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

10 – 14 November, 2008, Bangkok

Hajime ONIKI
Osaka-Gakuin University, Japan
oniki@alum.mit.edu
www.osaka-gu.ac.jp/php/oniki/

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I. INTRODUCTION

I. A. Objective of this paper

incentive-based pricing (IBP)

of spectrum

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’

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

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

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

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

1. formula:

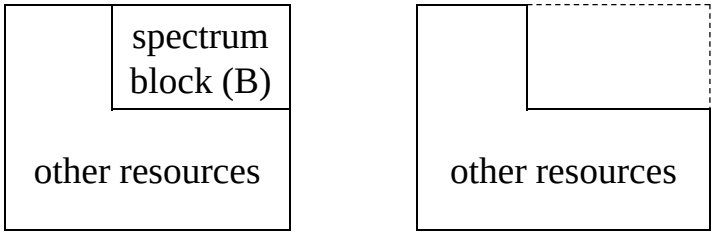
p_1 : the value of (incumbent) user with a spectrum block

p_2 : the value of the user without the block

The value of the block to the user:

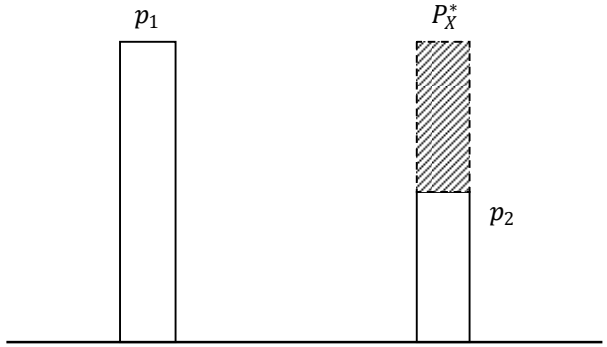
$$P_X^* = p_1 - p_2$$

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



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

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



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

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

1. formula:

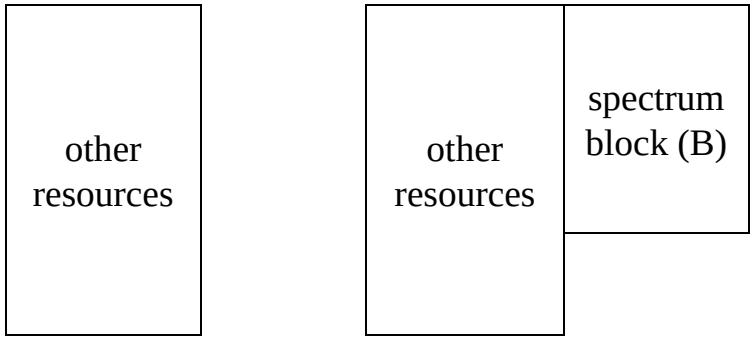
q_1 : the value of (potential) user without a spectrum block

q_2 : the value of the user with the block

the value of B to the user:

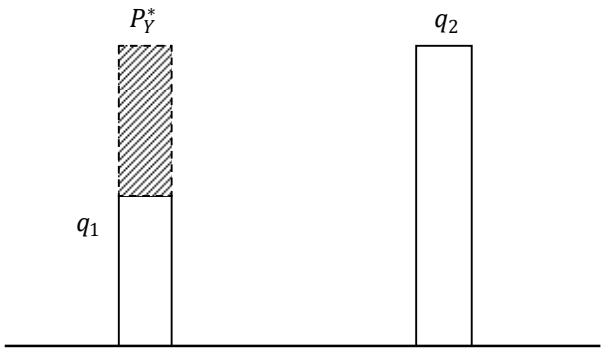
$$P_Y^* = q_2 - q_1$$

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



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

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



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

III. D. Welfare and trade implications of spectrum valuation (1/7)

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 (2/7)

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 (3/7)

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 (4/7)

In reality, however, 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 (5/7)

(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 (6/7)

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 (7/7)

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.

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IV. TRADE OF SPECTRUM BLOCKS BY DIRECT BARGAINING

Figure IVB.1: Trade prices of block B

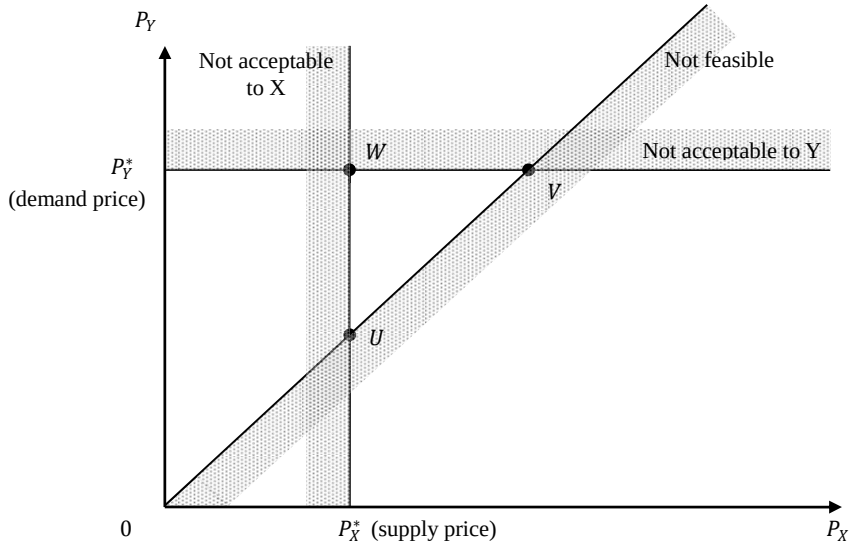
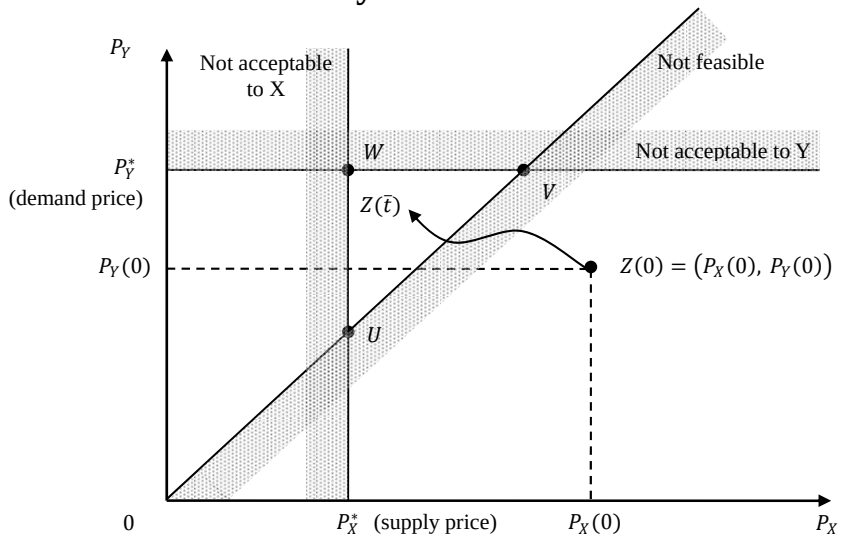


Figure IVD.1: Example of bargaining by X and Y of block B



IV. E. Business conditions of incumbent and potential users (1/4)

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 (2/4)

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 (3/4)

3. effects on bargaining:

a. maximum trade periods:

Y cannot wait for long as X can

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

b. the rate of revising prices offered/bid:

Y revises prices faster than X does.

c. likely outcome: no trade(!!)

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VI. CONVENTIONAL MARKET MECHANISM FOR SPECTRUM TRADE

VI. A. Assumptions:

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. 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.

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VII. EXTENDED MARKET MECHANISM (EMM) FOR SPECTRUM TRADE

VII. A. Outline (1/2)

1. market is centralized and operated by government

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

VII. B. Bill of spectrum rights and responsibilities (proposed) (1/4)

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) (2/4)

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) (3/4)

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) (4/4)

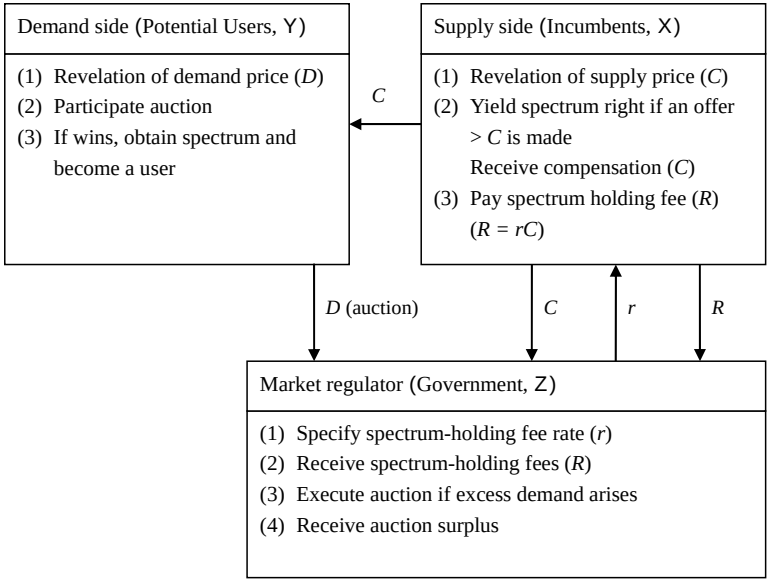
4. The user shall pay each year to the government a usage fee, which is equal to the product of the declared compensation and a fee rate to be specified by the government.

VII. C. Rights and obligations of incumbents

tradeoff to incumbents

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

Figure VIIA.2: Organization of EMM



VII. E. Roles of government with EMM:

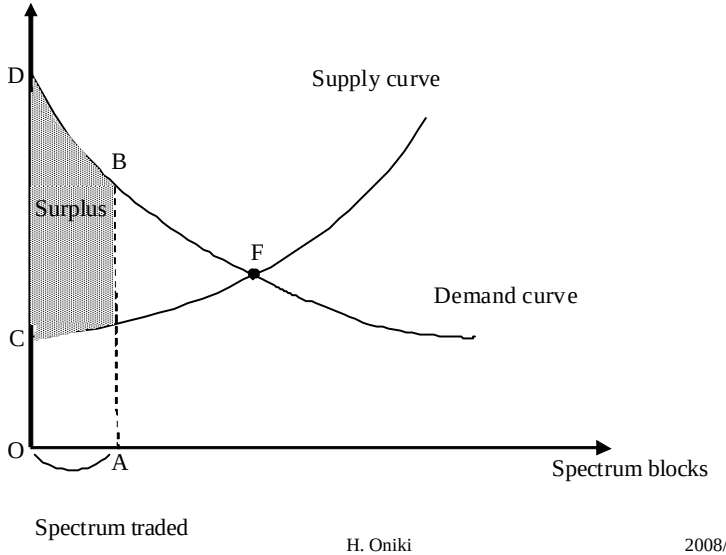
1. **spectrum holding fee**
   a. determines a fee rate (r):
      to control the speed of reallocation
      resembles to determination of discount rate by central bank
   b. receives spectrum fees (R)

VII. 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



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VIII. APPLICATIONS AND EXTENSIONS OF EMM

VIII. A. Secondary (indirect) users of spectrum with EMM (1/2)

1. Commons users:

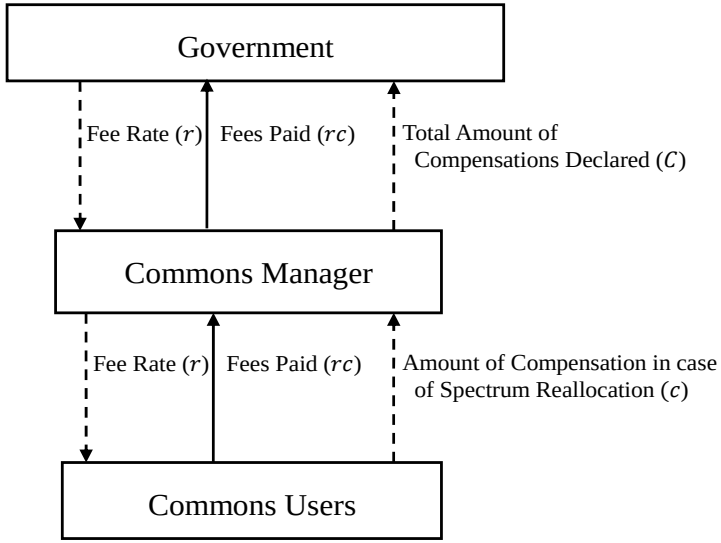
primary user:

commons administrator

secondary users:

general users (the public)

Figure VIIIA.1: Supply Price Revealed by Common Users



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

2. Subscribers to service using spectrum:

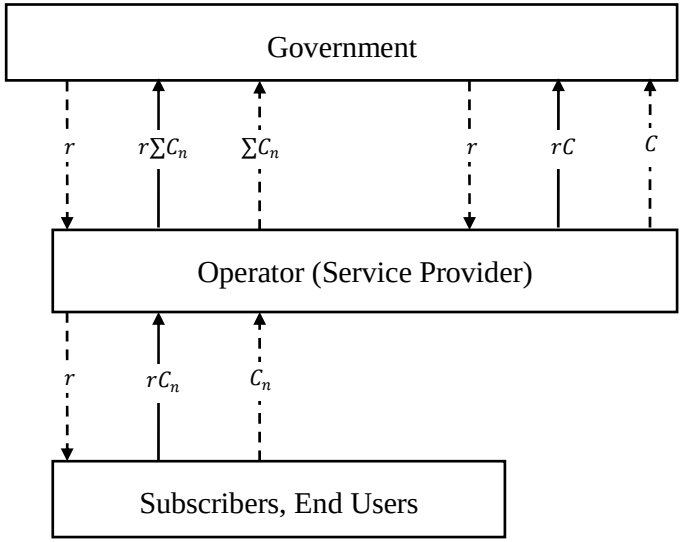
ex.: mobile phone users

wireless internet users

primary user: providers, broadcasters

secondary users: subscribers, "users"

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



VIII. B. Introduction of reallocation as a forward trading, forward supply price

EMM with timing of reallocation specified

ex.: reallocation x years after the current year

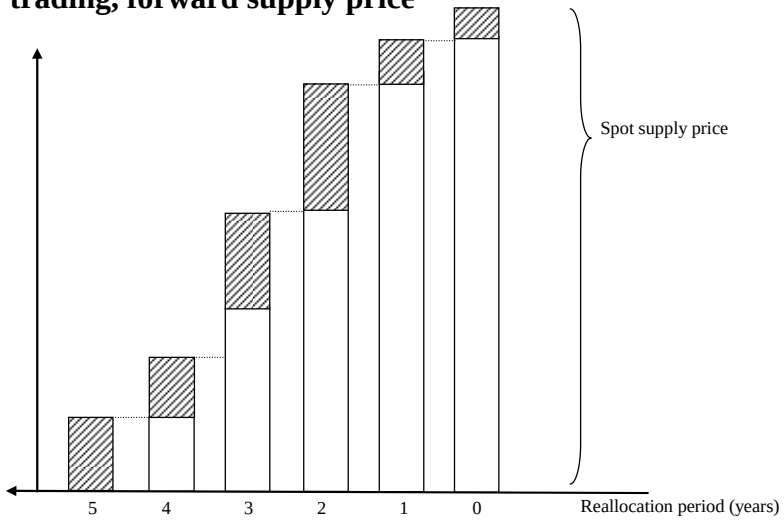
x = 1, 3, 5 and 10 years

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.

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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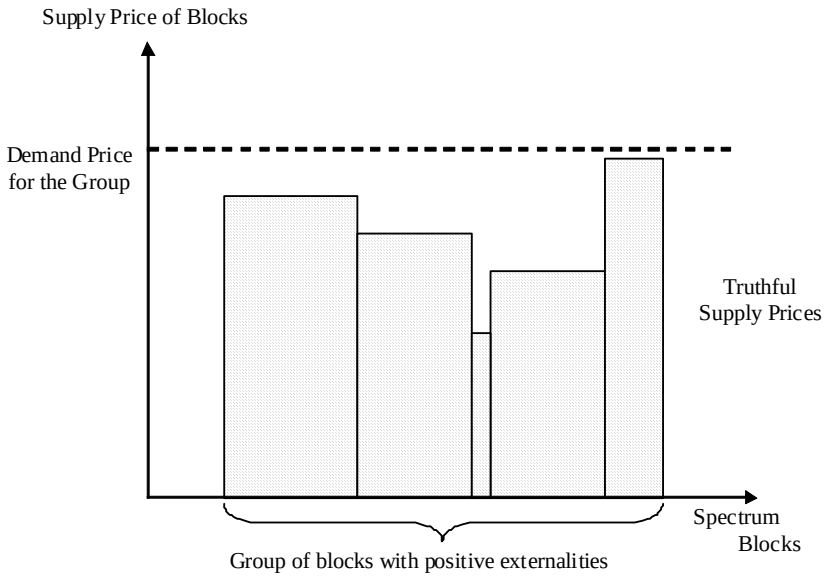

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Figure VIIIC. 2: Examples of truthful and untruthful supply prices

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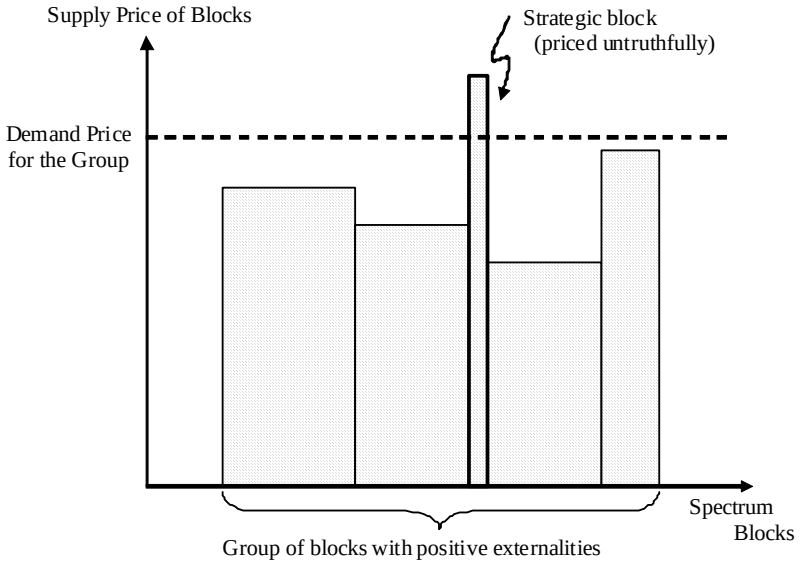

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VIII. D. Transition from the current system to EMM

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

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

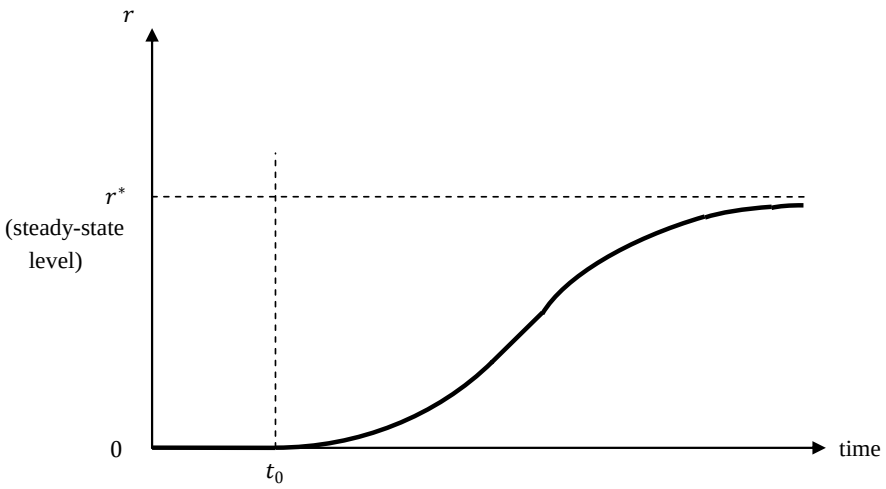

Figure VIIID. 2:
Expected change of spectrum-fee revenues