ACCESS PRICING: CASE OF UKRAINIAN ELECTRICITY DISTRIBUTION

by

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Abstract

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In vertically integrated industries such as electricity or telecommunications the efficiency of unbundling depends on regulation implemented down- or upstream. One of the examples when restriction of competition may be socially desirable is Ukrainian electricity supply. Using the model of Armstrong, Doyle and Vickers I found out that access charges to the grids of some local distribution companies in 1999 were lower than the efficient ones. This led to high dead-weight loss of social welfare. Moreover, for some of them low access charges allowed the entry of cost-inefficient firms leading to decrease in productive efficiency.

The new mechanism of access pricing should be implemented in Ukraine. Here a price cap could be the most suitable, since it leads to Ramsey pricing and therefore to the least market distortions from the first best. However, there is a need for more extensive discussion.

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GLOSSARY

Access pricing one of the ways of implementing fair access rules to bottleneck facilities that are aimed to improve economic efficiency by increasing competition in both downstream and upstream markets. (Valetti and Estach (1999))

Allocative efficiency when prices are set close to marginal costs.

Bypassing inefficient netw ork duplication as the result of high access charges.

Incumbent provider of the bottleneck facility

Independent suppliers electricity suppliers which are free to set their own retail prices

Fixed coefficient technology when one unit of access is required for one unit of final supply

Oblenergos local distribution companies in Ukraine

Productive efficiency when production conducted by the most cost-efficient firms

Vertically integrated industry when the bottleneck provider is operating in areas where firms from non-bottleneck sectors compete

ABBREVIATIONS

ADV Armstrong, Doyle and Vickers

ECPR Efficient component price rule. Access pricing methodology used in order to insure productive efficiency.

IRS Increasing Returns to Scale

CRS Constant Returns to Scale

NERC National Electricity Regulatory Committee, the Ukrainian electricity regulatory body

INTRODUCTION

Unbundling of telecommunication, electricity, railroad and other vertically related monopolistic markets brought competition in some sectors. However, other sectors are subject to natural monopolies and entrants need access to bottleneck facilities. For instance, as competition is allowed in electricity supply, new entrants will need access to electric grids and access price is price paid by the entrant for the right to use those grids. The role of access pricing is to optimize allocative and productive efficiency, that is to make sure that 1) products are offered at prices close to incremental costs of production and 2) firms entering the industry are cost- efficient. The problem of access is at the top of the agenda of regulators in many developed countries (e.g. USA, UK, Canada) but is quite new for the countries in transition.

My initial intention was to focus on the specific features of access pricing in transition economies. However, a review of the literature showed that this problem is quite similar in both developed (for e.g. United Kingdom) and transition economies (such as Ukraine), since many market distortions are similar and the process of liberalization in networks is fairy recent even for developed countries.

An important reason for studying access pricing is the fact that key issue for Eastern European countries is it is a necessary formal step towards admission to EU.

In Ukraine privatization in electricity supply started in 1995. However, cost-based methods of access charges design are still used and there is no or little discussion on determination of access rules. Access pricing is crucial for development of effective competition. As a case study I looked for access pricing in electricity distribution in Ukraine in 1999. I argue that methodology used for access pricing led to the access prices that are not optimal. Indeed, I found out that charges were much lower than the optimal ones. The estimated dead-weight losses are quite high relative to the level of regional industrial production. Therefore it may be more socially desirable to restrict entry.

I believe that the new mechanism of access pricing should be implemented in Ukraine. Here a price cap could be the most suitable, since it leads to Ramsey pricing and therefore to the least market distortions from the first best. However, there is a need for more extensive discussion.

The paper is organized in the following way. In Chapter 1 I give the basic understanding of access pricing, its importance in creation of the competitive market and discuss the reasons for regulatory interference. I look at access pricing in a contest of vertically integrated industry, one of the most popular and often used access pricing approach – the efficient component price rule (ECPR) and discuss its drawbacks. I used this approach for illustration by exploring access pricing practices in telecommunications in some countries. In Chapter 2 I describe distinctive features of Ukrainian electricity industry, Ukrainian access pricing methodology in electricity distribution and then my hypothesis. Then in Chapter 3 I describe basic empirical model for testing the hypothesis. In Chapter 4 I evaluate the optimal access charges and discuss the results of my analysis. Chapter 5 provides a short discussion of direction for further research from the view of the policy maker.

LITERATURE REVIEW

The literature related to the issue of access pricing represent the two main streams: how to regulate best (normative approach) and how it is regulated (positive approach). Normative approach is focused on the determination of welfare maximizing access charges by the well-informed regulator. For example, Laffont and Tirole (1994) concentrate on the case where prices for all activities of the vertically integrated monopoly, including the potentially competitive downstream activities, are subject to regulation. They consider the case of product differentiation with fixed coefficient technology, no bypassing and no market distortions. They use Ramsey pricing methodology, i.e. when access charges maximize the welfare and allow recovering total cost of providing the access which is usually subject to increasing returns to scale (IRS). Here higher prices are set for products with lower price elasticity and vise versa. The more generalized approach was proposed by Armstrong, Doyle and Vickers (1996), ADV. Their model allows setting optimal access charge in presence of market distortions such as non-optimal price set in the regulated final product market. However, for the case of product differentiation with fixed coefficient technology, no bypassing and no market distortions this general model produces the results identical to those of Laffont and Tirole (1994). Therefore, ADV's model could be viewed as the synthesis of Ramsey pricing and efficient component pricing rule (ECPR) proposed by Baumol and Sidak (1994). ECPR ensures entry of the most efficient firms and according to it access charges should cover direct and opportunity cost of providing access. It is the special case of Ramsey pricing and is optimal only under very stringent conditions. According to Domon (2000) ADV's model is just a reconsideration of opportunity costs used for ECPR. Both Ramsey pricing and ADV's model are static and require a lot of information and therefore is difficult to implement.

Positive approach studies the behavior of incumbent and entry firms under the implemented regulation in industries such as telecommunication, railway and electricity (e.g. Valetti (1999), Gabel and Weiman (1998), Riechmann (2000)).

This paper is in line with the positive approach studies. Here I consider access pricing in Ukraine electricity distribution as the part of the competition policy. Normative theory gives the benchmark, which could be used for estimation of competition policy efficiency.

Chapter 1

THEORY OF ACCESS PRICING

In a general context access pricing is one of the ways of implementing fair access rules to bottleneck facilities that are aimed to improve economic efficiency by increasing competition in both downstream and upstream markets. In the broader context, access pricing is related to the issues of competition policy: cross-subsidies, predatory pricing, non-pricing methods for foreclosure of rivals etc. (Valetti and Estach (1999))

In order to understand where access charges may occur let's consider the case of electricity distribution[1]. Local distribution company owns middle voltage grids (which are subject to economy of scale) and before deregulation was the only supplier of energy in the region. Deregulation allows competition in downstream activity, i.e. in electricity supply[2]. However, new suppliers need access to the grids of natural monopolist (see Figure 1). Access charge is the price that entrants pay for the usage of those grids.

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1 "Distribution business operates and maintains the assets which carry power from grid supply points to individual customers." (Electricity Association 2001 , p.16)

2 " The supply business covers the purchase of electricity in bulk through the wholesale market and sale of that electricity to customers" (Electricity Association 2001 , p.18)

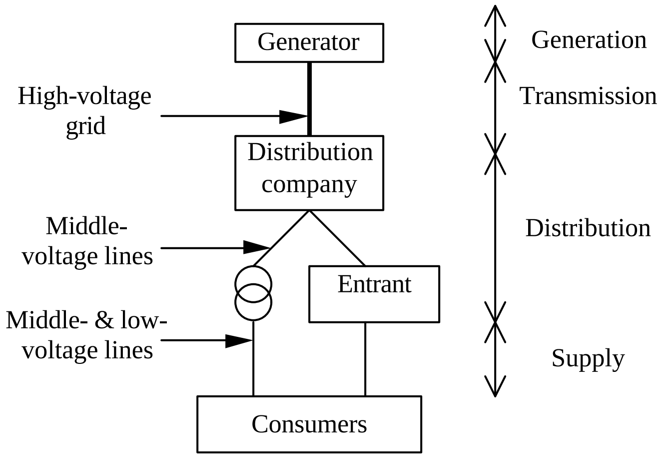

Figure1. Electricity industry: general framework

The role of access pricing can be summarized as follows:

1) Access pricing should encourage efficient entry to the market.

Competition is the way to increase allocative and productive efficiency, i.e. it brings prices closer to marginal costs and, at the same time, stimulates cost-minimizing production. In the case when previously monopolistic markets become opened to competition there is an incentive for monopoly supplier of the bottleneck facility to set high access charges or to use non-price methods of foreclosure of rivals. High charges prevent entry of more efficient firms. Therefore there is a need for regulatory interference. The regulator faces the dilemma, as there is a trade-off between allocative and productive efficiency. If access charge is too low then entrance of less efficient firms may occur. Therefore there is a need in optimal access price. Another trade-off the regulator faces is that he may want to preserve some cross-subsidization, what could be impossible if competition is allowed.

2) High charges set by the monopolist create danger of inefficient bypassing. Entrants may prefer to construct their own networks, which would lead to inefficient network duplication.

3) Access pricing policy should promote smooth transition to a competitive market (Alleman).
4) In the case of a natural monopoly with decreasing average costs (AC), the first best solution (marginal cost pricing) creates losses to the provider of the product. The most classical second best solution is to set price of the bottleneck that would cover the average costs of production. However, this raises some concerns. First, if there is the only producer of the service and he receives a price that covers his AC whatever they are, he has no incentives for cost minimization. Second, there is a question about who would bear future investment costs. Access pricing should allow the incumbent firm to cover its costs and earn reasonable rate of return on investments in order to send the right signals about future augmentation costs to the potential investors.

How should optimal access charge be defined?

The choice of approach depends on industry structure. Armstrong and Doyle (1995) consider five possible industry structures. However, I am interested only in the case of vertical integration, i.e. when the bottleneck provider is operating in areas where firms from non-bottleneck sectors compete. This is the case of distribution and supply in Ukraine, where distribution companies compete in electricity supply with other firms.

One thing should be noticed. "…Whenever possible, the use of access pricing as an instrument for promotion of too many goals should be resisted and other instruments should be used". (Valetti and Estach (1999), p. 23) Therefore, it is a good thing to focus on a single regulatory issue. I am going to concentrate on the promotion of entry in the case when regulators set cross-subsidies in pricing of the incumbent they regulate, since this was an issue for Ukraine in 1999. Actually, these two goals are incompatible, since efficient competition drives down prices for commodities that bring high profits, eliminating source of subsidy (Baumol, J. William (2001)).

The most famous, controversial and easy to implement is the efficient component price rule (ECPR) which is also known as the Baumol-Willing rule according to the names of its creators.

ECPR is the method used for determining access prices when prices of final goods are given (i.e. set by the regulator and not necessary at the optimal level). That is allocative efficiency is not affected by access charges. Therefore, the issue for regulator is to set access prices that would lead to productive efficiency. The optimal access charge is determined as the sum of direct and opportunity cost of providing access by incumbent. The opportunity cost for incumbent is foregone profit from selling the product on the final market himself.

$$a = c_0 + (p_1 - c_0 - c_1) \text{ or else } a = p_1 - c_1, \quad (1)$$

where p_1 is the price that the incumbent firm receive for the final good (the regulated price), a a is optimal access charge, c_0 is direct cost of providing access, c_1 is marginal cost of providing the component service in the final market. See also Figure 2.

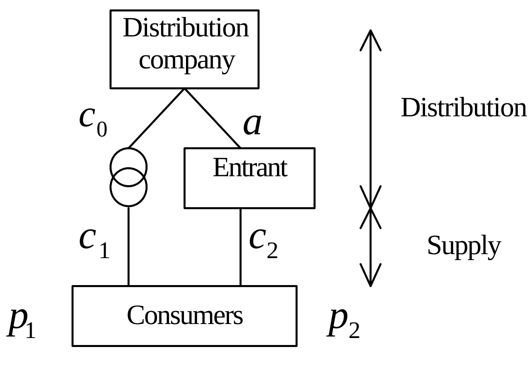

Figure 2. Vertically integrated firm: electricity distribution

ECPR insures that entry of more efficient firms occurs in the downstream market and that incumbent would receive revenues sufficient to cover its fixed costs.

This could be shown as follows

$$p_2 = a + c = (p_1 - c_1) + c_2 < p_1 \Leftrightarrow c_2 < c_1,$$

where p_2 is the price that the entrant firm receives for the final good, c_2 is the marginal cost of component service.

ECPR works under the following assumptions (Economides and White (1995)), which are consistent with the theory of contestable markets:

1) the final service provided by incumbent and by entrant are perfect substitutes,

2) entrant has no market power,

3) component service production technology is subject to constant returns to scale,

4) monopoly uses marginal cost pricing for the component service,

5) marginal cost of incumbent can be accurately observed and

6) demand for complement service is unchanged by entry (Economides (1995)).

If at least one of the assumptions does not hold then the entry of less efficient firm may be more socially desirable (Economides and White (1995)).

If all of these assumptions hold then a single, the most efficient firm would provide the component service. In this case, if the entrant is more efficient, then regulation of the incumbent's retail price becomes irrelevant, since the monopolist supplies only access. If the incumbent is more efficient, then there is no need to provide the access and the access charge is irrelevant (Laffont and Tirole (1994)).

Issue, which this model solves, is the entrance of firms more efficient than the incumbent firm occurs. ECPR has, however, several drawbacks:

1) Incumbent still has no incentive to minimize costs of providing bottleneck

2) This rule gives the monopolist the property right for monopoly rent (Gabel and Weiman (1998))

3) Ex post character of the pricing methodology. Undetermined retail pricing is crucial problem especially for industries in transition (Gabel and Weiman (1998))

4) No distinction between the market gained by the rival itself or "stalled" from the incumbent (Alleman (2001))

5) The development of substitute and complement services is not addressed (Alleman (2001)).

Regulatory implementations or access pricing in practice

The most popular method of pricing the access is to fully distribute costs (Laffont and Tirole (1994)). For example, to distribute the fixed costs of the bottleneck facility uniformly, the access charge is determined as follows:

$$p_0 = c_0 + \frac{k}{Q} \;;\quad p_1 = c_0 + c_1 + \frac{k}{Q} \;;\quad a = c_0 + \frac{k}{Q}$$

where k denotes the fixed charge and Q is the sum of quantities of bottleneck and final services provided by the incumbent and the final product provided by the entrant.

This accounting rule satisfies the ECPR.

ECPR was set in New Zealand telecom industry. This led to extensive discussion of the appropriateness of the ECPR (e.g. Economidies (1995)).

The ECPR is important. However, due to its drawbacks there is a need for access pricing approach that would work under more realistic assumptions. The so called UK group of economists (which consists of Mark Armstrong, Chris Doyle and John Vickers (ADV)) considered the welfare maximization problem which could be used for the case of imperfect retail pricing policy under more realistic cost and demand specifications than the ECPR. However, the description of their model I left for Chapter 3.

Chapter 2

Electricity industry performs vertically related services (such as generation, transmission, distribution, supply and metering). Some activities such as generation, supply or metering are subject to competition and others are not due to high costs of duplication and economies of scale. In order to implement competition in generation and supply reforms in energy sector led to unbundling of the industry both in developed and developing countries. The same had happened in Ukraine.

2.1 Power industry in Ukraine

The structure of the power sector in Ukraine is vertically unbundled. Restructuring and privatization were started in 1994 in order to increase productive and allocative efficiency by increasing competition and efficiency of management. Before that the experience of electricity reforms in other counties was intensively studied. It was found that the UK electricity reform of 1989-90 could be taken as the framework for Ukraine due to similarity of power systems of two countries (which are similar in size and structure of generation). (Lovei (1998))

However, the Ukrainian pool is differ from UK's in some distinctive features (Vovk (2001)):

1) capacity price is fixed and does not respond to fluctuations in electricity demand;

2) prices for generators are based on costs and controlled by National Electricity Regulatory Committee (NERC);

3) the marginal price in pool is based on prices of thermal power stations only;

4) the energy market is strictly regulated by the state;

5) generation and distribution is organized along regional lines.

After liberalization the Ukrainian power industry has the following structure[3] (see Figure 3):

Generation. Four joint stock generation companies operate the largest thermal power stations (TPS), two joint stock companies operate hydropower stations (HPS) and one generation company operates nuclear power stations (NPS). The state is the major owner of TPS, it has 100 percent of shares of HPS and NPS.

Transmission. High voltage network (of more than 220 kV) with length of 18000 kilometers is owned and operated by state company "Ukrenergo". It includes National Dispatch Center which is responsible for dispatch and control of the integrated energy system, and until recently included as a separate division the State Enterprise "Energorynok", which provided electricity market operation functions.

Distribution and supply. There are 27 joint stock companies (oblenergos) that own and operate low-voltage networks and some generation capacity in twenty-five oblast and two cities (Kyiv and Sevastopol). They supply electricity under the regulated tariffs. There are also many licensed independent suppliers. They purchase electricity on the wholesale market and supply it under unregulated tariff.

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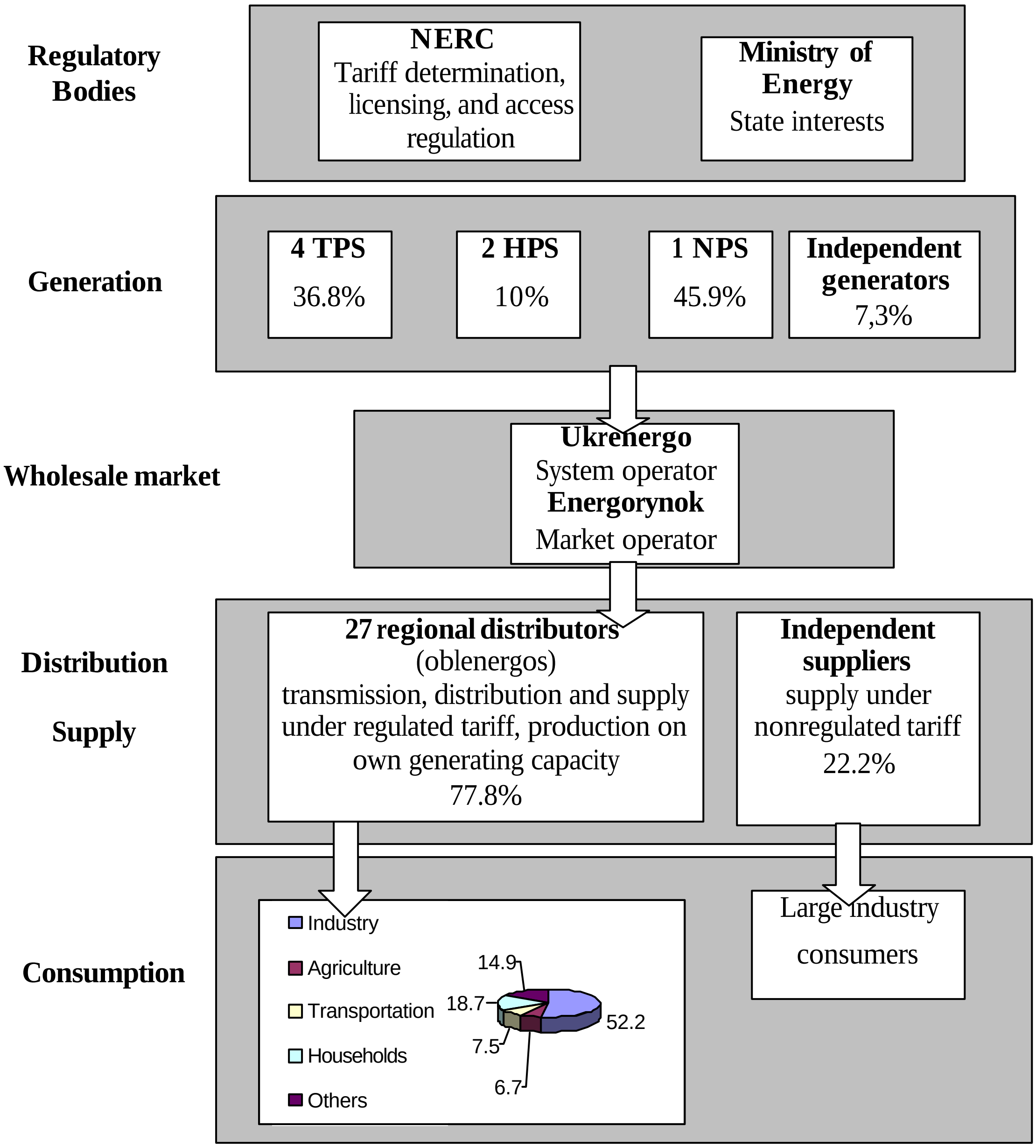
3 This description is according to information from Imepower (2000).

Figure 3. Ukrainian power industry[4]



[4] Source: author's design

Special rules and conditions of enterprise performance on the natural monopoly and adjacent markets, licenses for electricity generation, high-voltage transmission, low-voltage distribution, tariffs policy and access conditions are designed and provided by the National Electricity Regulatory Committee (NERC). Though it was initially created as independent regulatory agency, in reality it is subordinated to government and President.

Technical and financial operations on the wholesale market are mainly regulated in accordance with Wholesale Members Agreement.

Distinctive features of Ukrainian Electricity Market (Lovei (1998))

Ukrainian electricity market could be characterized by **"compromised" application of market rules**. The decisions about disconnection of non-payers, wholesale market price determination were raised to political level. Members of the governing body of the wholesale market were in most under control of Ministry of Energy, the representative of the state, and therefore were strongly influenced by the government policy.

There is a lag in the **privatization process** due to lack of privatization strategy. Besides, the privatization process could be thought as inefficient if we look at electricity losses and the level of cash payments for supplied electricity as the indicators of performance of privatized distribution companies. For example, electricity losses in low-voltage lines in the first half of 2000 were near 19.3% of transmitted electricity comparing with 4.4% in Germany and 7.7% in the United Kingdom. Most of these losses are so called commercial losses, which are mainly representing theft of energy. Decrease in consumption of electricity led to increase in costs of activities that are subject to IRS (such as transmission and distribution). This increase was so significant that it led to losses for some local distribution companies. This is one additional disincentive for potential investors.

In Ukraine, **industrial consumers subsidize households** (this is a distinctive feature: because households' electricity demand is less elastic than that of the industrial customers, therefore the former subsidizes the latter). The only exception is electricity supply. As I have already mentioned, one might expect that, as competition is allowed, entrants would come to the market at the expense of which the other market is subsidized. Not surprisingly, in Ukraine entry occurred to the electricity market for industrial customers. This also could be due to some other consideration, such as nonpayment.

In Ukraine as well as in other states of the former Soviet Union energy sector is characterized by long and intensive usage of **barter and other non-cash payments**. In 1999 level of cash payments was, on average, from 2.7% (Sumyoblenergo) to 25.3% (Kyivoblenergo) of electricity supplied. This led to intensive government control of cash payment discipline. In 2000 the level of cash payments reached 58.1%[5].

2.2 Access Pricing: the Ukrainian context

Access pricing for distribution is regulated by the Act of NERC 1 564, May 1998. According to the Act distribution tariff is set at the beginning of each year[6] and based on the forecasted total costs on distribution and forecasted volumes of electricity to be distributed. The "accounting" method is used due to its simplicity, familiarity, and "equitability" and because of practical difficulty of establishing optimal mark-ups over incremental costs (Armstrong and Doyle (1995)). The structure of accounting costs could be criticized for including not economically justifiable items, such as deprecation, some payments from profit and payments to state funds. Moreover, the Ukrainian accounting methodology

5 Ministry of Energy (2001)

6 Distribution tariff could be reconsidered during the year.

(which allows covering short-term total cost and includes some mark-ups) is not economically efficient. Not only it is allocatively inefficient, but also it doesn't provide incentives to minimize costs of the monopolist.

The Ukrainian access pricing could be expressed as[7]:

$$p_0 = (c_0 + \frac{k}{Q}) \ ; \ \ p_1 = (c_0 + \beta c_1 + \frac{k}{Q})(1 + \lambda) \ ; \ \ a = (c_0 + \frac{k}{Q})$$

where $\beta < 1$ is the coefficient stands to reflect the cross-subsidization (in Ukraine it is approximately equal to 0.4[8]), λ is the rate of return on costs and is usually positive and Q here is the sum of energy supplied by the incumbent and by the entrant.

As it stated in the Act 1 564, cross subsidizing encourages industrial customers to buy electricity from the regional suppliers and encourages regional suppliers to sell electricity to households. This is the rationale behind β .

λ reflects the policy of cross-subsidization, when industrial customers pay higher price for electricity consumed. This policy is inherited from the Soviet Union times. Besides, costs are usually overestimated from the economic point of view and also include items that indicate payment from profit (such as dividends).

After opening the electricity supply to competition a lot of new suppliers came into the market. Entry occurred in electricity supply to industrial consumers only and usually entrants sold at prices lower than that of incumbent. Therefore, there

7 Here I consider price for industrial customers, however, the formula is also appropriate for the households either, but in latter case β and λ would have different value.

8 Author's estimation.

is a question whether lower prices were due to higher cost efficiency or due to low access charge.

I hypothesize that access price for independent suppliers in 1999 was below the optimal level, allowing entrance for cost-inefficient firms (compared to the monopoly) and leading to market overcrowding.

Chapter 3

THEORETICAL MODEL

As a basic model for testing the Hypothesis I used the one proposed by Armstrong *et al.* (1996). In this model a) products provided by the incumbent and entrants are not necessary homogeneous, b) technology used by entrants need not be fixed coefficient, i.e. one unit of access is not necessary required for one unit of final supply and c) entrants are unable to supply access by themselves. However, I consider the case were products are homogeneous.

The model is a welfare-maximizing model with a two-stage game: first, incumbent determines the price of its final product and set access charge and then potential entrants decide whether to enter the market and, if they do, how to set their prices.

Let us assume that entrants are price-takers in a competitive market and set their price equal to marginal cost. Assume also that entrants have identical cost functions[9]. Therefore, we may consider these firms as if it were a single price-taking firm.

Let P and p denote incumbent's and entrant's prices, respectively. Let $v(P, p)$ be the consumer surplus. According to envelope conditions[10]

$$v_P(P, p) = -X(P, p); v_p = -x(P, p) \qquad (2)$$

9 Actually in general model there is no assumption on identity of cost functions of entrants but according to nested optimization model Armstong *at al.* (1996) also come to decision to consider the fringe of competitive firms which act as a single one.

10 Subscripts denote variable with respect to which the derivative was taken.

where X and x are demand functions for incumbent's and entrant's product. Assume that two final products are substitutes (not necessarily perfect), therefore $X_p \equiv x_P \geq 0$.

The profit-maximizing entrant with expenditure function e maximizes:

$$\pi(p, a) = \max_{s \geq 0} : ps - e(s, a) \qquad (3)$$

where s is final output of entrant and a is access charge.

According to envelope conditions:

$$\pi_p(p, a) \equiv s(p, a); \; \pi_a(p, a) \equiv -z(s(p, a), a). \qquad (4)$$

where $s(p, a)$ is the entrant's final product supply function, and $z(s, a) \equiv e_a(s, a)$ is the entrant's demand for access. Supply is increasing with output price and decreasing with access charge, i.e. $s_p \geq 0$ and $s_a \leq 0$.

In the equilibrium, given P and a which are fixed by regulator, entrant's supply is equal to demand at equilibrium price $\hat{p}(P, a)$:

$$s(\hat{p}(P, a), a) \equiv x(P, \hat{p}(P, a)). \qquad (5)$$

Equilibrium entrant's price is increasing in incumbent's retail price (since two final products are substitutes) and in access charge (since entrant's supply and access are complements).

Let $C(q, z)$ denote costs of incumbent of supplying q units of final product to its consumers and z units of access to entrant. The entrant supplies no inputs to incumbent. The profit of the incumbent is:

$$\Pi(P, a) \equiv P\hat{X}(P, a) + a\hat{z}(P, a) - C(\hat{X}(P, a), \hat{z}(P, a)) \qquad (6)$$

where $\hat{X}(P,a) \equiv X(P,\hat{p}(P,a))$ is incumbent's final product demand equilibrium, $\hat{z}(P,a) \equiv z(\hat{x}(P,a),a)$ is the equilibrium demand for access, where $\hat{x}(P,a) \equiv x(P,\hat{p}(P,a))$ is the entrant's equilibrium supply. The comparative static properties of these functions are:

$\hat{X}_a > 0$, i.e. the higher the access charge for entrant, the higher the demand for incumbent's final products;

$\hat{X}_P < 0$, i.e. the higher the retail price of the incumbent, the lower is the demand for its products;

$\hat{x}_a < 0$, i.e. the lower the access charge, the higher the demand for final products provided by entrant;

$\hat{x}_P > 0$, i.e. the higher the retail price of incumbent, the higher the demand for entrant's final products;

$\hat{z}_a < 0$, i.e. the higher the access charge, the lower the demand for access;

$\hat{z}_P > 0$, i.e. the higher the retail price for incumbent, the higher the demand for access.

The welfare criterion is the unweighted sum of the consumer surplus and total industry profits with the constraint for incumbent's profit being nonnegative. Lagrange multiplier $\lambda \geq 0$ is the shadow price for this constraint. Then maximization problem is:

$$W(P,a) = v(P,\hat{p}) + \pi(\hat{p},a) + (1+\lambda)\Pi(P,a)\,. \qquad (7)$$

Let $\theta = \dfrac{\lambda}{1+\lambda}$. Then the first-order conditions for *P* and *a* would be:

$$-(P - c_1 - c_0)\hat{X}_P - (a - c_0)\hat{z}_P = \theta \hat{X} \text{ and} \tag{8a}$$

$$-(P - c_1 - c_0)\hat{X}_a - (a - c_0)\hat{z}_a = \theta \hat{z} \tag{8b}$$

where c_0 is as usual incumbent's direct marginal costs of providing access to entrant and c_1 is incumbent's marginal costs of providing final product to consumers.

The first-best solution, which is $a = c_0$ and $P = c_0 + c_1$, given the break-even constraint (which implies $\lambda > 0$), is impossible to reach. However, for $P > c_0 + c_1$ the second first-order condition implies that $a > c_0$, so access price should be above marginal cost.

The general solution from the above first-order conditions is:

$$a = c_0 + \sigma(P - c_1 - c_0) + \frac{\theta \hat{z}}{-\hat{z}_a} \tag{9}$$

where

$$\sigma = \frac{\hat{X}_a}{-\hat{z}_a} > 0. \tag{10}$$

According to the terminology of Armstrong *et al.* (1996) σ is the "displacement ratio". The displacement ratio shows the effect of a small change in access charge on incumbent's final product sales relative to the change in incumbent's sales of access to the entrant.

The last term in the formula is positive and is so called Ramsey term, which indicates additional funds needed to cover the costs of providing access.

If break-even constraint is not an issue then $\theta = 0$ and access charge is simply

$$a = c_0 + \sigma (P - c_1 - c_0) \quad (11)$$

Adopting the model for Ukraine

1) Though final products of the incumbent and entrant are homogeneous, prices are not equal for two reasons: 1) retail price of incumbent is set by the regulator (and not at the level proposed by the above model) and 2) there is Bertrand competition among independent suppliers (since they are interested in attracting producers of very liquid goods or those clients which would pay for sure). So, I treat this price as given and do not optimize with respect to *P*.
2) Technology for entrants is not of fixed coefficient. It is due to losses of electricity that occur when electricity is transported through the grids.
3) Because of increasing returns to scale in electricity distribution entrants are unable to supply access by themselves.
4) As Armstrong *et al.* (1996) argue, when incumbent has an increasing returns to scale (IRS) technology, then the incumbent's break-even constraint should be binding at social optimum. However, in the case of Ukraine it is likely that regulation allows incumbent to earn profits because of tax revenue considerations and because it is interested in increasing attractiveness of regional distributors for privatization. Therefore, I considered constraint as not binding[11].

11 Anyway this produces the lower limit for access charge with which we may compare access charges existed in 1999.

Chapter 4

TESTING THE HYPOTHESIS

According to the model described in Chapter 3 the steps for testing the hypothesis are as follows:

1) estimate MC function of incumbent's electricity supply;

2) estimate MC of providing the access;

3) estimate demand function for final product provided by incumbent;

4) estimate entrant's demand for access;

5) estimate displacement ratio and

6) estimate the optimal access charge.

<u>1 and 2</u>. *Data description*

I assumed that some regional distribution companies have identical marginal costs. Therefore, for estimation of MC functions of providing the access and electricity supply I used panel data for 18 low-scaled oblenergos (with monthly supply of less than 450 thousand MW/h) out of 27 regional distribution companies[12] and for three months from December 1999 to February 2000.

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12 Data is not available for Poltavaoblenergo and Sumyoblenergo. It was reported that there is no independent suppliers in Kiev but they are in Kiev region, therefore I do not include Kievenergo in the sample. The rest of regional companies are different in scales, therefore, I grouped them in three groups (low-scaled, middle-scaled and high-scaled) and take the group, which include most of the companies (for details see FigureA1 in the Appendix).

Total costs were obtained from cost reports of regional energy suppliers (oblenergos) to NERC. I corrected these costs for depreciation and taxes that according to Ukrainian law are included in costs, since these accounting costs are not economic costs.

Quantities of supplied and distributed electricity are from the NERC.

Estimation

In order to estimate MC I used regression model for total cost function (Gujarati (1995)).

$$TC1_{it} = \beta_0 + \alpha_i + \beta_1 Q_{it} + \beta_2 Q_{it}^{\ 2} + \beta_3 Q_{it}^{\ 3} + u_{it} \qquad (12)$$

where *TC1* = total costs of incumbent's electricity supply, *Q*= electricity supplied (in thousands of MWh). I expected that following restrictions should be satisfied for classical U-shaped marginal cost curve:

1) β_0, β_1 and $\beta_3 > 0$,
2) $\beta_2 < 0$,
3) $\beta_2^2 < 3 * \beta_1 * \beta_3$.

However, the estimated coefficients of the cubic TC function are all insignificant. As the result I use the linear form. I also use random effects model because Hausman test shows that difference in coefficients is not systematic at 1.3% of significance. The estimated results are in Table 1.

Coefficient standing for fixed costs is low and insignificant at 20% level of significance. Fixed costs in electricity supply usually are low and they may be almost zero for the low-scaled production as they are in this case. However, they need not to be zero as the scale of production increase.

Fixed costs are in UAHs and operational costs are in UAN / MWh

As the result, marginal costs of chosen oblenergos in electricity supply are constant for any given level of production lower than 450 thousand MWh.

Table 1. Random effect GLS estimation of total cost functions

	TC1	*TC0*
Intercept	78528 (62.292)	703489** (2.0)
Q	1.306*** (0.249)	7.011*** (4.992)
R-Square overall	0.623	0.616
Observations	54	54

** and *** indicate 5% and 1% level of significance

Because of IRS in transmission in order to find incumbent's MC of providing the access I chose the linear form of total cost function:

$TC_{it} = \beta_0 + \alpha_i + \beta_1 Q_{it} + \varepsilon_{it}$ with expected $\beta_0, \beta_1 > 0$ (13)

Hausman test shows that difference in coefficients is not systematic at 1.3% of significance therefore I use random effects model.

Estimated results are in the Table 1.

R^2 is 0.616. All coefficients are significant at 5% significance level and with expected signs. Besides, as expected, fixed costs are quite high relative to the scale of production.

<u>3 and 4</u> In order to calculate displacement ratio I have to estimate demand function for electricity provided by the incumbent to the industrial customers and entrant's demand function for access. Though usually demand function for electricity is estimated in log-linear form (e.g. Berndt (1996)), I have to estimate the linear changes in demand for electricity provided by the incumbent to the industrial customers and in demand for access as access charge changes in order

to calculate the displacement (according to (10)). Therefore, I choose the linear functional form for both demands.

I estimated the following regressions:

$$Q_{it}^{I} = (a_{it}, P_{i(t-1)}^{ind}, Np_{i(t-1)}, D1, D2, GDP_{i(t-1)}) \text{ and} \quad (14)$$

$$Q_{it}^{e} = (a_{it}, P_{i(t-1)}^{ind}, Loss_{it}^{e}). \quad (15)$$

where i indicates region, t indicates time period. As the proxy for quantity demanded I use quantity of energy supplied to industrial consumers by the incumbent (oblenergo) (Q^I) for (14) and quantity of electricity bought by the entrant in the wholesale market and from the incumbent (Q^e) for (15). As the proxy for access charge (a) I use the tariff for electricity transportation paid by the entrant to incumbent for usage of incumbent's grids. P^{ind} is the incumbent's retail price for industrial customers, Np is the measure of level of nonpayment and nonmonetary payments for electricity supplied by the incumbent, *D1* and *D2* are the seasonal dummies (*D1*=1 for spring and 0, otherwise, *D2*=1 for autumn and 0, otherwise), *GDP* stands for industrial production and *Loss* is the total amount of expected electricity losses.

Intuition behind for the regressions is as follows:

1) Because retail tariff is determined by the incumbent according to the particular formula at end of each month I used the lagged value of retail tariff.
2) Access charge is set by the regulatory body, therefore, it is predetermined. Because of that access charges are taken for the current period.
3) I assume that the more is produced, the higher is the level of consumption and, therefore, the higher is demand for electricity. Past production level influences the enterprise decision of how much to consume in the next period, therefore, I use the lagged value of industrial production.
4) Electricity consumption is seasonal. Therefore, I use seasonal dummies. Since I have only data for three seasons there are two dummies, where base season

is summer. I expect that electricity demand is higher in autumn and spring than in summer. Therefore, expected signs are positive for dummy variables.

5) I expect that the possibility of paying in nonmonetary means when enterprises exercise the lack of liquidity as well as the possibility of electricity consumption without paying for it increases demand for electricity. Lagged value of *Np* is used because it reflects the expectations of consumers. This variable is specific for electricity demand function.
6) Losses of the previous period influence the entrant's decision about his electricity demand (demand for access). This is the specific variable that affects demand for access. I expect that there is a positive relation between the losses of the previous period and the access demand in the current period.

According to the model discussed in previous chapter I expect negative sign of coefficients before electricity retail prices and positive sign for access charges for incumbent's demand function and vise versa for entrant's demand for access function.

The good property of the model is that because of lagged values and predetermined access charges theoretically there is no endogeneity in the model.

Unfortunately monthly data for incumbent's electricity supply to industrial customers is not available. I assume that industrial and household's demand is not related, i.e. for example, increase in access charge or price of electricity for industrial customers does not lead to increase households' demand for electricity. Therefore, as a proxy for quantity of electricity demanded by industrial customers from the incumbent I use the total quantity of electricity supplied by the incumbent. I may do this because in the random effect models intercept absorb the deviation of households' demand between the regions. These deviations are fixed over time, since seasonal dummies control for seasonal changes in both households' and industrial customers' consumption.

Data description

I use panel data for 5 oblenergos[13] and 6 months of 1999 for (14) and data for 5 regions and 5 months[14] of 1999 for (15)[15].

Quantities of electricity supplied by the incumbent (in MWh), nonpayment (in thousands of UAH), nonmonetary payment (in thousands of UAH) and losses (in MWh) are from the NERC. Quantities demanded by the entrants (in MWh) are from magazine "Energobusiness". Access charges (in UAH/MWh) are available from the Internet. Actual retail prices (in UAH/MWh) were provided by oblenergos. All values in monetary terms I adjusted by the deflator of industrial production taken from the Ukrainian Economic Trends (1999).

For both regressions I may use random effect model because Hausman test for both regressions shows that difference in coefficients is not systematic at 1% of significance.

The results are as follows:

Table 2. Random effect GLS estimation of demand functions

	Q^I	Q^e
intercept	389743.1** (2.922)	58181.93* (2.682)
a	2370.439* (2.694)	-579.907*** (-3.776)
P^{ind}	-349.9612**	-264.632

13 Out of previously chosen 18 regional suppliers data is about prices is available only for Zakarpattjaoblenergo, Kirovogradoblenergo, Ternopiloblenergo, Hkersonoblenergo and chernigivoblenergo.

14 The data is available only for 5 months.

15 Because the number of periods is low, I expect that there is no autocorrelation problem in both regressions.

	(-1.619)	(0.155)
Np	8.189*** (10.192)	-
D1	25049.78** (1.991)	-
D2	-5679.25 (-0.533)	-
GDP	278.575* (1.811)	-
Loss	-	2.947** (2.504)
R-square (overall)	0.8715	0.597
Observations	30	25

*, ** and *** indicate 1%, 5% and 10% level of significance

Overall R-squares are quite high for both regressions.

All signs in first regressions are as expected (except for *D2*) and coefficients are statistically significant at 10% significance level. The seasonal dummy *D2* in the first regression is not statistically significant, i.e. I may not reject the hypothesis that coefficient before *D2* is 0. The fact that in autumn consumption does not differ much from that of summer could be explained by the fact that heating season usually starts in the second half of October.

In the second regression sign before the incumbent's retail price is negative, i.e. is not one the model predicts. The coefficient is also not significant, which could be explained by the fact that incumbent can not set prices lower than level set by the regulatory body, whereas entrants could sell at lower prices than this level. All other coefficients are significant at 2% level of significance and are of expected signs.

5. The displacement ratio could be obtained from the estimated regressions according to (10).

The estimated displacement ratio is 3.96.

Because estimated displacement ratio is more than 1, I expect that optimal access charges would be much more than those obtained according to the ECPR. In this case optimal access charges ensure cost-efficiency of entrants.

6. Regulatory body (NERC) sets the bounds for incumbent's retail prices which are available from the Internet. Taking the estimated displacement ratio as the same for 17[16] oblenergos and minimum retail prices it is possible to estimate the lower bound of the optimal access charges.

In the following table I put actual access charges, optimal access charges estimated according to (11) and those estimated according to the ECPR all for September 1999.

Table 3. Access charges: actual and estimated

Regional distributor	ECPR	a optimal	a actual	opt/act
Vinnytsiaoblenergo	47.59	167.90	40.79*	4.12
Volynoblenergo	56.39	202.79	37.02*	5.48
Zhytomyroblenergo	42.59	148.08	37.02*	4.00
Zakarpattiaoblenergo	50.29	178.61	41.80*	4.27
Kyivoblenergo	20.29	59.67	34.99	1.71
Kirovogradoblenergo	19.49	56.50	30.60	1.85
Krymenergo	33.69	112.80	41.67	2.71
Lvivoblenergo	36.39	123.50	37.15	3.32
Mykolaivoblenergo	37.99	129.84	40.79	3.18
Prykarpatiaoblenergo	35.59	120.33	37.02	3.25
Rivneoblenergo	29.19	94.96	37.02	2.56
Ternopiloblenergo	48.59	171.87	37.02	4.64
Khersonoblenergo	54.19	194.07	41.67*	4.66
Khmelnitskoblenergo	45.99	161.56	39.31*	4.11
Cherkasyoblenergo	21.79	65.62	34.23	1.92

16 There are no independent suppliers in Sevastopil, therefore Sevastopiloblenergo is not included.

Chernivtsioblenergo	37.79	129.05	39.31	3.28
Chernihivoblenergo	23.89	73.94	28.30	2.61

* states for actual access charges higher than those obtained according to the ECPR

Discussion of the results

As we might see from the above table, in September 1999 even given the minimum estimation level of optimal access charges, actual access charges were several times lower than the optimal ones.

There are two interesting aspects of the obtained results. First, since access charges are lower than the optimal ones, according to the model there should be a decrease in social welfare. Therefore, it may be interesting to estimate how significant this DWL is.

In the competitive downstream market electricity retail price equals to the sum of marginal cost of supply and access charge (Laffont and Tirole (1994)). I assume that entrants are as efficient as the incumbent (i.e. they have total cost function of supply similar to that of the incumbent). I also assume that because of competition, entrant's profit equals to zero. As the result according to (7) estimated DWL as the percentage of regional industrial production , for example, for Kirovograd region was approximately 7.3%.

Second, since the ECPR insures the productive efficiency[17], i.e. entry of cost-efficient firms only, and in 6 regions actual charges were lower than the minimum level of access charges estimated according to ECPR, i.e. they allowed the entry of cost-inefficient firms. However, in the case of Bertrand competition among the entrants only the most cost-efficient entrants may remain in the market.

17 It not need to be the efficient one. For example, here optimal access charges are lower than those under the ECPR, therefore, entry of cost-inefficient firms could be socially desirable.

Nevertheless, there are still some limitations: if, for example, the most efficient entrant is cost-inefficient comparing to the incumbent or if the production scale of the most efficient entrant is lower than the demand for its product.

Limitation of the results

1) Data limitations. Quantity of observations especially for demand functions is quite low and do not occupy all oblenergos discussed. Quality of data is also questionable. For example, for separating economic costs from the accounting, more detailed information is required.

2) One might think that what the regulator has to do after the reading of this paper is to automatically set the calculated access charges. However, estimated optimal levels correspond to inefficiently set electricity incumbent's retail prices. Therefore, there is also need for calculating the optimal access charges.

3) The model used in the paper is for market with the single product (for simplicity I considered the case for only one group of industrial customers). Though in reality it is the rare case. One way to improve the research is to use aggregated data about the industrial tariffs.

4) Costs for supply and distribution are not separated for industrial customers and households.

Chapter 5

POLICY IMPLICATIONS

Access pricing is crucial for development of effective competition and deviations from the optimal pricing could be costly for the society. Therefore, I believe that the new mechanism of access pricing should be implemented in Ukraine.

The best method of access pricing for differentiated products is Ramsey prising[18].

Ramsey prices are linear prices (i.e. one for each product) that allow covering average costs of multiple-product natural monopolist and at the same time minimize the deadweight losses in welfare (Viscusi, Vernon and Harrington (2000)). Therefore, Ramsey prices are viewed as second best solution. Ramsey prices are higher for products that have lower elasticity and higher for those that have higher elasticity. Mathematically rule for estimating Ramsey prices is as follows:

$$\frac{p_i - MC_i}{p_i} = \frac{\lambda}{(1+\lambda)}\frac{1}{\eta_i}$$

where p_i is the price of product i, η_i is so called supereasticity (which is price elasticity of demand for good i in final market modified to account for substitution possibilities among products and is smaller than the usual price elasticity) and λ is the shadow price of budget constraint (cost of public funds

18 Besides, both Armstrong *et al.* (1996) model of access pricing for differentiated products and Laffont and Tirole (1995) model provide Ramsey prices.

associated with distortion nature of taxation). In developed countries the latter is estimated at level of 0.3 and is higher the lower the efficiency of fiscal system (Valetti and Estach (1999)).

Another way to define Ramsey pricing is to cut output of all goods by same proportion until total revenue equals to total costs.

Problems with Ramsey pricing are distributional concerns (need for price discrimination could be difficult to implement legally), extensive information requirements and possibility of asymmetric information problem.

One way to solve these problems is to implement price cap regulation which leads to Ramsey pricing (Vogelsang and Finsinger (1979) cited in Riechmann (1998)). Besides, according to Beesley and Littlechild (1989) there is a strong reason for implementing price cap regulation in electricity distribution as privatization starts "given the potential productivity gains". Price cap regulation in electricity distribution is already set in the UK one of the most successful mover toward competition (see Figure 5).

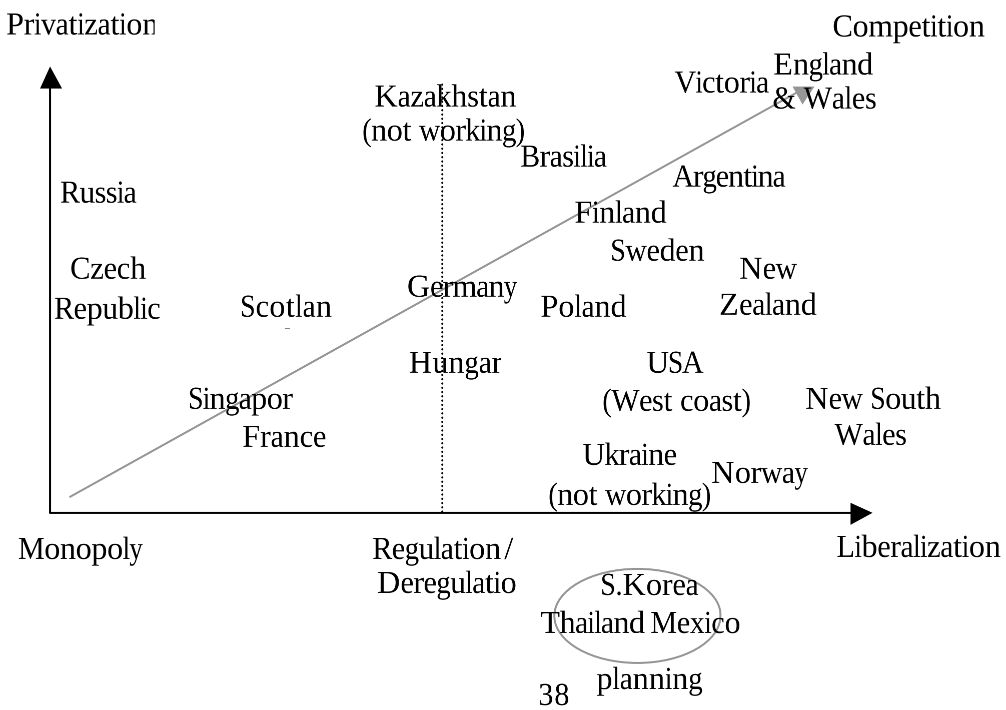

Figure 4. Efficiency of electricity reforms in different countries (Vovk (2001))

In UK in electricity distribution partial price-cap is used, i.e. regulator restricts the growth level of incumbent's revenue from access charges. This growth rate equals to retail price index (RPI) minus the X-factor – the expected growth in productivity of the incumbent. X-factor may be negative as it was initially set for UK electricity distribution. Therefore, aggregate revenue of the incumbent is predefined at the level of $\bar{R}$. In the simplest way price cap could be expressed as:

$$\sum_{i=1}^{n} a_i Q_i \leq \overline{R}$$

where i = 1,..,n indicates segment where access service is provided[19] and a_i is access charge.

In UK this approach is amended to the deviations in demand from the predetermined level (for example, due to changes in number of customers). The intuition behind this amendment is that total cost of access usually changes with demand for access, though not proportionally. For more details see Riechmann (2000).

By 1999 UK electricity retail prices for both households and industrial customers decreased by approximately 29% since privatization of industry in 1990. The interesting fact about UK electricity distribution price cap practice is that access charges set by the regulated incumbents were higher in those segments where

19 In UK segmentation is set according to customer size: those with the voltage level higher than 1MW, lower than 1 MW but higher than 100 kW and those with voltage level lower than 100 kW.

entrants had competitive advantages and where entry was more intensive (Riechmann (2000)). Therefore, higher access charges under price cap regulation seem to correspond to higher intensity of entry. However, this could be explained by entrant's strategic actions. Price cap mechanism sends signals to entrant's about future access charge decrease, therefore in order to gain market share entrants may decide to enter before access prices become lower.

Nevertheless, the applicability of price-capping as the way of promoting competition is the issue for further and more extensive discussion.

CONCLUSIONS

In my thesis I consider the case of access pricing in Ukrainian electricity distribution in 1999. The case is interesting as an example when restriction of competition may be socially desirable. I found out that actual access charges where lower than the optimal ones obtained according to ADV's model with predetermined retail price. Low access charges led to significant dead-weight losses in social welfare.

The second interesting aspect is that in some regions low access charges allowed for entry of cost-inefficient firms, which leads to decrease in productive efficiency. However, in the case of Bertrand competition this problem may be eliminated.

I believe that the new mechanism of access pricing should be implemented in Ukraine. Here a price cap could be the most suitable, since it leads to Ramsey pricing and therefore to the least market distortions from the first best. However, there is a need for more extensive discussion.

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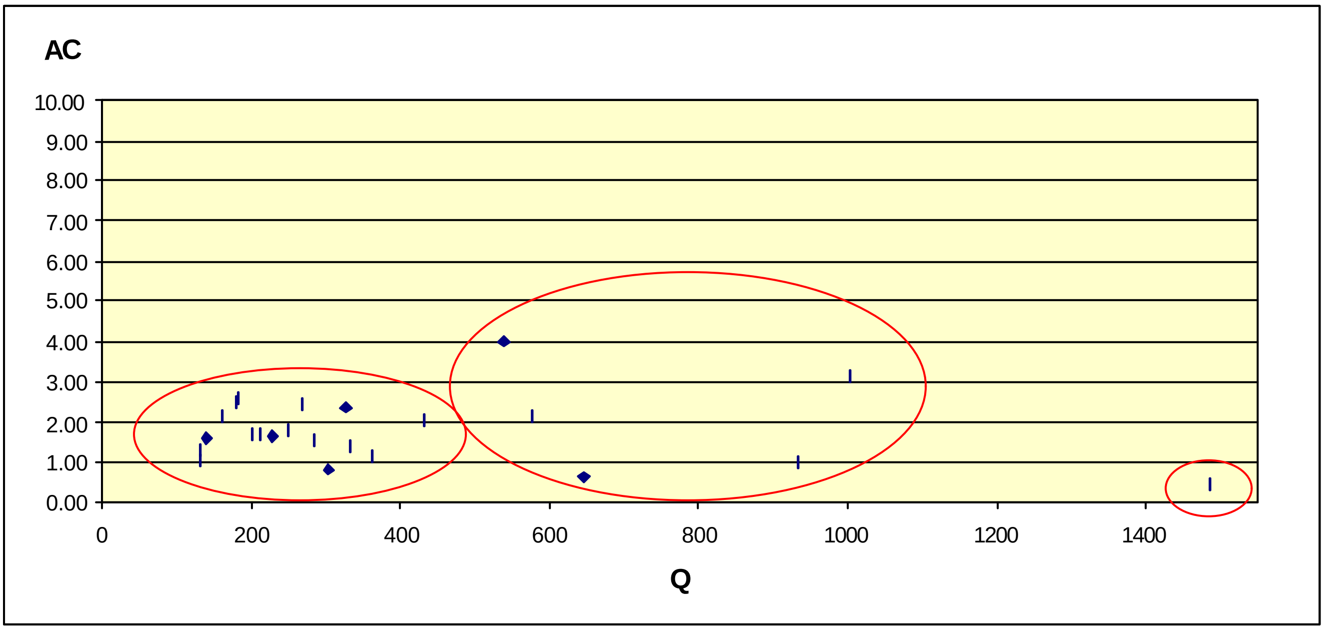
APPENDIX 1



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