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Resilience Index Development for Digital Ecosystems and Its Implementation: The Case of Russian Companies

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Abstract

Study examines the problems of business ecosystems, whose effectiveness and sustainability are determined by the organization of cooperation of all its participants using digital tools. The purpose of the research is to develop an index of digital ecosystem sustainability that would reflect changes in the value of the company. The article defines the main characteristics of digital business ecosystems by adapting the taxonomy of digital ecosystems to the Russian market and measuring the sustainability of Russian companies as Yandex and VK Group by using the digital ecosystem sustainability index (DESIn) that was developed by the authors for determining the strategic position of companies in the market. The authors identified the main classification features of digital ecosystems and measured their stability using financial and non-financial indicators as part of the DESIn index. The results of the research and the developed index of digital ecosystem sustainability can be used by Russian companies for developing their strategies, analysing their competitive positions, and choosing the optimal directions for digital ecosystem development.

Keywords: digital ecosystem sustainability index, digital ecosystems, sustainable development, taxonomy, digital transformation, strategy

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Introduction

A business ecosystem is a business model whose success and sustainability primarily depend on the organization of cooperation among all its participants. This type of business interaction is becoming increasingly popular, especially with the advent of digital tools that simplify processes, enable scaling, and enhance data accessibility and transparency through platform solutions, digital communication, and innovative technologies. Establishing ecosystem relationships and undergoing digital transformation require significant resources to ensure the sustainability of digital ecosystems. Well-established, profit-generating organizations are particularly attractive to investors. Globally, ecosystem-based business relationships are rapidly expanding. In Russia, digital ecosystems emerged recently, and only a few large companies represent this model today.

Despite the abundance of thematic and academic publications on digital ecosystems, this topic remains insufficiently explored, with various definitions of the term "ecosystem" still in use [1].

Literature Review

Defining the digital ecosystem and the values it creates

In this research, it is essential to clearly define the nature of a business model based on a digital ecosystem. Various publications [1–5] describe an ecosystem by using concepts such as interaction, collaboration, integration, and value creation.

The following key criteria of an ecosystem have been identified [4; 5]:

- Collaboration-based relationships rather than ownership-based structures.
- Purposeful interaction among key participants to create and share value.
- A broad network of partners.
- Network effects that allow companies to scale efficiently.
- Data integration and sharing.
- Advantages over traditional business models in terms of services, optimized business processes, and specialized communities.

The value generated within ecosystems is primarily linked to interaction processes among participants. According to stakeholder theory, value creation requires a broader understanding of stakeholders beyond just consumers. These processes involve various activities performed by different individuals or groups utilizing diverse resources [6–8].

Societal stakeholders—including government entities, external agencies, the media, and the academic community – contribute to and uphold a stable business environment through regulations and social norms. In return, businesses provide job creation, social and budgetary contributions, tax payments, sponsorships, and other benefits. Collaboration enhances organizational productivity by facilitating market access, strengthening competitive positions, and improving the exploration, acquisition, and utilization of resources and knowledge within business networks [9].

Literature emphasizes the importance of creating structures that enable stakeholders to express expectations regarding sustainable development outcomes. Such structures also encourage participation in addressing sustainability challenges that may emerge in value creation processes [8].

A digital ecosystem is one such structure that allows stakeholders to fulfil their needs effectively. Since it is founded on cooperation, it facilitates the creation and exchange of value when the business model is properly organized.

Digital ecosystems form a distinct category of ecosystems, marking a shift toward digitalization and interconnected business environments. They foster collaboration and value creation through digital tools [10]. The use of digital technologies offers several advantages that impact value creation [11; 12]:

- Enhanced interaction.
- Collaborative data usage.
- Resource sharing.
- Process optimization.
- Expanded market presence and regulatory compliance.

A digital ecosystem is often described as a virtual environment composed of digital objects such as software applications, equipment, and processes. It is supported by a distributed technological infrastructure that enables the creation, distribution, and interconnection of digital services via the Internet [13]. Digital ecosystems represent an advanced evolution of digital business models.

The primary goal of digital services within these ecosystems is to retain users by offering more than just individual products or services. Instead, they provide a comprehensive combination of offerings that generate added value beyond the sum of their individual parts [14]. Thus, based on all these identified characteristics, we define a digital ecosystem as a business model that facilitates stakeholder and organizational interactions in the digital space for the purpose of value creation and exchange.

The term "platform economy" is used in publications on digital ecosystems [1]. Here we will clarify that a platform-based ecosystem and a platform business model have differences: in a platform-based ecosystem, the interaction of participants and the organization's services plays a decisive role, while in a platform business model, the platform is a technological foundation on which players with different interests in interaction develop, and the services of the platform itself are important. Some authors consider the platform as one of the initial stages of the digital ecosystem formation [5].

Adaptation of the digital ecosystem taxonomy to Russian companies

The authors analyzed the digital ecosystems taxonomy reviews to identify key factors influencing value creation in digital ecosystems, develop value management methods, and ensure transparency and standardization in the field of digital technologies [2].

Digital global ecosystems are complex systems of interconnected digital components that function together to achieve common goals. The main features of such ecosystems are: 1) interdependence: ecosystem components (platforms, applications, services) are tightly integrated and depend on each other for normal functioning; 2) network effect: users, platforms, and services within the ecosystem reinforce each other's value as the ecosystem grows; 3) economic model: ecosystems have their own economic model based on complex business processes and monetization of various components; 4) innovativeness: complex, multi-sided systems based on the use of modern innovative and digital technologies; 5) flexibility and adaptability: ecosystems are able to quickly respond to market changes, introduce innovations, and adapt their components to the needs of users.

The digital ecosystems taxonomy includes the following main types: platform ecosystems formed around a key platform (e.g., Apple, Google, Amazon ecosystem); industry ecosystems uniting companies of the same industry (finance, healthcare, energy); regional ecosystems; small business ecosystems; public sector ecosystems.

Successful digital ecosystems are characterized by the presence of a leader-coordinator, clear user value, openness to innovation, and continuous development.

The academic literature presents various approaches to systematizing the features, elements, and competitive aspects of digital and ecosystem business models. These perspectives include:

- Financial, resource, exchange, and organizational aspects [15].
- Consumer focus, value creation, and opportunity identification [16].
- Interaction, management processes, and data utilization [17].
- Offerings, user experience, platform solutions, data analytics, and pricing models [18].

Based on these studies, a digital ecosystem has the following key characteristics:

1. Industry affiliation.
2. Operational duration.
3. Products and services offered.
4. Innovation and R&D activities.
5. Integration and compatibility of products.
6. Characteristics of the core company managing the ecosystem.
7. Business exchange channels.
8. Origin (online or offline).
9. Type of business integration (horizontal or vertical).
10. Geographic diversification.
11. Ecosystem management model (centralized, decentralized, self-governing).
12. Integration of sustainable development practices.
13. Availability of data storage and management services.
14. Cybersecurity measures.
15. Data accessibility for stakeholders.
16. Supplier-consumer relationship model.
17. Presence of feedback mechanisms.
18. Implementation of digital communication tools.
19. Availability of digital analytics services.

Financial sustainability indicators

The sustainable financial position of a digital business ecosystem and its participants ensures stability and reliability in interactions. Financial stability refers to a state in which the financial system effectively allocates savings to investment opportunities on a sustainable basis without failures [19]. It also implies the ability to meet financial obligations by:

- Efficiently replenishing funding sources.
- Maintaining an optimal balance between costly and affordable borrowed resources.
- Preventing financial distress that could lead to bankruptcy [20].
- Implementing effective financial risk management strategies.

Internal financial risks encompass business risks associated with financial resources that can be directly managed by the company [21]. The key financial indicators selected by the authors include:

- Current liquidity.
- Financial autonomy ratio.
- Net Debt / EBITDA.
- Return on assets.

Operating sustainability indicators

The study of ecosystems has identified operating mechanisms that enable firms to simultaneously compete and collaborate within business ecosystems. In particular, it was found that collaboration is linked to a higher level of absorptive capacity – companies within business ecosystems gain critical knowledge, the effective use of which enhances their ability to absorb and apply new insights.

Partnerships within an ecosystem can provide participants with several advantages, such as:

- Stronger market positioning.
- Cost-sharing opportunities.
- Reduced order lead times.
- Improved production efficiency.
- Access to valuable resources.

However, without developing knowledge absorption capabilities, businesses cannot fully leverage collaboration benefits in terms of supply chain flexibility and efficiency [9].

Given the complexity of digital ecosystems and the continuous advancement of technologies required to maintain competitive advantages, this business model must remain dynamic and secure, necessitating the constant monitoring of sustainability parameters.

This paper examines quantitative indicators of supply chain sustainability, including:

- Asset turnover.
- The overrun of the compound annual growth rate (CAGR) over three years compared to the share of R&D costs for the same period.
- Ratio of coverage of operating costs by received cash.
- Duration of the operating cycle.

Investment and market sustainability indicators

A digital ecosystem is a resource-intensive business unit that requires substantial capital investments. The return on these investments, the maintenance of fixed assets, and strategic acquisitions that introduce new products, services, and technologies are key indicators for sustaining competitive advantages, ensuring operational stability, and supporting long-term growth plans.

The investment sustainability metrics of a digital ecosystem include:

1. The share of investments in strategic partnerships and acquisitions.
2. The asset renewability ratio.
3. The ratio of capital expenditures to revenue.

Additionally, the market sustainability indicators are:

1. Market share and its changes over time.
2. Brand reputation.
3. Customer loyalty levels.
4. The average check indicator.

Furthermore, specific quantitative product metrics can be applied, such as:

- Monthly active users (MAU).
- Daily, weekly, and monthly user engagement levels.

Digital transformation sustainability indicators

The rapid advancement of technology in recent years compels digital ecosystems to keep pace with innovation, continuously improving, modernizing, and investing in operational processes. Digital approaches such as digital twins, predictive maintenance, and decentralized decision-making can significantly enhance a company's ability to respond to external disruptions, thereby increasing its resilience [22].

The digital transformation of the supply chain is defined as the use of digital technologies to connect, integrate, and optimize business activities, including those involving suppliers and customers [23]. A key aspect of supply chain resilience in digital ecosystems is cybersecurity.

To mitigate risks such as data breaches, account hacking, financial theft, and unauthorized access to critical systems, organizations must not only implement advanced software solutions but also establish comprehensive cyber risk management policies. These policies should address financial, reputational, and organizational risks associated with IT infrastructure incidents.

The security level of a digital ecosystem can be measured using the following key metrics:

- Number of security incidents and their impact on business processes.
- Financial losses incurred due to cyber threats.
- Time required to restore data after a cyberattack.
- Level of protection for digital assets and sensitive data.
- Effectiveness of user training in cybersecurity.
- Implementation of proactive security warnings for service users.

Development of the Digital Ecosystem Sustainability Index (DESIn)

Methodology of the Digital Ecosystem Sustainability

Index (DESIn)

In our research, the sustainability of digital ecosystems is analysed across nine key areas of organizational development for subsequent application in the balanced scorecard. Within each area, specific sustainability metrics are identified. These metrics are aggregated by area rather than being combined into a single indicator.

Financial, operational, and investment sustainability indicators are assessed using quantitative measures. The evaluation process for these quantitative indicators follows these steps:

1. Indicators are ordered from best to worst.
2. The best-performing indicator receives a score equal to the highest ordinal number among the companies studied, while the worst-performing indicator receives the lowest ordinal number.

In contrast, innovative sustainability, supply chain sustainability, digital transformation, ESG (environmental, social, and governance), and corporate governance indicators are evaluated using qualitative methods. These assessments are based on custom-designed questionnaires containing non-quantitative metrics, developed through a literature review.

The assessment process for non-quantitative indicators follows these steps:

1. Each digital ecosystem is classified into four groups based on the level of development and scale of the assessed indicator. Each group is assigned a score as follows:
   - 0 – indicator absent.
   - 0.5 – underdeveloped indicator.
   - 1 – moderately developed indicator.
   - 1.5 – highly developed indicator.
2. The total points for each digital ecosystem are summed within each sustainability area.

The market sustainability indicator is the only metric that combines both quantitative and qualitative indicators. Its aggregated result is calculated by:

- Grouping quantitative indicators using the same ranking method as above.
- Adding scores for non-quantitative metrics to derive a composite score.

This approach provides a comprehensive sustainability assessment for each research area, enabling comparisons over time and across different digital ecosystems.

Innovative sustainability indicators

For digital ecosystems, innovation is a fundamental mechanism that enables them to maintain competitive positions and enhance sustainability. Therefore, we propose evaluating innovative sustainability by analysing innovations based on three key criteria: novelty, scale, and significance.

The assessment is structured as follows:

- 0.5 points – innovations related to existing services, products, technologies, or projects that enhance user experience. Examples include new data processing methods, additional services, etc.
- 1.0 point – innovations or collaborative projects introducing a new direction already present in the market or enhancing socially significant products and services. In these cases, the primary focus is on user convenience rather than profit, such as accessible services for specific population segments.
- 1.5 points – breakthrough innovations that transform the digital ecosystem's market presence. These include major contracts, partnerships, or entirely new products and services that were previously unavailable in the market. Examples include expanding into a new country, launching a disruptive product, or adopting groundbreaking technologies.

The total score for each company is calculated by summing its innovation points, with standardization applied if necessary for comparison.

Market sustainability indicators

Despite the large number of product metrics, our index focuses on market position as a key sustainability indicator, comparing the services and products of different companies.

Market position is evaluated using the following ranking:

- If digital ecosystems operate within the same geographic area, market position is determined by the number of users.
- If digital ecosystems operate in different geographic locations, relative indicators are used instead. For example, market share is measured as the percentage of users relative to the total population in a given area.

Assessing services and products in digital ecosystems is more complex. The comparison is based on the following criteria:

1. Exclusivity – a unique offering available only in one of the studied ecosystems.
2. Novelty – whether a product is new to the market or has already gained widespread adoption with additional features.
3. Popularity – measured by the rating or number of users.
4. Diversity of additional features – for example, payment services may offer instalment plans, loans, cashback, and bonus points in addition to basic transactions.
5. User experience factors, including ease of use, interface quality, instructions, and various service conditions.

The comparison of digital ecosystems follows this sequence:

- Exclusive offerings receive the highest score (1.5 points).
- For non-exclusive services, popularity metrics are used to rank organizations.

If quantitative data is unavailable, the diversity of additional services is analysed:

- 0.5 points – standard set of features.
- 1.0 point – additional services that do not significantly impact usability.
- 1.5 points – enhancements that substantially improve the user experience.

Final aggregation and standardization:

1. If quantitative market data is available, organizations are ranked accordingly, and scores are assigned.
2. If both quantitative and qualitative metrics are used, the quantitative metrics are divided into four groups, each assigned a score of 0.0 / 0.5 / 1.0 / 1.5, following the same scale as qualitative indicators.
3. Finally, the scores for market position and service/product comparison are summed into a single indicator for each company, enabling direct comparison and standardization if necessary.

Supply chain sustainability indicators

Based on the literature review, we identified non-financial metrics that characterize supply chain sustainability, including:

1. Flexibility.
2. Reliability.
3. Visibility.
4. Collaboration.
5. Trust.
6. Foresight.
7. Omnichannel capabilities.
8. Efforts to reduce supply chain duration.
9. Supplier diversification.
10. Technological flexibility in production.
11. Supply chain coordination.
12. Employee skills.
13. Service quality.

These metrics are assessed within digital ecosystems using the following criteria:

- Existence of policies addressing each indicator.
- Consideration of ecosystem scale in policy implementation.

However, in some cases, explicit supply chain sustainability management policies are not publicly disclosed in corporate statements, development strategies, goals, analytical reports, or other business descriptions. In such instances, the openness of the digital ecosystem plays a critical role, as publicly available information may indirectly indicate how the company manages its supply chain quality.

We use such indirect information to estimate supply chain management as follows:

- 0.5 points – indirect evidence of supply chain sustainability management.
- 1.0 point – direct company statements on managing supply chain sustainability.
- 1.5 points – formal policies that:
  a. Consider ecosystem scale,
  b. Integrate metrics across all business areas,
  c. Include specialized programs, and
  d. Implement unique initiatives for control, management, and recovery procedures.

The final score is calculated by summing the assessed indicators for each company, allowing for comparative analysis and standardization if necessary.

Digital transformation sustainability indicators

The digitalization level of a digital ecosystem is evaluated across four main categories:

1. Digital Communications.
2. Digital Data.
3. Cybersecurity.
4. Digital Technologies.

Each category includes specific assessment criteria, detailed as follows:

1. Digital Communications.
   - Means of information exchange.
   - User engagement tools.
   - Feedback mechanisms.

Scoring criteria:

- 0.5 points – basic availability of a specific service.
- 1.0 point – improved version of the service, integrated with other services/products
- 1.5 points – multiple similar offerings or an exclusive feature that significantly enhances user experience.

2. Digital Data
   - Data availability and accessibility for participants.
   - Data management policies.
   - Data collection and storage infrastructure.
   - Data analytics tools.
   - Permissions for data usage by external users.

Scoring criteria:

Data management policy:

- 0.5 points – basic policy in place.
- 1.0 point – policy supplemented by transparency, accessibility, and regular updates.
- 1.5 points – comprehensive policy with defined roles, responsibilities, and the ability for users to delete personal data.

Data collection and storage:

- 0.5 points – presence of specialized data centres.
- 1.0 point – advanced security systems and high-tech data centres.
- 1.5 points – high-performance data centres with backup systems, loss prevention, and no major failures in the last three years

Data analytics:

- 0.5 points – basic analytics tools or pre-made reports.
- 1.0 point – advanced data visualization and a wider variety of metrics.
- 1.5 points – AI-driven analytics, machine learning, and sophisticated data processing tools.

Permissions for data usage:

- 0.5 points – permission granted, but with recorded privacy concerns.
- 1.0 point – strict confidentiality control and legal compliance.
- 1.5 points – full compliance with ethical and privacy standards, ensuring strict data security.

3. Cybersecurity:
   - Cybersecurity policies.
   - User data protection.
   - User data management.
   - Vulnerability detection programs.

Scoring criteria:

- Cybersecurity policy & data protection:
- 0.5 points – basic policy in place.
- 1.0 point – dedicated cybersecurity department and standard access verification technologies.
- 1.5 points – certified security measures, response protocols, and strict access controls.

User data management:

- 0.5 points – basic account access control.
- 1.0 point – enhanced security measures for user data.
- 1.5 points – full transparency and complete control over personal data, including the ability to delete all information.

Vulnerability detection programs:

- 0.5 points – basic feedback mechanisms.
- 1.0 point – structured programs for detecting vulnerabilities.
- 1.5 points – comprehensive research, training, and cybersecurity events.

4. Digital Technologies:
   - Blockchain.
   - Robotics and automation.
   - Artificial intelligence (AI) & machine learning.
   - Management platforms.
   - Big data analytics systems.
   - Cloud services & virtual storage.
   - Internet of Things (IoT).
   - Internet of Services (IoS).
   - Distributed ledger technologies.
   - Extended reality (XR): virtual reality (VR), augmented reality (AR), mixed reality (MR).

Scoring criteria:

Adoption & development:

- 0.5 points – use of a single blockchain or similar technology.
- 1.0 point – implementation of multiple digital technologies.
- 1.5 points – participation in technology development, attracting users, or specialization in a competitive area.

Sustainable development indicators – ESG

The sustainable development indicators used for calculating the index can be categorized into four key groups:

1. Quality of Life – accessibility, convenience, service quality, and safety.
2. Ethics and Integrity – information security, personal data protection, anti-corruption and anti-monopoly measures, responsible procurement, and content quality.
3. Human Development – employee well-being, service partnerships, and education for all.
4. Environmental Impact – energy efficiency of infrastructure, waste management, and carbon footprint.

Additionally, we evaluated corporate governance sustainability using the following criteria:

- Board independence.
- Board qualification level.
- Share of related party transactions in revenue.
- Presence of an audit committee.
- Independence of the HR and remuneration committee.
- Number of violations of minority shareholders' rights.

Application of digital ecosystem taxonomy and the DESIn index

Application of digital ecosystem taxonomy

The authors applied the adapted digital ecosystem taxonomy to the investigated companies, Yandex and VK Group. The results confirmed the relevance of selecting these companies for the study, as they are industry leaders within the same geographic region, operate in the same sector, utilize similar technologies, and offer comparable services and products. However, they differ in financial and operational indicators, strategies, and overall business activities.

To explore these differences, we applied the Digital Ecosystem Sustainability Index (DESIn), which was specifically developed to this end.

Using the DESIn index

The application of the DESIn sustainability index to the analysed digital ecosystems shows that VK Group is a weak company in of sustainability metrics. It lags behind Yandex in almost all areas, with the exception of quantitative investment indicators, where it it shows results better than Yandex.

Yandex, on the other hand, demonstrates a high level of sustainability across most areas, achieving scores close to the maximum, despite having the lowest result in the investment category. We attribute the latter to forced transformations within the company driven by geopolitical factors, particularly its redomiciliation in 2024.

Measurement of quantitative indicators of the DESIn index

The analysis of quantitative indicators of the DESIn index and the normalization of data are presented in Tables 1 and 2.

Table 1. Quantitative indicators of DESIn index stability

Digital ecosystem	Yandex			VK Group		
Time period	2021	2022	2023	2021	2022	2023
Financial indicators						
Current liquidity	1.80	1.28	0.89	0.80	1.02	0.88
Financial autonomy ratio	0.53	0.55	0.38	0.57	0.47	0.34
Net Debt / EBITDA	-0.66	-0.50	0.46	1.16	5.08	233.8
Return on assets (ROA), %	1.60	1.70	3.50	-5.20	-7.50	-8.60
Operational indicators						
Asset turnover	0.69	0.85	1.02	0.42	0.36	0.33
Exceeding the average revenue growth over three years over the share of costs in R&D, %		154			110	
Ratio of coverage of operating costs by received cash	0.90	0.98	0.97	1.09	0.85	0.98
Duration of the operating cycle	68.27	82.02	75.27	64.51	192.35	186.98
Investment indicators						
Share of investments in strategic partnerships and acquisitions, %	0.00	1.42	0.00	7.55	0.00	12.48
Asset renewability index, %	-0.02	19.63	27.55	2.37	21.15	11.04
CAPEX / Revenue, %	13.00	10.00	11.00	10.00	16.00	24.00

Source: calculated by the authors.

Table 2. Ranking and normalization of quantitative sustainability indicators

Digital ecosystem	Total		Normalization	
	Yandex	VK Group	Yandex	VK Group
Financial indicators	**9**	**4**	**8.2**	**3.6**
Current liquidity	2	1		
Financial autonomy ratio	2	1		
Net Debt / EBITDA	2	1		
Return on assets (ROA)	3	1		
Operational indicators	**8**	**5**	**7.3**	**4.5**
Asset turnover	1	2		
Exceeding the average revenue growth over three years over the share of costs in R&D	3	1		
Ratio of coverage of operating costs by received cash	2	1		
Duration of the operating cycle	2	1		

Digital ecosystem	Total		Normalization	
	Yandex	VK Group	Yandex	VK Group
Investment indicators	**3**	**6**	**3.3**	**6.7**
Share of investments in strategic partnerships and acquisitions	1	2		
Asset renewability index	1	2		
CAPEX / Revenue	1	2		

Source: calculated by the authors.

In terms of financial and operational performance, Yandex demonstrates strong results in several key areas, including return on assets and development efficiency. However, its low investment indicators may suggest a focus on shorter-term returns rather than long-term investments.

Conversely, VK Group lags behind, exhibiting the longest operating cycle and a negative return on assets.

Assessment of innovative sustainability indicators

Due to limited available information, our analysis relied on news articles, reviews, and publicly available information on the company's website.

Methodology for data collection and evaluation:

1. Internet searches were conducted using keyword combinations such as "new project", "new development", and "new product", along with the company's name and the period 2023–2024.
2. The collected information was then evaluated based on the predefined criteria for assessing this indicator.
3. To ensure comparability, we selected the same number of projects for each company from the first pages of search engine results and assessed them accordingly.

Findings:

- Yandex is focused on horizontal ecosystem expansion, introducing new brands and investing in autonomous vehicle development.
- VK Group, in contrast, concentrates on improving and enhancing existing services and products.

Assessment of market sustainability indicators

The comparison of digital ecosystems based on this criterion revealed differences in services and products.

VK Group's development strategy, which focuses on social networks, video content, and messaging services, does not encompass certain O2O (online-to-offline) assets (Table 3). As a result, this category of services and products received a lower evaluation in the assessment.

Table 3. Assessment of market sustainability indicators

Indicator	Normalization		Estimation	
	Yandex	VK Group	Yandex	VK Group
Coverage of the population within the geographical area, million people, %			56.70	46.10
Grouping	0.6	0.3	1.0	0.5
Quality of different services and products				
Differences	3.9	0.6	6.5	1
Bank			1	0
Browser			1	1
Car and kick sharing, taxi			1	0
Transport schedule			1.5	0
Telemedicine services			0.5	0
Delivery services			1.5	0

Indicator	Normalization		Estimation	
	Yandex	VK Group	Yandex	VK Group
Quality of similar services				
Similar services	3.6	1.8	6	3
Maps, route diagrams, navigators			1.5	0.5
Shop			1	0.5
Communication			0.5	1
Search engine			1.5	0.5
Other services			1.5	0.5
Total	8.2	2.7	13.5	4.5

Source: calculated by the authors.

After selling Zen to VK Group, Yandex lost part of its audience but simultaneously began developing Yandex Q. The company offers a wide variety of services, maintains continuous development, and provides strong alternatives.

Assessment of supply chain sustainability indicators

The level of openness of the studied digital ecosystems varies, resulting in limited or unavailable information on supply chain sustainability management policies. In such cases, analytical and news reviews, as well as company job postings, served as alternative sources of information. All companies demonstrate a high level of supply chain sustainability, which provides them with a competitive advantage.

Assessment of digital transformation sustainability indicators

Digitalization indicators are high for both companies, although VK Group's indicators are slightly lower, likely due to the company's level of information openness. Both companies utilize widespread modern digital technologies. Yandex has placed a strong emphasis on AI technologies, launching Neuro in early 2024 – an AI-powered search engine that provides detailed answers using Internet data and is integrated into other ecosystem products. VK Group, on the other hand, focuses on advancements in cloud services, including storage and data management. Both companies are actively developing across key areas of digitalization, which positively contributes to their long-term sustainability.

Assessment of sustainable development indicators – ESG

The normalized values of these indicators are presented in Table 4.

Table 4. Assessment of sustainable development indicators – ESG

Indicator	Yandex	VK Group
Quality of life	1.3	1.0
Available environment	0.6	0.6
Convenience, quality and security of services	0.6	0.3
Ethics and integrity	2.6	1.6
Information security and personal data protection	0.6	0.3
Responsible purchases	0.6	0.0
Content quality	0.6	0.6
Anti-corruption and anti-trust measures	0.6	0.6
Human development	1.9	1.9
Staff	0.6	0.6
Service partners	0.6	0.6
Education for all	0.6	0.6
Environmental impact	1.9	0.6
Energy efficiency of own infrastructure	0.6	0.3
Waste management	0.6	0.3
Carbon footprint	0.6	0.0
Risk management	0.6	0.6
Total	8.4	5.8

Source: calculated by the authors.

Assessment of corporate governance sustainability indicators

The normalized values of these indicators are presented in Table 5.

Table 5. Assessment of corporate governance indicators

Indicator	Yandex	VK Group
Board	5.3	3.7
Board independence	1.1	0.5
Qualification and election process:	1.1	0.5
Transactions with related parties	1.1	0.5
Audit Committee	1.1	1.1
Election process	1.1	1.1
HR and Remuneration Committee	2.1	2.1
Independence of the committee	0.5	0.5
Powers and responsibilities of the committee	0.5	0.5
Committee involvement in company processes	1.1	1.1
Shareholder rights	2.6	2.6
Right to participate in company management	1.1	1.1
Right to receive information	1.1	1.1
Right to receive dividends	0.5	0.5
Total	10.0	8.4

Source: calculated by the authors.

Analysis of the impact of the DESIn index on EVA

Investigating the impact of the DESIn index on EVA using financial modelling

To investigate the impact of the DESIn Digital Ecosystem Sustainability Index, developed by the authors, for Yandex and VK Group, we constructed financial models that include the following steps:

1. Data collection and analysis.
2. Revenue forecasting.
3. Estimation of operating expenses.
4. Assessment of capital expenditures and investments.
5. Calculation of the free cash flow (FCF).
6. Evaluation of the weighted average cost of capital (WACC).
7. Calculation of the economic value added (EVA).
8. Estimation of the discounted cash flow (DCF) for comparison with the EVA method.

Financial model for Yandex

The assumptions and indicators were analysed and selected to ensure the correct calculation of metrics for the Search and Portal division, which includes services such as Search, Geoservices, Weather, and several other offerings in Russia, Belarus, and Kazakhstan, and accounts for nearly all of Yandex's advertising revenue.

Additionally, market indicators were identified and analysed for the E-Commerce division, which includes services such as Yandex Market, the express grocery delivery service Yandex Lavka in Russia, and the grocery delivery service Yandex Food. The company's revenue streams were categorized into the following areas:

- Search advertising.
- Performance CPX.
- Performance video.
- Media advertising.
- E-commerce.
- Ridetech.
- Delivery.
- Yandex Plus.
- Yandex Music.
- Kinopoisk.
- Yandex Afisha.
- Yandex Studio.
- Yandex SDG.
- Yandex Cloud.
- Yandex 360.
- Yandex Education (Practice).
- Devices.
- Alice.

Operating expenses were calculated based on historical unit rates and revenue percentages, with growth rates and revenue percentages validated by market research. Capital expenditures were estimated based on historical revenue percentages, and similar percentages were applied to depreciation and working capital. The WACC calculations, based on the Yandex financial model, are presented in Table 6.

Table 6. WACC estimation for Yandex

WACC calculation			
Cost of equity	**Calculation**	**%**	**17.02**
Risk-free rate	OFZ 15y	%	13.80
Beta unlevered	Cbonds, YNDX	#	0.42

WACC calculation			
D/E	Analogous	#	0.05
Tax rate	Tax code RF	#	20%
Beta levered	Calculation	#	0.42
ERP	Kroll	%	6.22
Size-premium	Kroll	%	0.50
Target capital structure			
D/E	Damodaran	#	0.05
Cost of debt	**YTM of Softline's bonds**	**%**	**16.00**
Marginal Tax rate	Tax code RF	%	20.00
After tax cost of debt	Calculation	%	12.80
WACC	**Calculation**	**%**	**16.69**

Source: calculated by the authors.

The calculations were verified by constructing a discounted cash flow (DCF) model. The low debt-to-equity (D/E) ratio was determined based on a retrospective analysis of Yandex's historical financial reports, as well as a comparison with competitors. Yandex maintained negative net debt from 2019 to 2022. The calculations of economic value added (EVA) for Yandex are presented in Table 7.

Table 7. Calculation of economic value added (EVA) for Yandex

Indicator	2024	2025	2026	2027	2028	2029
Equity value	369.2	490.5	693.8	967.5	1 326.0	1 784.6
Added value	33.9	57.5	139.7	193.7	254.1	319.3
Current invested capital	888.5					
PV of value added	696.7					
Equity value	1 585.2					
Value per share	4 204.8					

Source: calculated by the authors.

Financial model for VK Group

Similar macroeconomic and market assumptions to those used for Yadex were applied in developing the financial model for VK Group. The assessment of the company was conducted across various segments of its ecosystem, as reflected in the developed model. The only significant difference is the higher WACC, attributed to the company's substantial debt burden (Table 8).

Table 8. WACC estimation for VK Group

WACC calculation			
Cost of equity	**Calculation**	**%**	**26.39**
Risk-free rate	OFZ 10y	%	13.80
Beta unlevered	Damodaran	#	1.08
D/E	Analogous	#	1.00
Tax rate	Tax code RF, %	#	20
Beta levered	Calculation	#	1.94

WACC calculation			
ERP	Kroll	%	6.22
Size-premium	Kroll	%	0.50
Target capital structure			
D/E	Damodaran	#	1.00
Cost of debt	VK bonds	%	15.62
Marginal tax rate	Tax code RF	%	20.00
Cost of debt after tax	Calculation	%	12.50
WACC	**Calculation**	**%**	**18.19**

Source: calculated by the authors.

The calculations of economic value added (EVA) for VK Group are presented in Table 9.

Table 9. Calculation of economic value added (EVA) for VK Group

Indicator	2024	2025	2026	2027	2028	2029
Equity value	173.3	175.5	178.5	182.5	188.2	196.1
Added value	(23.2)	(12.4)	2.2	22.2	49.9	88.7
Required return on invested capital	31.5	31.9	32.5	33.2	34.2	35.7
PV of value added	108.2					
Equity value	108.2					
Value per share	478.4					

Source: calculated by the authors.

Main conclusions of financial modelling

Our financial models show that the value of Yandex is expected to grow for the following reasons:

1. Yandex remains the most successful Russian Internet company with a highly diversified business portfolio.
2. Despite external challenges, the company's revenue grew by 46% in 2022 and by 53% in 2023. This growth is expected to continue, driven by the rapid development of the e-commerce, ridetech, and delivery markets, where Yandex holds a significant share: in 2023, these markets generated 420 billion roubles (+61% YoY). The advertising market will further drive stock market growth.
3. The departure of many foreign companies has encouraged Yandex to focus on the development of its own ecosystem.
4. Although the e-commerce segment is still operating at a loss, all assets in this area are nearing breakeven. Yandex Market, for example, was close to breaking even as of July and is expected to become profitable in the coming quarters. Ridetech has historically posted positive EBITDA, and O2O services are working toward operational efficiency, with expectations for profitability in the next few years.
5. The number of service subscribers is growing rapidly, with Yandex.Plus subscribers increasing by 66% in 2022 and 58% in 2023. This indicates that Yandex is successfully pursuing its growth strategy and will continue on this path.
6. The company maintains a low debt-to-EBITDA ratio of 0.7, showing a low debt burden.

Key risks for Yandex:

1. Yandex is expanding its business in various segments, but faces high competition in all areas. There is a risk that failure in any major segment could hinder growth expectations.
2. Legislative and regulatory challenges may affect operations.
3. Western sanctions against the Russian Federation negatively impact collaborations with foreign companies and the acquisition of foreign expertise. The ban on high-tech equipment from Western countries may significantly increase modernization costs or lead to technological backwardness.
4. The company has been generating negative free cash flow in recent years due to active investments in growth.
5. Yandex does not currently pay dividends.

6. Shares are traded at a high EV/EBITDA multiple of 15.7 for the Russian market, though this could be justified given the company's growth projections.

In contrast, our analysis for VK Group indicates that the company's shares should be sold at this time for the following reasons:

1. Slowing revenue growth: VK's Social Media & Content Services revenue growth slowed to 31% in H2 2023, down from 41% in H1. This slowdown is partly due to the low base effect.
2. Decreasing profitability: Social Media EBITDA dropped significantly from 19% in H1 2023 to just 1% in H2 2023, reflecting a significant deterioration in profitability.
3. High investment, low profitability: Despite a 10–11% growth in MAU/DAU, the company is still incurring significant losses. For instance, the EdTech segment posted an EBITDA loss of RUB 111 million in H2 2023.
4. Negative free cash flow: The company reported a free cash flow (FCF) loss of RUB 35 billion in 2023 (RUB 44 billion including M&A), compared to a loss of RUB 12 billion in 2022.
5. Growing debt burden: VK's net debt increased from RUB 98 billion in H1 2023 to RUB 139 billion by the end of the year, indicating a deteriorating financial position.
6. Weak share performance: The company's shares show a negative free cash flow yield of –29% in 2023, –14% in 2024, and –3% in 2025, making them less attractive to investors.
7. Profitability issues in other segments: Segments such as VK Play, RuStore, and voice technologies have also shown EBITDA losses, which negatively impact the company's overall profitability.
8. Overvaluation: The current EV/EBITDA of 64.6 indicates that VK shares are significantly overvalued compared to the market average, which may necessitate a revision of their value.

These factors highlight the significant financial and operational risks associated with owning VKontakte (VK) shares, making them less attractive to investors.

Key takeaway: Financial modelling confirms that the DESIn index calculations are correct. Yandex's ecosystem is more developed than VK's, which requires modernization to stay competitive.

Conclusion

In our research on digital ecosystems, we adapted a taxonomy for Russian companies based on a comprehensive review of the literature and global digital ecosystems. This taxonomy enables us to identify the key classification features of business models and form a clearer understanding of their specifics. The elements of this taxonomy can also be applied to develop business models for digital ecosystems.

Our literature review and financial modelling demonstrated a positive impact of the Digital Ecosystem Sustainability Index (DESIn) on economic value added (EVA). Companies with high DESIn scores, such as Yandex and VK Group, show higher EVA. This confirms that the sustainability of digital ecosystems contributes to an increase in company value by enhancing operational efficiency, reducing risks, and attracting investment. The DESIn index we developed provides a framework for detailed, full-scale studies of digital ecosystems, with flexible implementation. It uses data for external users and examines key areas of an organization's activities through both quantitative and non-quantitative indicators.

Digital ecosystems with high DESIn values demonstrate significant improvements in operational efficiency, including better supply chain resilience management and use of digital infrastructure. These improvements lead to higher asset turnover, reduced operating costs, and optimized business processes, all of which contribute to EVA growth. High DESIn values also positively impact the investment attractiveness of companies. Sustainable digital ecosystems attract more investors due to their stability and long-term growth potential, thereby increasing company value.

Companies with high DESIn scores are also more likely to implement innovations that help them maintain competitive advantages and adapt to rapidly changing market conditions. Innovative sustainability metrics show a strong correlation with EVA growth, leading to greater investor confidence and, ultimately, an increase in company value.

In conclusion, our study has achieved its objectives and solved the set tasks: we identified the main features and criteria of digital ecosystems, explained the relevance of sustainability indicators and their impact on company value, and developed a method for measuring the sustainability of digital ecosystems. The DESIn index has shown its effectiveness in analysing digital ecosystem sustainability.

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