire customer group. Provided that the capacity augmentation itself does not reduce economic welfare,[1] competitive neutrality in the downstream coal market would seem to require at least some degree of socialisation of these investment costs.

In some cases, capacity augmentation of an existing trunk line would be expected to reduce average costs across all customers. In those cases, this problem would be less divisive between customers as there would be potential for everyone to benefit (in a transport cost sense) from network expansion.

However, in other cases significant expansion of trunk capacity may be so expensive that average costs would rise. This may occur if heavy traffic makes track possessions short and expensive, if the available land is constrained, or if very lumpy capacity investments are required (such as duplicating a tunnel, major bridge, or long sections of track).

Where average costs are forced to rise as a result of capacity augmentation, the tension between competitive neutrality across customers, on one hand, and respect for incumbent customer contractual entitlements must be resolved somehow.

Below, we draw on economic theory and regulatory practice in other jurisdictions to recommend a balance between these competing principles that is suitable for the circumstances facing Aurizon Network.

3.1 Current regulatory environment

Export demand for Queensland coal increased dramatically circa 2005, many years after the original QR Undertaking put in place the fundamental features of the current regulatory environment. As a consequence, the design of the Undertaking is not particularly well suited to high growth conditions. Current demands for

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1 The relevant test is whether the benefits of new capacity outweigh the costs. The benefits accrue from the reduction in deadweight loss in the end market for coal. As transport capacity constraints are freed up, output increases, prices may fall, consumer surplus and potentially producer surplus increase.

Some situations can be conceived in which a very expensive capacity addition is underutilised for a long time, perhaps because the user that triggered it abruptly left the market. In such situations (in hindsight), this welfare test would not be met and the expansion should not have proceeded.

Where the expansion is triggered by a speculative or risky new source of demand for access capacity, existing users could legitimately object to bearing part of that speculative risk.

infrastructure augmentation, near ports, in the trunk part of the network and in feeder systems, are far greater than those anticipated by the original authors of the regime.

3.1.1 Examples to illustrate the policy challenge

Two examples are provided in this section to highlight the nature of the policy challenge. The first example shows how an unprecedented situation of rising average costs is looming on several of Aurizon Network's central Queensland coal systems. The second example shows that the "musical chairs" situation and the perverse incentives that go with it represents a live concern for the Goonyella system.

Increasing average costs

Incumbent miners on the Goonyella, Newlands, Blackwater and Moura systems benefit from access prices that reflect a low RAB per tonne of coal hauled. The infrastructure on these systems has been in place for many decades and is heavily depreciated.

In comparison to the historic RAB values, capacity expansions that are being contemplated on each of these systems would drastically increase the asset valuations (i.e., more than double for Goonyella and Newlands). At the same time, the immediate impact on tonnage hauled from these expansions would be modest (i.e., 30% increase for Goonyella, 40% increase for Blackwater and Moura combined). As a result, average prices would increase.

If the incremental cost were borne only by new mines and expansion tonnes at existing mines, then the access prices for those tonnes would be drastically higher than for incumbent tonnes. Table 1 below, based on public data, indicates the rough magnitude of these pricing effects.

Table 1. Indicative pricing impacts of capacity expansions

WACC	**Existing system:**	Goonyella	Newlands	Blackwater + Moura
9.96%	Opening RAB FY10 ($)	980,362,789	165,290,428	1,284,393,569
	(excl. Electric + spur lines)			
	FY09 depreciation ($)	39,327,664	6,895,018	47,291,204
	Implied remaining life (yrs)	24.93	23.97	27.16
	FY10 system haulage (mt)	99.7	17.5	69.6
	annuity ($m/yr)	107.7	18.3	138.4
Old average capital charge	annuity/tonne hauled	1.08	1.05	1.99
	Proposed expansions:	Triplication of Connors Range	Northern missing link, etc.	Wiggins Island Rail Project
	Projected capital cost ($m)	1,000	1,100	900
	Estimated life (yrs)	50	50	50
	Incremental haulage (mtpa)	30	50	27
	annuity ($m/yr)	100.5	110.5	90.4
Incremental capital charge	annuity/increm tonne	3.35	2.21	3.35
New average capital charge	annuity/(old+new tonnes)	1.61	1.91	2.37
Ratio of incremental charge to old average charge		310%	211%	168%
Ratio of new average to old average charge		149%	182%	119%

While crude, these figures provide an indication of how important the difference to individual miners of average versus incremental pricing can be.

Jostling for position to avoid incremental cost

Boyle (2010) lists (table 2.2) Queensland Export Coal Projects and Proposals in FY 2009-2010 where mining leases are granted or under application. Extracts from this table are summarised below in Table 2.

Table 2. Selected Goonyella system coal projects and proposals FY2009-10

Company	Mine/Project	Planned mtpa	Start date
Anglo Coal	Grosvenor	4.5	2013
	Moranbah South	Up to 4.5	2014
BMA	Goonyella Riverside expansion	+8	2014
	Peak Downs expansion	+2.5	2013
	Saraji East	5	2016
Jellinbah Resources	Lake Vermont	6	2014
Peabody	Millennium expansion	Up to 7	2012
Rio Tinto	Hail Creek expansion	17	2013

If all of these listed projects went ahead, the total new capacity required on the Goonyella system would be approximately 54.5 mtpa.

It is conceivable that some of these projects, in isolation, could be accommodated with relatively inexpensive signalling work on the Connors Range. Clearly, though, at some time before all of them come on stream, the much more expensive triplication of the Connors Range would be required.

Any first come-first served pricing rule that allowed first movers to avoid the incremental cost associated with triplication would create strong, and unhelpful incentives for these projects to get ahead in the queue. This concern about timing and incentives is not merely theoretical. It is a live issue for the Goonyella system in the coming few years.

3.1.2 Approach taken in current undertaking and issues raised

In the current version of the Undertaking, which applies a revenue cap rule, costs of new investment in common-user infrastructure would be fully socialised, as long as the investments themselves are approved for inclusion in the RAB.

For the trunk capacity investments considered in Table 1, it is clear that average costs would rise post-expansion. Under current settings, existing users would, perhaps for the first time, face significant price increases that are unrelated to anything they have done or plan to do. To one way of thinking, they face costs that they did not 'cause.'

This situation may not have been considered a real possibility when the Undertaking was first put in place. Now that it is looming, a sober assessment of the revenue cap rule for significant new investments, in which socialisation of common costs is implicit, is advisable.

3.2 Economic principles and assessment criteria

Cost-reflective pricing is a well-accepted maxim of regulatory decision-making. However, applying it can be a challenge when costs are common across different customer groups. Which customer 'caused' the price change? Individually, perhaps none did, but collectively all contributed to the change.

A substantial regulatory literature exists around the allocation of common costs, of which Faulhaber (1975) is a leading example. Young (1985) provides a good account of the main ideas and their application to many different fields. More recent work has focused on the application of these concepts, including the "core", Shapley values, and the nucleolus, to electric power transmission problems (see Hogan (2011), Ruiz and Contreras (2007), and Zolezzi and Rudnick (2002)).

These authors emphasise that while there are several different ways to select a preferred allocation from among a wide field of alternatives, the "best" method will depend on the circumstances—especially the nature of the characteristic cost function, and the purpose of the allocation (i.e., regulated utility pricing, management accounting, etc.)

Generally accepted is the notion that any solution should lie within the "core," if possible. This means essentially that allocations should satisfy the stand-alone cost ceiling test and the incremental cost floor test for all possible combinations of agents. In some situations there is no solution that meets these requirements.

They also emphasise the incentive problems that sometimes occur. The socially optimal investment may be difficult to achieve because certain agents or combinations of agents have a commercial incentive to prevent it. In those cases, regulatory intervention is required to secure the best outcome overall for the economy. It is quite possible that the present issue with socialisation of new common capacity costs falls into this category.

Returning to assessment criteria for the pricing of new common capacity costs, any allocation of these costs must satisfy the following basic requirements:

- Competitive neutrality between mines must be preserved;
- Cross-subsidies (as formally defined by floor and ceiling tests) must be prevented; and
- Perverse incentives regarding the timing of mine development should be avoided.

3.3 Review of approach and analysis of options

The discussion below sets out my reasons for concluding that full incremental cost pricing is inconsistent with the relevant economic principles. Some degree of socialisation of new investment costs is preferable, provided that the investment in capacity meets the fundamental welfare test on an expected value basis. The optimal degree of socialisation of new common costs depends on the application of stand-alone cost ceiling and incremental cost floor tests to ensure that an average cost-type rule does not lead to cross-subsidy between mines.

3.3.1 Sequence of entry-based prices

One could, in principle, rely on the sequence of entry to determine pricing, if a 'grandfathered price' rule were applied. For example, where average costs steadily rise with usage, the first customer would pay a low price. The next customer would pay a somewhat higher price (while the first customer continued to pay its original price). The following customers would each pay higher prices to use the same service. Over time, significant variations in price could arise.

There are several problems with this approach. First, and most obviously, the grandfathered price rule is a double-edged sword. If average costs fall with usage (which would be the more normal situation for rail infrastructure), then the first customer would be locked into the highest price, and latecomers would obtain a potentially important price advantage over their more established rivals.

Second, the idea of different customers paying different prices for what is essentially the same service sits extremely uncomfortably with the notion of competitive neutrality. The access prices would in effect serve to distort competition between coal mines. Declaration under Part IIIA of the Competition and Consumer Act 2010 (Cwlth) has sometimes been considered as a remedy for pricing that, if modified, would promote competition in a market.[2]

Given these points, pricing that is driven by the sequence of entry—that is, pure incremental cost pricing—is unlikely to be acceptable to regulators or even to incumbent customers if it is applied rigidly in all situations.

3.3.2 Socialised cost prices

The main alternative method of pricing capacity expansions is to fully socialise the costs. As noted earlier, this approach is implicit in a revenue cap form of regulation, and is usually uncontroversial when average costs are tending to fall with increased utilisation of the network.

Socialised cost pricing becomes controversial when average costs rise with increased utilisation. Then, interests diverge between incumbents on one hand and both entrants and expanding incumbents on the other. Accepting that there will be commercial tensions between customer groups, Government and the regulator will be guided by the public interest. There are three hypothetical possibilities. Capacity expansion would be either:

- A positive sum game for the economy overall;
- A zero sum game; or
- A negative sum game.

If expansion is a positive sum game, then economic theory says unequivocally that it should go ahead. Government intervention in the form of regulation, compulsory price-setting and the application of other tools necessary to induce the investment is a valid response to strategic behaviour by some players that may otherwise prevent the investment proceeding in a purely voluntary manner.[3]

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2 The relevant provision is found in s44G(2)(a). I am not suggesting that a Part IIIA declaration is possible for Aurizon's network, which is subject already to an effective state-based access regime, thus exempt. The point is simply that discriminatory pricing with no justification other than historical accidents of timing is inconsistent with legal formulations of the competitive neutrality doctrine.

3 See, for example, Hogan (2011), p. 3, discussing the analogous case of electric power transmission investment. "*The alignment of efficient market investment incentives may break down in the absence of the assumed regularity conditions. ... Thus efficient investment may*

The second possibility—exactly zero sum game—is unlikely to occur in practice. In the remaining possibility, involving a negative sum, the investment should not go ahead because its costs would exceed the benefits (including all externalities, etc.)

Presumably, the negative sum game situation is precluded by existing regulatory hurdles that must be passed before bringing new investment into the RAB. However, special attention must be focused on a situation where uncertainty over future demand has the potential to lead to an incorrect classification of a particular investment.

Hypothetically, consider a part of the network that is operating near its capacity. A large new development has a 50% chance of coming on stream, requiring a large infrastructure investment that would increase average costs overall by 50%. There is also a 50% chance that it does not go ahead, in which case no expansion would be needed. Given the lead times, let us say that the rail investment would need to take place before the uncertainty is resolved.

If the new development did go ahead and make the hoped-for long-term contribution to tonnages railed, then the economy would derive a net benefit from expansion. Socialised cost pricing would best meet the objective of competitive neutrality.

If the new development did not go ahead, then the best outcome for the economy would be not to expand. Again, there would be no reason to depart from socialised cost pricing.

If the expansion was justified based on the expected value of future tonnage—that is 50% of the hoped-for long-term extra tonnage, then a risk-neutral investor would still gain an expected net benefit from expansion. In that case, too, socialised cost pricing would provide a preferable result to incremental cost pricing.

If expansion was not justified for 50% of the hoped-for long-term extra tonnage, then the expansion should not go ahead.

The point of this example is to demonstrate that one objection sometimes raised to socialised cost pricing—that it rewards opportunistic but unreliable entrants and

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need regulatory mandates and a regulatory cost allocation. In addition, for large entities lumpy transmission investments can inherently undermine the price taking assumption. This leads to both strategic problems where market participants may seek to benefit from price changes, and often creates free-riding concerns about beneficiaries who do not bear an appropriate share of the total costs of investment."

punishes incumbents for this unreliability—is really a problem with the evaluation of welfare benefits with the expansion. As long as expansions are only undertaken when the expected welfare benefit is positive (positive sum game), then socialised cost pricing is an appropriate method of recovering the expansion costs.

3.3.3 Limits to socialised cost pricing

Up to this point, the term "socialised cost pricing" has been employed fairly loosely, to imply that costs of new capacity on the common user part of the network are spread among the users of that part. The precise mathematics of how the common costs are allocated to individual users must be subjected to the incremental cost floor and stand-alone cost ceiling tests to ensure that cross-subsidies are not imposed.

Note here that the incremental cost, as specified in the Undertaking, may not be well defined. See Appendix 1 for more detail.

Under the prohibition against cross-subsidy, customers must not be asked to pay for infrastructure that they don't use. In maximising revenue under a no cross-subsidy rule, customers may pay what amounts to different prices to run an equivalent train across a particular section of track as part of their journey. There is nothing objectionable in principle to this situation.

3.3.4 Precedents from other jurisdictions

The combinatorial stand alone cost ceiling test in the NSW Rail Access Undertaking has the effect of socialising all common costs, whether they are associated with new or existing assets, as long as the assets have been accepted in the RAB. This approach is consistent with revenue cap regulation. Despite initial misgivings by coal miners and some train operators, the inter-dependency of pricing on other operator usage that is implicit in this approach is now well accepted in New South Wales. NSW is the only other large-scale coal rail access jurisdiction in Australia.

Although ARTC has moved from coverage under the NSW Rail Access Undertaking to a Hunter Valley Undertaking, the pricing rules remain substantially similar. The socialisation of common costs, in particular, is expected to remain a feature.

The situation for other freight types, such as bulk grain or intermodal freight, is quite different to coal. Non-coal traffic (apart from iron ore, which is transported almost entirely on vertically integrated, single user systems) is generally insufficiently profitable to make rail access price regulation relevant.

Freight rail access arrangements have been more fluid over time in Victoria, owing partly to the changing ownership status of the network. During the period of Pacific National ownership of the Victorian freight network, average cost pricing was imposed on grain, to the significant detriment of rail's market share. The problems there were not with average cost pricing per se, but rather with the funding paradigm for lightly used lines that were strongly exposed to road competition.

4 Treatment of mine-specific infrastructure

For historic reasons, Aurizon Network is party to many arrangements in which it either owns, paid for, or is responsible for managing spur lines that exist only to serve one particular customer. We understand there is a lack of uniformity of such arrangements, leading to mismatches between the incidence of costs and benefits of these spur lines between Aurizon Network and some of its customers, and potentially among its customers.

In principle, the most straightforward way to approach this issue is to ask each customer to pay for its own private access route to the common infrastructure network. With larger mine developments, however, one-off negotiations may take place. Hypothetically, a network owner such as Aurizon Network may perceive strategic benefit in having some influence over the way that such spur lines are designed—for example by providing electric traction infrastructure on the spur.

The cluster-based pricing methodology that has been applied in previous undertakings may tend to reduce the clarity of the user-pays concept for spur lines by spreading some of these mine-specific costs across other mines in the cluster.

To the extent that contracts permit renegotiation of some of these historical arrangements, there may be merit in seeking to apply a more consistent economic framework to this issue.

Below, we test existing arrangements against economic theory and regulatory precedent and recommend a forward-looking approach that is optimal for Aurizon Network's situation and takes due account of its contractual commitments.

4.1 Current regulatory environment

Prior to UT3, the cluster pricing system resulted in some mine-specific infrastructure being wholly or partially included in the "common" costs of a mine cluster, which were recovered from all mines within the cluster.

For some of the larger mine-specific spur lines bespoke agreements were reached between the miner and QR. Features of many such agreements were not standardised and therefore give rise to a complex patchwork of contractual conditions.

In part, these historical circumstances arose because at the time of the original Undertaking demand for coal was relatively restrained and there was a perceived need to encourage new mine development in Queensland. Since that time, however, export demand has burgeoned. In this new high-growth environment, it is important to iron out the special agreements to the extent permissible under contract and put in place instead a consistent pricing framework that is well supported by economic theory.

4.1.1 Example to illustrate the policy challenge

Consider a hypothetical cluster of mines that each has a sole-use spur line to a single common junction point, from which it shares with the other mines in the cluster a mainline corridor to port. If a new mine is subsequently established that requires a longer-than-average spur line to access the junction point, should it bear the entire cost of constructing its own spur line, or should the other members of the cluster bear some of this cost?

On one hand, the principle that each customer pays its own direct cost is well established in regulatory economics, suggesting that the new mine should pay for its own spur line.

The contrary argument has several distinct aspects:

- By joining the cluster, the new mine might help to improve utilisation and reduce average costs on the common mainline corridor. Thus it could reduce costs to the other cluster members, for which they may be willing to make some investment to encourage the new mine to enter;
- Of course, it is also possible that the new mine might force a costly upgrade of the common mainline, giving the other cluster members a strong reason to discourage the new mine;
- There may be legacy contracts on foot under which other cluster members received some form of financial support to construct their spur lines, either from the network owner or from earlier joiners of the cluster. Considerations of fairness and competitive neutrality might suggest that any historical cross-subsidy policies be continued.
- If the new mine pays for its own spur line, a vulnerability is thereby created to opportunistic free-riding by later entrants that may attempt to use this spur line. These late entrants may attempt to use regulatory intervention to achieve an access price that is lower than the net cost paid by its host, the line’s foundation customer.

4.1.2 Approach taken in current undertaking and issues raised

Some mines have legacy contracts with Aurizon Network that were agreed when a price cap, rather than the present revenue cap applied to access prices. Many of these contracts are non-standard. Some of these mines made an up-front capital payment toward the construction of a sole-use branch line. Subsequently, by agreement, QRN took ownership of the line and included it in the RAB, and rebated to that mine a portion of access charges paid by other mines.

Rebate arrangements were complex. Due to the changing basis of price regulation over time, these arrangements have become impractical from QRN's perspective, embodying perverse incentives in some cases. These arrangements are often difficult to unwind because of the taxation implications for the mine owners.

In effect, these ad hoc arrangements tend to socialise some of the costs that pertain only to a single mine situated at the end of a sole-use branch line. The spreading of these costs to other mines in the same cluster is in sometimes subtle. The mine in question may pay a smaller proportionate contribution to the common costs of the trunk network. An expectation has evolved that the end-to-end access price, the 'system price', will be equalised across mines in a cluster, even when some of these mines impose a far greater cost to serve. Such equalisation implies that some mines are paying for infrastructure that they do not use, which means a cross-subsidy is taking place.

4.2 Economic principles and assessment criteria

Given the economic principles set out in section 2, it is straightforward to determine assessment criteria that should be applied to the options for pricing of mine-specific infrastructure.

The prohibition on cross-subsidy rules out the possibility of one mine paying for infrastructure that exists for the sole benefit of another mine. Additionally, any cost-shifting of this type between competing mines would violate the competitive neutrality doctrine. Therefore, socialisation of mine-specific infrastructure costs is unacceptable.

It is important, however, to bear in mind the strict definition of cross-subsidy. Unless either the stand-alone cost test is failed for some combination of mines, or the incremental cost floor test is failed for some combination of line sections, there is no cross-subsidy. The mere fact that some mines pay different access prices (in either dollar per tonne terms or cent per net tonne-kilometre terms) to use the same common infrastructure does not, by itself, demonstrate cross subsidy.

4.3 Review of approach and analysis of options

My preliminary view is that each mine should bear its own mine-specific cost to the extent it is completely avoidable if the mine did not proceed. That does not necessarily mean that every mine in a cluster should pay exactly the same contribution to the common costs of the mainline to port, either on a dollar per tonne or a cents per net tonne kilometre basis. However, every mine must make a positive contribution to these common costs in order to prevent cross-subsidy. This rule provides some flexibility for negotiation with mines that may otherwise be disadvantaged by high sole-use branch line costs, but who could make some contribution to common costs that would benefit other mines in the cluster.

Opportunistic free-riding by late entrants wishing to use the mine-specific infrastructure at a later date can be avoided by crafting access pricing rules that are appropriate for those situations. It is particularly important that the 'foundation customer' not be disadvantaged by later entry. Where the foundation customer has taken particular risks in being the first mover, there should be scope for that customer to receive upside benefits that are not available to customers that did not bear that risk.

5 Conclusions

In this report I have set out what I believe to be the most pertinent findings of economic theory for the cost allocation problem that underlies both the question about using incremental or average cost rules for new network capacity and the question about funding of mine-specific infrastructure. Some of the literature is summarised in a slightly more technical vein in Appendix 2.

Based on these economic principles, I conclude that pure incremental cost pricing, as exemplified in a sequence of entry-based pricing rule, would be unacceptable on both dynamic efficiency and competitive neutrality grounds. That leaves some form of socialised cost pricing. The precise choice of socialisation formula should be guided by the no cross-subsidy rule that is implemented in stand alone cost ceiling and incremental cost floor tests. Note that care must be taken in defining the incremental cost to ensure that it does not unintentionally lock in a form of sequence of entry-based pricing.

Regarding mine-specific infrastructure, the general rule that each customer should meet its own avoidable costs should apply. That does not necessarily imply that every mine in a cluster must make an equal contribution to the system common costs, but every mine must make at least a positive contribution, in order to avoid cross-subsidy. The extent of each mine's contribution could be estimated by observing a version of the competitive neutrality rule: while allocations of common costs among mines may be altered, the alteration should not be so great as to change the rank order of the mines' total transport costs to port. Note the emphasis here on rank order, rather than on demanding complete equalisation.

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Appendix 1: Definition of incremental cost

There is a definitional problem with the incremental cost floor test. While the stand-alone cost ceiling is well defined for a particular coalition of customers, the incremental cost is not. The Undertaking defines the incremental cost as "*those costs of providing Access ... that would not be incurred ...if the particular train service(s) did not operate*". The ambiguity in this definition arises from what is assumed about the operation of other train services. A simple example will illustrate the problem.

Let us say there are three mines, A, B and C. The table below gives the combined cost to serve every possible combination of these mines.

Combination	Rail inf cost	Incremental cost of A	Incremental cost of B	Incremental cost of C
A	7	7		
B	8		8	
C	9			9
A+B	12	12-8 = 4	12-7 = 5	
B+C	14		14-9 = 5	14-8 = 6
A+C	13	13-9 = 4		13-7 = 6
A+B+C	25	25-14 = 11	25-13 = 12	25-12 = 13

A range of different incremental costs are derived for each mine depending on what the starting combination was. For example, consider the entries in the last column. The cost of serving C alone is 9. Serving no mines would save 9. The cost of serving B and C is 6 more than the cost of serving just B, so C's incremental cost is 6 in that situation. The cost of serving A and C is 6 more than the cost of serving only A. The cost of serving A, B and C is 13 more than the cost of serving only A and B. Thus there are four discrete possible ways of estimating the incremental cost of serving C, and three different possible results.

One could take the view that the most relevant estimate is the one based on the combination that was served before C entered the system. However, to take this approach is to accept sequence of entry-based pricing—something that was rejected in the discussion above.

Another approach that does not suffer from this problem is to adopt the Shapley value. In layman's terms, the Shapley value is the weighted average of all possible incremental cost estimates. The weightings correspond to the likelihood of particular initial combinations occurring. This estimate of the incremental cost has the attractive feature that it ignores the sequence of entry. It should be noted, however, that for some types of characteristic cost functions, the Shapley value does not lie in the "core", meaning that this incremental cost estimate does not satisfy the floor and ceiling tests.

Appendix 2: Literature on the economics of cost allocation

Young (1985) surveys the economics of cost allocation, illustrating the points with examples from allocation of water management systems among functions, airport recovery of runway costs, and regulated utilities. He notes that cost allocation problems fall within the ambit of cooperative game theory. The *core* of a cost allocation game consists of all the possible allocations that satisfy one of two equivalent tests. The first of these conditions is the stand-alone cost test. The second is the incremental cost test.

Allocation problems are usually only of interest when the cost function is *subadditive*, which is a mathematically precise expression of the intuitive concept of scale or scope economies. Unfortunately, the subadditivity of the cost function is not sufficient to guarantee that any allocations lie within the core (i.e., satisfy the stand alone cost test.)

When the cost function is *submodular*, the core is guaranteed to be nonempty. Submodularity implies, for two coalitions of customers, S and T (which may overlap):

$$c(\text{union}(S,T)) + c(\text{intersection}(S,T)) \leq c(S) + c(T)$$

Here, c(x) means the cost of serving the customer coalition x.

It is possible that Aurizon Network's cost function for large capacity additions in the trunk network do not satisfy the submodularity requirement. Whether or not this cost function is submodular could be established fairly easily by examining data similar to that presented in Table 1 above. The significance of submodularity is that if the core for Aurizon Network's investment cost function is empty, then there may be no allocation that satisfies the stand alone cost test—perhaps a situation that was not contemplated by the original authors of the Undertaking.

Depending on the purpose of cost allocation, one of several well-known methods may be better suited. Two of the most theoretically appropriate are the Shapley value and the nucleolus.

Young (p. 13) explains the motivation for the Shapley value approach:

> [Participants in a cost allocation problem are] *"thought of as signing up, or committing themselves, in some random order. At each stage of the sign-up the allocation rule is myopic: each player must pay the incremental cost of being included at the moment of signing. The assessments will therefore depend on the particular order in which the players join.*
>
> *"Instead of actually proceeding in this way, rational agents might simply evaluate their prospects from the comfort of their armchairs by calculating their expected payoffs from such a scheme. Assume that all orderings are a priori equally likely."* [The 'expected' cost assessment for each player is then given by the Shapley value formula.]

Note that the Shapley value will only lie inside the core if it exists and if the cost function is submodular.

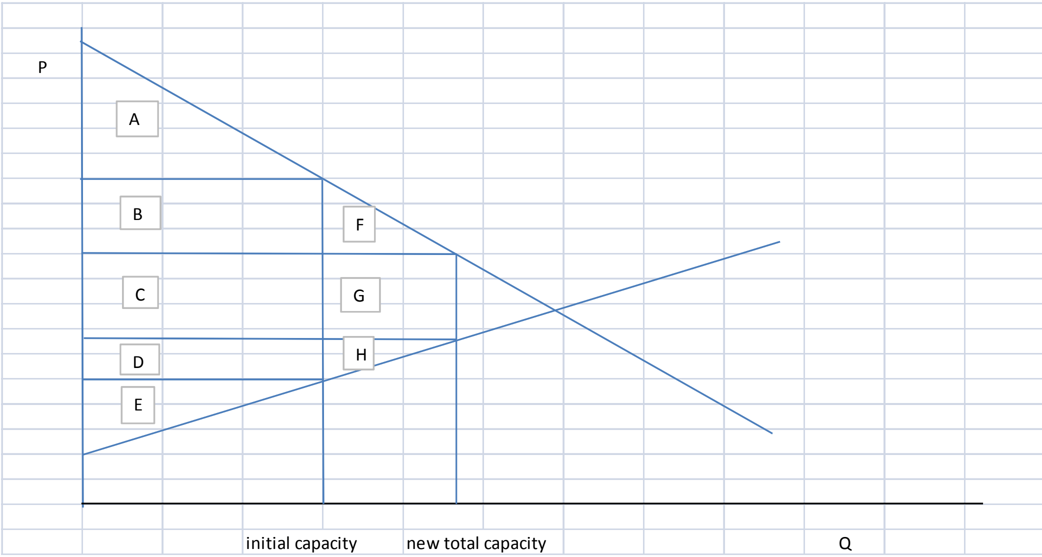
The nucleolus is a unique allocation within the core (again assuming that it is a non-empty set) in which the least well-off coalition of customers is as well-off as possible. Young expresses that intuitive point in more precise mathematical terms on pages 13-14.

Various tests of the reasonableness of an allocation are discussed, including: additivity, monotonicity, and consistency. These objectives are precisely defined in Young's chapter. There are inherent tensions between these objectives, and some allocations will satisfy some but not others. For example, the nucleolus is consistent, but may not be monotonic. The Shapley value is additive and monotonic, but may not be consistent.

Faulhaber (1975) was one of the earliest authors to systematically apply these ideas to public utility pricing. More recently, Ruiz and Contreras (2007) and Zolezzi and Rudnick (2002) apply these ideas to the problem of allocating electric power transmission costs among participants. The power transmission problem has many parallels to the investment cost allocation problem facing Aurizon Network now. In many ways, however, the railway infrastructure capacity problem is much simpler than the analogous power transmission problem because there are no circular flows in the railway, and the export ports are not co-located with any of the mines.

Hogan (2011) presents in diagrammatic form, a good illustration of the welfare consequences of transmission investment. Hogan's Figures 2 and 3 are summarised in the diagram below.

Figure A.1 Costs and benefits of transmission expansion



The downward-sloping line is the demand for electricity among importers. The upward-sloping line is the supply schedule for electricity exporters.

Before capacity expansion, the electricity importer benefit is the area of triangle A, the exporter benefit is the area of triangle E, and the congestion rents (that accrue to the transmission system provider) are the sum of areas of rectangles B, C, and D.

After capacity expansion, the importer benefit is A+B+F, the exporter benefit is D+E+H, and the congestion rents are C + G.

The comparison of these benefits before and after for each party depend on the actual slopes and positions of the demand and supply schedules and on the initial and ultimate transmission capacity levels.

Clearly the transmission investment should go ahead as long as F+G+H (the welfare benefit from the expansion) > TC (the total cost of expansion). However, it is important to recognise that expansion may create some winners and losers. B is initially part of the network provider's congestion rent benefit, but expansion transfers that to the importer. Similarly, D is initially part of the congestion rent, but expansion transfers that to the exporter. The network provider may have little to gain in a commercial sense from expansion unless a side payment can be arranged, or a regulatory allocation of costs and benefits can be imposed.

There is even a case when expansion may be desired by some participants despite the costs exceeding the welfare benefits, for example if

$$B+F+G+D+H > TC > F+G+H$$

In this 'business stealing' case, a sufficiently large coalition of private beneficiaries could capture enough transfers in B+D to make the investment privately profitable but socially inefficient. In this case voluntary funding would not be consistent with efficient investment (Hogan, p. 7).

While these electricity transmission examples do not translate precisely to the rail access environment, they do illustrate the potential pitfalls with a commercial approach that relies exclusively on the voluntary agreement of all parties to a capacity investment. Social efficiency should be the guiding principle for investment.