Industrial ecosystem entities business success

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Abstract. The sustainable development and success of industrial regions is largely determined by the efficiency of enterprises in the territory, united in ecosystems, often around the city-forming enterprise. The study of industrial ecosystems, their evolution and the interrelations of participants will make it possible to more effectively implement the goals of sustainable development in the territory, ensure a fair distribution of income, well-being and rational environmental management. The purpose of the article is to assess the relation between the development of entities of the industrial ecosystem on the example of the industrial ecosystem of the Magnitogorsk urban district in Russia. The study used data from Rosstat and the Federal Tax Service for 2007-21. The main results of the study are as follows: five groups were identified in the industrial ecosystem (the core of the ecosystem, companies affiliated with the core, customers of the core, suppliers of the core and other beneficiaries from the work of the core and the ecosystem as a whole, "fellow travellers"). The connection between the performance of the ecosystem core and other companies turned out to be statistically significant, especially strong for revenue growth rates. Among individual ecosystem groups, affiliates and core clients experienced the greatest influence of the core, while the connection of the results of the core with suppliers and fellow travellers was weaker. The connection, taking into account the time lag of one year, turned out to be weaker than the year-to-year connection. In general, the results confirm the hypothesis of a strong connection between the stability of the core and other participants in the industrial ecosystem.

1 Introduction

The research of industrial ecosystems, including large industrial enterprises, their suppliers, customers, financial structures and social infrastructure of the territories, will help to improve the efficiency of the implementation of programs aimed at achieving sustainable development goals. As practice shows, companies surrounding the core of the industrial ecosystem, with much lower gross economic activity, can have a key impact on environmental pollution, violation of the principles of a fair distribution of income, and a decrease in the quality of life. For this reason, it is important to research not the individual

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largest enterprises of industrial territories, but them together with the environment, answering questions about their connection. There are a large number of industrial territories in Russia, which historically emerged during the industrialization in the Soviet Union. Enterprises in such territories have evolved, gradually acquiring the appearance of industrial ecosystems with distributed roles of participants. Scientific interest is the opportunity to trace how these ecosystems have evolved, how the ratio of their elements has changed, and what is the strength and direction of the interconnection of key indicators of their activity. The paper aims to assess the interconnection between the development of elements of the industrial ecosystem on the example of the industrial ecosystem of the Magnitogorsk urban district in Russia.

2 Literature review

Business borrowed the definition of ecosystems from biology. British botanist Arthur Tansley introduced the term in the 1930s. Ecosystem he called local communities of organisms that interact with each other and the environment. To thrive, these organisms compete and cooperate, co-evolve and adapt to external shocks.

In the early 1990s, business strategist James Moore adopted this concept and proposed to consider the company not as a separate player, but as a representative of a business ecosystem that includes many participants from different industries. “Like its biological counterpart, the business ecosystem is gradually moving from a random set of elements to a more structured community,” J. Moore noted.

One of the first who touched on industrial ecosystems were E.A. Lowe, L.K. Evans. They considered this concept based on industrial ecology. Industrial Ecology (IE) is an emerging framework for environmental management aimed at transforming the industrial system to bring its inputs and outputs into line with planetary and local bearing capacity. The central goal of PE is the transition from a linear to a closed system in all areas of human production and consumption. In these and other ways, the industrial world can approach the ecological model in its dynamics. Industrial ecosystems embody a specific strategy for the development of closed systems at the local level, in industrial parks or regions [1].

K. Grumadaite and G. Yutsevich considered industrial ecosystems through industrial clusters. They analyzed the scientific literature and identified the following pathways of cluster emergence: 1) large firms act as anchors for attracting smaller companies to the cluster; 2) a cluster as a means of serving the needs of a large customer outside the cluster; 3) emergence of a cluster through professional associations; 4) emergence of a cluster through local entrepreneurs; 5) the emergence of a cluster through representatives of local science; 6) the emergence of a cluster through community mobilization; 7) The government as the main agent of change. That is, all these subjects can influence the emergence of industrial clusters, and later industrial ecosystems [2].

U.S. Ashton, Sh.S. Chopra and A.R. Kashyap considered industrial ecosystems as communities of firms in various industries that spontaneously participate in industrial symbiosis; that is, firms independently develop bilateral and multilateral interactions that involve the exchange of materials, energy, and knowledge for individual and collective benefit [3].

R.M.A. Hollen and F.A.J. Van den Bosch, according to his research, says that in an industrial ecosystem, firms need to interact with each other, not compete [4].

E. Susur, A. Hidalgo, D. Chiaroni say that industrial symbiosis is the main contribution to the emergence of industrial ecosystems. Industrial symbiosis describes the phenomenon in which a group of firms that traditionally have no relationship with each other cooperate to better manage their resources, especially by-products or utilities, and thereby realize
public and private economic, environmental and social benefits [5].

A. Andreoni defined industrial ecosystems as multi-level production systems, including heterogeneous agents operating in industry value chains and contributing to the scope of the ecosystem (and its participants) with closely complementary, but different sets of resources and capabilities. The geographic boundaries of the industrial ecosystem are defined by the evolving interdependencies that link organizations within the ecosystem, and by new ties that grow beyond it [6]. K. Hardy and T.E. Gredel viewed industrial ecosystems as co-located enterprises that exchange products and by-products in ways reminiscent of resource exchange in biological ecosystems [7].

O.L. de Weck argued that an industrial ecosystem is a structured production space centered primarily on its manufacturing organizations, but also on other institutions, intermediaries and demand actors purposefully involved in value creation processes along various types of trajectories of diversification and innovative industrial renewal [8].

Titova N. Yu., Ziglina V. E. characterize industrial ecosystems as sustainable socio-economic formations, which also have the characteristics of clusters, holdings, financial and industrial groups, technology parks and business incubators [9].

Kleiner G.B. considered industrial ecosystems as a type of socio-economic ecosystems. He argued that industrial ecosystems are created in order to minimize the costs for the functioning of all elements of industrial production: research and development, marketing, tooling, pre-production, prototypes, mass or batch production, service maintenance. The industrial ecosystem will create conditions for maintaining sustainable interaction between ecosystem participants, short-term (turbulent) and long-term (laminar) business processes in a business environment favorable for industrial production and the institutional sphere as a whole [10].

M.A. Soldak considers industrial ecosystems in the context of technological development. She explores the concept of an ecosystem through a biological concept. She found that, as in biology, ecosystems in industry can be of different levels: local ecosystems located in one city, district or region; regional ecosystems covering the space of individual regions; national ecosystems, that is, systems on the scale of states with sovereignty, national institutions and culture; supranational ecosystems that unite interconnected and interacting enterprises and institutions of neighboring countries or even continents [11].

V.A. Zaitsev defines industrial ecosystems as an interconnected network of companies and organizations in the region that use the products, waste and energy generated along the way [12]. Radaikin A.G. understood the industrial ecosystem as the interaction of industrial enterprises, which implements the principles of circularity. Industrial ecosystems provide sustainable development and rapid response to new technological transformations [13].

When studying industrial ecosystems, it is important to mention the concept of organizational ecosystems. N. Back argued that organizational ecology and its theory of competition are largely based on the Emile Durkheim’s fundamental work of the division of labor and on the Amos Hawley’s thoughts of human ecology. He emphasized that competition is the core of the theory of organizational ecology, not the biological aspects of evolution. N. Back singled out the subconcepts of organizational ecology associated with competition and market formation: density dependence and resource sharing. The first concept concerns the impact of the number of competitors on the survival and chances of an organization to create. The latter concerns the effect of market concentration on the vital signs of specialized and general-purpose organizations [14].

D.A.S. Baum and T.L. The Ambergis argued that organizational ecology seeks to explain how social, economic, and political conditions affect the relative abundance and diversity of organizations, and to explain their changing composition over time. Ecological analysis articulates organizational change and variability at the population level, emphasizing the differential creation of new and the decline of old organizations and
populations with heterogeneous attributes [15].

H. Leung and J. Olvera understood organizational ecology as a theoretical approach to the study of organizations, populations of organizations and the organizational environment. They paid particular attention to the role of resources and environmental constraints in shaping the nature of organizations, as well as the emergence, growth and decline of various organizational forms [16].

K. Wang and S. Zhai identified a concept as "the core of the ecosystem" or "resource core", which provides the basis for the existence and progress of the ecosystem [17]. Other authors, S. Orekhov, M. Godlevsky, G. Malykhon and T. Goncharenko, also identified the core of the ecosystem, but called it the "semantic core". They said that any branch (sub-sector) of the digital economy is based on the knowledge economy. The carrier of knowledge in the ecosystem of the digital industry should be the semantic core, the support and development of which is an extremely important and knowledge-intensive activity in the digital economy. The core of the industrial ecosystem should be a specially organized enterprise - an institution for the development, support and dissemination of the ecosystem [18].

Russian researchers also pay great attention to the study of the industrial ecosystem. D. Pletnev approaches this issue from different perspectives. In their work with V. Barkhotov, they studied the quality of life of the population, including in single-industry towns like the Magnitogorsk urban district [19]. With K. Naumova and S. Mirvahedi, D. Pletnev studied fast-growing companies in the transport sector in Russia [20]. With E. Nikolaeva and S. Mirvahedi, attention was paid to agricultural corporations of the leading industries: the oil and gas industry, transport, retail trade and metallurgy [21]. The last branch is just the main one of our research.

3 Data and methods

This article is a methodological development the existing approaches to the study of industrial ecosystems. The article highlights the largest elements of the industrial ecosystem: the core, affiliated with the core, core clients, core suppliers and core fellow travelers who receive other effects from interaction with the ecosystem. Based on the data of Rosstat and the Federal Tax Service, an assessment was made of the growth rates of revenue and profitability of sales of companies included in the ecosystem. Further, the companies are grouped according to the described types, and for each type, the average values of the same indicators are calculated. At the next stage of the analysis, the correlation of the results of the core ecosystem and individual groups of companies was assessed, year-to-year and with a lag of one year. The proposed approach makes it possible to reliably assess the presence of a connection between the core and other elements of the ecosystem, as well as to study the structure of such a connection.

4 Results

The sample formed by the authors included 50 companies registered in Magnitogorsk, of which 9 were affiliated companies with PJSC Magnitogorsk Metallurgical Combine, 7 were clients of this enterprise, 10 were supplier. Let us define the studied set of companies as an interconnected ecosystem. Schematically, the studied ecosystem looks like this:
Consider the main financial indicators (revenue and net profit) that characterize the activities of the central company of the industrial ecosystem under study - PJSC MMC. Revenue and net profit of the enterprise in dynamics are presented in Figure 2.

The revenue of the central company of the ecosystem PJSC MMC is growing in the period under review. In general, over 15 years of production activity, the company's revenue increased by 4.9 times (or by 624.5 billion rubles in absolute terms). A decrease in the studied indicator was observed in 2009 (by 39.2% compared to 2008), as a result of a decrease in effective demand due to the negative impact of crisis factors on the construction industry and a decrease in production volumes in the engineering industry. In 2012-2013...
the company's revenue was declining against the backdrop of unfavorable market conditions (decrease in metal prices in foreign markets, insufficiently active demand in the domestic market). At the end of 2020, revenue decreased (by 8.0%) due to the COVID-19 pandemic and related restrictions. The largest positive “leap” in the dynamics of the studied financial indicator was observed in 2021 – by 96.4% compared to the crisis year of 2020.

In general, a similar trend can be seen in the dynamics of PJSC MMC's net profit. For the reviewed period 2006-2021, the indicator increased by 6.0 times (or by 183.8 billion rubles in absolute terms). Large "failures" in the dynamics of net profit were observed in the corresponding crisis periods of 2008-2009, 2013, 2020. At the same time, 2011, 2013-2014 turned out to be unprofitable for the enterprise. The most significant profit growth of the company was also recorded in 2021 – 4.3 times compared to the pandemic 2020.

Next, consider the main financial indicators - revenue and net profit (loss) of the studied industrial ecosystem as a whole (excluding PJSC MMC). The dynamics of financial indicators is shown in Figure 3.

Fig. 3. Dynamics of revenue and net profit (loss) of the industrial ecosystem in 2006-2021.

Within the period under review 2006-2021, the indicator of the total revenue of ecosystem enterprises is growing. In general, over 15 years, total revenue increased by 3.4 times (or by 95.2 billion rubles in absolute terms). The dynamic trend of the total revenue of the ecosystem is similar to the trend in the change in the revenue of the “core” of the ecosystem of PJSC MMK: significant declines in the indicator were observed in the crisis years - 2009 (by 32.5% compared to 2008), 2020 (by .5% compared to 2019). The most significant increase in total revenue was also recorded in 2021 – by 23.0%.

The total net profit of ecosystem companies over the past 15 years showed an increase (by 4.6 times, or by 5 billion rubles), as well as the profit of the backbone enterprise PJSC MMC. However, despite the growth in the net profit indicator in general for the period under review, in 2006-2021 there are significant fluctuations in dynamics, the vectors of which are in different directions. This situation is associated with a wide variety of companies included in the analyzed ecosystem. Their activities range from metallurgical and machine-building enterprises to agricultural firms and water and heat supply organizations.

For a more objective assessment of changes in revenue indicators, consider the growth rate of this indicator. In particular, the growth rate of PJSC MMC's revenue and the ecosystem’s revenue as a whole (without PJSC MMC). The dynamics by indicators is shown in Figure 4.
Within the period under review, the dynamic series of the studied indicators of the revenue growth rates of the "core" of the ecosystem and the ecosystem as a whole are similar in the directions of the ongoing changes. In particular, the most serious decrease in both values was observed in the crisis year of 2009 (the growth rate of PJSC MMC's revenue and the ecosystem decreased almost by two times compared to 2008). A significant increase in growth rates was also recorded within the same periods: recovery in 2010 and 2021.

At the same time, it can be noted that the negative impact of the metal market situation in 2012-2013 did not negatively affect the ecosystem in question as a whole (the total revenue of the companies showed an increase in the range of 7.0-11.0%), in contrast to PJSC MMC itself.

When considering indicators of the growth rates of total revenue by groups of companies included in the ecosystem (affiliated companies with PJSC MMC, client companies, supplier companies, and others), it is possible to analyze the relationship of individual types of companies with the ecosystem they form and the central subject of this ecosystem. Dynamic series of the above indicators are presented in Figure 5.

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**Fig. 4.** Dynamics of PJSC MMC's revenue growth rate and the industrial ecosystem (without PJSC MMC) 2007-2021.

**Fig. 5.** Dynamics of the growth rate of revenue of affiliated companies (with PJSC MMC), supplier companies, client companies and other companies forming the industrial ecosystem, 2007-2021.
With a more detailed study of the ecosystem in the context of individual groups of companies, the following conclusions can be noted: for a number of key periods, the dynamics of changes in the indicators considered earlier (Figure 4) and in Figure 5 is similar. This concerns, first, the crisis and post-crisis years, that is, the “failure” of values in 2009 and 2020 and an increase in revenue growth rates in 2010 and 2021. Otherwise, the dynamics of revenue growth rates for groups of companies in the ecosystem is quite strong varies relative to each other and to previously presented values. For example, in 2013 the situation on the domestic and foreign metal markets had a negative impact on MMC's client companies (the growth rate decreased by 14 p.p. to 0.87), while not adversely affecting the financial performance of the group of affiliated and other companies in the industrial ecosystem.

It is also worth noting that a noticeable decrease in the growth rate of the total revenue of client companies in 2016 (by 39 p.p. to 0.72) was due to the suspension of the activities of one large company included in this group. In general, without taking into account this extremum of the linear function, the change in the indicator is within the cumulative trend.

Next, we analyze the return on sales (ROS) indicators for PJSC MMK and the ecosystem as a whole. This will allow us to evaluate and compare the effectiveness of the activities of the studied subjects. The dynamics of these indicators is shown in Figure 6.

![Fig. 6. Dynamics of the return on sales (ROS) of PJSC MMC and the industrial ecosystem (without PJSC MMC), 2006-2021.](image)

In the period 2006-2021, the return on sales of the central company of the ecosystem and the ecosystem as a whole differ significantly. ROS of PJSC MMC in most of the studied years is above 10.0%, while the profitability indicators for the ecosystem are insignificant and vary between 0.1-4.3%. At the same time, the volatility of return on sales of the "core" of the industrial ecosystem in 2006-2021 is significant - from -22.7% to 28.1%.

In this case, one can note the difference in the impact of the negative factors of 2008 and 2013 on the metallurgical combine and the ecosystem as a whole: due to the wide variety of activities of the companies in the ecosystem, the crisis impact is less noticeable, in contrast to the metal-oriented activities of PJSC MMC.

We will also consider an indicator that reflects the share of net profit in revenue for individual groups of companies that form the industrial ecosystem. The dynamics of ROS of affiliated companies (with PJSC MMC), client companies, supplier companies and the totality of other companies in the ecosystem is shown in Figure 7.
In 2006-2021, the change in return on sales indicators for individual groups of the ecosystem varies significantly, which does not allow us to identify a key trend that is common to all. However, the vector of decline in 2009 also remains relevant for this sample. At the same time, according to the results of 2013, the negative impact of the metal market situation was largely reflected in the change in ROS of companies affiliated with PJSC MMC and supplier companies. In general dynamics, ROS indicators for individual groups of companies vary to a lesser extent than the PJSC MMC’s return on sales, but significantly more than the indicator for the ecosystem as a whole (the range of values is from -3.0% to 9.3%).

It is also worth noting that the negative value of ROS of supplier companies in 2019 (-3.0%) is due to the high unprofitability of one large company included in this group. In general, without taking into account this extremum of the linear function, the change in the indicator is within positive values.

Next, we will analyze the industrial ecosystem using econometric tools. In particular, we will calculate the coefficients of variation in the growth rates of revenue and return on sales for the ecosystem as a whole and separately for the groups of companies that form this ecosystem.

The values of the coefficient characterizing the relative measure of the deviation of the actual values of the indicator from its arithmetic mean (coefficient of variation) are presented in Table 1.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Ecosystem (without PJSC MMC)</th>
<th>Affiliated</th>
<th>Suppliers</th>
<th>Clients</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient of variation by revenue growth rate</td>
<td>0.1567</td>
<td>0.2071</td>
<td>0.1460</td>
<td>0.2261</td>
<td>0.1426</td>
</tr>
<tr>
<td>Coefficient of variation ROS</td>
<td>0.4838</td>
<td>0.8631</td>
<td>0.9041</td>
<td>0.6539</td>
<td>0.6899</td>
</tr>
</tbody>
</table>

The coefficient of variation in the growth rate of the entire ecosystem is 0.157 (15.7%), which is in the range of the average values of the indicator and indicates the average spread of values within the analyzed period. A similar situation is observed for groups of supplier companies and other ecosystem companies: the variability in revenue growth rates in 2006-2021 is at an average or moderate level. In the case of affiliated companies and client companies, the difference in the considered indicators is defined as significant (> 0.2). At the same time, in general, according to the growth rates of the revenue of this sample, we
can conclude that their values are homogeneous (the coefficients of variation are less than 0.33 (33.0%)). In terms of PJSC MMC's revenue growth rates, the coefficient of variation also does not exceed 0.33.

The opposite situation develops in the framework of determining the coefficient of variation according to the return on sales data. Both for the ecosystem as a whole and for individual groups of companies, the calculated coefficient exceeds 0.33 (33.0%), which allows us to conclude that the analyzed data is not uniform. The highest value of the coefficient of variation is observed in the sample of supplier companies, which indicates a large spread in the values of return on sales in 2006-2021. According to PJSC MMC's ROS, the coefficient of variation also significantly exceeds the limit value of homogeneity.

As another analysis tool, it is proposed to consider the linear correlation coefficient. Indicators that make it possible to identify the relationship between the revenue growth rates of the "core" ecosystem of PJSC MMK and the ecosystem as a whole, or individual groups of companies in the ecosystem, are presented in Table 2 and Table 3 (taking into account the time lag of 1 year).

**Table 2.** Correlation for PJSC MMK's revenue growth rates and the ecosystem as a whole and by groups of companies; for return on sales (ROS) of PJSC MMC and the ecosystem as a whole and by groups of companies.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Ecosystem (without PJSC MMC)</th>
<th>Affiliated</th>
<th>Suppliers</th>
<th>Clients</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation for revenue growth rates</td>
<td>0.6818</td>
<td>0.6867</td>
<td>0.4955</td>
<td>0.6748</td>
<td>0.4056</td>
</tr>
<tr>
<td>Correlation for ROS</td>
<td>0.3936</td>
<td>0.0896</td>
<td>0.3646</td>
<td>0.3527</td>
<td>0.2728</td>
</tr>
</tbody>
</table>

The correlation of the growth rates of PJSC MMC's revenue and the ecosystem as a whole in the analyzed period amounted to 0.682, which indicates the presence of a noticeable direct relationship (it is in the range of 0.5-0.7 on the Chaddock scale) between the data on the ecosystem's central company and the ecosystem as a whole. A similar situation is observed for groups of affiliated companies and client companies: the relationship between PJSC MMC's revenue growth rates and the revenue growth rates of these groups can be defined as noticeable and direct. Moderate direct correlation (range from 0.3 to 0.5) is observed between datasets of the metallurgical combine and supplier companies and other companies in the ecosystem.

In the case of determining the correlation between indicators of return on sales, a moderate direct relationship is observed only between the data of PJSC MMC and the ecosystem as a whole, PJSC MMC and supplier and client companies. In contrast to a noticeable connection in terms of the revenue growth rate, in the situation with a comparison of the return on sales of the metallurgical combine and affiliated entities, the connection is practically absent. A weak feed-forward relationship is observed for the ROS "core" of the ecosystem and other ecosystem companies.

In addition, for a more objective assessment of the current situation, we will consider the correlation between the above data arrays with a time lag of 1 year.

**Table 3.** Correlation for PJSC MMC's revenue growth rates and the ecosystem as a whole and by groups of companies; for return on sales (ROS) of PJSC MMK and the ecosystem as a whole and for groups of companies, taking into account a time lag of 1 year.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Ecosystem (without PJSC MMC)</th>
<th>Affiliated</th>
<th>Suppliers</th>
<th>Clients</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation for revenue growth rates</td>
<td>0.8218</td>
<td>0.7837</td>
<td>0.6401</td>
<td>0.6879</td>
<td>0.5984</td>
</tr>
<tr>
<td>Correlation for ROS</td>
<td>0.2986</td>
<td>-0.0532</td>
<td>0.2734</td>
<td>0.3472</td>
<td>0.3075</td>
</tr>
</tbody>
</table>
Taking into account the time lag, the correlation in terms of revenue growth increased for all considered data sets. A strong direct relationship was noted between the indicators of PJSC MMC and the ecosystem as a whole; PJSC MMC and affiliated companies (correlation is in the range of 0.7-0.9 on the Chaddock scale). According to the correlation of other groups of companies and the metallurgical combine, the connection can be defined as noticeable and direct (in the range of 0.5-0.7 of the scale).

In contrast, when taking into account the one-year time lag, the relationship for most groups of the ROS indicator decreased (except for the value of the coefficient for the group of other companies in the ecosystem). A moderate direct relationship in terms of ROS is observed between PJSC MMC and client companies, as well as a smelter and a group of other companies in the ecosystem (in the range of 0.3-0.5 on the Chaddock scale). There was a weak direct relationship in 2006-2021 between PJSC MMC's return on sales data and the entire ecosystem, the combine and supply companies (range 0.1-0.3). There is practically no connection between the ROS data of the “core” of the ecosystem and its affiliated companies.

In general, according to the analysis of the calculated coefficients, the following conclusions can be drawn: the indicators of revenue growth rates are characterized by homogeneity within the considered ecosystem in 2006-2021. Also, the correlation between these indicators for PJSC MMC and various sets of companies in the ecosystem is predominantly significant. At the same time, profitability of sales is highly heterogeneous within the same industrial ecosystem. Relationships for this indicator range from moderate values to no correlation.

5 Conclusion

Based on the analysis of the presented ecosystem of PJSC MMC (50 companies, including 9 affiliated companies, 7 client companies, 10 supplier companies), a number of conclusions can be drawn. The connection between the "core" of the ecosystem and the ecosystem as a whole can be characterized as significant, which is confirmed by similar time series of revenue and net profit indicators in 2006-2021, as well as indicators of the linear correlation coefficient, primarily in terms of the revenue growth rate. At the same time, the connection between PJSC MMK and individual groups of companies that form the ecosystem slightly differs from the system-wide one. For example, the correlation of a metallurgical plant with affiliated business entities for a number of indicators (in particular, the linear correlation coefficient for revenue growth rates) is higher than the connection with the ecosystem as a whole. At the same time, the connection between the "core" of the ecosystem and other groups is less significant, which is determined both by the calculated coefficients and, in general, by the type of dynamic series of financial indicators. This situation is associated with a wide variety of activities carried out by companies that form the studied industrial ecosystem. In this situation, the factors that have a strong impact on the metallurgical combine (decrease in prices and demand in the metal market) do not have the same significant influence on other companies in the ecosystem, for example, engaged in agricultural activities.

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References