Can spectrum trading and pricing co-exist?[1]

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Abstract

There have been moves towards greater reliance on market mechanisms for spectrum management – auctions, trading, private band management and leasing – in North America, the EU and a number of other countries. Alongside these developments, regulators have applied administratively determined spectrum prices with the aims of recovering administrative costs and promoting spectrum efficiency through prices reflecting opportunity cost and/or extracting producer surplus. A critical policy question is whether such pricing is compatible with the development of spectrum markets or whether the two policies are incompatible, in the sense that spectrum pricing may harm economic efficiency when spectrum is tradable.

In this paper we identify circumstances in which spectrum pricing may increase efficiency but find that spectrum pricing may reduce the efficiency of spectrum markets even where spectrum prices are set below expected opportunity cost (obligations on spectrum licence holders may have a similar impact by reducing potential gains from trade). The implication is that trading should in general be applied in preference to pricing (given its dynamic advantages). Spectrum pricing may, however, have a role in relation to spectrum utilised by government agencies where prices may provide stronger incentives than the opportunity to profit from trading (depending on the overall nature of incentives relating to government agencies including the process for setting and resetting their budgets).

Introduction

Economists have advocated the use of markets rather than administrative decision making to allocate spectrum since the 1950s (Herzel, 1951; Coase, 1959). The first substantial moves towards such markets were made in New Zealand in 1989 under a legal framework that created spectrum management rights and spectrum licences both of which were tradable (Mueller, 1993). Auctions of spectrum rights have since become common place but governments have been more reluctant to permit trading of rights that have been auctioned or assigned administratively, although some rights of spectrum access have been tradable for some time in Australia, Canada, El Salvador, Guatemala, New Zealand, Norway, the United States and a number of EU countries (Mayo and Wallsten, 2010).

However, in practice, trading is not in general universally allowed and , in particular, UHF spectrum currently utilised for broadcasting is generally either non-tradable or subject to requirements that

[1] This paper builds on work undertaken for T-Mobile on the interaction of spectrum pricing and trading in 2009.

[2] These ideas were originally presented for a single big band reallocation of spectrum (Kwerel and Williams, 2002)

[3] Article 9b, Framework Directive, 2009. This Directive must be implemented by 26 May 2011. http://ec.europa.eu/information_society/policy/ecomm/doc/library/regframeforec_dec2009.pdf

prevent trade (yet UHF spectrum may be more highly valued for the provision of mobile broadband than broadcasting and absent restrictions trading might be anticipated).

Further initiatives to allow and promote spectrum trading are proposed in, for example, the US and Europe. In the US the FCC has proposed that licensees are able to offer spectrum into an auction rather than engage in bilateral trades[2] (OBI, 2010; FCC, 2010). This would in effect allow the trade of UHF spectrum currently utilised by broadcasters. In the EU it is proposed that member states may be obliged to ensure undertakings can transfer or lease spectrum access rights in harmonised bands specified by the European Commission.[3]

In parallel with these developments administratively determined spectrum pricing – which we refer to in this paper as AIP which stands for administrative incentive pricing – has been applied by some regulators to provide rights holders with incentives for efficient spectrum use and/or to recover producer surplus. AIP was first applied in the UK in 1998 to spectrum rights that had not been auctioned but where there was excess demand for spectrum. This was done at a time when spectrum trading (or leasing) was not possible.

Other countries have also considered the application of spectrum pricing to provide incentives for efficient use often in circumstances where spectrum is not tradable but sometimes in response to a perceived failure of trading to achieve efficient spectrum use and/or in a belief that spectrum prices set below the market clearing price will do no harm to efficiency (Aegis-Plum, 2008). For example, the (Ofcom, 2004) spectrum trading statement observed that *"AIP is complementary to trading if it is set conservatively, in that it will not harm trading if it is set somewhat below the market clearing level."* However, following review (Ofcom, 2010) have adopted a revised Framework for spectrum pricing which includes the following principle "*When spectrum is tradable we will consider the extent to which trading is expected to promote optimal use, and will also have particular regard to the risk of undermining the development of secondary markets.*"

This paper focuses on the question of whether spectrum trading and pricing can co-exist and promote efficiency, or whether they are to an extent mutually exclusive policy instruments in pursuit of an efficient allocation of spectrum. The answer to this question is important as spectrum is a valuable economic resource, existing spectrum allocations may involve large inefficiencies given emerging demand from new applications and because of the diversity of approaches adopted by governments to promote efficient use ranging from administrative mechanisms to pricing or trading alone to pricing alongside trading (in addition to one off auctions).

Markets versus administrative mechanisms

The key advantage of markets is that they draw on decentralised information (and judgements) and provide rewards for good decisions. Markets are particularly good at achieving an efficient allocation of resources over time i.e. at dealing with uncertainty and promoting efficient investment and innovation. Commenting on the role of markets McMillan (2002: preface) noted:

> *"The mechanisms for transacting develop from the bottom up, via innovations made by the participants. Spontaneous evolution is the main driver of markets. To reach their full potential, however, markets need help from the government. Markets and governments have*

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an uneasy relationship. Markets coordinate the economy better than any centralized alternative; government is essential if the economy is to reach its full potential."

Markets provide high powered incentives for efficiency (cost minimisation and efficient resource allocation) because a competitive price is exogenous to any individual firm or consumer's decision i.e. individuals are price takers. Individual firms' decisions that may result in lower costs and so higher profitability do not automatically result in lower prices – rather prices are determined in the market as a whole. Markets are also inherently forward looking adjusting dynamically to reflect new information – prices and decisions reflect expectations about the future[4].

Administrative mechanisms (including AIP) cannot match the above characteristics of markets in terms of incentives, timeliness and utilisation of information and in terms of commitment:

- Incentives: Administratively determined changes to prices may use information regarding the actions and outcomes for individual firms (e.g. specific auction results or information from trades). If prices are reset using this information then incentives for innovation and resource reallocation will be weakened if the firm believes some of the value from its actions will result in a price increase.
- Timeliness and utilisation of information: Administrative mechanisms substitute a centrally determined periodic judgement for a continuous competitive assessment of expected developments which draws on privately held information regarding possible market developments. Inevitably the timing of adjustments to prices will be sub-optimal.
- Commitment: It may not be possible for administrative mechanisms to offer protection against the risk of *ex post* opportunism. This is because governments have difficulty fettering the discretion of their successors. This leaves open the possibility, which may be socially optimal *ex post* (but not *ex ante*) of extracting value once irreversible commitments (e.g. sunk investments) have been made by firms. In markets such risks are addressed, albeit imperfectly, via contracts and common ownership in addition to reputation.

However, in particular circumstances markets may be absent or not work well and administrative mechanisms such as AIP may promote, or at least not harm, efficiency. We consider these first, and then go on to elaborate the circumstances in which AIP might inhibit efficient spectrum trading and so harm efficiency.

Circumstances where AIP may promote efficiency

We identify and evaluate three circumstances where AIP may promote efficiency:

- First, where spectrum is held by government agencies.
- Second, where trading is not permitted.
- Third, where trading is inefficient due to information asymmetries and limited competition.

We conclude that AIP may offer benefits in the first and second cases but not the third.

[4] Decisions in markets also reflect option values, namely the value of the opportunity to wait for new information before committing resources to a particular course of action, say investing or trading. An observation that the volume of trading is low or spectrum is unused (even with excess demand) does not therefore necessarily imply inefficiency. For example, this can be an efficient reason for non-use of land for which there is excess demand in the property market. (Ooi, Sirmans and Turnbull, 2006).

AIP and spectrum holdings by government agencies

AIP might be justified for spectrum held by government agencies even if it were not justified for spectrum held by commercial entities. The reason for this is that government agencies face a budgetary cost with AIP, whereas the opportunity to trade involves potential income which they may not be able to reallocate to other outputs if they sell spectrum. In other words they may not retain any revenue gained by selling spectrum. Commitment by government in the central budget process to allowing gains from trade to be retained might provide sufficient assurance for the opportunity to trade to provide strong incentives. However, in practice it is hard for governments to credibly commit to such an approach.

These arguments are not a justification for applying AIP to commercial users who one would expect to be motivated by the opportunities arising from trade and who are not subject to an externally imposed budget process.

AIP in the absence of the opportunity for trading

In the absence of the opportunity to trade, AIP may also promote efficiency in relation to the commercial use of spectrum since in these circumstances other incentives for a reallocation of spectrum are absent or weak. If users face no price, or opportunity cost, they may hold excess spectrum or seek additional spectrum when current spectrum holdings or additional spectrum would be more efficiently allocated to others.

Reallocation may eventually occur in the absence of both trading and pricing, for example at the end of fixed duration licences or in response to industry pressure, though the process of reassignment may be slow and/or partial. For example, the administrative decision to reallocate/auction some of the UHF spectrum released by digital switch over happened through administrative decision making under pressure from industry and evidence of the benefits from the reallocation.

AIP and bilateral trading with information asymmetry

In principle, AIP could lead to more efficient outcomes where trading is inefficient due to asymmetric information with bilateral trading (Myerson and Satterthwaite, 1983; Gibbons, 1992; Gul and Postlewaite, 1992). With AIP spectrum may be returned to the regulator because the price paid (AIP) exceeded the user's spectrum value and this spectrum might ultimately be reallocated to a higher valued use even though bilateral trading would not have occurred. For this to be the case the government would have to be relatively well informed about the incremental value of spectrum in different uses compared to market participants, so that AIP is set at a welfare enhancing level, and be willing to act on that information in a timely manner.

We consider this unlikely in practice because government typically has even less information than market participants and can rarely respond in a timely manner to new information. As a general point we observe that the trading inefficiency just described occurs in many sectors of the economy. We are not aware of any sectors where administratively determined prices are regarded as providing an improvement on market determined outcomes.

Circumstances where AIP might do no harm

Provided AIP is set below the opportunity cost of spectrum, is not adjusted to reflect new information specific to the firm/s in question over time and remains below the opportunity cost of spectrum, then AIP would be expected to do no harm.

The reason that AIP would do no harm in these circumstances is that whilst it reduces the private value of spectrum to existing users and potential users it reduces it by the same fixed amount for the buyer and seller and reallocation, via trade, will still occur where it is efficient. This conclusion also holds if transaction costs of trade are introduced, as demonstrated by the following.

Suppose transaction costs are *T*, the current licence holder (the potential seller) has a value of *Vs* and a potential buyer has a value of *Vb>Vs.* Suppose AIP is set at 0, trade will take place if *Vb>Vs+T.* Now suppose AIP = *p>0 and p< Vb.* Then trade takes place if *Vb-p>Vs-p+T,* i.e. as before.

However, we note that if AIP is fixed and market circumstances change one cannot be confident that AIP will still remain below the value of the spectrum to the seller or the buyer. Therefore, whilst the assumptions necessary for AIP to do no harm could occur by chance, there is no guarantee of this as circumstances change over time.

Circumstances where AIP may harm efficiency

AIP, applied to spectrum used for commercial purposes alongside trading, may harm efficiency.[5] We consider two cases, namely where:

- AIP is adjusted to reflect new information about spectrum value endogenous to potential parties to a trade (e.g. value revealed by new uses or traded prices) and therefore stays more or less aligned with opportunity cost.
- AIP remains fixed over time and therefore does not always reflect opportunity cost (either because AIP was wrong initially, or opportunity cost changed, or both).

Adjusting AIP to reflect endogenous spectrum value information

AIP which is adjusted to reflect new information over time may prevent efficient trades. The reason for this is that adjusting AIP over time to reflect new information specific to potential parties to a trade (endogenous information) may reduce the margin between the value of spectrum to buyer and seller, therefore reducing the likelihood of trade in the presence of transaction costs which include the costs of searching for buyers/sellers, negotiating and contractual and regulatory compliance costs of completing a transaction.

Uncertainty over the value of spectrum to seller, buyer or both, may also interact with transaction costs (by introducing “real options” effects). There are therefore two cases to consider, namely adjusting AIP to reflect endogenous information regarding spectrum value with and without uncertainty.

[5] Obligations, such as coverage obligations, may also harm efficiency by reducing potential gains from trade in an analogous manner to AIP. Ideally universal coverage objectives should be met via publicly funded competitive technology neutral procurement auctions (Wallsten, 2008).

Without uncertainty

Suppose transaction costs are *T*, the current licence holder has a value of *Vs* and a potential buyer has a value of *Vb>Vs.* Suppose AIP is set at 0, trade will take place if *Vb>Vs+T.* Now suppose AIP = *β Vs* initially and AIP = β *Vb* post trade where 0< β ≤1. Trade takes place if (1- β*) Vb* > (1- β*) Vs +T* i.e. trade will only occur if *Vb>Vs* + T/(1- β *).* Since 1/(1- β) >1 the value differential required for trade to occur is increased relative to the situation where AIP=0, and *ex ante* trade is less likely. In particular if AIP were dynamically adjusted to equal the full opportunity cost of spectrum pre and post trade (i.e. β =1) then, in the presence of even minimal transaction costs, there would be no incentive to trade.

The impact of AIP on trading with transaction costs is illustrated by comparing Figure 1 (without AIP) and Figure 2 (where AIP related to spectrum value pre and post trade is imposed with β = ½).

Figure 1: Spectrum trading without AIP

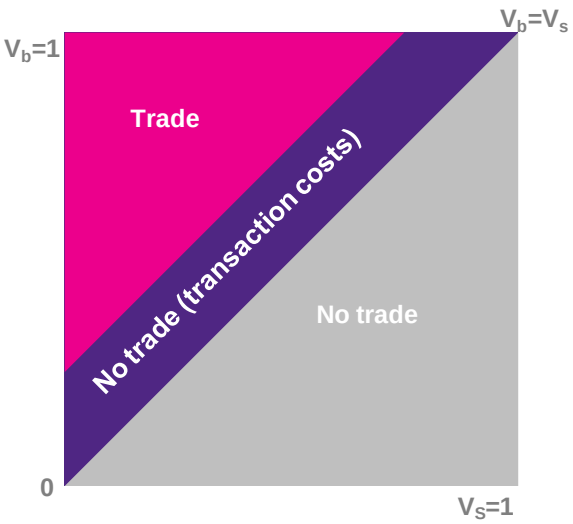
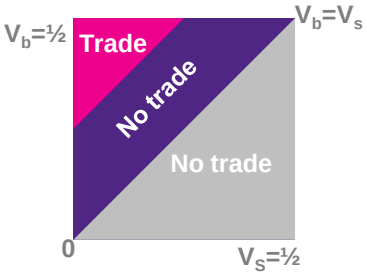


Figure 2: Spectrum trading with AIP set at half the current use opportunity cost



In Figure 1 a continuous range of possible spectrum values are shown for the potential seller (horizontal axis) and potential buyer (vertical axis) in the interval 0 to 1. Transaction costs are assumed to be 0.25 (25% of the maximum value for *Vs* and *Vb*) and are represented by the diagonal purple band. Trade is profitable whenever the value to the buyer exceeds the value to the seller plus transaction costs, i.e. potential trades are in the upper left hand magenta triangle.

Suppose AIP is introduced and set equal to half of current use spectrum opportunity cost (a situation that approximates policy in a number of countries), then the values to the potential seller and buyer on each axis in Figure 1 are halved, as shown in Figure 2. In the absence of transaction costs all trades that would have occurred without AIP would still occur i.e. even though gains from trade are halved they are still positive.

However, with the same fixed level of transaction costs as shown in Figure 1 the diagonal band is proportionately larger compared to the potential gains from trade. The magenta zone of prospective trade is relatively smaller as a result – indicating a reduction in the scope for trade.

With uncertainty

Uncertainty over the value of spectrum can amplify the barrier transaction costs introduce to trade. This is due to so called "real option" effects which relate to the value of waiting before committing resources irreversibly when there is uncertainty i.e. keeping a decision open has value (Dixit and Pindyck, 1994). The basic idea is that there may be a real option associated with the resources involved in trading i.e. the transaction costs.[6] For simplicity one might think of the transaction costs and option values as involving an investment decision on the buyer side only.

The basic idea is illustrated in Figure 3 (the transaction costs illustrated are smaller than those in Figure 1, 0.1 versus 0.25, since we wish to focus on and illustrate the option value premium in this example).

Figure 3: Option value premium on transaction costs without AIP

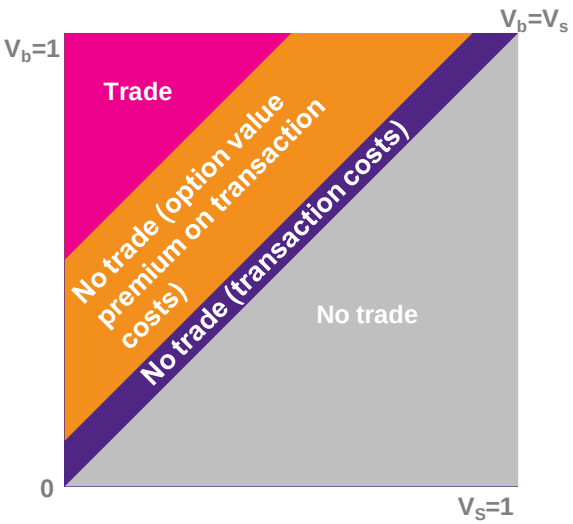
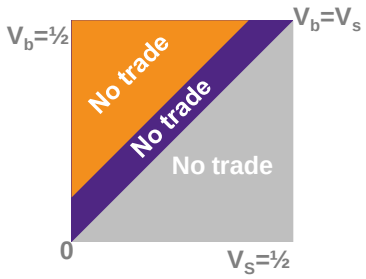


Figure 4: Option value premium on transaction costs with AIP



For the example shown in Figure 3 the option value premium on transaction costs involves a several - fold increase in the overall barrier to trade.[7] In this case setting AIP equal to half of estimated opportunity cost in the pre or post trade use would eliminate trade (since transaction costs plus the real option value already account for half of the potential gains from trade) – as illustrated in Figure 4.

In conclusion, the introduction of AIP linked to endogenous information regarding spectrum value pre and post trade will depress the private gains from trade, which in the presence of transaction costs and any associated real option due to uncertainty, may result in socially efficient trades not occurring.

[6] There may separately be real options associated with the development options for spectrum for both potential seller and potential buyer. These options may interact and we do not consider this possibility. For a discussion of the interaction of sequential real options see Trigeorgis (1996), Section 7.2.

[7] An example from another sector illustrates the potential option value mark-up. For example, an estimate of the impact of real options in relation to entry in the copper mining industry implied that the "dynamic" entry premium was over six times the "static" entry premium (Dixit and Pindyck, 1994: 264-267).

Not adjusting AIP to reflect new information

Not adjusting AIP to reflect new information involves the risk that AIP is set too high or too low relative to opportunity cost. Setting AIP too high typically involves higher economic costs than setting AIP too low since non-use of spectrum with excess demand is generally more economically costly than insufficient incentive for reallocation of spectrum. This is the conventional argument for setting AIP conservatively relative to estimated expected opportunity cost (Indepen-Aegis, 2007: Appendix E). Note that the problem in relation to uncertainty is not that the best possible estimate of AIP based on possible outcomes and their probabilities is not considered, rather that upside errors involve greater efficiency costs than downside errors and AIP should be set conservatively relative to expected to opportunity cost. To illustrate, if there are two equally probable alternative uses for spectrum which are more valuable than current use with values of, say, 5 and 15, then the expected opportunity cost is 10. If AIP were set equal to expected opportunity cost then should the alternative use turn out to be the one with the lower of the two values, then spectrum would remain unused.

In practice, once fixed AIP is likely to be slow to adapt, for example, because of requirements for and the time taken for consultation and revision of statutory instruments. This could result in values being too high at a point in time. In contrast market prices are driven by expectations which can change very rapidly (as indicated by the volatility in mineral, oil and stock market prices).

Even if AIP is initially set at the efficient level (i.e. equal to expected opportunity cost) there may be lags in reallocating any released spectrum and circumstances may subsequently change such that AIP is too high or too low. Even with good information and intentions administrative lags in adjusting AIP and/or relocating released spectrum may therefore involve costs with AIP which trading avoids.

Figure 5 illustrates the general argument (with transaction costs included). Seller and buyer valuations are assumed to be uniformly distributed from zero to one, and whilst the distribution is common knowledge the regulator does not know the actual opportunity cost (or alternatively does not update AIP based on such information – perhaps to avoid the incentive problems illustrated previously).

Figure 5: AIP results in the possibility of inefficient spectrum non use

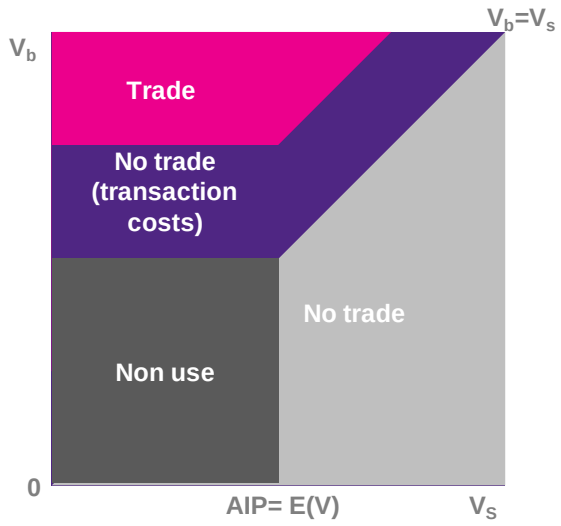


Figure 5 illustrates that, with trading, AIP set equal to expected value involves a cost of non-use (the risk that AIP is too high) and no benefit (if AIP is set low trading achieves an efficient outcome in any case).

In practice the estimates of opportunity cost that AIP is based on omit the option value of spectrum which could potentially be a large source of value.[8] AIP may therefore be set conservatively in practice (even if this were not intended). However, with trading AIP should be set very conservatively since the risk of efficiency costs if AIP is set too high remains whilst the efficiency cost involved in setting AIP too low should be largely eliminated given that the opportunity to trade provides an incentive for spectrum to be allocated to its highest value use.

AIP and opportunism

The risk of opportunism is a general problem with regulatory and administrative mechanisms since it may be difficult for governments and their agencies to commit not to expropriate value *ex post* (Levy and Spiller, 1994). The usual private solutions of contract or common ownership may not be available and a good reputation may be more difficult to establish when the parties to the relationship do not have a choice. A typical example of the risk of opportunism is that a regulator will lower allowed prices once investment is made.

The problem of potential opportunism also arises in relation to AIP, since once spectrum has been reallocated through trading to a higher value use, complementary investment in service provision has been made and a successful outcome observed AIP might be increased to extract any gains without allowing a return on sunk costs incurred in achieving such gains. Whilst the risk of government/regulatory opportunism always exists in markets the risk may be perceived as manageable given well established property rights and norms, for example as apply to land and buildings. The existence of AIP, or the prospect of AIP, can be expected to increase the perceived risk of opportunism.

Whilst AIP is intended to promote efficiency *ex ante*, to the extent that the existence of AIP raises the risk of *ex post* opportunism it undermines the extent to which a market based approach will deliver better outcomes in terms of efficient spectrum allocation, innovation and complementary investment.

Conclusion

AIP may increase efficiency for government spectrum use and where trading is not present. However, our analysis implies that the application of AIP to commercial spectrum where trading is permitted may harm efficiency. AIP, even if set below the opportunity cost of spectrum, could inhibit the development of trading and the transition to a market-driven approach. Further, the existence of trading is itself grounds for setting AIP conservatively. Therefore we conclude that in the long term AIP should not be applied to commercial spectrum where trade is permitted and that policy makers should move from administrative to market mechanisms for spectrum management, phasing out intermediate approaches where they have been applied in relation to commercial uses of spectrum.

[8] The option value of spectrum is the value to a firm of having the flexibility to invest at the optimal time in a context where there are irreversible costs associated with making investments, there is the possibility of waiting for new information to arrive and uncertainty over investment returns. Option values are either zero or positive.

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