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ANALYSIS AND MODELLING OF UKRAINIAN ENERGY SECTOR

This article is dedicated to the investigation of major mechanisms that define overall performance of power energy sector of Ukraine. Special attention is given to the examination of electricity consumption and import-export operations with electric energy.

1. Introduction

The Ukrainian energy industry is vital to the country's economy. This situation is partially due to high energy intensity of production; nevertheless, power energy sector still retains its strategic importance because of an extensive energy distribution network that Ukraine inherited after the dismantling of USSR. As a matter of fact, prior to the dismantling of USSR, Ukraine contributed to about 99% of total centralized distribution of power energy.

Surprisingly, within the context of general economic slowdown, production of power energy was less affected by economic crisis than other sectors of Ukrainian economy. Drastic worsening of an overall macroeconomic situation, naturally, has significantly affected energy industry. However, a 30-percent reduction of power energy production could not be compared to a huge decline in production, for example, in heavy and light industries.

Since independence, a lot of changes took place in Ukrainian energy sector. Among them are: privatization of energy generation facilities, significant accumulation of unpaid energy bills, introduction of independent operators in the energy resources market, and promissory notes circulation. These restructuring efforts and loans for international financial organizations, consequently, have brought the industry and its problems to the attention of businessmen and politicians in Ukraine and abroad. In this work the most acute problems of energy sector are indicated and formalized to ensure further analysis and recommendations to tackle existing bottlenecks of power energy sector.

2. Econometric modeling

Energy models are extremely wide spread in world practice of economic analysis. Each model relies on its unique set of assumptions and grounds on the elaboration of original methodological approach. All previously developed models, however, deal mostly with forecasting of electricity consumption. For that purpose, they have assumed that underlying economic system is institutionally stabile. This assumption, unfortunately, does not hold for Ukraine. Hence, it is necessary to develop own approach that will account for the peculiarities of a transition period.

The goal of our investigation is to examine major mechanisms that define overall performance of power energy sector of Ukraine. For that purpose we have selected several fields of research that can, to our mind, indicate main tendencies decisive for the operation of Ukrainian electricity industry. Among of them are: consumption of electricity (non-payments) and import-export operations with electric energy.

It is necessary to mention that we carried our calculations on the basis of quarterly observations starting from 1995 till 1999. Data were obtained from the State Committee of Statistics, Ministry of Power Engineering and National Electricity Regulatory Committee. T-statistics is indicated in parentheses.

2.1. Consumption of electricity

Regarding consumption of electricity, we can state that the most striking fact about the deliveries of electric power is the existence and accumulation of unpaid electricity bills. This problem applies to different group of consumers: population, industrial, non-industrial and agricultural consumers.

Average power rates for *industrial consumers* exceed rates established for other groups of consumers. This makes deliveries of energy to industrial enterprises profitable. However, the share of supplied energy that have been paid by industrial consumers is low and only small part of consumers is paying for electricity in cash. The same can be told about *non-industrial consumers.* This group of consumers is also characterized by poor payment discipline. The amount of their debt to (regional) energy delivering companies is significantly high and increases permanently.

Average rates for *agricultural consumers* hardly cover average costs of energy production. However, this market segment is characterized by sharply declining consumption of electricity and poor payment ability. At the same time, *transport companies,* are characterized by normal payment ability and high level of electricity rates.

Population is mainly the only source of receiving "real money" for delivered energy. But this advantage is aggravated by low level of average electricity rates, high level of commercial losses (unregistered energy consumption) and by presence of huge number of privileged consumers (about 70 % of total number of consumers).

As can be seen, non-payments define the amount of electricity consumed. Hence, for that purpose we have decided to estimated the dependence of the amount of electricity consumed on the level of electricity rates and the amount of arrears.

$$\log(D) = 10{,}956 - 0{,}202*\log(P) + 0{,}030*\log(A)$$
$$(14{,}025)\quad(-0{,}696)\qquad(0{,}34)$$
$$R^2 = 0{,}037 \qquad \text{DW stat.} = 1{,}71$$
$$\text{Adj. } R^2 = -0{,}112$$

$$\log(S) = 10{,}841 + 0{,}094*\log(P) - 0{,}103*\log(P_{coal})$$
$$(12{,}794)\quad(0{,}212)\qquad(-0{,}559)$$
$$R^2 = 0{,}047 \qquad \text{DW stat.} = 1{,}88$$
$$\text{Adj. } R^2 = -0{,}099$$

$$\log(D) = \log(S - NX),$$

where D — amount of electricity consumed, P — average electricity rate (in Hryvna), A — arrears (wage arrears and inter-enterprise arrears), S — supply of electricity, P_{coal} — price of coal (Hrn per 1 ton of coal), and NX — net exports of electric power.

The above system of equations was estimated on the basis of 16 observation (starting from the first quarter of 1995 and till the fourth quarter of 1998). Despite the number of observations is very low and model statistics indicates that the adequacy of estimated system is also low, we can derive some useful conclusions. We can see that with the expansion of arrears in the economy the amount of electricity consumed will also increase. It means that the amount of unpaid electricity bills will be generated proportionately to the amount of arrears existing in other industrial sectors. This result suggests that the expansion of non-payments within economy is self-supporting and in order to get rid of non-payments in economy as a whole, we have to stop the development of a "non-payments multiplier effect" (this issue will be discussed further in conclusions).

2.2. Balance of trade in operations with electric power

Prior to 1996, Ukraine have produced electricity in excess of domestic demand and exported it to the Eastern European countries, including Poland, Czechia, Hungary, and Slovenia. But already in 1996, it has exported to Poland and Slovakia only 4,4 bln kW*h of energy (that is $104 mln). The biggest part of exported electricity was exchanged for coal. Also exports to Bulgaria and Turkey has almost ceased during this period. Since 1991, export volumes declined from 593 mln kW*h to 123,6 in 1996. Despite this reduction in exports of electricity, it is still possible for Ukraine to restore its export capacities given a sufficient investment inflow to improve existing in Ukraine energy system.

Investigating the issue of import-export operations with electricity is extremely challenging because it can clarify mechanisms underlying this kind of transactions. Several aggregate indicators of imports and exports of electricity include technological systemic exchanges of electricity between neighboring energy systems. Therefore, these transactions cannot be considered as purely market operations: they (transactions) are guided by a quite different rational, such as, for example, temporary excess or deficit of electricity within the network.

However, we have adopted another approach and excluded part of imports and exports of electricity that corresponds to technical exchanges between energy systems. We have suggested that the amounts of imports and exports of electricity depend of the exchange rate:

$$M = 2755{,}71 - 93{,}23*E, \text{ and}$$
$$(4{,}88)\quad(-3{,}11)$$
$$R^2 = 0{,}47 \qquad \text{DW stat.} = 2{,}42$$
$$\text{Adj. } R^2 = 0{,}42$$

$$X = 2177{,}23 - 75{,}61*E,$$
$$(10{,}24)\quad(-6{,}70)$$
$$R^2 = 0{,}80 \qquad \text{DW stat.} = 1{,}63$$
$$\text{Adj. } R^2 = 0{,}79$$

where M — import of electricity, X — export of electricity, and E — exchange rates (Hrn/USD).

While estimating balance of trade, we have suggested that import-export activities can be examined as depending on the magnitude of exchange rates. As can be seen, this relationships appear to be strong (R^2 is enough high indicting the existence of relationship between factors). However, the sign of exchange rate variable in the "export" equation is negative instead of being positive. It means that as Hryvna depreciates, imports of electricity decrease but volumes of export should increase. While subtracting the first equation from the second one, we receive the following dependence of net exports on exchange rates:

$$NX = -578{,}51 + 17{,}62*E.$$

The above equation shows that with depreciation of real exchange rates net exports will rise.

3. Conclusions

The major problem of economic modeling of electric power sector is to define whether this system is demand- or supply-driven. We have met a lot of

arguments defending each point of view. As we have seen, demand-supply approach adopted at the first stage of our estimations indicates that the adequacy of a market model is very low ($R^2 = 0,037$ and $R^2 = 0,047$ for demand and supply equations, correspondingly).

Despite the low adequacy of estimated model, we can draw some useful conclusions. First of all, expansion of arrears in economy causes the amount of electricity consumed to increase. It will lead to the acceleration of unpaid electricity bills. Hence, in order to stop the expansion of arrears, we have eliminate them legally. To do this, we can adopt different strategies, such as, for example, mutual cancellation of debt and barter transactions.

Regarding the balance of trade in electricity, it was shown that the depreciaiton of Hryvna will cause net exports of electricity to rise. As a result, external economic positions of Ukraine will improve significantly. With this respect it appears unreasonable to conduct a policy of exchange rate corridor, adopted by the National Bank of Ukraine. Liberalization of exchange rates allows growing net exports of electricity, improving external (trade) balance and increasing GDP of Ukraine.

We expect our research on the performance of Ukrainian electricity sector to be useful for the conduction of economic analysis in this field. Economic theory and econometric methodology quided our investigation leading us to valuable conclusions. Hence, we hope that this subject will be examined further in order to indicated whether economic reforms in Ukraine follow its right track.

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АНАЛІЗ І МОДЕЛЮВАННЯ ЕНЕРГЕТИЧНОГО СЕКТОРА УКРАЇНИ

Стаття присвячена дослідженню споживання електроенергії та експортно-імпортних операцій з електроенергією.