Is spectrum pricing compatible with spectrum markets?

A report for T-Mobile

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Executive Summary

Government and Ofcom spectrum policy is based on increasing reliance on market driven approaches to spectrum management. This policy is to promote the efficient allocation and assignment of spectrum and efficient and timely innovation and investment in new services such as mobile broadband.

Policy context

The application of a market-based approach to spectrum management started in 1998 with the introduction of administrative incentive pricing (AIP) in bands where there was excess demand for spectrum. While this was an administrative and not a market intervention, it was used to provide financial incentives for efficient spectrum use in circumstances where licences had been assigned by administrative means (i.e. for all licences at that time). Auctions of vacant spectrum soon followed and then in 2004 spectrum trading and liberalisation started to be introduced.

Arguably trading alone provides commercial spectrum users with the correct incentives for efficient spectrum use. However, AIP was part of the policy mix when trading was introduced. 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."* The benefits of applying AIP set out by Ofcom in 2004 included providing complementary incentives where trading volumes are low and therefore will not fully promote efficiency; the fact that AIP imposes an actual cost – particularly for government use; and a concern that licensees may otherwise hold unused spectrum.

The Cave Review and Ofcom's Spectrum Framework Review both envisaged a long term situation in which market forces (i.e. auctions and trading) were the norm for commercial spectrum use. AIP would only be used where market approaches were not feasible, as Figure 1 illustrates.

Figure 1: What is the transition path?

Ofcom has initiated a Strategic Review of Spectrum Pricing. As part of this review Ofcom is considering a number of fundamental questions concerning the role and application of AIP. In this paper we focus one question being considered by the SRSP, namely "Is AIP needed on spectrum used for commercial purposes when licences are tradable?"

What are the costs and benefits of AIP when licences are tradable?

In answering the question as to whether AIP is needed at all on spectrum used for commercial purposes when licences are tradable, the costs and benefits of maintaining AIP in parallel with trading need to be assessed. We conclude that the costs of AIP have been understated once liberalisation and the opportunity to trade develop and that the potential benefits have been overstated (leaving issues related to government use of spectrum to one side). In terms of potential benefits, the value of AIP for commercial spectrum diminishes as opportunities for trade and reallocation of use expand, since the opportunity for trade also offers incentives for efficient spectrum use without the risk that non-market clearing prices persist.

In relation to the concern expressed in the 2004 Ofcom spectrum trading statement that licensees may hold unused spectrum, it is both unclear why such holdings would necessarily be a concern nor why AIP would necessarily help. Holding unused spectrum may be efficient, even if there is excess demand for spectrum. The reason for this is that holding unused spectrum keeps open the option/s for utilisation which may be more valuable than any immediate use in an uncertain environment, and where using the spectrum involves the commitment of other resources (e.g. infrastructure investment). Such outcomes are not atypical in the commercial property and other resource markets and are consistent with the normal and efficient functioning of markets.

We identify three circumstances where AIP may promote efficiency. First, as mentioned earlier where spectrum is held by government agencies. Second, where trading is not permitted for commercial spectrum. Third, where trading is inefficient due to information asymmetries with bilateral trading. In relation to the latter the regulator would have to be relatively well informed about the opportunity cost of spectrum compared to market participants in order to promote efficiency via the application of AIP. This is unlikely to be the case in practice. 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 instances where administratively determined prices are regarded as providing an improvement on market determined outcomes.

However, provided AIP is set below the opportunity cost of spectrum, is not adjusted to reflect new information about spectrum value endogenous to potential parties to a trade over time and remains below the opportunity cost of spectrum, then AIP will do no harm. However, we note that if circumstances may change one cannot be confident that AIP will remain below opportunity cost if AIP remains fixed. Therefore, whilst the assumptions necessary for AIP to do no harm could occur by chance, there is no guarantee of this and the approach of fixing AIP does not therefore appear to provide a sound basis for policy.

AIP, applied to commercial spectrum alongside trading, may harm efficiency. 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. revealed by new uses or traded prices) over time and therefore stays more or less aligned with opportunity cost.
- AIP remains fixed over time and therefore does not reflect opportunity cost (either because AIP was wrong initially, or opportunity cost changed, or both).

In the first case AIP reduces the potential gains from trade and therefore the likelihood of gains from trade exceeding transaction costs i.e. AIP can be expected to reduce trade if AIP is related to information about spectrum value endogenous to potential parties to a trade. With uncertainty over

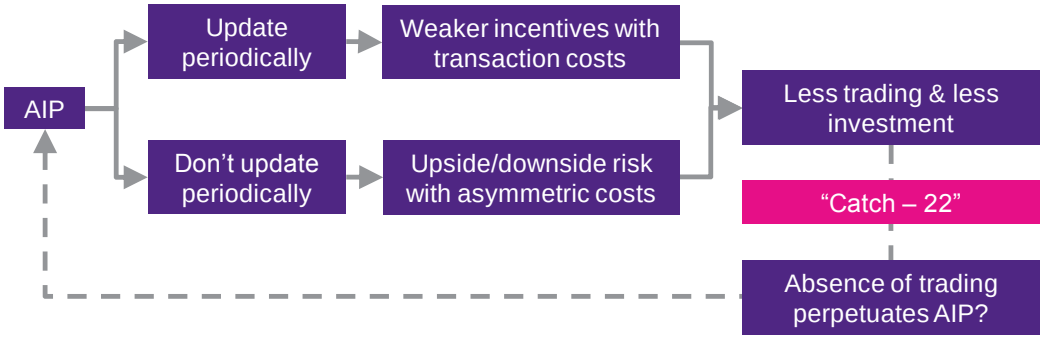
spectrum value the impact of transaction costs may be increased by a "real option" premium related to the value of waiting before committing resources to trading. The combined effect of transaction costs and the real option premium would increase the impact of AIP in reducing trade.

In the second case where AIP remains fixed based on an estimate of opportunity cost, AIP involves a risk that spectrum is unused. This will typically involve higher economic costs than if the level of AIP were set too low, particularly if trading is permitted.

Finally, there is also a risk of *ex post* opportunism whereby the gains from trade, investment and innovation are removed once resources have been irretrievably committed and value created. The existence of AIP introduces a policy instrument that market participants may perceive as increasing the risk of *ex post* opportunism, particularly given recent policy documents linking AIP to spectrum value.

These points are summarised in Figure 2.

Figure 2: Interaction of AIP and trading



A "catch 22" is evident in Figure 2, namely that AIP may depress trading – thereby potentially perpetuating AIP since the lack of trading may be interpreted as an indication that market incentives are insufficient to achieve an efficient allocation of spectrum. It is for this reason that clarity over the transition path is required to allow a virtuous circle to develop whereby a market-driven approach replaces administrative mechanisms including AIP for commercial spectrum.

Conclusions

Whilst there are circumstances in which AIP may increase efficiency, our analysis suggests that the application of AIP to commercial spectrum where trading is permitted is likely to harm efficiency. Therefore we conclude that AIP should not be applied to commercial spectrum where trade is permitted - consistent with the Ofcom regulatory principle to operate with a bias against intervention.

This conclusion points to a need for a transition strategy whereby reliance on AIP for commercial uses of spectrum is phased out as greater reliance shifts to a market-driven approach involving auctions, trading and liberalisation. Initially the strategy could involve a policy of not increasing existing levels of AIP and of not introducing AIP at licence renewal on spectrum which has been allocated by auction. A plan for reductions in AIP down to levels required to recover spectrum management costs could follow.

1 Introduction

Ofcom is conducting a Strategic Review of Spectrum Pricing (SRSP). In the lead up to the release of a consultation document on the SRSP in the Autumn Ofcom has asked industry for input on the following questions:

i. Is AIP needed on spectrum used for commercial purposes when licences are tradable?
ii. How do we determine whether a band is congested and should be subject to AIP?
iii. Should Ofcom set AIP-based fees when there are factors making it difficult or even impossible for users to change their spectrum use in the short/medium term?
iv. How should we use auction outcomes or trading prices to inform AIP fees?
v. How should Ofcom take into account the constraints created by international agreements or harmonisation measures when setting AIP?
vi. Should we move towards generic pricing as recommended by Professor Cave?
vii. Should Ofcom be less conservative in setting AIP fees?
viii. What should be the priority given to reviewing fee levels by class or band?

Plum was asked by T-Mobile to prepare a paper addressing question (i).

Section 2 of this report sets out the policy background to spectrum pricing in the UK and how spectrum pricing fits within the context of Ofcom's overall spectrum policy.

Section 3 addresses Question (i). It provides both conceptual arguments and illustrates the scale of the distortion that AIP may introduce if spectrum is tradable.

Our recommendations are given in Section 4.

2 Policy Context

In this section we describe the development of policy in respect of administrative incentive pricing (AIP), auctions and trading. In particular we refer to discussion of the role and consequences of applying of AIP when spectrum is tradable.

2.1 Initial moves to a market-based spectrum policy

In 1996 the Radiocommunications Agency commissioned consultants (NERA-Smith) to advise on the use of spectrum pricing[1]. NERA-Smith recommended:

- The adoption of AIP in frequency bands where spectrum was not auctioned, where AIP would be set at a level equal to the opportunity cost of spectrum.
- Where practical, assigning cleared spectrum by auction.

NERA-Smith calculated values for AIP for frequency bands where there was likely to be excess demand at the prevailing spectrum fees. These included frequency bands used to provide cellular mobile, private mobile radio and fixed links.

In 1998 the government passed the Wireless Telegraphy Act (1998) which permitted the application of spectrum pricing or AIP after taking account of:

- Current and future spectrum demand.
- The desirability of:
  - promoting the efficient use and management of the radio spectrum
  - any economic benefits arising from the use of wireless telegraphy
  - the development of innovative services and
  - competition in the provision of telecommunications services

In addition spectrum auctions were permitted under the Act having regard to the desirability of promoting the optimal use of spectrum. In 1998 Radiocommunications Agency started the application of AIP. There was a phased transition to fee levels that were around half those recommended by NERA-Smith.

NERA-Smith also discussed options for spectrum trading but policy took longer to develop in this area. In respect of the interaction between pricing and trading they noted (p94) that:

- If licences could be traded then spectrum pricing was not needed to promote efficient spectrum use.
- Provided spectrum was relatively unencumbered efficiency will be promoted and spectrum will move to a higher value use with more certainty under trading than through spectrum pricing.
- The application of spectrum pricing to tradable spectrum would:

[1] Study into the Use of Spectrum Pricing, NERA and Smith for the Radiocommunications Agency, April 1996. http://www.ofcom.org.uk/static/archive/ra/topics/spectrum-price/documents/smith/smith1.htm

– Reduce the likelihood of trades occurring because of increased uncertainty over the future level of administratively determined prices.

– Lead market participations to conceal the value of trades least this resulted in changes in administratively determined prices.

2.2 The Cave Reviews

In 2002 an Independent Review of Radio Spectrum management was conducted by Professor Martin Cave[2] with a view to advising on principles that should govern spectrum use and actions required to ensure all users are focused on using spectrum in the most efficient way possible.

The Review's overarching vision (paragraph 24) was that auctions and the trading of licences would apply where feasible and administratively set prices would apply elsewhere. It endorsed the policies of spectrum auctions and trading, and regarded pricing as a complement to these market mechanisms for licences not assigned by auction.

The Review considered that "*once spectrum trading is enabled, then licensees will face a market determined opportunity cost of their spectrum use*" ... and *"that trading rights should be granted free rather than sold"* so that trades are not deterred (paragraph 78, p19). Although the Review did note that if the Government was concerned about windfall gains then administratively set annual charges could be set until licences are re-assigned by auction (paragraph 79).

The Communications Act 2003 introduced measures allowing spectrum trading. The issue of applying market mechanisms to Government spectrum use was addressed in 2005 in the Independent Audit of Spectrum Holdings also conducted by Professor Martin Cave[3]. The Audit regarded AIP as an important mechanism for promoting spectrum use in the public sector, particularly for those bands where the opportunity to trade remains limited.

2.3 Ofcom's Spectrum Strategy

The Communications Act 2003 (and paving legislation) established Ofcom and gave it duties (amongst many others) to ensure the optimal use of radio spectrum under its management. Echoing the 1998 Wireless Telegraphy Act, in carrying out its spectrum management duties Ofcom must have particular regard to the availability of spectrum; and current and future demand for spectrum, and to the desirability of promoting:

- Efficient management and use of the spectrum.
- Economic and other benefits arising from its use.
- Development of innovative services.
- Competition in electronic communications services.

The 2004 Spectrum Framework Review (SFR)[4] developed Ofcom's strategy for managing radio spectrum in the medium and long term consistent with its statutory duties. This strategy involved

[2] http://www.ofcom.org.uk/static/archive/ra/spectrum-review/2002review/1_whole_job.pdf

[3] http://www.spectrumaudit.org.uk/final.htm

[4] http://www.ofcom.org.uk/consult/condocs/sfr/

increasing use of market forces wherever this is judged to be in the best interests of the consumer-citizen. The strategy built on previous policy decisions and affirmed:

- The use of auctions to assign cleared spectrum.
- The continued use of administrative incentive pricing (AIP), though specific discussion of the role of AIP in an environment that makes widespread use of market forces was postponed to a subsequent consultation of spectrum pricing.
- The progressive introduction of spectrum trading and liberalisation between 2004 and 2007 *(sic)*.

In the long term market mechanisms policies were expected to apply to around 70% of the spectrum. The SFR also placed emphasis on the encouragement of licence exempt spectrum applications where they promoted the overall objective of optimal spectrum use (thought to be around 7% of the spectrum in the long term).

Ofcom's view was that the most appropriate policy stance was to increase clarity over time for spectrum users while retaining its ability to vary rights under certain conditions. These conditions might include market failure, compliance with international obligations and directions from the Secretary of State.

Ofcom reviewed its spectrum pricing policy in 2004/5.[5] This review proposed some revisions to AIP levels and affirmed the continued need for AIP to promote greater efficiency despite the advent of spectrum trading. It noted that, provided AIP fees are set conservatively, trading should not be impaired.

A similar view was set out in Ofcom's 2004 Statement on Spectrum Trading, namely that:[6]

> *"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."*

The benefits from applying AIP set out by Ofcom include providing complementary incentives where trading volumes are low *"and therefore will not fully promote efficiency"*; the fact that AIP imposes a cost – particularly for government use; and a concern that in the absence of AIP licensees may hold unused spectrum.

2.4 Recent initiatives in regard to 2G and 3G spectrum

Spectrum at 900 MHz and 1800 MHz that is licensed to mobile operators is not (at the time of writing) tradable or liberalised. Proposals for changes in these areas have been the subject of consultations from Ofcom[7] and the Independent Spectrum Broker (ISB).[8] In both cases there are proposals to apply AIP at the "full economic value" or the spectrum opportunity cost to liberalised and tradable 900 and 1800 MHz spectrum licences.

The objective of applying AIP in these cases is to promote efficient spectrum use and Ofcom proposes to revise current AIP levels taking into account auction results and up to date market information. Ofcom notes that the AIP could also substantially reduce the impact of asymmetric profit shocks

[5] http://www.ofcom.org.uk/consult/condocs/spec_pricing/

[6] Ofcom. August 2004. A statement on spectrum trading. Page 40. http://www.ofcom.org.uk/consult/condocs/spec_trad/statement/sts.pdf

[7] http://www.ofcom.org.uk/consult/condocs/spectrumlib/

[8] http://www.culture.gov.uk/reference_library/publications/6147.aspx

(although that would not of itself be the objective in revising AIP)[9]. We observe that if the AIP is set at the opportunity cost then there will be no incentive to trade at the margin (as all of the marginal value will have been extracted by AIP) though infra-marginal trades may occur. This issue does not appear to have been considered in the relevant consultation documents.

Further, the final Digital Britain report proposes to make *"...existing operators' 3G licences indefinite rather than term licences (though AIP will be payable to reflect the economic value of the licence) in order to provide certainty for investment and an incentive towards greater roll-out towards universality."*[10] It therefore now appears that AIP is proposed as a permanent element of spectrum policy.

The final Digital Britain report also proposes a specific universality objective of 2 Mbps broadband by 2012, which, it appears, may be primarily met by fixed infrastructure given expectations that speeds of 1 to 1.5 Mbps are a likely outcome for mobile broadband by 2012 (paragraph 113). However, the report notes in paragraph 115 that the Government *"Wants a universal coverage for mobile broadband that matches that of current GSM coverage (99%)."*

2.5 Summary

Figure 2-1 summarises policy developments in the UK in the move to a market-based approach to spectrum management. It raises the question of how we get from where we are now to the end points envisaged by the Cave Review and Ofcom's Spectrum Framework Review. We return to this question in Section 4.

Figure 2-1: Spectrum Policy Development – 1998 – 2015+

The key points to be noted from the last 10 years of spectrum policy development are that:

- AIP was developed and applied in the absence of spectrum trading. AIP was set at levels around half the estimated opportunity cost of spectrum.
- AIP in the context of trading and liberalisation has been justified as a means of dealing with windfall gains and providing economic incentives for efficient spectrum use when trading markets

[9] Where an asymmetric profit shock was a change in the relative profits of the MNOs that could arise if there were significant cost differences between 900MHz spectrum and other spectrum, and firms without 900MHz spectrum matched the quality of 900MHz operators and incurred a higher cost.

[10] DCMS and BIS. June 2009. Digital Britain – Final Report. http://www.culture.gov.uk/images/publications/digitalbritain-finalreport-jun09.pdf

are “thin”. However it has also been noted that if AIP is used in this way it could deter trading and/or liberalisation.

- The Cave Review saw AIP as having a role when auctions and trading were not feasible or recovery of windfall gains was important.
- By contrast recent policy discussions around trading and liberalisation for 2G spectrum suggest applying AIP at the full opportunity cost once the spectrum is tradable and liberalised on efficiency grounds. In addition, the final Digital Britain report proposes that AIP is applied indefinitely to 3G spectrum.
- Ofcom’s long term strategy does not discuss how AIP sits in an environment where most spectrum is subject to market forces (auctions and trading/liberalisation). Neither the SFR nor the accompanying Pricing and Trading Statements provide a clear transition path from where we are now to an environment (from around 2015) in which spectrum use would be largely governed by market forces.

3 What is the impact of AIP when spectrum is tradable?

One of the key questions raised in relation to the Strategic Review of Spectrum Pricing (SRSP) is whether AIP is needed on spectrum used for commercial purposes when licences are tradable. In this section we analyse this question.

3.1 Markets versus administrative mechanisms

Ofcom's spectrum strategy is focussed on moving to greater reliance on a market led approach. Whether AIP is complementary to this strategy, or might become an impediment to it, depends on an assessment of the role of administrative versus market 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 noted:[11]

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

Ofcom expressed a similar view in the SFR:[12]

> *"We believe that market forces should be allowed to prevail where this is in the best interests of citizens and consumers. This is based on the belief that firms have the best knowledge of their own costs and preferences and a strong incentive to respond to market signals and put resources to their best possible use."*

3.1.1 Markets support high powered incentives and dynamic adjustment

Markets provide high powered incentives for efficiency (cost minimisation and efficient resource allocation) whilst adjusting dynamically to reflect new information. Markets are also inherently forward looking – prices and decisions reflect expectations about the future.

The reason markets can provide both high powered incentives and a linkage between changing information and prices is that 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 higher profitability do not therefore result in lower prices – rather prices are determined in the market as a whole. Further, expectations about the future reflect information and judgements by many players, and good judgement is rewarded.

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

[11] McMillan. 2002. Reinventing the bazaar – a natural history of markets. Preface.

[12] http://www.ofcom.org.uk/consult/condocs/sfr/sfr/

not therefore necessarily imply inefficiency.[13] Spectrum may lie idle, and/or change of use may arise infrequently and yet involve large gains in fully functioning markets.

3.1.2 AIP cannot be expected to match the efficiency of markets

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, 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.

3.2 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 for commercial spectrum.
- Third, where trading is inefficient due to information asymmetries and limited competition.

3.2.1 AIP and spectrum holdings by government agencies

AIP might be justified for spectrum held by government agencies even if it were not justified for 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

[13] 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. March 2006. "The option value of vacant land." http://aysps.gsu.edu/urag/workingpapers/2006/URAG_Wp_06-05.pdf

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 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.

3.2.2 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 should be allocated to others.

We note that reallocation may eventually occur in the absence of both trading and pricing 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. However, where trade is permitted, it is far from obvious that AIP would improve overall incentives.

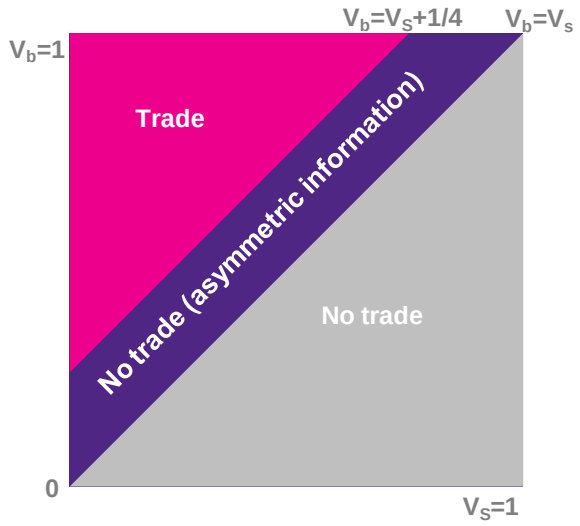
3.2.3 AIP and bilateral trading with information asymmetry

In principle, AIP could lead to more efficient outcomes where trading is inefficient due to asymmetric information with bilateral trading. The best possible equilibrium outcomes with bilateral trading and information asymmetry involve trade occurring only if the value to the buyer exceeds the value to the seller plus ¼ (for values uniformly distributed on the interval zero to 1) – as illustrated in Figure 3-1.[14]

[14] Myerson and Satterthwaite. 1983. Efficient mechanisms for bilateral trading. *Journal of Economic Theory*: 28. See also Robert Gibbons. 1992. A primer in game theory.

As the number of players in the market is increased with asymmetric information inefficiency shrinks. Gul and Postlewaite. November 1992. "Asymptotic Efficiency in Large Exchange Economies with Asymmetric Information." *Econometrica*, Vol. 60(6).

Figure 3-1: Bilateral trading inefficiency with asymmetric information



In this case trade can involve inefficiency which AIP might in principle overcome.[15] Spectrum returned to the regulator because of AIP might ultimately be reallocated to a higher valued use even though bilateral trading would not have occurred. However, for this to be the case the regulator would have to be relatively well informed about the opportunity cost of spectrum compared to market participants. In our view it is unlikely that the regulator would have better information than market participants. Hence it is therefore unlikely in practice that AIP would lead to improved outcomes in these circumstances.

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 instances where administratively determined prices are regarded as providing an improvement on market determined outcomes.

3.3 Circumstances where AIP would 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 even 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.* 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 remain below opportunity cost. Therefore, whilst the assumptions necessary for AIP to do no

[15] Paul Milgrom argued for auctions rather than some arbitrary allocation of spectrum (say a lottery) followed by trade on similar grounds. However, auctions do not suffer from the risk that spectrum remains unused - provided reserve prices are not set too high.

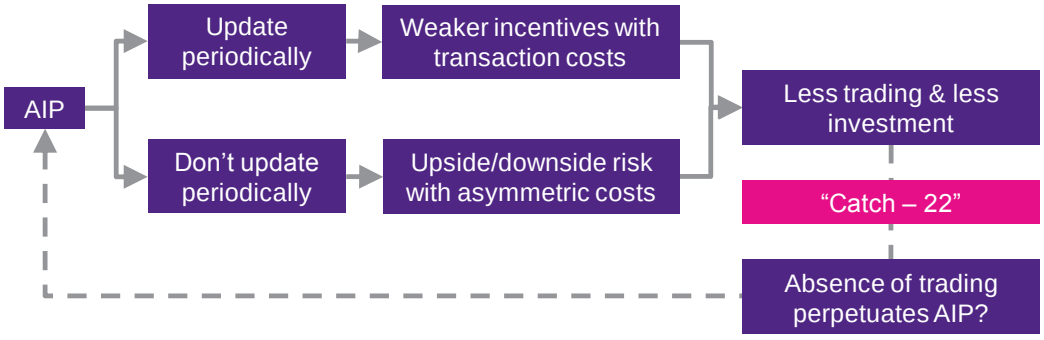
harm could occur by chance, there is no guarantee of this. The approach of fixing AIP does not therefore appear to provide a sound basis for policy.

3.4 Circumstances where AIP may harm efficiency

AIP, applied to commercial spectrum alongside trading, may harm efficiency. 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. revealed by new uses or traded prices) over time and therefore stays more or less aligned with opportunity cost.
- AIP remains fixed over time and therefore does not reflect opportunity cost (either because AIP was wrong initially, or opportunity cost changed, or both).

Figure 3-2 below illustrates the interactions between AIP and trading considered in the remainder of Section 3.



3.4.1 Adjusting AIP to reflect endogenous spectrum value information

AIP which is adjusted to reflect new information over time may prevent socially 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.

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.

3.4.1.1 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 = βVs initially and AIP = βVb post trade where $0< \beta \leq 1$. Trade takes place if $(1- \beta) Vb > (1- \beta) Vs + T$ i.e. trade will only occur if $Vb>Vs + T/(1- \beta)$. Since $1/(1- \beta) >1$ 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 set at 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 3-3 (without AIP) and Figure 3-4 (where AIP related to spectrum value pre and post trade is imposed with β = ½).

Figure 3-3: Spectrum trading without AIP

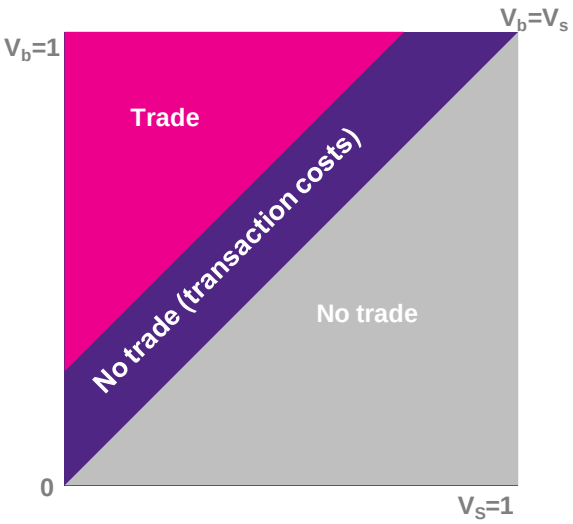
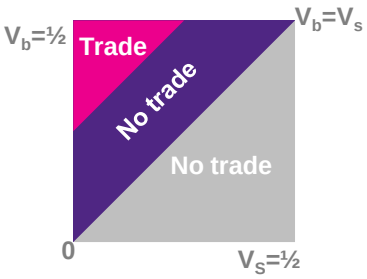


Figure 3-4: Spectrum trading with AIP set at half the current use opportunity cost



In Figure 3-3 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 (as has been Ofcom policy so far), then the values to the potential seller and buyer on each axis in Figure 3-3 are halved, as shown in Figure 3-4. 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 3-3 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.

3.4.1.2 With uncertainty (introducing "real options")

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.[16] The basic idea is that there may be a real option associated with the resources involved in trading i.e. the sunk transaction costs.[17] 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 3-5 below (the transaction costs illustrated are smaller than those in Figure 3-3, 0.1 versus 0.25, since we wish to focus on and illustrate the option value premium in this example).

Figure 3-5: Option value premium on transaction costs without AIP

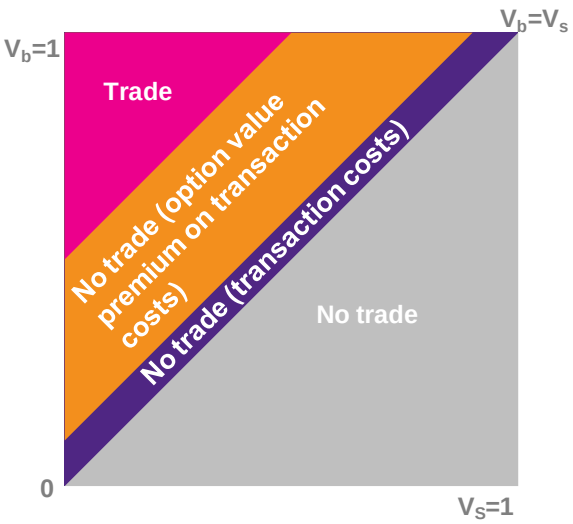
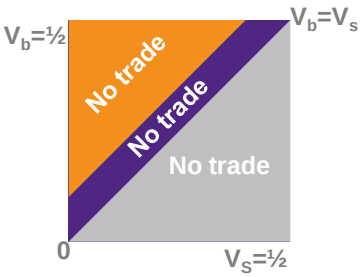


Figure 3-6: Option value premium on transaction costs with AIP



For the example shown in Figure 3-5 the option value premium on transaction costs involves a five-fold increase in the overall barrier to trade giving a total barrier of 0.5. 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 3-6.

Whist the example used for illustrative purposes, involving a real option value which increases the impact of transaction costs five-fold may seem extreme; option values can have a large impact in practice. The following example illustrates the magnitude of impact of real options for a specific example, entry (and exit) in the copper mining industry.

Modest (irreversible) transaction costs can be amplified considerably when real options effects are considered. An illustration of the potential magnitude of the impact of uncertainty and irreversibility on "trading" is provided by calculated entry and exit thresholds in copper mining (where one can think of entry and exit as analogous to trading in a spectrum market). Real options greatly expand entry (and

[16] Dixit and Pindyck. 1994. Investment under uncertainty.

[17] 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. Real options – managerial flexibility and strategy in resource allocation. MIT Press. Section 7.2.

exit) thresholds in the copper mining industry beyond what the fixed costs of entry (and exit) would suggest. For an entry threshold of $0.88 per pound (10 per cent above variable costs of $0.8 per pound) real options are estimated to amplify this threshold to $1.35 per pound, roughly 68% per cent above variable costs i.e. the "dynamic" entry premium is over six times the "static" entry premium.[18] Entry is therefore rare and copper prices are more volatile than they would otherwise be.

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.

3.4.2 Not adjusting AIP to reflect new information

Not adjusting AIP 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.[19] This is the conventional argument for setting AIP conservatively relative to estimated expected opportunity cost.[20]

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.

To illustrate how circumstances might change, consider the case of wireless fixed links. In some markets these compete with fixed backhaul infrastructure, for example in carrying mobile traffic to and from base stations. Fixed backhaul is now moving to scalable Ethernet based services and BT Wholesale have agreements with network mobile operators to provide such services as part of the 21CN upgrade. The costs of backhaul are therefore falling and so too may be the opportunity cost of spectrum for fixed links. This may, in some circumstances; result in the return of fixed link spectrum to Ofcom. If the level of AIP was not changed quickly to reflect changes in opportunity cost and returned spectrum made available for reallocation, these dynamics could result in inefficiency.

Figure 3-7 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

[18] Dixit and Pindyck. 1994. Investment under uncertainty. Pages 264-267.

[19] 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 the argument for setting AIP conservatively is 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.

[20] An argument developed, for example, in the Indepen-Aegis report for Ofcom of April 2007. Aeronautical and maritime spectrum pricing. Appendix E. http://www.ofcom.org.uk/research/radiocomms/reports/spectrumaip/aipreport.pdf

update AIP based on such information – perhaps to avoid the incentive problems illustrated previously).

Figure 3-7: AIP results in the possibility of inefficient spectrum non use

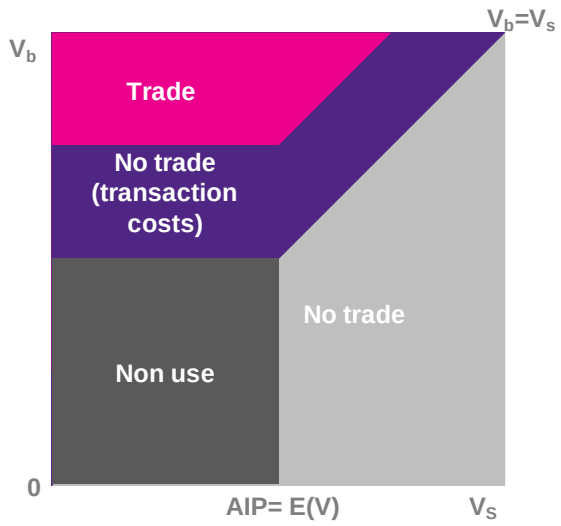


Figure 3-7 illustrates that, with trading, AIP set equal to expected value involves a cost of non-use (the risk that AIP is too high) and no benefit (if AIP is set low trading achieves an efficient outcome in any case).

We note that 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.[21] 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.

3.4.3 AIP and opportunism

The problem of opportunism is distinct from the problem discussed in Section 3.41 in that it involves adjusting AIP to reflect not only the value of spectrum, but the value of spectrum ignoring sunk costs such as investment.[22]

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.* 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

[21] 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.

[22] Levy and Spiller. 1994. "The Institutional Foundations of Regulatory Commitment: A Comparative Analysis of Telecommunications Regulation," *Journal of Law, Economics and Organization*, 10, 201–246.

example of the risk of opportunism is that a regulator will lower allowed prices once investment is made (an issue considered by Ofcom in relation to next generation broadband investment).

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.[23]

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. Further, existing administrative instruments that could be utilised to extract value may be limited, though they are not entirely absent, for example, both the quid pro quo required for planning approval and the level of stamp duty on property transactions discourage property trade and have varied in the past.

The existence of AIP, or the prospect of AIP, can be expected to increase the perceived risk of opportunism, particularly given recent policy statements suggesting a linkage between the level of AIP and spectrum value, rather than to principles of efficient pricing, for example:

- Kip Meek: *"2G spectrum liberalised in the hands of existing users should be subject to revised administrative incentive pricing (AIP) to reflect the full economic value of the spectrum."*
- Ofcom spectrum liberalisation proposals: *"To review the level of Administered Incentive Pricing (AIP) applying to the 900 MHz and 1800 MHz spectrum so that in future it reflects the full economic value of this spectrum post liberalisation, so as to encourage its efficient use."*
- Digital Britain final report:
  - *"The alignment of AIP for liberalised 2G licences reflecting the full economic value of spectrum."* Page 13.
  - *"...existing operators' 3G licences indefinite rather than term licences (though AIP will be payable to reflect the economic value of the licence) in order to provide certainty for investment and an incentive towards greater roll-out towards universality."* Page 15,
  - *Making indefinite the 3G Licence term in return for proper AIP from the end of that term and additional coverage obligations."* Page 74.
  - *"The Government will look at AIP levels that take into account the contribution being made by operators to universal service."* Page 80.

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.

[23] Opportunism may also take the form of new obligations rather than higher AIP. The final Digital Britain report notes (paragraph 115) that the Government "Wants a universal coverage for mobile broadband that matches that of current GSM coverage (99%)." Coverage obligations may be the subject of public and political interest and over time there could be pressure for upward revision in performance terms (e.g. data rates). Uncertainty regarding the future level of obligation and the prospect of upward revision of obligations may deter innovation and trade. Ideally universal coverage objectives should be met via publicly funded competitive technology neutral procurement auctions.

Wallsten. April 2008. "Reverse auctions and universal telecommunications service; lessons from global experience." Federal Communications Law Journal, Volume 61. http://www.law.indiana.edu/fclj/pubs/v61/no2/9-WALLSTENFINAL.pdf

3.5 Conclusion

AIP may increase efficiency for government spectrum use and where trading is not present. However, our analysis suggests that the application of AIP to commercial spectrum where trading is permitted could harm efficiency (whether or not AIP is adjusted over time to reflect new information). 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 - consistent with the Ofcom regulatory principle to operate with a bias against intervention.

4 Recommendations

Given that AIP and trading interact and are both designed to achieve an efficient allocation of spectrum, they should be considered together in the Ofcom Strategic Review of Spectrum Pricing.

Further, the costs of AIP in terms of foregone trades should be assessed by Ofcom in deciding whether continued reliance on AIP is appropriate where trading is permitted and whether where AIP is applied it should be set conservatively.

Our judgement is that the costs outweigh the benefits of AIP where trading is allowed. Hence AIP for commercial uses of spectrum should be phased out as greater reliance shifts to a market-driven approach involving auctions, trading and liberalisation. In circumstances where AIP is applied to reallocate windfall gains it is important for Ofcom to consider carefully whether this will be seen as opportunism and so have a potentially negative impact on longer term incentives for innovation and investment.

We note that whilst the above arguments apply to AIP calculated to reflect the value of spectrum, they do not apply to fees designed to cover the administrative costs of spectrum management which are a separate matter.

In order to achieve a transition to spectrum markets and the phase-out of AIP the following steps could be considered for tradable spectrum:

- Removal of AIP where no longer justified with reference to an assessment of excess demand.
- Adoption of a policy of not increasing existing levels of AIP and of not introducing AIP at licence renewal on spectrum which has been allocated by auction.
- Development of a plan for reductions in AIP down to levels required to recover spectrum management costs.