

# Quantitative Methods for Assessing Levels of Vertical Integration as a basis for Determining the Economic and Organizational Sustainability of an Industrial Corporation

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## Abstract

**Background/Objectives:** The article is aimed at assessing qualitative and quantitative methods for measuring the vertical integration impact occurring when the intermediate stages of production are united within one company in an effort to enhance the firm's economic and institutional sustainability. **Methods:** The authors have applied quantitative analysis to assess the group's vertical integration level based on the method of the production and sales break-even volume. Qualitative methods of the analysis were used for interpretation of the obtained results and estimates. **Findings:** An effective method for qualitative assessment of integration has been proposed that involves the following steps: determining the types of companies and their interactions; determining the conditions of organizational sustainability within the integrated company; assessing the economic sustainability of each company; assessing the concentration of raw materials suppliers and buyers of intermediate products in the markets; analyzing the companies' specific assets; assessing the diversification of the integrated company; and assessing the impact of changes in the external environment. The method was tested on an industrial holding company and demonstrated good results. Within the framework of interaction between two companies in the group, four conditions of sustainability have been outlined on the basis of the break-even point, and the conditions of comprehensive sustainability have been determined for both companies, as well as conditions insufficient for sustainability. Additional factors regarding institutional and economic sustainability of the group have been identified for the purpose of further research. **Applications/Improvements:** The developed method allows making conclusions about preservation or destruction of the companies in a group in the future.

**Keywords:** Economic Interests, Integration, Interaction, Institutional Sustainability, Vertical Integration  
JEL Codes: D43, L11, L65.

## 1. Introduction

Business today is characterized by a high level of concentration and the dominance of large, diversified and integrated structures. The main organizational and economic reason for the inefficiency of major corporations, and of attempts at restructuring them, is the fact that they are made up of a large number of companies that together suffer from hierarchical management structure, inefficient supply chains and the failure to coordinate economic interests, and whose cooperation with each other is irrational.

Large corporations made up of hundreds of subsidiaries and affiliated companies, the mergers of capitals and assets and the increases in the number of employees that were typical of the industrial era are being replaced by a new type of interaction. In an innovation-oriented economy, the consolidation of economic activity is reflected in the organization of strategic management and value chains in mesoeconomic network structures with a single logistics center, intangible assets and a special system of long-term contracts. In the case of an industrial corporation, integration involves a variety of connections and interactions, the most important of

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which remain the technological relations that provide the basis for the emergence of commodity and financial flows. The increasing complexity of the organization and the interdependence of the integrated structures determine the economic sustainability of the entire integrated system as a set of complex, open sub-systems in the short term and, more importantly, in the long term.

The concept of “sustainability” describes both a state and a property of an object. That is, sustainability/stability refers to the ability of a complicated system to maintain properties and characteristics that do not change under external influence. The resilience of an object under the influence of external factors is a function of the intrinsic properties of the object itself (the system), so an understanding of sustainability requires an investigation of the actual and optimal structure, identification of contributing factors and suggestions for how the structure of the integrated system may be improved.

Many problems relating to the operation of integrated companies relate to justifying a merger and the form it might take, defining the limits and directions of a company’s growth (including the number of companies within a group and their production capacity, assets and capital), and determining the number of processing stages, depth of diversification, types of products and other similar factors. The limits and directions of integration can be determined on the basis of growth in economic efficiency, financial sustainability, risk reduction and the increased competitiveness and value of the integrated company.

The lengthy evolution of the concept of integration has generated three basic approaches:

- The neoclassical approach views integration from the perspective of the more efficient operations and related benefits that characterize a monopoly and the technological specifics of production. Here the main factors that contribute to integration are the reinforcement of market power, the technological benefits that result from the combination of successive stages of the production process, reduction of risk and of environmental uncertainty and the alleviation of tax and price controls. The efficiency of integration therefore depends primarily on the amount of competition, the market structure and the interchangeability of production factors. This approach is the basis for the methods used for quantitative assessment of the degree of competition and for diagnostics of the type and structure of the

market<sup>1-3</sup>. It should be noted that the concentration indices thus developed may produce results that are the opposite of what was intended, actually impeding the correct assessment of the competitive environment and distorting the magnitude of the effects under consideration.

The field of Industrial Organization (IO) economics, which was formed at the neoclassical approach, the primary determinant of VI is a market structure – or rather asymmetric market structures<sup>4</sup>. This school has traditionally been preoccupied with VI when focusing on barriers to entry<sup>5</sup>, raising rivals’ costs<sup>6</sup> and foreclosure<sup>7</sup>.

The neoclassical approach is designed to answer some of the fundamental problems of financial management, such as whether a company should produce in-house or buy from the third party providers, or should retain or sell a non-core asset. These questions can be solved for individual companies, products, works and services on the basis of calculations of the economic efficiency regarding administrative decisions in specific circumstances. This approach does not; however, offers insights into the optimal structure of a company and its organizational structure or ways in which operational efficiency might be maintained or increased in the context of changes in what can be a highly volatile external environment. Moreover, the connection between the organizational sustainability of the integrated company and its efficiency is unclear.

- The institutional approach analyzes integration in the context of transaction costs, agency relations, property rights and the evolution of economic institutions. According to Williamson<sup>8</sup>, integration is based on the transition from market-based coordination to cooperation within the system (which can be network-like or hierarchical, according to the degree of interdependence among the participants). This researcher defined an integrated company as “a conscious agreement jointly achieved by agents (or a group) for the purpose of consistent coordination of their actions on a regular basis”.

The main advantages of integration are increased adaptability in the face of uncertainty and contractual protection. The uncertainty arises from two sources, one being internal, in relation to the behavior of the interacting parties, and the other being external, in relation to the difficulty of making accurate predictions about how possible scenarios may play out. Williamson offered an innovative interpretation of strategic relations connected to quasi-rents, the interdependence of participants

and the length of the contract term<sup>8</sup>. Approached this way, the critical factors in integration include reduced costs in recurring transactions and their internalization within the company and increased certainty regarding property rights, which creates negative external effects and solutions to external problems and to the asset specificity problem. Integration is to be implemented if the hierarchical structure has greater transactional efficiency compared to the market, if the companies have specific assets and if there is considerable uncertainty regarding the external environment. From the perspective of institutional theory, an integrated company is both a coalition of owners of rights to resources<sup>8</sup> and a cluster of interrelated assets<sup>10</sup>. The process of the integration of companies will continue until the marginal benefits and marginal costs near parity. If the companies' production processes are capital-intensive and slow to respond, they should be placed as far as possible from the boundaries of the market in order to reduce uncertainty, accelerate changes in technological processes and improve product quality.

A number of researchers (in particular Coase<sup>11</sup>; North<sup>12</sup>; Langlois<sup>13</sup>; Jeggertsson<sup>14</sup>; Richter and Lindstadt<sup>15</sup>; Itoh and Morita<sup>16</sup>) have shown that integrative cooperation is performed in cases where the hierarchical structure has relatively greater efficiency in comparison with the market. That is, from the point of view of the institutional approach, integrated structure is an association aimed at the establishment of such relations between the participants that are different from market transactions; this definition is focused on the interaction between the members and its non-market nature.

It should be borne in mind that, in order to preserve the integrity of the system, it is necessary to use special mechanisms of interaction that are designed to harmonize conflicting economic interests among various elements of the system (i.e., structural units, companies, divisions). Usually, the coordination of interests is performed by corporate centers, with varying degrees of decentralization of the management functions within the subdivisions. As a consequence, a hybrid form of coordination emerges, along with a mechanism for the coordination of interests. Such an approach has to be used to justify the need and feasibility of restructuring, integration and disintegration of a company. However, in practice, the formation of an integrated structure or a plan for the company restructuring is often framed in

terms of economic efficiency. The institutional approach explains the management of an integrated structure as a hierarchical system, but it gives insufficient attention to the centralization of management and the institutional sustainability of the company.

- The approach based on dynamic comparative advantages links the need for and extent of integration to the life cycle of products and technologies, and is based on resource theory (Barney<sup>17</sup>; Grant<sup>18</sup>; Rumelt<sup>19</sup>; Wernerfelt<sup>20</sup>, and Hart<sup>21</sup>). Within the field of strategic management (SM) multiple approaches have been applied to ease managerial processes in situations with high uncertainty. The SM-approach is heavily grounded in managerial and organizational practice<sup>4,22</sup>. Despite its explanatory power regarding the complementary use of resources, assets and competencies<sup>23</sup> and the emergence of competitive advantages and other synergies of integration, this approach does not provide a quantitative assessment of sustainability. It also does not address the length of time during which benefits from the combination of complementary assets are experienced, which is a factor that can determine the feasibility of organizational unity within the integrated company.

In studies that have been conducted in terms of the framework of approaches that focus on the feasibility, efficiency and impact of integration, there has been offered no explanation for what limits there may be to the merger of companies, or for how the form of interaction aimed at in the integration should be determined. Nor is there in the available literature any substantiation of methods or tools for providing a quantitative assessment of the level of integration that contributes the organizational sustainability of the company that has undergone integration. Finally, no approaches have been suggested for determining the effects of the interaction, nor is there any methodology for assessing the impact of changes in the external environment on the activities of integrated companies.

### 1.1 Research Limitations/Implications

For the purpose of further research, we have identified additional factors regarding institutional and economic sustainability of the group, among them technology, production and sales structure, the group's level of diversification and market structure and the degree of

concentration of intermediate products therein. It is also necessary to take into account the role of the corporate center in the value chain management as regards the distribution of resources and income. Moreover, an in-depth analysis is required of the uncertainty factors in the external environment, including technology, the current situation in the market regarding intermediate products, governmental regulation and competition within the industry.

### 1.2 Practical Implications

The new method for determining the level of integration and degree of interdependence of the companies in a group was tested using an industrial holding company as an example and demonstrated good results.

### 1.3 Social Implications

Stability of the large company is important for the society and national economy as it defines efficiency of activity, employment and a salary of workers, taxes, stable economic relations with other participants of the market system. The developed method allows making conclusions about preservation or destruction of the companies in a group in the future.

### 1.4 Originality/Value

The method we developed for determining the level of integration and the institutional and economic sustainability of a group of companies allows us to provide a quantitative and qualitative assessment of integration influence within the group. Effective methods for determining the level of integration and degree of interdependence of the companies in a group including: the level of vertical integration; the companies' types of dependency and the modes of interaction among them; the conditions for organizational sustainability of the integrated company and assessment of the economic sustainability of each individual company; the degree of concentration of raw materials suppliers in the market for the group and in the market of buyers for the intermediate product; analysis of specific assets of the companies of the group; the level of diversification of the integrated company; and the impact of environmental changes on the integrated company. Within the framework of interaction between two companies in the group, four conditions of sustainability are outlined on the basis of the break-even point, and the conditions of comprehensive sustainability

are determined for both companies, as well as conditions insufficient for sustainability.

## 2. Methods

Primary data are obtained in the large chemical company, including the data on types of production, volumes of purchase and sale, the prices of semi-finished products in the group of companies. Primary data were collected for one year. The company is a typical object in the large business.

Secondary data include the reports of the large companies of the mineral fertilizer sector submitted on the websites. Secondary data were collected for three years.

Quantitative methods of analysis include analytical procedures: the assessment of the level of vertical integration in the group, based on the production and sales break-even volume method; determination of the types of dependency among the companies and modes of interaction between them on the basis of comparison of volumes of purchase and sale of products in the group; determination of the conditions for the organizational sustainability of an integrated company and assessment of the economic sustainability of each individual company on the basis of comparison of volumes of purchase and sale of products in the group; assessment of the degree of concentration in the market of suppliers of raw materials.

Qualitative methods of the analysis include interpretation of the obtained results and estimates.

In our opinion, the decision to create a vertically integrated company, or to increase the number of successive stages that it performs, must take into account not only the economic costs (income) related to economic incentives (including the market of resources, the product market, the specificity of resources and commodity products), but also transaction costs (income) related to institutional incentives (including resistance of interactions, impossibility of changing the buyer/supplier and efficient logistics). At the same time, the economic efficiency of a corporation, as defined in the theory of organization, must be complemented by determination of the degree of interdependence among the participants on the basis of an institutional concept. Further, the qualitative explanations for the pooling of resources in the framework of resource theory for strategic management must be complemented by identification and quantitative



assessment of the effects of the interactions among the constituent parts.

In sum, the neoclassical approach provides a basis for determining the degree of concentration in the markets of raw materials suppliers for the group and in the market of buyers of intermediate products. The institutional approach serves as a theoretical foundation for determining the specificity of the assets and the level of corporate control. The resource approach is used as a basis for assessing the interdependence among companies and the level of diversification.

### 3. Results

Vertical integration is one of the most controversial forms of economic organization. There are examples of both successful and unsuccessful integration; the results of integration may become apparent immediately, or only after a considerable period of time. The widespread occurrence of vertical integration can be explained in terms of the desires to limit competition by replacing the market mechanism with an intracorporate process and to obtain synergies through unified policies governing pricing, finance, investment and technology.

Vertical integration is widespread in industry, especially in the oil and gas and mineral sector companies shown in Table 1. Thus, the degree of integration in oil industry is the highest, measured at 0.67, while in mechanical engineering the figure is 0.305 and in food industry 0.303<sup>24</sup>.

**Table 1.** Largest mineral and chemicals companies in terms of net profit

No.	Index	Revenue, USD mln			Net income, USD mln		
		2011	2012	2013	2011	2012	2013
1.	Mosaic	9,937	11,107	9,974	2,514	1,930	1,888
2.	PotashCorp	8,715	7,927	7,305	3,081	2,079	1,785
3.	CF Industries	6,097	6,104	5,474	1,761	1,923	1,532
4.	Agrium	15,470	16,024	15,727	1,375	1,498	1,063
5.	Yara	13,388	15,152	13,848	2,010	1,892	936
6.	OCP	6,568	6,835	5,608	2,248	1,597	866
7.	ICL	7,068	6,672	6,272	1,512	1,305	820
8.	Uralkali	3,495	3,714	3,233	1,185	1,634	648
9.	K+S	5,173	5,213	5,427	753	844	598
10.	EuroChem	4,078	5,481	5,406	995	1,072	374

Source of the data: official websites of companies<sup>31-40</sup>

The conceptual model of interactions among the companies takes into account both economic and institutional factors:

- The desire to achieve the companies' economic goals within certain targets determines their economic sustainability;
- The companies' economic sustainability depends on multiple sustainable interactions among member companies, which interactions reduce the risks and improve economic performance;
- Multiple sustainable interactions lead to interdependence among the companies, integration of their relations and the formation of a unified system that helps to coordinate interests;
- The same system that brings the companies together develops its own goals, interests and results, the achievement of which maintains the efficiency and organizational and economic sustainability of the integrated system.

The concepts of integration and cooperation analyzed here are used as a basis for the method of determining the degree of interdependence among the companies in a group, as well as the organizational sustainability of a vertically integrated company. The institutional sustainability of the integrated company is understood as a specific composition of the system (its divisions and companies) with established systematic interactions among the elements that are sufficient for the conditions of the external environment and that do not require restructuring. Changes that may take place within the system, examples being the conflict of economic interests among the actors, the strengthening or weakening of commodity or resource dependence, the development of the market and the competitive environment and the changes in the degree of asset specificity, all contribute to the transformation of the system. The system's structure will evolve through changes in the number of elements or in the nature of connections among them, in the course of which the new parameters of the system should not decrease its sustainability.

The method we have developed includes the following steps:

- The assessment of the level of vertical integration of the group, based on the selected method;
- Determination of the types of dependency among the companies and modes of interaction between them;
- Determination of the conditions for the organizational

sustainability of an integrated company and assessment of the economic sustainability of each individual company;

- Assessment of the degree of concentration in the market of raw materials suppliers for the group and the market of intermediate products buyers;
- Analysis of specific assets of the companies within the group;
- Assessment of the level of diversification in the integrated company;
- Evaluation of the impact of changes in the business environment on the integrated company.

The details of each stage and the rationales behind them are discussed below.

The first stage is aimed at providing the rationale for the use of a specific method for determining the level of vertical integration. The analysis revealed a number of indicators that are calculated in the same way. The universal indicators (in terms of the sectors) are the VI ratio and a calculation based on the break-even point of the supplier company. The sector-specific indicator for measuring the degree of integration between the upstream and downstream processes is the ratio of self-sufficiency in oil.

The VI ratio is determined by formula (1)

$$VI_{ratio} = VA/R \quad (1)$$

where VA (Value added of a firm) is the value added by a separate company in the group in the process of manufacturing marketable products and R (final sales revenue) is the total income received from sale of the marketable products produced by the integrated company.

This formula is based on the concept of a value-added chain<sup>25</sup> and further studies.<sup>26,27</sup> This concept is a tool for the analysis of the price formation processes in the integrated company that are performed to increase the competitiveness of the company. Competitiveness here is considered from two perspectives: in terms of the generation of value added and in terms of the redistribution of value added among the members that participated in the manufacture of the final product. The managing entity (the corporate center) in the chain is entitled to distribute added value among the members.

The purpose of formula (1) is to determine the contribution of a specific participant in the resulting cost of the product. The proportion of companies involved in the creation of value added is determined based on

the labor intensity of the production processes. The drawback of the formula is the need to determine the multiple relations between a given intermediate stage and the other stages of production, to calculate the costs for specific stages and to calculate the amount of value added.

The level of vertical integration (I) is determined on the basis of the break-even point for the supplier of an individual company based on the ratio of its sales within the group to the volume of break-even production and sales by formula (2)

$$I = \frac{Q_{integr}}{Q_{comp}} \quad (2)$$

where  $Q_{i\ integr}$  is the sales volume of the supplier within the group and  $Q_{i\ comp}$  is the break-even sales volume of the supplier.

The purpose of formula (2) is to determine the level of economic security of the seller (buyer) within the group in terms of such risks as “failure to deliver” and “failure to sell.” For the sake of the example, 50% of the mutual (internal) turnover determines the level of vertical integration in the following way: if the supplier company sells more than 50% of the products within the integrated company, and the buyer company buys more than 50% from the supplier company within the integrated company, then the group is considered to be vertically integrated. In this case, it remains unclear whether these volumes are sufficient to provide profitable operation of each company. The minimum requirement for the volume of sales by the supplier within the group is equal or greater than the break-even volume of sales by the supplier. This condition is illustrated by formula (2). The higher the value obtained, the greater the margin of safety and sustainability is for both individual companies in the group and for the integrated company as a whole.

Formula (2) is easily applicable to the companies that produce a single type of products. Many integrated companies (groups), however, have a complex structure, are diversified and sell their products both within the group and in other markets. For such companies, formula (2) can be modified and presented as formula (3), according to which the weighted average of the level of integration in terms of sales is defined.

$$I = \frac{Q_{i\ integr}}{Q_{i\ comp}} \quad (3)$$

where  $Q_{i \text{ integy}}$  is the sales volume of the supplier company on the  $i^{\text{th}}$  type of products sold within the group;  $Q_{i \text{ comp}}$  is the break-even sales volume of the supplier on the  $i^{\text{th}}$  type of product.

In the case of vertically integrated oil companies, the ratio of self-sufficiency in oil is determined by formula (4).<sup>28</sup>

$$I = \frac{Q_{\text{prod}}}{Q_{\text{ref}}} \quad (4)$$

where  $Q_{\text{prod}}$  is oil production by the company and  $Q_{\text{ref}}$  is the amount of oil refining.

The purpose of the indicator is to compare the volumes of oil production and refining, or, for raw materials mined and processed within the group, to account for any external volumes. It is noteworthy that the optimum values of vertical integration for oil and gas companies have been empirically determined as 0.5-0.6<sup>24</sup>.

The complexity of applying the indicator to other types of raw materials that are processed (e.g. mineral feedstock) is related to the variety of commodity products made from these raw materials. Since the price of such products is several times higher than the price of the raw materials, one cannot compare the products with the raw material either in kind or in terms of value. It is possible, however, to compare the volume of raw materials and products in terms of value, as in formula (5)

$$I = \frac{\sum_{i=1}^{i=n} Pr_i Q_i}{\sum_{i=1}^{i=m} Pr_{i \text{ pos}} Q_{i \text{ pos}}} \quad (5)$$

where  $i$  is the number of product types that can be produced from the feedstock,  $n$  is the number of types of products manufactured by the integrated company,  $m$  is the number of types of products made from the feedstock,  $Pr_i$  is the price of the  $i^{\text{th}}$  type of product,  $Q_i$  is the sales of  $i^{\text{th}}$  type of product,  $Pr_{i \text{ pos}}$  is the price of the  $i^{\text{th}}$  type of product, taking into account possible production outside the company, and  $Q_{i \text{ pos}}$  is the sales of  $i^{\text{th}}$  type of product, taking into account possible production outside the company.

Formula (5) compares the cost of commodity products actually produced in the integrated company and the possible value of the products obtained from all of the processed feedstock, including outside the company.

Comparison of advantages and disadvantages of the methods used for calculation considered here suggests that formula (3) is the best for assessing the level of vertical integration, since this formula is applicable to all companies, does not require the collection of additional information, makes clear economic sense and enables determination of the level of vertical integration for specific types of commercial products. The assessment of vertical integration based on break-even values is the easiest method to use because it makes use of information from financial statements.

The value of the vertical integration indicator determines the levels of commodity and resource dependencies in the integrated company. Commodity dependence is understood as the sale of intermediate products from the seller company within the group to buyers that are members of the same group. Resource dependency refers to the purchase of intermediate products by buyer companies within a group from suppliers that belong to the same group.

The second stage is designed to determine the type of dependency between buyer and supplier companies in the integration and their modes of interaction. The following scenarios are possible:

- One division (the supplier company) supplies 100% of its product (raw materials) to another division of the integrated company (the buyer company) for processing in the form of in-house supplies. This creates total commodity dependence for the supplier, which has no alternatives to the in-house sale of its end product;
- The division that produces commercial products at the higher processing stages (the buyer company) purchases 100% of the raw materials supplied by another unit (the seller company), and the remaining materials are purchased in the external market. The degree of resource dependence is determined for the buyer company, with due account for the structure of the competitive market of suppliers outside the company;
- A division of the company must deliver all the raw materials for processing within the integrated system in accordance with the terms of the contracts, and the processing company can buy raw materials only within the system. The supplier is then in a state of complete commodity dependency and the buyer is in a state of a complete resource dependency;
- Symmetrical interdependence, which is a stable interdependence based on cost-effective interactions between the buyer and seller at comparable levels of

**Table 2.** The conditions for organizational sustainability of a group of companies

Description of the option	Condition for company A	Result for company A	Condition for company B	Result for company B
1. Sustainability of the group (of the buyer-seller system)	$Q_{AHodg} \geq Q_{ABEP}$	Sustainability	$Q_B \geq Q_{BBER}$	Sustainability
2. Interim sustainability of the group, with unsustainability of the seller	$Q_{AHodg} \leq Q_{ABEP}$	Unsustainability	$Q_B \leq Q_{BBER}$	Sustainability
3. Interim sustainability of the group, unsustainability of the buyer	$Q_{AHodg} \geq Q_{ABEP}$	Sustainability	$Q_B \geq Q_{BBER}$	Unsustainability
4. Unsustainability of the group (of the buyer-seller system)	$Q_{AHodg} \leq Q_{ABEP}$	Unsustainability	$Q_B \leq Q_{BBER}$	Unsustainability

Note: Conventional systems: is the sales volume of company A within the group; and are the volumes of break-even production and sales of companies A and B; and is the sales of company B.

commodity and resource dependency between the companies.

The types of dependency determine the nature of interactions among the companies. In the development of its structure, any integrated company chooses a balance between market flexibility, which is greatest in the absence of integration, and control, which is greatest in case of full integration. Between these two extremes, there are numerous intermediate forms of vertical control and vertical restraints, which are characterized by varying degrees of integration. The weakest degree of interaction among the companies is characteristic of network-like cooperation, strategic alliances, consortia and similarly flexible structures, which tend to have no formal organizational or legal relationships. The maximum intensity of interaction is typical of holding company-like structures and groups of firms that share proprietary coordination, economic control and corporate governance.

The third stage outlines the conditions for organizational sustainability of the group. The simplest situation shown in Table 2 is one of interaction between two companies (A and B) in the group in terms of their commodity and resource dependence. Company A is the supplier producing a semi-finished product (intermediate product) that can be sold both inside and outside the group. Company B is the buyer, which sells products at the market that is external to the group.

In the first situation, where each of the companies produces and sells volumes of products that exceed the break-even volume of production, the condition of sustainability is met. The measure (margin) of

organizational sustainability can be determined by analogy with the financial safety margin indicator, which is expressed as a percentage.

In the second situation, when the amount of product that company A sells in the group is lower than the break-even point for production, the position of the supplier is not sustainable because it depends on the market that is external to the company. Here the situation is aggravated by the fact that, despite the existence of a market for intermediate products, the technological relationship between the enterprises, the specificity of commodity products (asset specificity) and the risk of oversupply all increase sales risks for company A.

Company B finds itself in a similar situation (the third case), but its finished product can be sold in a variety of markets, including competitive ones, which somewhat reduces sales risks.

The latter situation (unsustainability of both companies) may emerge if company B, operating in the market that is external to the group, fails to generate sales that exceed the break-even volume of production owing to volatility, lower demand or other changes in market conditions. Under these circumstances, because of the consumption of intermediate products required by company A to manufacture the end product, the position of the supplier becomes unsustainable as well. The safety margin for Company A is also important here.

To develop this approach further, it is possible to include the analysis of the intermediate state, in which the amount of products that the buyer company (the seller company) sells in the group exceeds the amount of break-even production, but remains less than the entire



output of the company. Under these circumstances, the volume of sales depends on both the level of competition in the product market and the degree of specificity of such products.

The fourth stage includes the assessment of the degree of concentration in the markets for raw materials of the group's suppliers and in the market for the buyers of its intermediate products. The methods for assessing market concentration are well known (see, for example, Sherer and Ross)<sup>3</sup>.

The concentration index is calculated using formula (6)

$$CR_k = \sum_{i=1}^k \frac{Q_i}{Q} \quad (6)$$

where  $Q_i$  is the volume of production of i-company,  $Q$  is the total market volume and k is the number of companies for which the index is determined.

The Herfindahl-Hirschman Index is calculated using formula (7)

$$HHI = \sum_{i=1}^n \delta_i^2 \quad (7)$$

where  $\delta_i$  is the share of i-company and n is the number of companies.

The Tideman-Hall index is calculated using formula (8)

$$HT = \frac{1}{2 \cdot (\sum_{i=1}^n R_i \delta_i) - 1} \quad (8)$$

here  $R_i$  is the rank of i-company.

The fifth stage involves the analysis of specific assets (resources) of the group of companies. Williamson<sup>8</sup> defines specific assets as a result of special investments that are valuable only within certain limits. Specific assets are those that cannot be converted for alternative use without the loss of their production potential, are not freely available to other users, are intended for long-term operation and are highly capital-intensive. This being the case, the termination of the transaction is equivalent to the loss of part of the value of specific assets, since they are oriented toward the specific features of the partner and are hence less valuable for anyone else. Specific resources

(e.g., semi-finished products) are also unsuitable for universal use, being designed for specific customers; and since the buyer's market may be highly concentrated, it is necessary to have guarantees for their sale.

In the context of the availability of a market of resources, it is not necessary to own the sources of supply or the distribution channels. There are hardly any resources markets for specific assets, so integrated companies create their own internal markets. The theoretical basis for analysis of these markets is Coase's contractual theory of a firm, with the fundamental difference between this market and the external market being the fact that the economic agents are deprived of "freedom of access"<sup>11</sup>. Transaction costs economics have received considerable attention in explaining the existence of VI. In particular, the arguments of asset specificity, which refers to the existence of significant transaction specific sunk costs<sup>29</sup>, and uncertainty, are given considerable power to explain the occurrence of VI.

The specificity of assets and resources can be measured with the use of the following methods:

- Expert evaluations, with rankings on a special scale;
- Determination of the degree of specificity of assets (k) using formula (9).

$$k = \frac{Y_e - Y_a}{Y_e} \cdot 100\% \quad (9)$$

where  $Y_e$  is the expected revenue in case of the best use of the resource and  $Y_a$  is the expected revenue in case of the best alternative use.

The degree of specificity can be assessed as a percentage from 0 (standard assets of general purpose) to 100 (idiosyncratic assets), though use of this formula is quite complicated in practice.

The sixth stage involves assessing the level of diversification of the companies, and is therefore only applicable to diversified companies.

Although the concepts relating to diversification are highly developed in general, the lack of either a unified theory or a universal classification, together with such factors as the absence of substantiated limits to the diversification of companies and the small number and poor informative value of the indicators, make it difficult to assess the level of diversification accurately. Further, diversification can be classified on the basis of any number of characteristics. By way of example, the US Federal Trade Commission suggested a fairly simple classification based on the following parameters:

product diversification, which means penetration of the company into new product fields related to the products it manufactures; expansion (diversification) of the market, which means the company's penetration into new territories; complete diversification (conglomeration), which is characterized by the company's entry into entirely new activities unrelated to its core activity, or into markets unrelated to each other. Another classification scheme, similar in its economic import, refers to limited, related and unrelated diversification. Limited diversification in a company means that one type of activity dominates; related diversification refers to the development of several businesses that are interconnected in terms of such factors as production, technology and sales; and unrelated refers to the development of several businesses unrelated to each other.

Quantitative studies of diversification in the countries with advanced market economies and developed capital markets have recommended the following indicators of diversification:

- The number of sectors in which the company operates is determined by the codes of Standard Industrial Classification (SIC) used in the United States.
- The modified Herfindahl-Hirschman index (H).

$$H = 1 - \sum_{i=1}^n p_i^2 \quad (10)$$

where  $i$  is segments (branches), in which the company operates,  $i = 1, 2, \dots, n$  and  $p_i$  is the share of the company's

sales in the  $i^{\text{th}}$  segment (sector) in relation to the total revenue of the company.

The Entropy Index (E)

$$E = \sum_{i=1}^n p_i \ln\left(\frac{1}{p_i}\right) \quad (11)$$

where the conventional symbols are the same as in formula (10).

The entropy index shows the number of sectors (branches) in which the company operates; the distribution of total revenue/assets among these segments and the degree of relatedness between the different sectors in which the company operates.

Diversification index (D)

$$D = \frac{1}{\sum_{i=1}^n p_i^2} \quad (12)$$

where the conventional symbols are the same as in formula (10).

It is also possible to use qualitative criteria:

- Companies that include several independent businesses manufacturing products for different markets are highly diversified groups.
- The presence of several unrelated key competencies (e.g., unrelated technologies, different types of equipment) in a company operating only in one market shows that this is a company with an average level of diversification.
- The same equipment is used for the production of different types of products: companies with low and medium levels of diversification.

Unfortunately, even the calculations have not enabled researchers to reach definitive conclusions regarding the degree of diversification.

The final stage determines the sustainability of the integrated company or group in the face of influences from the external environment. The organizational sustainability of the group depends on the nature of technological links, the structure of internal production and sales and on the trends in the market structure, particularly with respect to market concentration. Organizational sustainability is affected by the uncertainty of the external environment, which is a function of such factors as technological developments, demand, resource costs, governmental regulation and the behavior of competitors. The nature of interaction in a horizontally integrated or diversified company becomes even more complicated, since it embraces relationships both within the company and beyond it. After the strategic analysis of the external environment, it is necessary to monitor the conditions of organizational sustainability (stage 2) of the group in order to analyze the new positions of sellers and buyers and the sustainability of the group as a whole.

The proposed method was tested on the companies of the mineral/chemical complex (the first four stages), and the analysis is presented below. The subject of the study is EuroChem Mineral and Chemical Company group and Kovdor MCC (Mining and Concentration Complex) JSC (the supplier company within the group).

EuroChem Mineral and Chemical Co group (Eurochem) is a multinational and one of Russia's largest producers of mineral fertilizers. This vertically integrated company includes upstream operations (nitrogen, phosphate, potassium), fertilizer production facilities and logistics and distribution networks. The company has a complex, multifaceted structure, with divisions located in

different regions, which forces it to maintain a distributed hierarchical control system. Kovdor MCC JSC is wholly owned by the EuroChem group and produces three main types of commodity products: Apatite Concentrate (AC), Baddeleyite Concentrate (BC) and Iron Ore Concentrate (IOC). The markets for commodity products vary considerably: the company has a global monopoly on baddeleyite concentrate, an oligopolistic market (Russia, the world) for iron ore concentrate, and an intracompany market for apatite concentrate.

The calculations were performed for apatite concentrate, which is purchased by several companies in the group shown in Table 3. Fixed costs for the production of apatite concentrate amount to USD 147.67 million, with variable costs of USD 28.12/ton. It should be noted that the entire volume of apatite concentrate is sold within EuroChem Mineral and Chemical Cogroup shown in Table 3.

**Table 3.** The sales of apatite concentrate in EuroChem Mineral and Chemical Co

Consumer Company	Sales, metric tons	Price, USD per metric ton
Lifosa (marine transport)	600,656	280.2
Lifosa (rail transport)	294,145	283.2
Phosphorite	886,711	163.7
Nevinnomyssk Azot	3,599	208.9
Balakovo Mineral Fertilizers	519,664	182.0
Total	2,304,775	233.8

The break-even volume of production and sales volume are defined by the familiar formula (13).

$$BEP = \frac{FC}{P - AVC} \quad (13)$$

Where BEP is the break-even point, FC is fixed costs, P is the price of commodity products and AVC is average variable costs.

The calculations performed in the first stage (formulas (3) and (6)) give the following results: the break-even volume of production and sales is 718,120 metric tons, and the level of vertical integration of EuroChem in respect to apatite concentrate is 3.2. This value indicates a significant margin of safety for the seller company in respect to this type of intermediate product. It is obvious that even if the apatite concentrate price declines by half, a significant margin of safety will remain, equal to 1.4. The

result shows the extent to which the supplier company can withstand the decline in prices, which is related both to the changes in market prices and to the pricing policy of the corporate center of the integrated company.

In order to determine the companies' levels of commodity and resource-based dependency on the group and to perform a deeper analysis of the integration, it may be advantageous to consider such factors as:

- The structure of revenue and the share of AC in the total revenue of the supply company;
- The effect of different volumes, product types and market opportunities on the revenue of the supply company;
- The costs structure of buyer companies and the share of the total cost represented by AC;
- The possibility to switch buyer companies to other suppliers (in the market), which is determined by the overall structure of the market for intermediate products.

The second stage determined the type of dependency in the integrated company, which is complete commodity dependence of the supplier company within the group of companies (the rigid type of integration secured by the organizational and legal situations).

The third stage is the control of the conditions of organizational sustainability of the group.

The implementation of the first stage showed that the supplier company (Kovdor MCC JSC) complies with the condition of break-even point achievement with respect to apatite concentrate. The concentrate is a raw material used for the production of a variety of phosphorus fertilizers at several plants of the group (Table 3), in particular ammonium phosphate, diammonium phosphate and sulphoammophos, as well as feed phosphates and complex fertilizers. Thus, the group is arranged as a system of a supplier and several buyers. The share of the phosphate segment in the revenue is 46%, and the cost efficiency in the phosphates segment in the group is 34%. The break-even level for the phosphorus-containing products in terms of value (profitability threshold) can be determined both for each company and for the group as a whole. Thus, in terms of the feedstock and commodity products, the phosphate segment of the company is found to belong to the first type of organizational sustainability, namely the sustainability of the group (of the supplier-buyer system).

The fourth stage is the analysis of the structure of the markets and the concentration ratios in the markets of suppliers and buyers.

The market for phosphorus-based raw materials (apatite concentrate) consists of two companies: FOSAGRO JSC, with a share of 85%, and EuroChem MCC JSC, with a 15% share. Each integrated company uses the domestic market for the concentrate to satisfy the needs of its group. The first group has access to sufficient quantities of raw materials, while the EuroChem group experiences a deficit of its own materials.

The analysis of the type of market and concentration in the market of phosphate fertilizers is based on the data in Table 4.

We calculated the indices of concentration for three and for five companies, as well as the Herfindahl-Hirschman index and Tideman-Hall index; we constructed a Lorenz curve to distribute companies according to market share shown in Figure 1.

The concentration index for three companies is ,  $CR_3 = 0.996$  and for five companies  $CR_5 = 0.996$ .

**Table 4.** Distribution of companies in the market of phosphate fertilizers

Company	Production, mln metric tons
FOSAGRO JSC	8,98
EuroChem Mineral and Chemical Co JSC	2,93
URAL CHEM UNITED CHEMICAL COMPANY JSC	0,64
AKRON JSC	0,35
YABERIA HOLDINGS Ltd.	0,05
GAZPROM-PROCESSING	0,03
BASIS LLC	0,02
Total	13,00

The values of the indices ( $HHI = 5313$ ,  $HT = 0.51$ ) lead us to the conclusion that the market for phosphate fertilizers is oligopolistic.

The final stages (5-7) determine the degree of specificity of intermediate products (apatite concentrate) and the share of sales by the main type of production in the integrated group, which calculation determines in turn commodity and resource dependency. The group's 4 mining enterprises make 5 types of intermediate products, and 7 of the group's plants produce more than 100 types of end products, so that all the enterprises have a complex structure of revenue, making it necessary to take into account the level of diversification of the integrated company.

The level of diversification of EuroChem group can

be determined in different ways: 1) the firm operates in 5 sectors (mining apatite-baddeleyite ore, gas, production of nitrogen and phosphate fertilizers, distribution); 2) it has a hundred different end products; 3) it has 5 types of intermediate products (apatite, baddeleyite and iron ore concentrates; oil and gas). All calculations are based on publicly available information from financial statements and the group's sustainable development report.

The nature and the impact of changes in the external environment is determined with due account for the interval of integration efficiency evaluation. Failure to do so can lead to compromised results, as the following example demonstrates. In 1981, the chemical corporation DuPont, intending to make savings by producing its own raw materials, bought the oil company Conoco for USD 7.8 billion. Sometime later, it became clear that chemical production was much less costly in China, so Conoco became an uncalled non-core asset. This acquisition was not only a strategic mistake, but also a tactical blunder, since the ill-timed purchase took place when global oil prices had peaked, after which they remained low for over 15 years. In 1997, it was decided that Conoco did not fit into DuPont's strategy, and the asset was sold at a loss the following year.<sup>30</sup>

## 4. Conclusions

- The method we developed for determining the level of integration and the institutional and economic sustainability of a group of companies allows us to provide a quantitative and qualitative assessment of the influence of integration within the group based on the interactions and interdependence of the participants.
- Effective qualitative assessment of integration needs to include analysis and harmonization of the objectives of the group and the companies, identification of economic dependence of the group's companies and targeting of potential synergies of interaction.
- Effective methods for determining the level of integration and degree of interdependence of the companies in a group include or take into account the following: the level of vertical integration; the companies' types of dependency and the modes of interaction among them; the conditions for organizational sustainability of the integrated company and assessment of the economic sustainability of each individual company; the degree of concentration in the market of suppliers of raw materials for the group and in the market of buyers for the intermediate product; analysis of specific



assets of the group' companies; the level of diversification of the integrated company; and the impact of environmental changes on the integrated company. The method was tested using an industrial holding company as an example.

- Within the framework of interaction between two companies in the group, 4 conditions of sustainability are outlined on the basis of the break-even point, and the conditions of comprehensive sustainability are determined for both companies, as well as conditions insufficient for sustainability.
- For the purpose of further research, we have identified additional factors regarding institutional and economic sustainability of the group, among them technology, production and sales structure, the group's level of diversification and market structure and the degree of concentration of intermediate products therein. It is also necessary to take into account the role of the corporate center in the value chain management as regards the distribution of resources and income. Moreover, an in-depth analysis is required of the uncertainty factors in the external environment, including technology, the current situation in the market regarding intermediate products, governmental regulation and competition within the industry.

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