Designing a Mechanism for Reallocation of Spectrum with Incentive-based Pricing

Joint Research Project
Spectrum Valuation for 3G Services:
Application of the 1900 MHz Band

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I. INTRODUCTION

I. A. Objective of this paper

incentive-based pricing (IBP)

of spectrum

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I. B. Spectrum use in the future (1/3)

Power of mobile communication:

in the past, direct meeting only

now mobile-connected in voice

broadband connection in the future

informational ‘teleportation’

6

I. B. Spectrum use in the future (2/3)

What do we need to bring in broadband?

(1) more spectrum

spectrum reallocation is important

to promote technological progress and new business initiative

I. B. Spectrum use in the future (3/3)

What do we need to bring in broadband?

(2) use of economic incentives

some *economic mechanism* for converting private efforts into a public goal

I. B. Spectrum use in the future (3a/3)

Goal:

To let spectrum be used by those who can best promote the benefits of the people

Designing a Mechanism for Reallocation of Spectrum with Incentive-based Pricing

II. SPECTRUM AS AN ECONOMIC RESOURCE --- A SHORT OVERVIEW

II. A. What is spectrum? (1/2)

- a space resource with limited capacity
- no depletion, no depreciation
- can be used in exclusive or shared mode
- externalities, positive and negative
- technological progress increases efficiency

II. A. What is spectrum? (2/2)

- spectrum is a real estate,
  like land, producing "rent"
  (income to nonsubstitutable factor
  of production)
- management of spectrum rents

II. A. What is spectrum? (2a/2)

- history of spectrum use:
  started 100yrs ago with tech regulations
  no scarcity (no rent) until 1990's
  has become scarce with mobile tech
  huge rents & vested rights

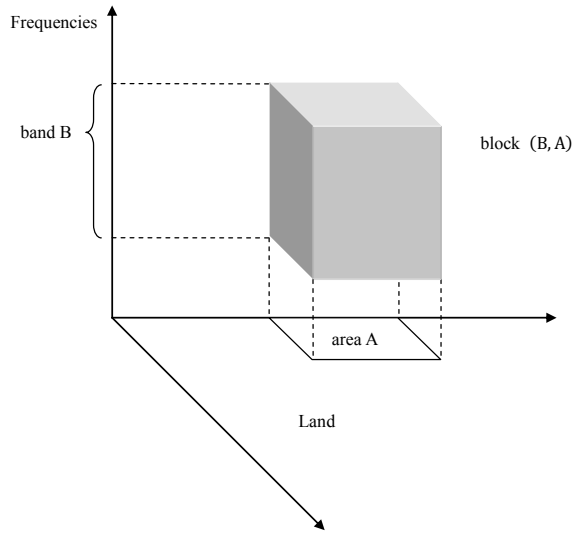
II. B. Division of spectrum into bands/blocks (1/2)

band: a segment of one-dimensional frequency space

II. B. Division of spectrum into bands/blocks (2/2)

block: (of the terrestrial spectrum) a subset of three-dimensional space composed by the frequency space and the surface of the land

Figure IIB.1: Example of Spectrum Block (B, A) in the 3-dimentional Spectrum Space



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III. VALUE OF SPECTRUM BLOCKS TO USERS

III. A. Theory of valuation (in general) (1/13)

1. value of economic objects in competitive-market environment

economic objects:

- property, e.g. , land, houses
- organization (e.g., a corporation)
- human labor
- spectrum blocks

III. A. Theory of valuations (in general) (2/13)

2. calculation

$(the\ value\ of\ an\ object\ at\ time\ t_0)$

$= (the\ sum\ of\ expected\ returns\ to\ the\ object\ in\ the\ future\ discounted\ with\ regard\ to\ both\ time\ and\ uncertainty, DPV)$

$$= \sum_{t=t_0}^{\infty} \left\{ \frac{1}{(1+d)^{(t-t_0)}} \right\} \cdot R_t$$

$= V(\{R\}, i, r)$, where

III. A. Theory of valuations (in general) (3/13)

R_t: return to the object during period t

d: discount factor

(= interest rate plus risk-premium rate)

III. A. Theory of valuations (in general) (4/13)

3. remarks

a. value of an object depends on
the economic environment in which the object is placed,
the purpose of valuation,
the "owner (controller)" of the object.

III. A. Theory of valuations (in general) (5/13)

b. value of an object becomes significant, when the "state" of the object is changed or about to be changed.

III. A. Theory of valuations (in general) (6/13)

examples:

market value:

when the object is sold/bought in a market.

III. A. Theory of valuations (in general) (7/13)

supply value (supply price):

when the owner is about to yield the ownership of the object.

demand value (demand price):

when a (potential) owner is about to acquire the object.

III. A. Theory of valuations (in general) (8/13)

c. value of a quantifiable object:

unit value changes depending on the quantity of the object to be evaluated:

(theory of demand and supply curves).

III. A. Theory of valuations (in general) (9/13)

d. value of an object composed of "parts".

(1) The value of the entire object is the sum of the values of the parts if there is no externality between the parts.

III. A. Theory of valuations (in general) (10/13)

example:

calculation of DPV of a corporation (Z):

R_t: the value (the return) from Z in period t.

$\frac{R_t}{(1+d)^{(t-t_0)}}$: the value of R_t discounted to period t_0.

$\sum \frac{R_t}{(1+d)^{(t-t_0)}}$: the sum of the discounted R_t over all periods in the future on the assumption there is no externality between R_t's.

III. A. Theory of valuations (in general) (11/13)

(2) If there is (positive) externalities between parts, then the value of the entire object **exceeds** the sum of the values of the parts:

III. A. Theory of valuations (in general) (12/13)

example:

the value of 2 pieces of land (or spectrum blocks) *u* and *v* used separately or jointly:

III. A. Theory of valuations (in general) (13/13)

separate use: $V(u)$: value of u

$V(v)$: value of v

joint use: $V(u,v)$: value of u and v used jointly.

$V(u,v) \geqq V(u) + V(v)$ because of the external economies between u and v.

III. B. Spectrum valuation by incumbent users: (1/12)

1. formula:

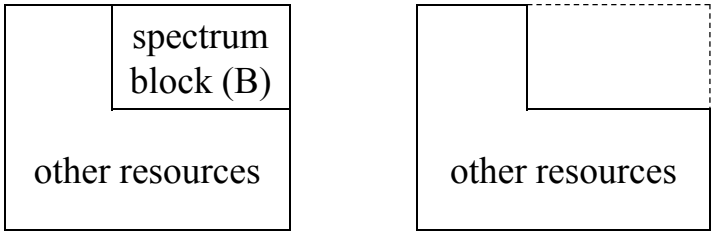
p_1 : the value of (incumbent) user with a spectrum block

p_2 : the value of the user without the block

The value of the block to the user:

$P_X^* = p_1 - p_2$

Figure IIIB.1: Business resources of X with and without the block B



A: With the block

B: Without the block

III. B. Spectrum valuation by incumbent users: (2/12)

2. example:

a. A telecom operator (X) uses spectrum block (B).

b. p_1 is the value of the operator X with B kept.

Remark: p_1 represents the total value of the returns to the operator X in the future.

III. B. Spectrum valuation by incumbent users: (3/12)

p_1 may be calculated

(1) by using the DPV formula with numerical forecasts of returns to X, or

(2) by relying on the insights of experts/executives as to the expected performance of X in the future, or

(3) by the total value of the (corporate) stocks as exhibited in the stock market.

III. B. Spectrum valuation by incumbent users: (4/12)

c. Suppose that X loses the right of using B, and that the "best" alternative is to shift to using optical fibre instead.

p_2 is the value of X without B but with optical fibre obtained.

III. B. Spectrum valuation by incumbent users: (5/12)

Remark: p_2 is the value of X without B.

When X loses (sells) B, there may be several options that X can take.

One may be to simply decrease the scale of X's operation by allowing some of X's customers to leave.

III. B. Spectrum valuation by incumbent users: (6/12)

Another may be to keep the operation of X at the same level as before by substituting some other means for spectrum (such as using optical fibre instead of spectrum or employing new technology for using spectrum more efficiently to cover the capacity of spectrum sold);

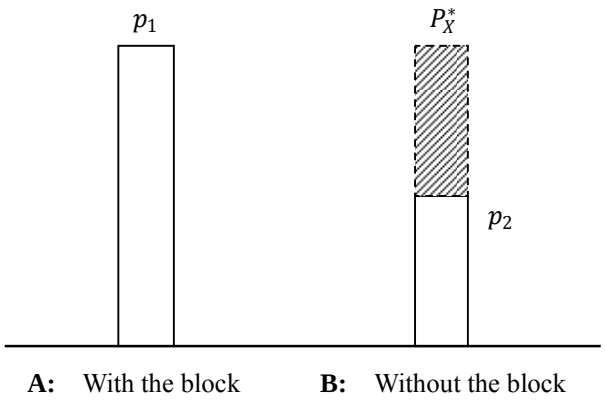
III. B. Spectrum valuation by incumbent users: (7/12)

in such cases, X will need to spend some amount for transfer. p_2 is the value of X without B, which is the sum of DPV of returns from X without B minus DPV of costs needed for X to shift from its business with B to that without B (but with, e.g., optical fibre).

III. B. Spectrum valuation by incumbent users: (8/12)

d. The value of B to X is $p_1 - p_2$, where p_2 is the sum of discounted future returns to X without B but with optical fibre plus once-and-for-all cost of shifting from B to fibre, including construction cost of fibre deployment, employee retraining cost, cost of losing customers (and customer confidence) arising from the shift to fibre, and others.

Figure IIIB.2: Value of X with and without B and the supply price of B by X



III. B. Spectrum valuation by incumbent users: (9/12)

3. implications to incumbent users:

The value of B: the **supply price** of B, the lowest amount of compensation for which X agrees to give up the use of B.

III. B. Spectrum valuation by incumbent users: (10/12)

4. expected behavior of incumbent users:

a. If a price above the supply price is offered for B, X will "sell" B. The higher the price used for a sale, the better off X will be.

III. B. Spectrum valuation by incumbent users: (11/12)

b. If X is asked to exhibit a price for B, X can choose any price above the supply price. (In other words, X can tell a "lie" with regard to the "true" supply price of B.) The chances of successful sale, however, will be lower, the higher the price offered by X.

III. B. Spectrum valuation by incumbent users: (12/12)

c. For a price lower than the supply price, X will never agree to give up B.

III. C. Spectrum valuation by potential users (1/13)

1. formula:

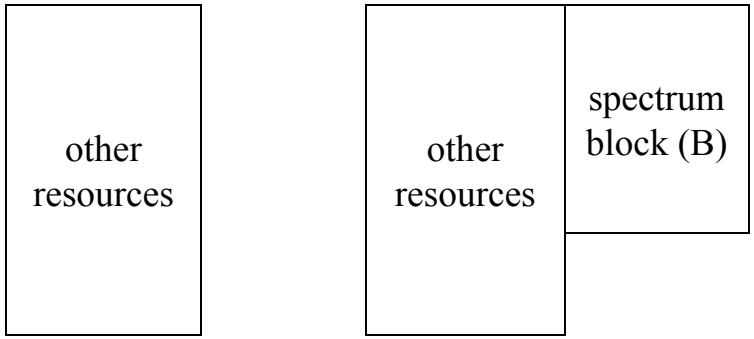
q_1 : the value of (potential) user without a spectrum block

q_2 : the value of the user with the block

the value of B to the user:

$$P_Y^* = q_2 - q_1$$

Figure IIIC.1: Business resources of Y without and with the block B



A: Without the block **B:** With the block

III. C. Spectrum valuation by potential users (2/13)

2. example:

a. A mobile operator (Y) intends to acquire spectrum block (B).

III. C. Spectrum valuation by potential users (3/13)

Remark:

In a typical case, Y has successfully developed new technology by means of which Y can provide new services (such as the 3rd generation mobile telephony) to customers if additional spectrum becomes available. Another case may be a wireless Internet service provider with new technology intending to expand its business by acquiring spectrum for this.

III. C. Spectrum valuation by potential users (4/13)

b. q_1 is the value of Y without B.

(q_1 may be represented by the market value of Y's stocks.)

III. C. Spectrum valuation by potential users (5/13)

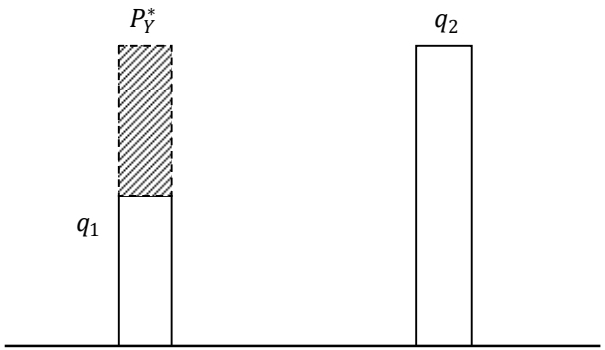
c. Suppose that Y obtains the right of using B, which will increase the value of Y.

q_2 is the value of Y with B.

III. C. Spectrum valuation by potential users (6/13)

d. The value of B to Y is $q_2 - q_1$, where q_2 is the sum of discounted future returns to Y with B.

Figure IIIC.2: Value of Y without and with B and the demand price for B by Y



III. C. Spectrum valuation by potential users (7/13)

3. implications to incumbent users:

The value of B: **the demand price**, the greatest amount of money for which Y agrees to pay for obtaining the right of using B.

III. C. Spectrum valuation by potential users (8/13)

Remark:

It is noted that the principle of deriving the demand price for spectrum as indicated above is analogous to that of deriving the supply price except that the direction of comparing the operator's value is reversed. In other words, spectrum pricing is symmetrical between incumbent and new users at the theoretical level.

III. C. Spectrum valuation by potential users (9/13)

In reality, of course, there is a great deal of difference between forming of a supply price and that of a demand price. A single most important factor may be risk and uncertainty accompanying Y's operation when it is of new category such as the case Y intends to use B to start a new service to customers with newly developed technology.

III. C. Spectrum valuation by potential users (10/13)

In many cases, as we know well, returns from such venturing operation are uncertain; the demand price for B has to be formed with risk factors. In calculating DPV, risk may be taken into account by increasing the discount rate. In short, therefore, the difficulty arising from the risk attached to future returns tends to lower the demand price for spectrum.

III. C. Spectrum valuation by potential users (11/13)

4. expected behavior of potential users:

a. If B is available to Y at a price lower than the demand price, Y will "acquire" B.
The lower the price used for such a trade, the better off Y will be.

III. C. Spectrum valuation by potential users (12/13)

b. If Y is asked to reveal a price for B, then Y can choose any price lower than the demand price. (In other words, Y can tell a "lie" with regard to the "true" demand price for B.) The chances of successful purchase, however, will be lower, the lower the price bid by Y.

III. C. Spectrum valuation by potential users (13/13)

c. For a price higher than the demand price, Y will never agree to pay for acquiring B.

III. D. Welfare and trade implications of spectrum valuation (1/10)

1. assumptions:

spectrum block B

P_X^* : the supply price of B to incumbent user X.

P_Y^* : the demand price for B to potential user Y.

III. D. Welfare and trade implications of spectrum valuation (2/10)

2. welfare implications:

a. If $P_Y^* > P_X^*$, then the sum of the value of X and that of Y combined will be increased by $(P_Y^* - P_X^*)$ if B is transferred from X to Y.

III. D. Welfare and trade implications of spectrum valuation (3/10)

Further, if B is "sold" to Y by X at a price p such that $P_Y^* \geqq p \geqq P_X^*$, then at least one (and possibly both) of the value of X and that of Y will be increased and neither the value of X or that of Y will be decreased.

III. D. Welfare and trade implications of spectrum valuation (4/10)

In short, welfare improvement is achieved by a transfer of B from X to Y both at the individual and the aggregate levels

(Pareto improvement =

increased efficiency of spectrum use)

III. D. Welfare and trade implications of spectrum valuation (5/10)

In reality, most of the spectrum blocks are being used inefficiently in the Pareto sense.

Reason (historical): Continuation of the old-time use of spectrum, formed when spectrum was not scarce.

III. D. Welfare and trade implications of spectrum valuation (6/10)

(increase in income by transfer of B: from Y to X)

$$= P_Y^* - P_X^*$$

(measure of efficiency improvement)

$$= 1.0 - \left(\frac{P_X^*}{P_Y^*}\right)$$

(measure of aggregate efficiency improvement)

$$= 1.0 - \frac{\sum P_X^*}{\sum P_Y^*}$$

III. D. Welfare and trade implications of spectrum valuation (7/10)

b. If $P_Y^* \leqq P_X^*$, then there is no possibility of welfare improvement.

III. D. Welfare and trade implications of spectrum valuation (8/10)

3. trade implications:

a. If $P_Y^* > P_X^*$, and if X and Y can agree upon a price p such that $P_Y^* \geqq p \geqq P_X^*$ for trading B from X to Y, then trade of B will take place.

III. D. Welfare and trade implications of spectrum valuation (9/10)

b. If $P_Y^* > P_X^*$, but X and Y cannot agree at a price p such that $P_Y^* \geqq p \geqq P_X^*$, then trade of B may not take place in spite of the possibility of welfare improvement to one or both of X and Y by trading B.

III. D. Welfare and trade implications of spectrum valuation (10/10)

c. If $P_Y^* \leqq P_X^*$, then there is no possibility of trading B from X to Y.

Designing a Mechanism for Reallocation of Spectrum with Incentive-based Pricing

IV. TRADE OF SPECTRUM BLOCKS BY DIRECT BARGAINING

IV. A. Notations: (1/5)

1. spectrum blocks and users:

spectrum block: B

incumbent (current) user of B: X

potential user of B: Y

IV. A. Notations: (2/5)

2. block prices derived from spectrum valuation:

supply price for B by X: P_X^*

demand price of B by Y: P_Y^*

IV. A. Notations: (3/5)

3. block prices used in bargaining:

price offered for B by X: P_X

price bid for B by Y: P_Y

IV. A. Notations: (4/5)

4. block prices used in actual trade:

price received for B by X: $\tilde{P}_X$

price paid for B by Y: $\tilde{P}_Y$

IV. A. Notations: (5/5)

5. bargaining periods: t

$t = 0$: initial period

$t = \bar{t}$: final period reached

$\bar{t}_X$: maximum bargaining period for X

$\bar{t}_Y$: maximum bargaining period for Y

IV. B. Overall view of trade possibilities

assumption: $P_X^* < P_Y^*$

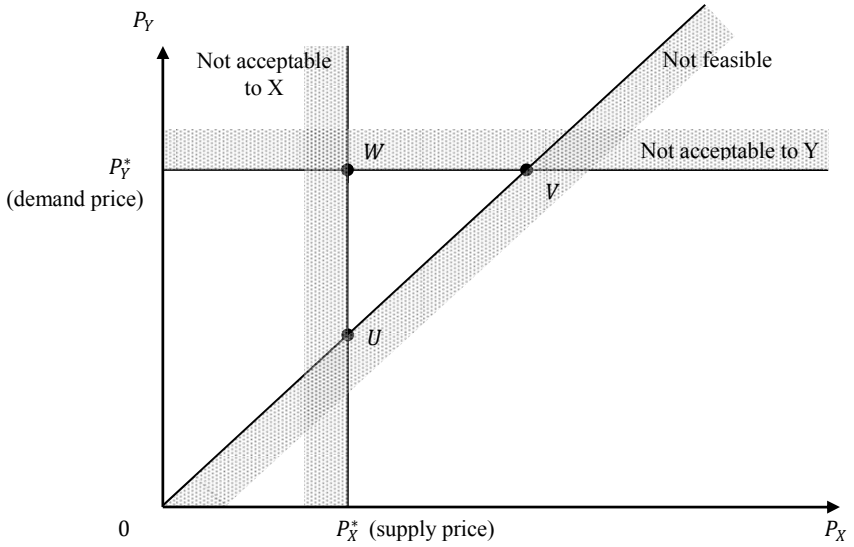
the range of successful trade prices $(\tilde{P}_X, \tilde{P}_Y)$:

$TR = TR(P_X^*, P_Y^*)$

$= \{(\tilde{P}_X,\ \tilde{P}_Y): P_X^* \leqq \tilde{P}_X \leqq \tilde{P}_Y \leqq P_Y^*\}$

$= \Delta WUX$ in Figure IVB.1.

Figure IVB.1: Trade prices of block B



IV. C. Assumptions (1/2)

1. incumbent user (X):

prices offered: $P_X(t) \geqq P_X^*$, for all t.

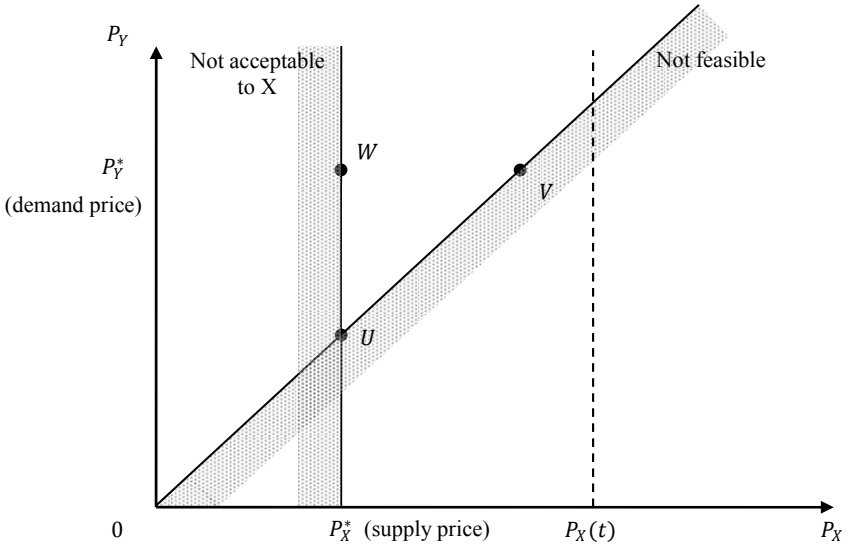
$P_X(0) \geqq P_X(1) \geqq P_X(2) \geqq \cdots$

information held by X when revising $P_X(t)$:

supply price P_X^*

other business conditions of X.

Figure IVC.1: Possible pricing of block B for trade as seen by X



IV. C. Assumptions (2/2)

2. potential user (Y):

prices bid: $P_Y(t) \leqq P_Y^*$, for all t.

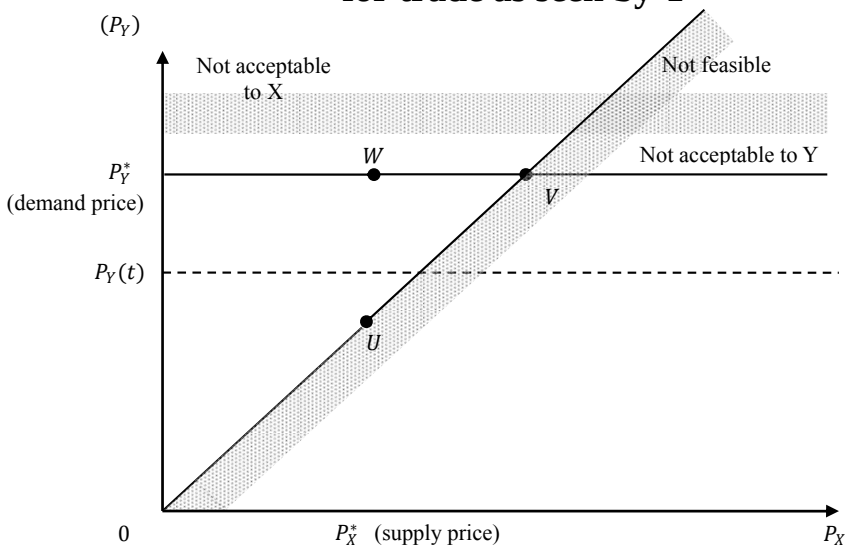
$P_Y(0) \leqq P_Y(1) \leqq P_Y(2) \leqq \cdots$

information held by Y when revising $P_Y(t)$:

demand price P_Y^*

other business conditions of Y.

Figure IVC.2: Possible pricing of block B for trade as seen by Y



IV. D. Bargaining Process (1/4)

1. let $t = 0$

   set $P_X(0), P_Y(0)$: initial prices

IV. D. Bargaining Process (2/4)

2. (main bargaining process)

   while $P_X(t) > P_Y(t)$, repeat a., b., and c.:

   a. revise $P_X(t)$ and $P_Y(t)$ into $P_X(t+1)$ and $P_Y(t+1)$, respectively;

   b. if $t \geqq \bar{t}_X$ or $t \geqq \bar{t}_Y$, then go to 4;

   c. let $t \leftarrow t + 1$.

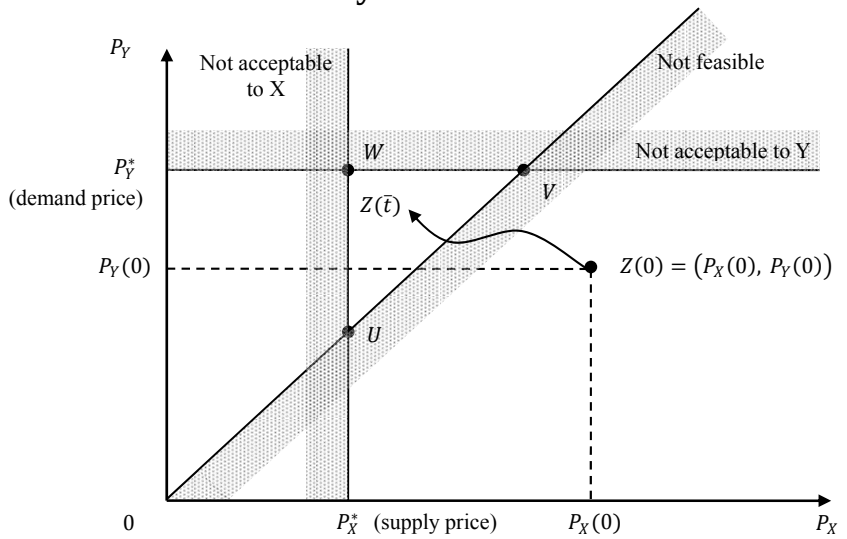
IV. D. Bargaining Process (3/4)

3. (successful trade prices reached:
   $P_X(t) \leqq P_Y(t)$)
   choose $\tilde{P}_X$ and $\tilde{P}_Y$ such that
   $P_X(t) \leqq \tilde{P}_X \leqq \tilde{P}_Y \leqq P_Y(t)$ according to a predetermined rule;
   go to 5.

IV. D. Bargaining Process (4/4)

4. (maximum trade period reached, no trade)
5. let $\bar{t} = t$;
   end.

Figure IVD.1: Example of bargaining by X and Y of block B



IV. E. Business conditions of incumbent and potential users (1/5)

1. incumbent user (X):

running business using B

with extra profits incl rent on B

business condition is good with accumulated profits

no urgent need to sell B

IV. E. Business conditions of incumbent and potential users (2/5)

2. new user (Y):

creating new business on starting new use of B

no extra profits accumulated

need to pay interests/dividends on newly prepared capital

urgent need to obtain B

IV. E. Business conditions of incumbent and potential users (3/5)

3. effects on bargaining:

a. maximum trade periods:

$\bar{t}_X > \bar{t}_Y$.

Y cannot wait for long as X can

IV. E. Business conditions of incumbent and potential users (4/5)

b. the rate of revising prices offered/bid:

$\hat{P}_X(t) < \hat{P}_Y(t)$, where

$$\hat{P}_X(t) = \left| \frac{P_X(t) - P_X(t-1)}{P_X(t-1)} \right| ,$$

$$\hat{P}_Y(t) = \left| \frac{P_Y(t) - P_Y(t-1)}{P_Y(t-1)} \right| .$$

Y revises prices faster than X does.

IV. E. Business conditions of incumbent and potential users (5/5)

c. likely outcome: no trade(!!)

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V. BLOCK STRUCTURE --- EXTERNAL ECONOMIES IN USING SPECTRUM BLOCKS

V. A. External economies (1/2)

1. notations:

individual block: A, B, C, …

group (of blocks): AB, ABC, CD, …

two or more (neighboring) blocks used jointly

value of blocks, groups:

V(A), V(B), V(AB), …

V. A. External economies (2/2)

2. external economies:

Let u and v be (neighboring) blocks/groups.

Then,

$$V(u) + V(v) \leqq V(uv),$$

Where uv is the group formed by u and v;

i.e., the value function is convex with regard to forming a group.

V. B. Examples: (1/3)

1. tree-type (hierarchical) grouping of blocks

a spectrum group is either

a block, or

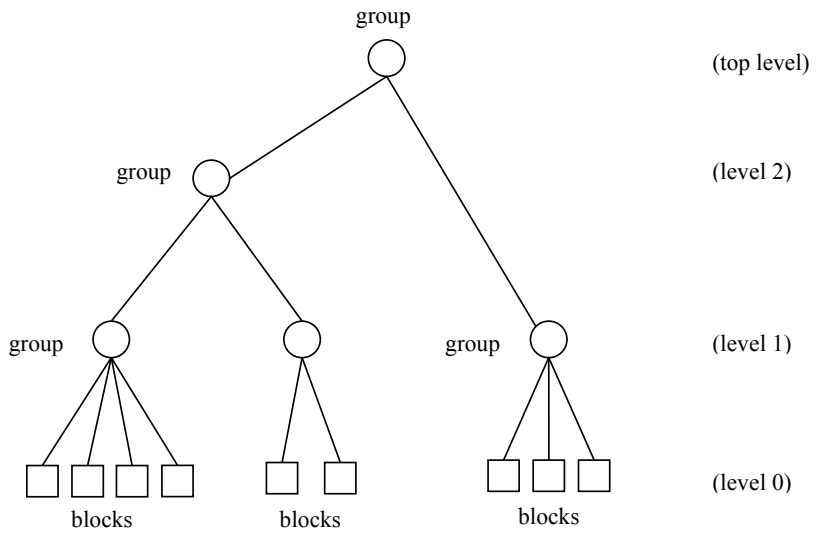
a collection of blocks, or

a collection of groups.

V. B. Examples: (2/3)

(may be defined mathematically as a *tree*, a subcategory of *graphs*, where end nodes (leaves) are spectrum blocks)

Figure VB.1: Spectrum Groups (Block Structure)



V. B. Examples: (3/3)

2. convex value function

Figure VB.2:
Value of blocks A, B and group AB

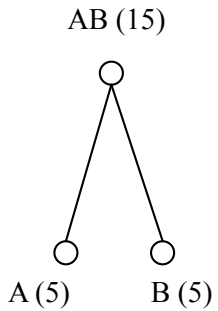
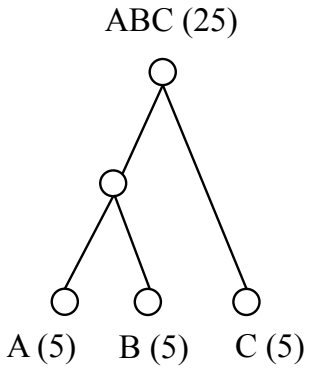


Figure VB.3:
Value of blocks A, B, C and groups AB, ABC



V. C. Implications of externality: (1/4)

1. **pricing of blocks/groups with externalities:**

   will increase the domain of objects for pricing greatly.

   may be handled by means of a computer.

V. C. Implications of externality: (2/4)

2. false pricing:

possible but limited by the convexity condition.

V. C. Implications of externality: (3/4)

3. effects on the behavior of incumbent and potential users:

externality itself affects both incumbent and potential users symmetrically.

V. C. Implications of externality: (4/4)

however, externality will increase the asymmetry between incumbent and potential users arising from their business conditions (→IVE).

Designing a Mechanism for Reallocation of Spectrum with Incentive-based Pricing

VI. CONVENTIONAL MARKET MECHANISM FOR SPECTRUM TRADE

VI. A. Assumptions: (1/3)

1. market is decentralized.

2. incumbent and potential users meet randomly in the market to form a pair of an incumbent user and a potential user.

VI. A. Assumptions: (2/3)

3. the two of a pair engages in bilateral bargaining.
   if the bargaining ends with successful trade, then the two will retire from the market;
   else the two will be separated and begin new random meeting to form a new pair.

VI. A. Assumptions: (3/3)

4. market will be closed at some time.

VI. B. Expected outcome:

Pareto-improving trade will be achieved but only to a limited extent. The overall economic state will remain suboptimal after the market is closed.

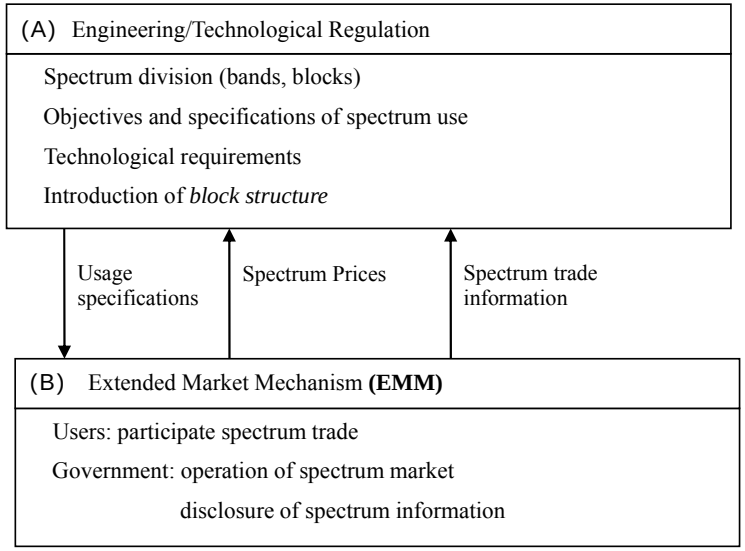
Designing a Mechanism for Reallocation of Spectrum with Incentive-based Pricing

VII. EXTENDED MARKET MECHANISM (EMM) FOR SPECTRUM TRADE

VII. A. Outline (1/2)

1. market is centralized and operated by government

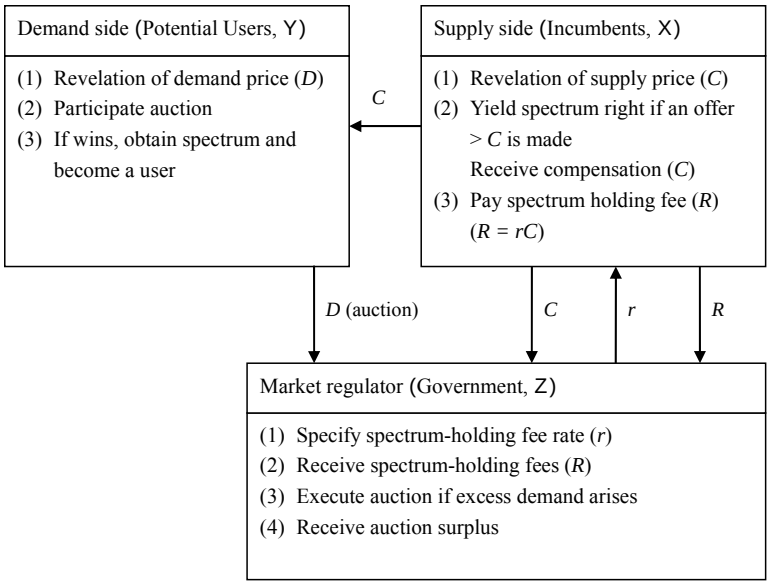
Figure VIIA.1: Division of public regulation of spectrum into two sections: (A) and (B)



VII. A. Outline (2/2)

2. incumbent users are asked to reveal their supply prices (false revelation is possible) and to pay spectrum holding fees

Figure VIIA.2: Organization of EMM



VII. B. Bill of spectrum rights and responsibilities (proposed) (1/5)

1. Spectrum is a property owned by the people collectively; the benefits of using, and the income from operating, spectrum shall therefore be attributed to the people.

VII. B. Bill of spectrum rights and responsibilities (proposed) (2/5)

2. Spectrum may be used exclusively by a user for an **indefinite period**; the right to use spectrum, however, is by no means permanent.

VII. B. Bill of spectrum rights and responsibilities (proposed) (3/5)

3. The user shall yield the right of using spectrum when requested by a party with a compensation which exceeds the amount declared by the user prior to such a request.

VII. B. Bill of spectrum rights and responsibilities (proposed) (4/5)

4. The user shall pay each year to the government a usage fee, which is equal to the product of the declared compensation and a fee rate to be specified by the government.

VII. C. Rights and obligations of incumbents (1/6)

1. Revelation of supply price (*c*) of each group (block)

c: the least amount of compensation for which incumbent agrees to yield the right of using the group

VII. C. Rights and obligations of incumbents (2/6)

2. Payment of spectrum usage fee (*R*)

$R = r\,C$.

C: the sum of *c*'s declared with top-level groups

r: (annual) rate of spectrum usage fee to be determined by the government

VII. C. Rights and obligations of incumbents (3/6)

3. Incumbents

may continue using a group
if there is no offer > *c*

must yield the block
if there is an offer $\geqq c$

VII. C. Rights and obligations of incumbents (4/6)

4. Determination of *c* by incumbents:

Incumbents tend to declare

a high *c* for continuing the use of a group

a low *c* for saving payment *R*

VII. C. Rights and obligations of incumbents (5/6)

tradeoff to incumbents

"holding up" a block or a group may be costly

VII. C. Rights and obligations of incumbents (6/6)

5. Who should be "incumbents"?

all users of spectrum

private, business, and government users

VII. D. Rights and obligations of potential users (1/4)

1. Obtain information of *c*'s and *C*'s

VII. D. Rights and obligations of potential users (2/4)

2. Make offers by showing
   demand price (*D*) for groups (blocks) chosen

VII. D. Rights and obligations of potential users (3/4)

3. If there is no competing offer,
   then potential user obtains spectrum right for paying *D*.

VII. D. Rights and obligations of potential users (4/4)

4. If there is a competing offer,

   then auction will be conducted on such groups

   winning potential user obtains spectrum right for paying *D*.

VII. E. Roles of government with EMM: (1/4)

1. **spectrum holding fee**
   a. determines a fee rate (*r*):

      to control the speed of reallocation

      resembles to determination of discount rate by central bank

   b. receives spectrum fees (*R*)

VII. E. Roles of government with EMM: (2/4)

2. market auctioneer

a. conducts auction for each group with $D > c$

use combinatorial auction (computerized)

bidding rule, stopping rule

VII. E. Roles of government with EMM: (3/4)

determines winning bids so as to maximize the total amount of bid price minus c

(= total surplus)

b. receives total surplus

VII. E. Roles of government with EMM: (4/4)

3. collection and dissemination of information

a. *c*, *C*, *D*, auction process, auction results

b. the state of spectrum rights:

registration

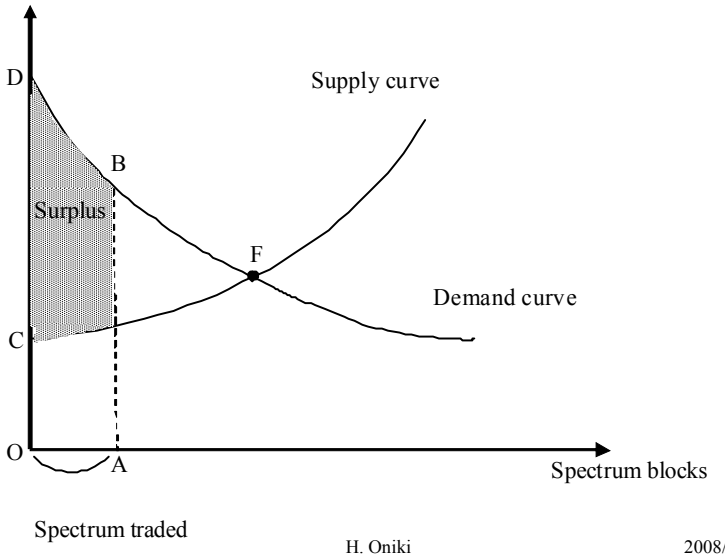
information disclosure

VII. F. Expected outcome from EMM:

Pareto-improving reallocations will be realized gradually step by step

speed of reallocation is controlled by *r*

Figure VIIF3: Spectrum trade expressed by means of "Demand and Supply" Curves



Designing a Mechanism for Reallocation of Spectrum with Incentive-based Pricing

VIII. APPLICATIONS AND EXTENSIONS OF EMM

VIII. A. Secondary (indirect) users of spectrum with EMM (1/5)

1. Commons users:

primary user:

commons administrator

secondary users:

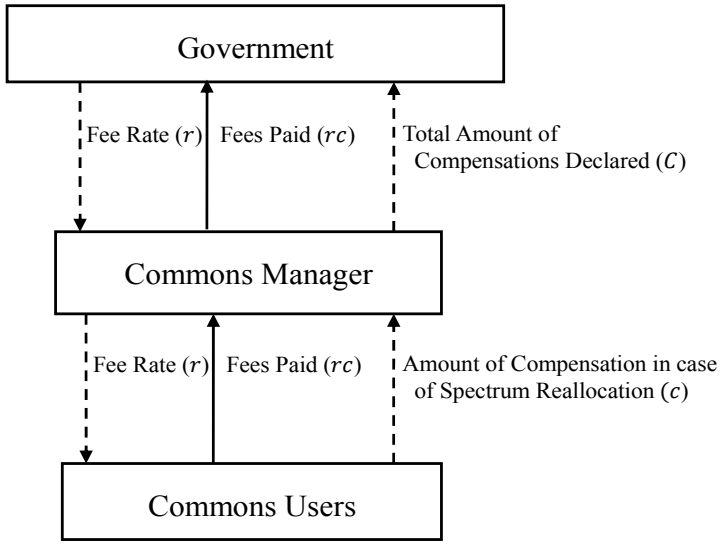
general users (the public)

VIII. A. Secondary (indirect) users of spectrum with EMM (2/5)

C: the sum of all compensations declared by the users

R: may be collected at purchasing a device for using a commons block (payment may be made together with that of insurance fees for breakage)

Figure VIIIA.1: Supply Price Revealed by Common Users



VIII. A. Secondary (indirect) users of spectrum with EMM (3/5)

2. Subscribers to service using spectrum:

ex.: mobile phone users

wireless internet users

primary user: providers, broadcasters

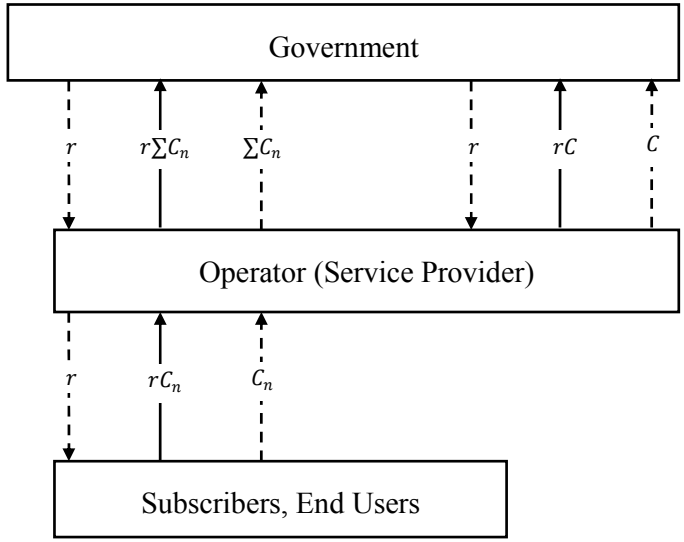
secondary users: subscribers, "users"

VIII. A. Secondary (indirect) users of spectrum with EMM (4/5)

C: the sum of compensations declared by the primary and the secondary users

R: may be collected by primary user from secondary users to remit to government

Figure VIIIA.2: Supply Price Revealed by a Service Provider and Subscribers



VIII. A. Secondary (indirect) users of spectrum with EMM (5/5)

3. Transition to DTV in the presence of EMM

would have been a case of reallocation of commons blocks under EMM

VIII. B. Introduction of reallocation as a forward trading, forward supply price (1/2)

EMM with timing of reallocation specified

ex.: reallocation x years after the current year

x = 1, 3, 5 and 10 years

c, C, D, r to be specified for each x.

EMM is applied for each x.

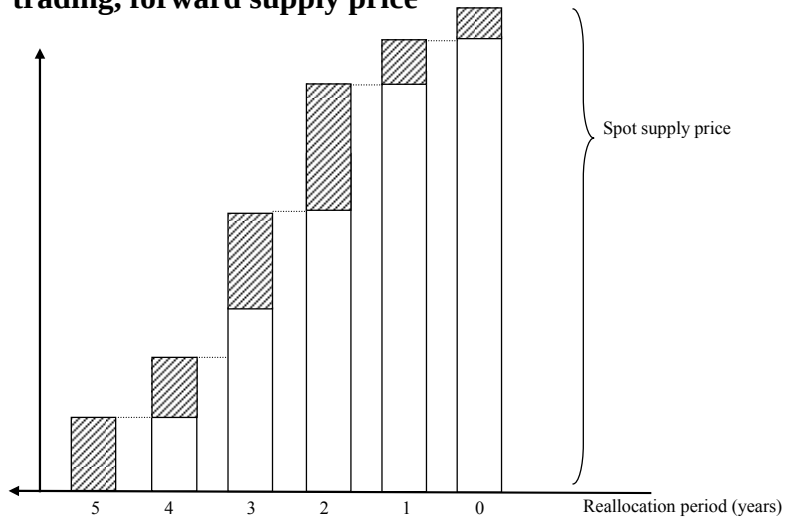
actual reallocation to be done in the year x.

VIII. B. Introduction of reallocation as a forward trading, forward supply price (2/2)

both incumbent and potential users

will be benefited.

Figure VIIIB. 1: Introduction of reallocation as a forward trading, forward supply price



Note : A shaded area denotes the increase in the supply price when the period of trade execution is shortened by 1 year.

VIII. C. Preventing speculation with EMM

speculation is possible on a strategically positioned block wrt externalities

regulation:

impose a penalty on a steep increase in *C*.

Figure VIIIC. 1: Example of truthful supply prices

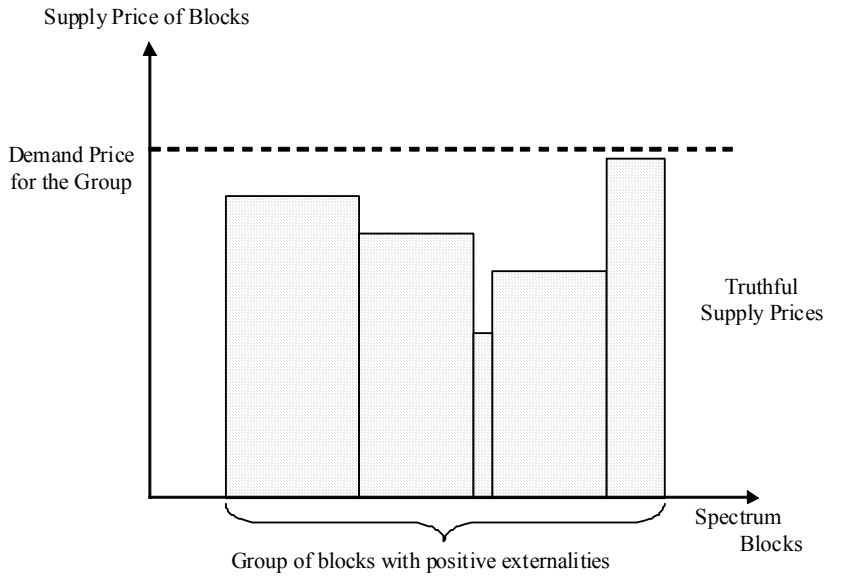


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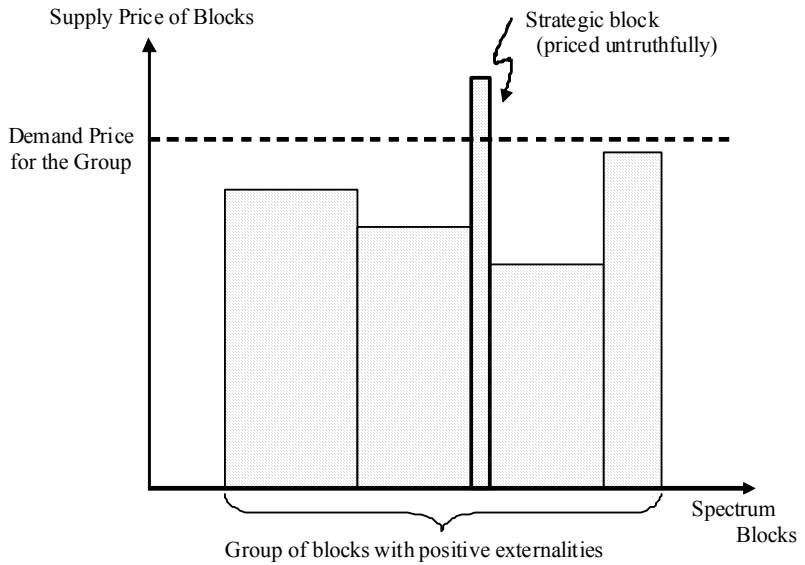
Figure VIIIC. 2: Examples of truthful and untruthful supply prices



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VIII. D. Transition from the current system to EMM

gradual transition is recommended

no "big bang"

set *r* at a level close to zero initially

increase *r* gradually thereafter

decrease the rate for current spectrum fees simultaneously

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Figure VIIID.1:
Proposed time path of spectrum–fee rate

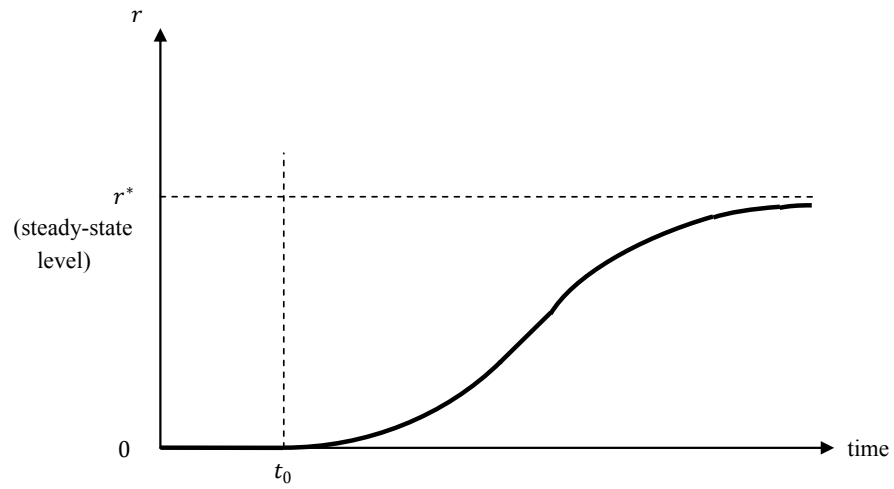

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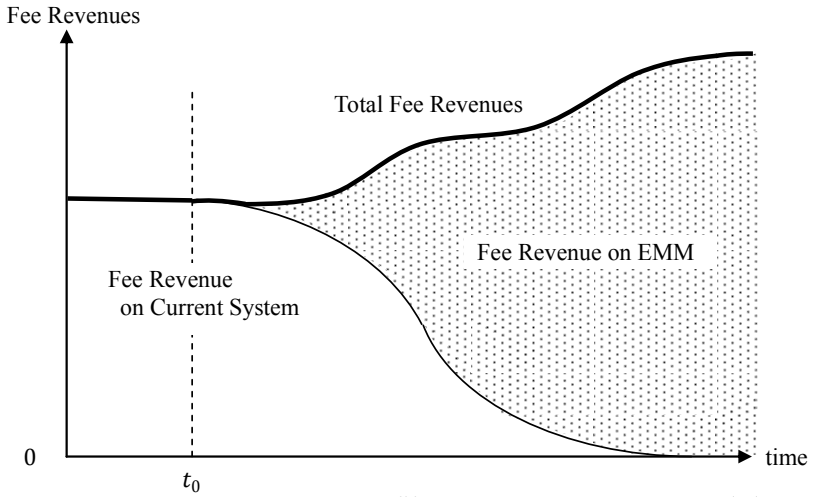
Figure VIIID. 2:
Expected change of spectrum-fee revenues



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