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Modelling of resource flows in the Coal industry of Ukraine

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SUMMARY

The mechanism for Ukrainian coal mining industry`s sustainable development management has been formed as a result of the study. It has been proved that balancing mining, production of coal raw materials and their subsequent use in the production processes are the ways to ensure rational use of coal resources of Ukraine. The processes for coking coal is metal production, and for anthracite - thermal energy production. Relationship between growth rates of coking coal mining and production, coke mining, exports and imports of coke and ironmaking during 2008-2017s have been studied. It has been demonstrated that imports of coking coal essentially depends on the market pricing and has little to do with the needs of the metallurgical industry of Ukraine. It has been shown that the system for rational use of coking coal`s capacity in Ukraine should include balancing flows of coal mining, coke and semi-coke mining according to the needs of national metallurgical industry, taking into account cyclical nature of its development. The necessity of coordinating the volumes of anthracite extraction, production and consumption and taking into account short cycles of heat power development has been defined.

Introduction

Total resources of coal in Ukraine are 112,3 billion tones, proved coal reserves – 51,9 billion tonnes, including 17,1 billion tonnes of coking coal (30,5 %) and 7,6 billion tonnes of anthracite (13,5 %). Reserves of coking coal and anthracite amount to 31,5 % and 14,3 % of total resources of coal in Ukraine. However, there is a need to develop system of rational treatment for this important mineral. Therefore, the problem of developing effective coal management system in Ukraine based on optimization of resource flows for mining, use, export and import of coal in Ukraine based on their interconnection needs to be solved.

Method

In the analysis, general-scientific methods (analysis and synthesis, induction and deduction) and special methods of phenomena and processes analysis (abstraction, econometric and econometric-mathematical modeling) have been used.

Results

The study of correlation between coking coal mining and production growth rates, coke production, export and import of coke, cast iron production during 2008–2017s has been carried out. The results are presented in Fig.1.

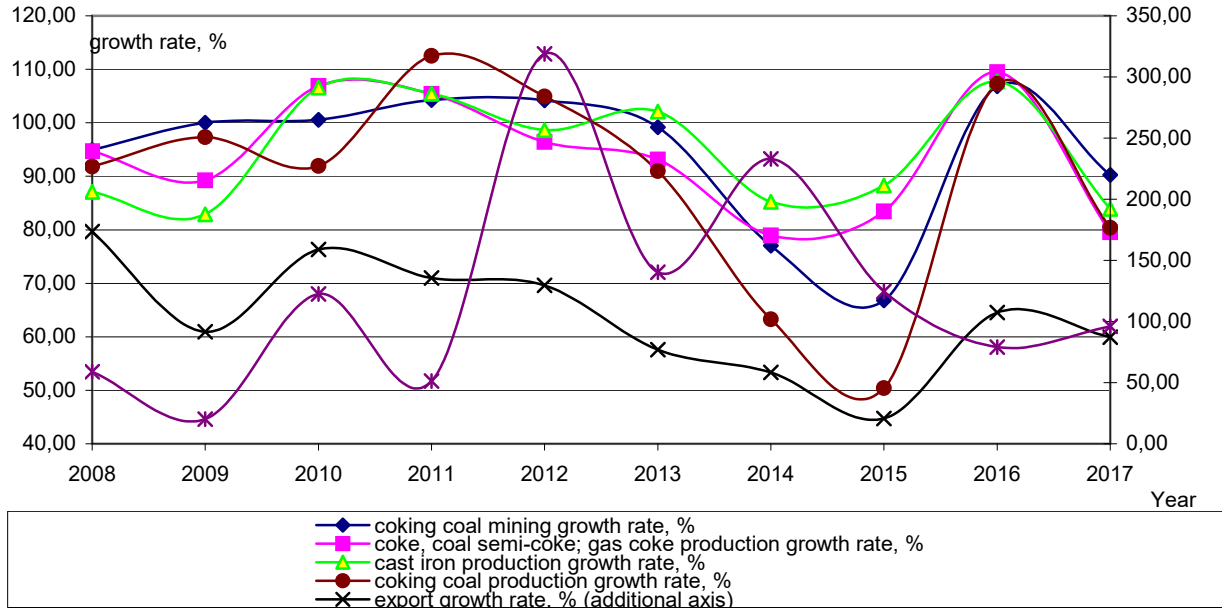

Figure 1. *Dynamics of coking coal mining and production growth rates, coke production, coke exports and imports, cast iron production during 2008 – 2017*

During 2008 – 2013s the dynamics of coking coal mining did not correspond with the relative indices of coal, coke, coal semi-coke production and metallurgy (cast iron production). The discrepancy in the dynamics of mining and production of coal can be explained by the different level of its losses in the process of mining. Coking coal production increased by 2013, but other indices changed on a periodic basis. The significant drop in production in 2015 can be explained by the beginning of armed hostilities in Donbass, as a result part of mines came to be in temporarily uncontrolled territories. The dynamics of coke production since 2013 coincides with the dynamics of coal production. During the reviewed period, the dynamics of exports of coke were fully consistent with trends in coke production. By 2011 Ukraine imported coke during the period, when domestic coal production grew. Since 2021 the pattern has changed, import rose when production declined. Since 2013, all the named indices fit the trend – cyclical, as the small cycle period is three years.

One to one correlation coefficient was used to identify relationship between coking coal mining, coke production, its export and import. The function characterizes density of connections between each element of time series of dependent (resultant) y_t and explanatory x_t variables` values relatively shifted to one time lag τ. One to one correlation coefficient is determined by the formula:

$$r_\tau = \frac{(n-\tau)\sum_{t=1}^{n-\tau} y_t x_{t-\tau} - \sum_{t=1}^{n-\tau} y_t \sum_{t=1}^{n-\tau} x_{t-\tau}}{\sqrt{[(n-\tau)\sum_{t=1}^{n-\tau} y_t^2 - (\sum_{t=1}^{n-\tau} y_t)^2][(n-\tau)\sum_{t=1}^{n-\tau} x_{t-1}^2 - (\sum_{t=1}^{n-\tau} x_{t-\tau})^2]}} \quad (1)$$

where y_t and x_t – elements of vector of dependent (resultant) and explanatory variables relatively shifted to one time lag τ; n – number of quantitative r_τ. values.
Calculations are presented graphically in Figure 2.

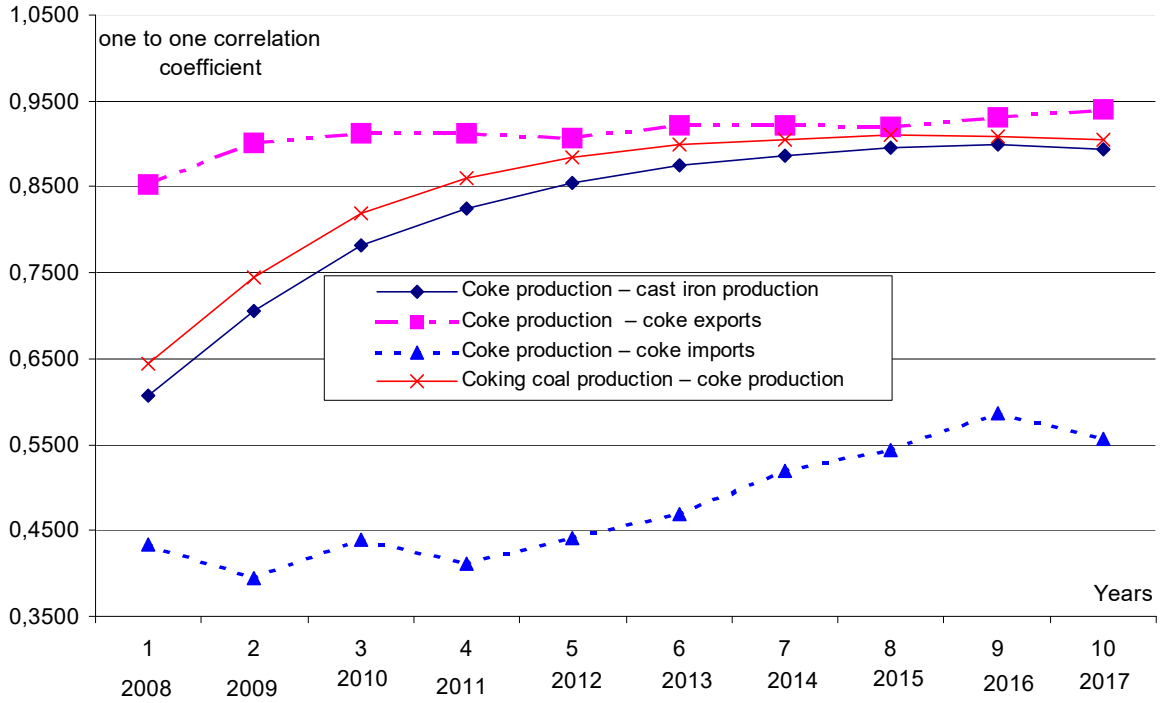

Figure 2. *One to one correlation functions for coking coal mining, coke production, exports, imports and application in metallurgy*

As we can see, the process of coke production and its export has the highest level of interconnection. Processes of coking coal production, coke production and its application in metallurgical production are characterized by almost the same interconnection level. The correlation between import of coke and its production is low, but the level has increased in recent years.
To specify export-import transactions` peculiarities we compared coke and semi-coke exports and imports growth rates; as well as of retort carbon`s (code 2704 UCGEED) and corresponding price indexes. The obtained results are presented in Fig. 3.
The analysis of Figure 3 shows that the frequency of export and import prices` growth rate changes coincides. Thus, we have small cycles lasting 3-4 years. Comparison of import growth rates and corresponding price growth rates proves that these indices change in counter-phase, that is, import prices increase, if imports decrease and vice versa. Interdependence between export prices and export reveals matching trends, i.e. export prices go up with export volumes, except the period of 2013 – 2015s, which is explained by the production drop as a result of armed hostilities in Donetsk and Luhansk regions.
Thus, coking coal imports are significantly dependent on price trends and are almost unrelated to the needs of Ukraine's metallurgical sector. Therefore, in our opinion, management system of the country's coking coal potential should include balanced flows of coal mining, coke and semi-coke production depending on the needs of national metallurgical sector. Taking into account cyclical nature of metallurgical sector development, coking coal mining and coke, semi-coke production have to be cyclic too. The small cycles` period is 3-4 years.

Let us make similar assessment of steam coal – anthracite. Analysis` results are shown in Fig.4. As we can see, there is correlation between anthracite mining growth rates, other coal / anthracite production, coal exports and imports, anthracite (code 2701 UCGEED) and thermal energy production during 2008–2017s. Dependencies have periodic nature, indicating small cycles lasting 3-4 years. 2017 was the exception for exports and imports.

Figure 5 illustrates the results of correlation analysis on anthracite mining and production, exports and imports, its application in the process of thermal energy production. As we can observe, unlike the situation with coking coal, there is high level of correlation between the analyzed values regarding anthracite. Besides, since 2014, correlation between production and exports has become even more significant.

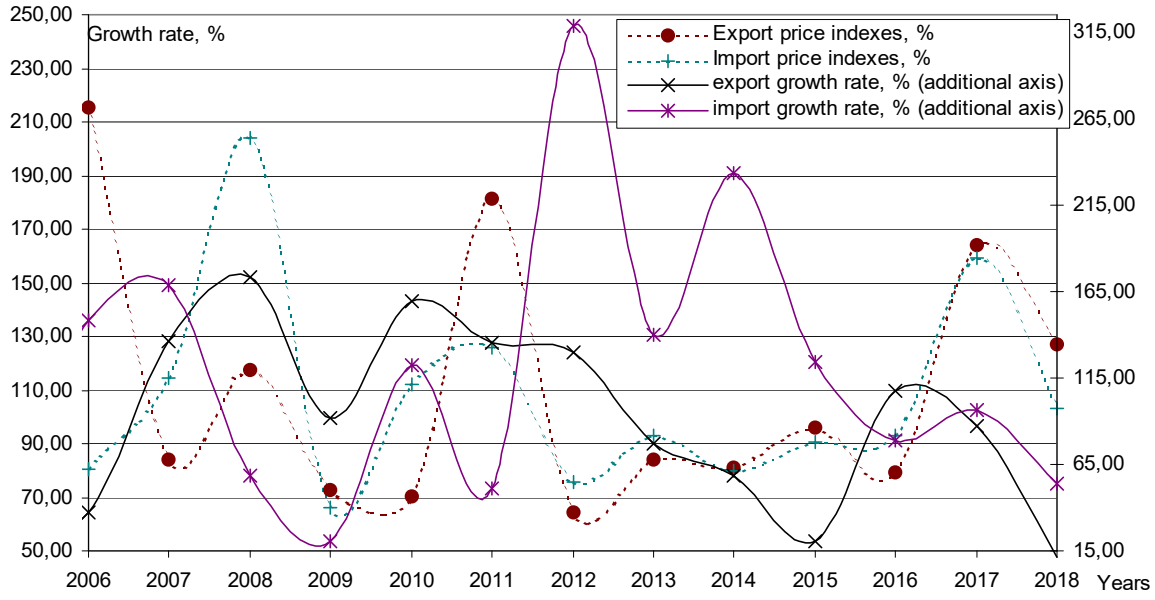

Figure 3. *Dynamics of coke and semi-coke exports and imports growth rates; retort carbon (code 2704 UCGEED) and corresponding price indexes during 2006 – 2017*

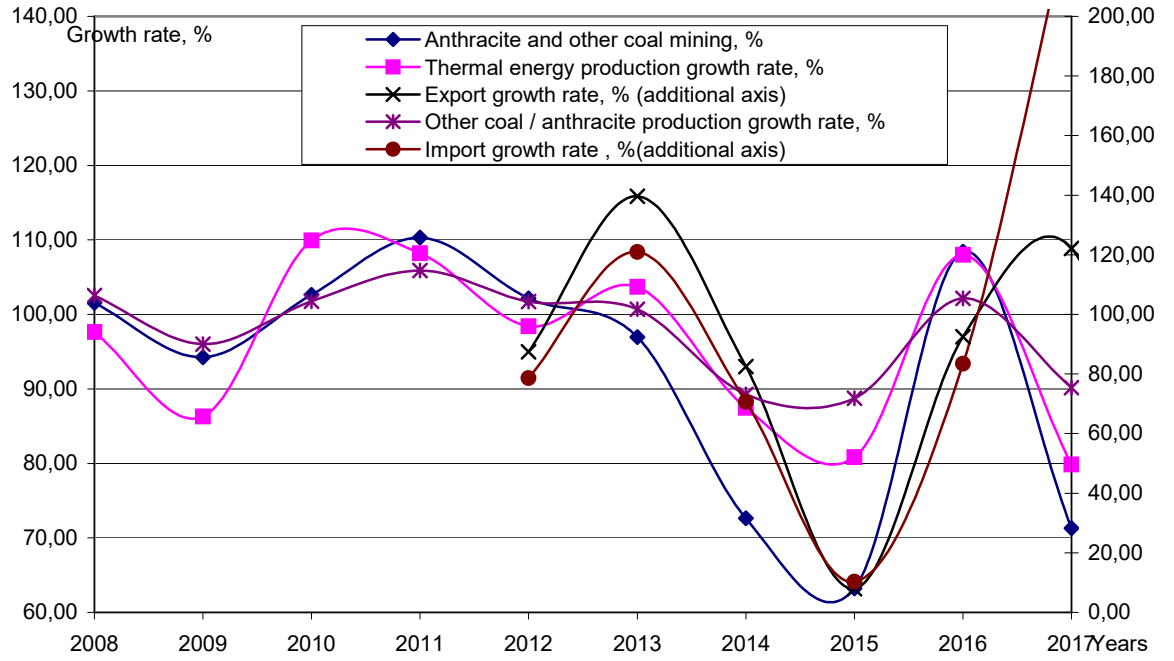

Figure 4. *Dynamics of anthracite mining, other coal / anthracite production, coal exports and imports, anthracite (code 2701 UCGEED) and thermal energy production during 2008 – 2017*

We will analyze the import growth rates and corresponding rates and prices (Fig. 6). Exports and imports growth rates are identical as the same are price indexes. The trend for imports is economically justified, as when import prices drop down, its volume goes up. Application of the same approach for exports is not economically justified, because it brings losses. The situation has changed since 2015, both export and import prices, as well as volumes began to rise. We consider, that the increase in anthracite imports is consequence of lower production caused by the armed hostilities in Donetsk and Luhansk regions, where most of the mines are concentrated. In the situation, higher exports of the deficit resource having strategical importance for the national energy security may be unjustified.

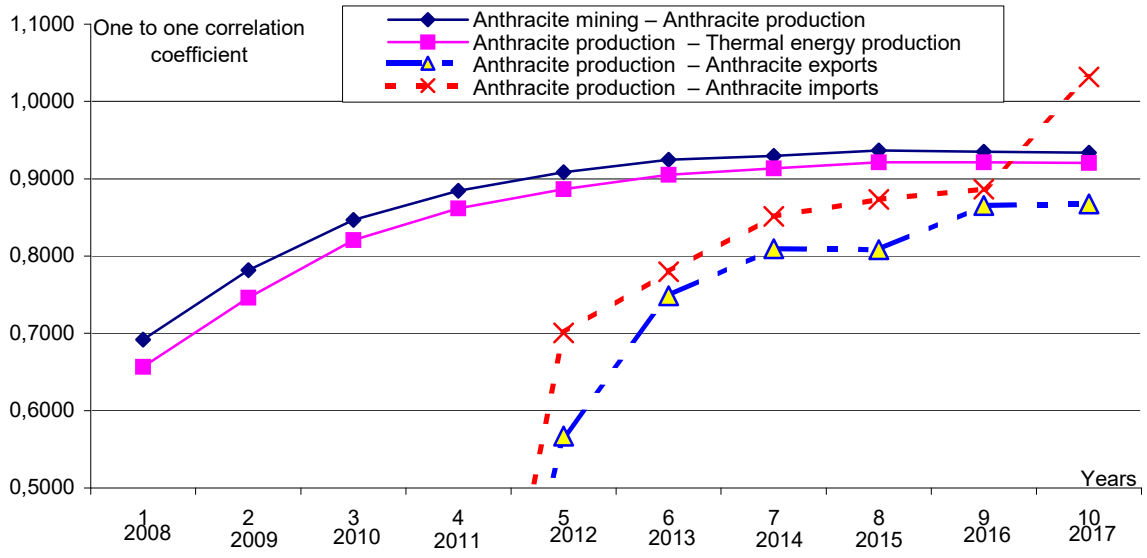

Figure 5. *Functions of one to one correlation for anthracite mining and production, exports and imports, its application for thermal energy production*

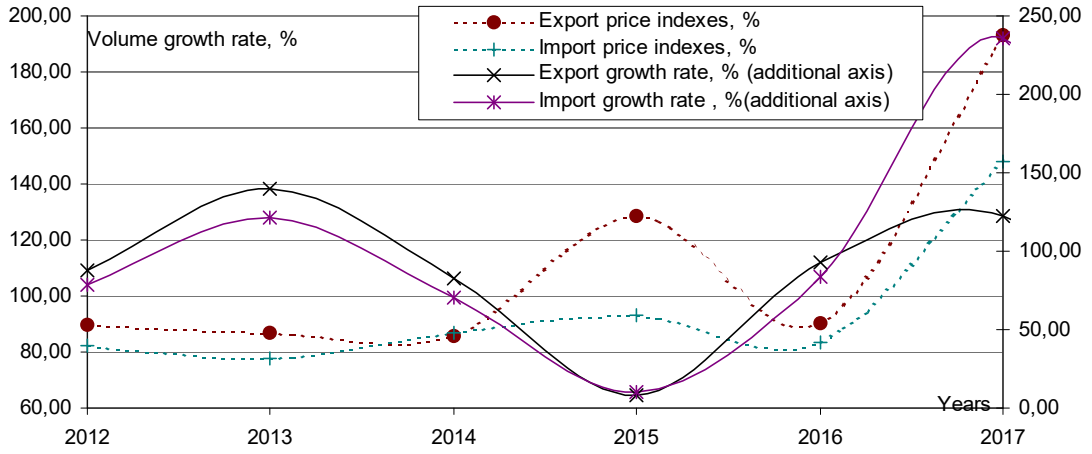

Figure 6. *Dynamics of coal exports, imports growth rates, anthracite (code 2701 UCGEED) and corresponding price indexes during 2012 – 2017*

Conclusions

To set priorities in the managerial system of coal industry, analysis of the relationship between coal mining, production, use, exports and imports in Ukraine have been made. It has been illustrated that managerial system of coking coal potential`s substantial use should include balancing flows of coal mining, coke and semi-coke production depending on the needs of the country's metallurgical industry (cast iron production), taking into account its cyclical development nature. Small cycles presence in the development of all subsystems has been proved. Moreover, correlation between anthracite mining and production, export and import growth rates and thermal energy production have been proved if

there are small cycles lasting 3-4 years. The results obtained indicate that it is advisable to reconcile anthracite mining, production and consumption amounts and to take into account small cycles of heat power industry development.

Thus, finite nature of minerals and inefficient export transactions pose a threat to the national resource security. In addition, optimization activities may include the following: exploration of mineral deposits, funding of mines` reconstruction, which will reduce the amount of mining coal losses and increase the efficiency of industry performance.