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Veröffentlichungsversion / Published Version
Zeitschriftenartikel / journal article

TOOLS FOR EVALUATING THE COMPETITIVENESS OF INNOVATIVE CLUSTERS (SILICON SAXONY CASE)

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Received 20 March 2019
doi: 10.5922/2079-8555-2020-2-10

Federal programmes to support regional clusters in Russia were introduced several years ago. Today, they need updating and revision. A promising starting point for effective support for hi-tech and innovative clusters may be evaluation of cluster performance aimed to understand whether further development and financing of cluster projects are required and whether the list of supported clusters should be extended or reduced.
This article analyses the case of the Silicon Saxony innovation cluster (Germany), using the World Bank methodology for cluster competitiveness evaluation. Each analysis tool is provided with concrete data obtained for Germany and Silicon Saxony over the past ten years. Competitive clusters considered in the analysis are Minalogic in Grenoble (France) and Micro- and Nano systems in Catania (Italy). The results of employing the methodology are examined from the perspective of its possible use in evaluating the competitiveness of innovative clusters in the Russian Federation. Early recommendations on adapting the methodology are produced.

Keywords:
innovation cluster; regional cluster; evaluation of competitiveness; cluster projects; Silicon Saxony

Introduction

World experience and recent theoretical studies have indicated that progressive structural transformations of national and regional economies are more ef-

To cite this article: Akhunzhanova, I. N., Tomashevskaya, Yu. N., Osipov, D. V. 2020, Tools for evaluating the competitiveness of innovative clusters (Silicon Saxony case), *Balt. Reg.,* Vol. 12, no 2, p. 153—173. doi: 10.5922/2078-8555-2020-2-10.

fective if the cluster approach is adopted. Its use in economic policy makes it possible to accumulate private, public, and state interests, diversify risks, and tap the resources of territories to achieve a synergistic effect[1] [1; 2].

Since 2000, most European countries have provided government support for major cluster initiatives. Examination, monitoring, and evaluation of clusters and their support programmes make it possible to calibrate and build strategies for a national cluster policy [3; 4].

Federal programmes to support regional clusters were launched in Russia in 2012.[2] The methodology and implementation of Russia's cluster policy resemble those of similar European programmes, particularly French and German ones [6]. European support programmes, however, always include cluster monitoring and evaluation [7; 8]. The experience of European countries can serve as the basis for a methodology to evaluate Russian clusters.

The literature has proposed several ways to measure the development and competitiveness of clusters. These approaches include a method based on calculating cluster-generated effects [9; 10]; methods for assessing the economic efficiency of clusters as investment projects [11]; parametric techniques for assessing cluster efficiency [1]; methods based on assessing various aspects of cluster competitiveness (market position, technological leadership, ability to innovate, cluster policy effectiveness) [12-14]. Although the tools described in the above empirical studies are universal, they do not always meet the comprehensive assessment criterion.

The methodology for cluster competitiveness assessment developed by the International Trade Department of the World Bank[3] is more complete because it evaluates the current state of a cluster and makes it possible to put it on a new

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[1] *Innobarometer* on cluster's role in facilitating innovation in Europe. URL: http://ec.europa.eu/commfrontoffice/publicopinion/flash/fl_187_sum_en.pdf (accessed: 10.02.2019).

[2] *Concept* of long-term socio-economic development of the Russian Federation until 2020 (approved by the Government's directive No 1662-r of November 17, 2008). URL: http://www.consultant.ru/document/cons_doc_LAW_82134/28c7f9e359e8af09d7244d8033c66928fa27e527/ (accessed: 09.02.2019); *Guidelines* for the implementation of cluster policy in constituent entities of the Russian Federation dated December 26, 2008, No 20636-ak/d19. URL: http://economy.gov.ru/wps/wcm/connect/6c823780409dd522a6bcef2c73e16b99/metod_recom_cluster.doc?MOD=AJPERES&CACHEID=6c823780409dd522a6bcef2c73e16b99 (accessed: 08.02.2018); *Innovation* development strategy of the Russian Federation until 2020 (approved by the Government's directive No 2227-r of December 8, 2011) URL: http://www.garant.ru/products/ipo/prime/doc/70006124/ (accessed: 08.02.2019).

[3] *World* Bank International trade department. Cluster for competitiveness. A Practical Guide & Policy Implications for Developing Cluster Initiatives. URL: http://siteresources.worldbank.org/INTRANETTRADE/Resources/cluster_initiative_pub_web_ver.pdf (accessed: 05.02.2019).

path of development. The approach stimulates interactions among all cluster participants, creates a common vision, facilitates new joint projects that benefit everyone involved, and contributes to the triple helix effect [15—17].

The World Bank methodology is a conceptual study based on a consistent review of cluster activities. It uses standard strategic analysis tools; each one can be supplemented and expanded.[4] The advantages and drawbacks of these tools have been discussed in detail by Oleg Vikhansky, Tatyana Kutaeva [18], Svetlana Orekhova [19], Rais Fathutdinov, Irina Tsulaya [20], Ramziya Shakirova [21], and Anatoly Shamin [22].

This study, which uses the World Bank methodology, consists of four stages and ten steps. Table 1 lists the tools for assessing cluster competitiveness.

Table 1

Tools for assessing cluster competitiveness

Stage of study	Tools
I. Cluster definition	Tool 1. Cluster mapping
II. Cluster analysis	Tool 2. Product and market segmentation Tool 3. SWOT Tool 4. GAP analysis Tool 5. Porter's five forces analysis Tool 6. Value chain analysis Tool 7. Market trends analysis Tool 8. Competitive positioning analysis
III. Institutional support assessment	Tool 9. Old and new institutions for collaboration
IV. Process control	Tool 10. Monitoring and evaluation

Source: prepared by the authors based on World Bank materials.[5]

This article presents findings obtained using the World Bank methodology to assess the competitiveness of Silicon Saxony, Germany's innovation cluster, and to demonstrate its potential and prospects. The study sets out to understand whether this methodology can be adapted to assessing innovation cluster competitiveness in Russia.

[4] *World* Bank International trade department. Cluster for competitiveness. A Practical Guide & Policy Implications for Developing Cluster Initiatives. URL: http://siteresources.worldbank.org/INTRANETTRADE/Resources/cluster_initiative_pub_web_ver.pdf (accessed: 05.02.2019).

[5] *World* Bank. International trade department. Cluster for competitiveness. A Practical Guide & Policy Implications for Developing Cluster Initiatives. URL: http://siteresources.worldbank.org/INTRANETTRADE/Resources/cluster_initiative_pub_web_ver.pdf (accessed: 05.02.2019).

Germany was chosen for cluster analysis for the following reasons:

— in 2018, Germany ranked fifth on the global competitiveness index; it is the first richest country by GDP in the EU and the fourth in the world, beaten only by the US, China, and Japan;

— according to TCI Network, Germany has the greatest number of cluster initiatives in the world, 432; the US ranks second with 103.[6] Bavaria, Baden-Württemberg and North Rhine-Westphalia pioneered cluster initiatives in the 1980s, long before the advent of European support programmes;[7]

— German federal cluster programmes, BioRegio and InnoRegio, have set a benchmark for their European counterparts.

Initiative Kompetenznetze Deutschland includes 97 clusters from all major high-tech industries, located in the country's eight most innovative regions[8] [23; 24]. Silicon Saxony was created in 2000 to achieve synergies and develop businesses and companies producing microelectronic components, semiconductors, and microsystems.

Assessing the competitiveness of Silicon Saxony using the World Bank methodology

Before analysing the competitiveness of Silicon Saxony, we will provide a brief description for each tool used in the World Bank methodology.

Stage I. Cluster definition

Tool 1. Cluster mapping

Cluster mapping aims at determining the place a cluster has in the economy as well as at describing its employment and innovation rates, linkages, etc.[9]

Figure 1 shows cluster mapping results for Silicon Saxony.

[6] *TCI* Network. Cluster Resources // Cluster initiatives. URL: http://www.tci-network.org/initiatives (accessed: 10.02.2019).

[7] *Cluster* policy in Europe. A brief summary of cluster policies in 31 European countries // Oxford Research AS, 2008. URL: https://www.kooperation-international.de/uploads/media/Cluster.policy.europe.2008.pdf (accessed: 24.01.2019).

[8] *Tactics*. Where the cluster winds are blowing in Europe, 2013. URL: http://abclusters.org/wp-content/uploads/2013/12/Where-the-cluster-winds-areblowing-in-Europe.pdf (accessed: 10.02.2019).

[9] *Cluster* for competitiveness. A Practical Guide & Policy Implications for Developing Cluster Initiatives. URL: http://siteresources.worldbank.org/INTRANETTRADE/Resources/cluster_initiative_pub_web_ver.pdf (accessed: 05.02.2019).

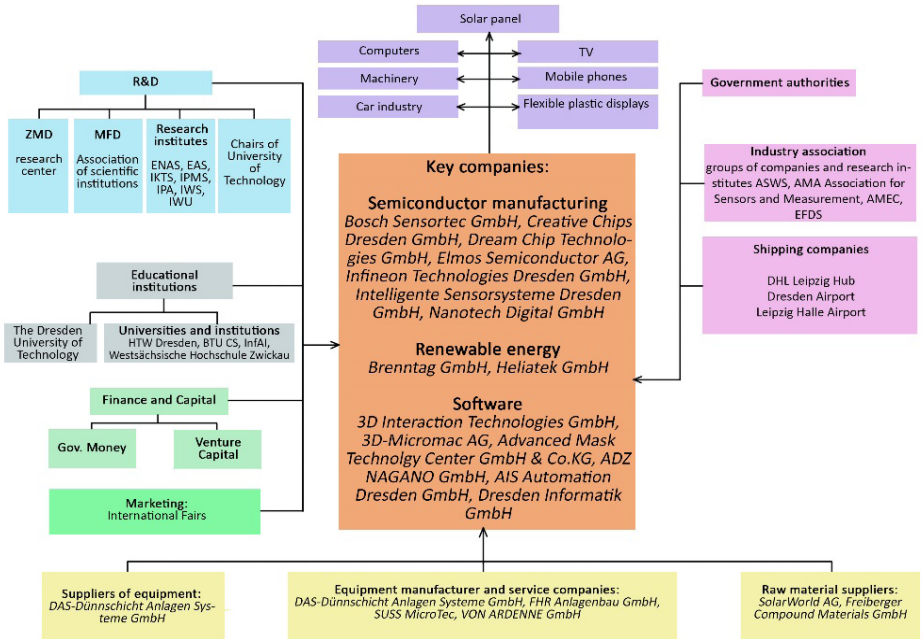

Fig. 1. Cluster mapping for Silicon Saxony (Germany)

Source: prepared by the authors based on data from the European Network of Mis croeconomics[10].

Since 2000, about 20 companies in the Saxon microelectronics industry have joined Silicon Saxony e.V. as full or associate members. Currently, Silicon Saxony is a self-financed association that brings together manufacturers, research institutes, public institutions, consulting companies, and service providers.

The cluster has over 300 member companies (see the official website of Silicon Saxony[11] for the full list) and employs over 20,000 people. Small and medium-sized enterprises account for 76% of the cluster members; research organisations, technology centres, and universities, for 7% (there are 23 of them). The total annual turnover of the cluster is 4.5 billion euros.

The cluster is organised as an association. It is managed by the board of directors and the scientific board. The latter advises the former on strategic issues, keeps it updated on technological trends, and supports regional, national, and international research cooperation as well as technology transfers.[12]

[10] *The European* Network of Microeconomics. URL: http://www.mems-russia.ru/images/stories/associaciya_silicon_saxony_e.v.pdf (accessed: 11.03.2019).

[11] *Mitglieder* Silicon Saxony. The High-Tech Network. URL: https://www.silicon-saxony.de/nc/mitglieder/alphabetische-sortierung/ (accessed: 10.02.2018).

[12] *Silicon* Saxony. The High-tech Network. Structure. URL: https://www.silicon-saxony.de/en/network/association/structure (accessed: 10.02.2019).

Cluster members pay annual fees of 600—2,000 euros depending on how many employees the company has. They take part in various expert events: fora, symposia, conferences.

The cluster is running four large long-term projects: Smart Systems Hub, a technological platform for the development of intelligent systems; SenSa, a pilot line project for innovative sensors; Cool-RFID, a project seeking to develop passive RFID sensors; ICOOL, which aims to internalise cluster activities for the development of key energy-efficient electronic technologies in Germany and Europe.

Cluster mapping issued to reveal the structure of the cluster. All cluster members have long-term close relationships based on cluster membership. The cluster is a sustainable association driven by a synergistic effect.

Stage II. Cluster analysis

Tool 2. Product and market segmentation

This tool aims at identifying key products and market segments as well as at detecting opportunities and threats.

Figure 2 shows the structure of the main production areas of the Saxon microelectronics industry, the number of companies and employees, and annual turnover.

Silicon Saxony has a wide specialisation. Along with microelectronics, informatics, sensor technologies, communication and information transmission technology, telecommunications and electrical equipment, the cluster manufactures technological equipment, automotive equipment, biotech and medtech products, pharmaceuticals, and renewable energy equipment. Software development for electronic components and printed circuit boards accounts nevertheless for most companies (61%) and a significant percentage of employees (37%).

Silicon Saxony is dominated by large companies: microchips are produced by GLOBALFOUNDRIES Inc.; microcontrollers, by Infineon; special semiconductor elements, by X-Fab; semiconductors, by ZMD (Dresden Microelectronics Center); silicon wafers, by Siltronic AG and DeutscheSolarAG. The largest enterprises of Silicon Saxony are either foreign companies (mainly those from the US, including AMD and Applied Materials) or firms from Western Germany (Infineon, Siltronic, Siemens).

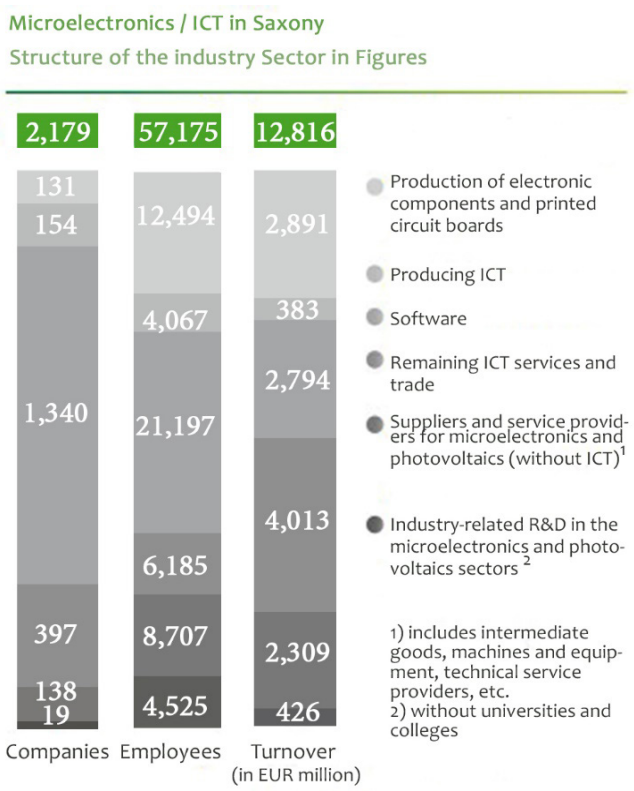

Fig. 2. The structure of the microelectronics/ICT industry in Saxony[13]

Cluster members manufacture complementary goods: the products of micro- and nanoelectronics companies (Power Electronics GmbH, 3D Interaction Technologies GmbH, Applied Materials GmbH) facilitates software development by their fellow cluster members; Siltronic AG uses Qimonda chips to manufacture silicone discs; Freiberger Compound Materials AG is a supplier of Siltronic AG; finally, silicone discs are delivered to Microelectronic Packaging Dresden (MPD) GmbH.

The Dresden University of Technology is responsible for a significant proportion of R&D, along with non-university research institutes (Max Planck Society, Leibniz Association and the Fraunhofer Gesellschaft), centres for nanotechnology, the Association of Information Technology, Telecommunications and New Media Saxony (*SAX-IT — Verband der Informationswirtschaft, Telekommunikation und Neue Medien Sachsen eV*), and the

[13] *Microelectronics* — Powerhouse Eastern Germany. URL: https://www.powerhouse-eastern-germany.de/PEG/Content/DE/_SharedDocs/Download/factsheet-cluster-microelectronics-pdf.pdf?v=5 (accessed: 14.02.2020).

Saxon Telecommunications Centre (*Sächsisches Telekommunikationszentrum eV — Sächs-Tel*). Moreover, they take part in developing and implementing new products of cluster companies.

According to a study commissioned by the Saxon State Ministry for Economic Affairs, Labour, and Transport [19], the system of raw material and product suppliers for microelectronics enterprises is not fully developed in the cluster. The cluster is dominated by large companies with a narrow range of products, whereas external companies are often the source of innovation.

Cluster growth areas can generate new knowledge and technologies in semiconductor manufacturing, organic electronics, photovoltaics, nanoelectronics, and sensor systems through closer cooperation between manufacturing companies and research institutes. Greater involvement of local small and medium enterprises can also benefit the cluster.

Tool 3. SWOT

This tool makes it possible to identify the place of the cluster in the domestic and international market, compare the performance of cluster companies with that of their competitors, and devise a market positioning strategy.

Table 2 presents general conclusions based on analysis of various sources of information.

Below we will consider in detail the external and internal factors included in SWOT analysis.

Saxony's successful education system provides a pool of highly qualified and motivated employees: 45.5% of local graduates are specialists in science and technology.[14]

Silicon Saxony enjoys significant investment support from the German government and Go-Cluster — a cluster excellence initiative from the Federal Ministry for Economic Affairs and Energy.

Cluster companies have a clear marketing strategy that provides them with globally recognisable brands. They participate in exhibitions in Hanover (the Hanover Fair) and the largest computer exhibition *CeBIT* to promote themselves in the microelectronics market. Major support comes from Regionalforum Mitteldeutschland.

[14] *Office* of Economic Development Dresden (Saxony). URL: http://invest.dresden.de/en/Statistics_and_Downloads/Science_3289.html (accessed: 20.02.2019).

Table 2

The SWOT of Silicon Saxony

Factor	**Strengths** • A recognisable brand • 'Best minds', including international experts • Availability of AMD research centres • Availability of direct buyers • Access to raw materials • Active work of associations and alliances • Efficient logistics system • The engineering-oriented regional education system • High level of R&D	**Weaknesses** • A low share of venture capital • Vertical integration of companies within the cluster • High tax rates
Opportunities • A growing market • Centricity of the region • Developed infrastructure in the region • Efficient local administration • National support and promotion programmes (GA program) • High standards of living in the region • Active government investment in R&D • A simplified bureaucratic system	**Opportunities / Strengths** Silicon Saxony is a strong competitor of British and French IT clusters thanks to its stable business environment, developed infrastructure, and geographical location	**Opportunities / Weaknesses** Horizontal integration of production can be achieved by attracting public funds. Silicon Saxony Management GmbH can ensure development by interacting with the government and external stakeholders
Threats • High competition, including that from Asian countries • A decreasing share in the semiconductor market	**Threats / Strengths** Positioning in global markets	**Threats / Weaknesses** A low share of venture capital usage combined with high tax rates may cause the cluster to lose its competitive edge in the European market and beyond.

Silicon Saxony works with a group of direct local consumers: Niles-Simmons-Hegenscheidt and StarragHeckert (metalworking), UNION Werkzeugmaschinen GmbH Chemnitz (machine tools), BMW, Volkswagen, Siemens Mikroelectronics Center Gmbh (SIMEC), and Solarworld AG and Siltronic-Werk (Saxon solar industry companies). An increase in global demand for semiconductors is expected to sustain the growth of the cluster.[15]

[15] According to *Gartner*, the global sales of microelectronic components in 2017 increased by 21.6% and will increase to $ 482 billion by 2022.

Weaknesses include the vertical integration of companies within the cluster. This type of integration may upset the capacity balance in each link of the value chain and reduce the production flexibility of cluster companies. Another weakness is the complexity of the German tax system: corporate income is double-taxed, the tax totalling about 30-32% or even 40% if the corporation has only one owner.[16] Moreover, the proportion of venture capital in Silicon Saxony is rather low. The last venture investment in the development of the cluster was made in 2016: the Federal Ministry of Economic Cooperation and Development and the European Investment Fund invested 1 billion euros.

The most significant external threat is competition from Asian chip producers, which thrive on cheap labour and government support measures. Besides, these countries have a more favourable tax system, particularly as concerns exports. Companies can, therefore, lower the prices of their products. In South Korea, income tax on exports was halved. In China, corporate income tax was abolished on May 1, 2016; Chinese companies pay VAT instead. Faced with competition from Taiwan, the European share in the semiconductor market has fallen from 23% to 15% (see the report of the European Semiconductor Industry Association[17] (EIA)).

SWOT analysis demonstrates how strategic planning can be implemented to the benefit of Silicon Saxony given existing opportunities and potential threats. The intersections of SWOT factors (Opportunities/Strengths, Opportunities/Weaknesses, Threats/Strengths, Threats/Weaknesses) show what external factors can create new development options and what strengths can be used to mitigate threats (Table. 2).

Tool 4. Gap analysis

This tool examines gaps between actual performance and desired performance; its focus is always beyond the study object. Table 3 shows the results of the gap analysis for Silicon Saxony. Based on data from a study performed by Swedish scientists Göran Lindqvist and Örjan Sölvell [5], our analysis employs the expert survey method.

[16] *Worldwide* Tax Summaries Online. URL: http://taxsummaries.pwc.com/ID/Germany-Overview (accessed: 20.04.2019).

[17] *Semiconductor* Industry Association. URL: https://www.semiconductors.org/industry_statistics/semiconductor_capacity_utilization_sicas_reports (accessed: 20.02.2019).

Table 3

Gap analysis for Silicon Saxony

Factor	Agents				
	Cluster to Research	Cluster to capital	Cluster to government	Cluster to education	Firm to firm
Knowledge / awareness	Low	Sufficiently low	Sufficiently high	Sufficiently high	High
Interaction channels	Rare	Limited	Firm enough	Limited	Firm enough
The 'language' of interaction	Various	Common	Various	Various	Common
Norms and Relationships	Various	Similar	Some differences	Various	Similar
Vision	Different	Different	More common than not	More common than not	Predominantly common
Trust level	Low	High	Sufficiently high	Sufficiently high	Sufficiently high
Result	Strong obstacles / gap	Some obstacles/ Gap	Weak obstacles/ interaction	Some obstacles/ gap	Weak obstacles/ interaction

Gap analysis revealed gaps in cooperation between cluster companies, on the one hand, and research, educational and financial organisations, on the other. The open innovation strategy of Silicon Saxony can help streamline cooperation between the cluster and the scientific community. The strategy will enhance research cooperation through sharing technologies and patents and submitting joint grant applications for additional financing.[18] Measures to bridge the gap between the cluster and universities include the introduction of educational programmes meeting the demands of Silicon Saxony companies. Information exchange and

[18] *Silicon* Saxony. The High-tech Network. URL: https://www.silicon-saxony.de/en/network (accessed: 20.02.2019).

bilateral interactions with investment companies and local banks can contribute to strong partnerships between cluster companies and financial organisations, including venture companies.

Tool 5. Porter's five forces analysis

Porter's five forces analysis [25] helps determine the intensity of competitive forces. It is used to assess the strategic effectiveness of a cluster and identify the long- and short-term effects of competition in certain market segments.

The five forces analysis [26] for Silicon Saxony uses matrices reflecting a low, medium or high degree of threat. Table 4 shows the summarised results.

Table 4

Porter's five forces analysis and cluster development prospects

Parameter	Degree	Description	Focus area
Threat of substitute products or services	Medium	Cluster companies have various but not unique offers in the microelectronics market	Making the product unique. Focusing on a unique value proposition
Rivalry among existing competitors	Medium	This promising market is highly competitive, yet there are price growth constraints	Constant monitoring of offers from competitors; mitigating the effect of price competition on sales by increasing customer value
Threats of new entrants	Medium	This threat exists; there are, however, barriers to new entrants, including the high level of initial investment	Constant monitoring of new entrants; increasing end-user product awareness
Bargaining power of buyers	Medium	The customer portfolio has risks; sales will drop if the cluster loses key customers	Diversifying customer portfolio; loyalty programmes
Bargaining power of suppliers	Low	Stability in relations with suppliers	Adopting a policy of price reduction by negotiations

Five forces analysis shows how Silicon Saxony can level threats and identifies strategic alternatives that can boost cluster development.

Tool 6. Value chain analysis

Value chain analysis involves two stages:

• a snapshot of the current value chain is prepared, showing all key productivity issues;

• a value-chain proposal is developed so that greater value can be added during production.

The value chain of Silicon Saxony is typical for companies in the industry (Fig. 3).

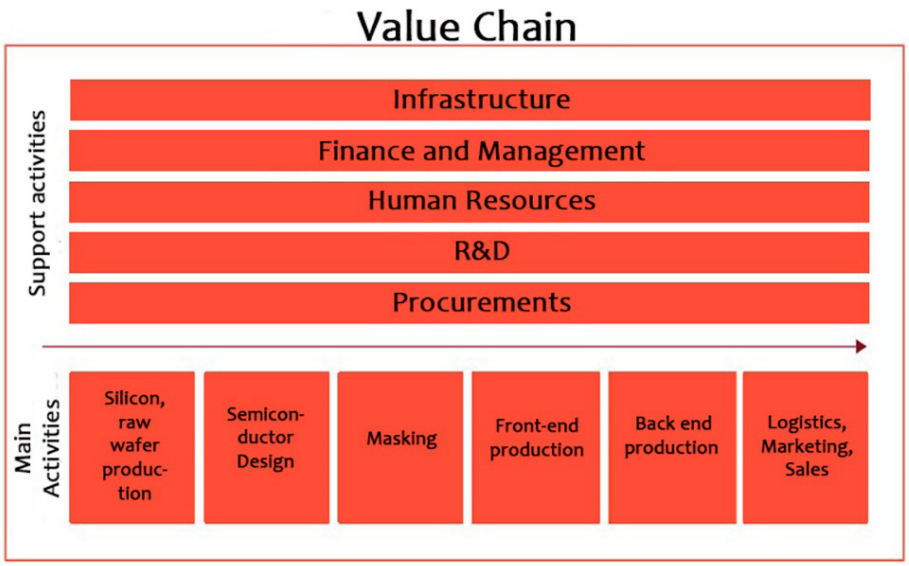

Fig. 3. Silicon Saxony value chain

Source: prepared by the authors[19].

The value chain of the cluster contains all necessary elements: from design and prototyping companies, assemblers and suppliers (*Infineon, X-Fab*) to a well-developed network of companies promoting products and services in international markets (*Silicon Saxony Management GmbH*). The value chain of Silicon Saxony has a more complex structure than those of the semiconductor industry do because it includes companies from related industries (3D Interaction Technologies GmbH, Applied Materials GmbH, Freiberger Compound Materials AG).

In this science-driven industry, networks of research centres have an important role in the chain. In the case of Silicon Saxony, this network includes the Dresden University of Technology and non-university research institutes: Max Planck Society, Leibniz Association, and Fraunhofer Gesellschaft. New technology is developed both by cluster companies (private laboratories) and through collaborations with research centres and universities in Saxony.

[19] *Entwicklungsstand* und Handlungserfordernisse zum weiteren Ausbau des Mikroelektronik-/ IKT- Clusters in der Region Dresden // Studie im Auftrag des Amts für Wirtschaftsförderung der Landeshauptstadt Dresden. 2008. S. 69—87.

The value chain of the cluster is dominated by infrastructure-intensive companies — materials, tools, and equipment suppliers as well as services providers (over 100 companies). Raw materials come from both German and international suppliers. In 2017, the Dutch company RoodMicrotec became the microchip supplier of the Rohde & Schwarz group, which is part of the Silicon Saxony cluster. Such decisions increase transaction costs associated with low cluster agglomeration.

Silicon Saxony Management GmbH has a pivotal role in technology marketing and transfer along the value chain of the cluster. The company looks for concessional financing opportunities for startups, provides marketing support, and encourages the participation of cluster companies in international trade fairs.

Cluster support services are provided by more than 20 consulting companies: Ostsächsische Sparkasse Dresden, advertising companies, service companies (for example, catering firms), and logistics and planning businesses (for example, those working in environmental protection).

According to McKinsey research, chain strength is determined by three factors: right product, right time, and right location. In the case of Silicon Saxony, key cluster production facilities are located at a considerable distance from principal consumers. The cluster can significantly reduce the cost and complexity of trading by employing blockchain technology, which ensures transparency of operations. Semiconductor production is an international business that requires efficient logistics schemes, continuous improvement of processes, and product recognition.[20] International shipping needs faster, safer, and more efficient paperwork. Blockchain technology can shorten shipping and delivery times (operational time) as well as improve inventory management.

Tool 7. Market trend analysis

This tool is necessary to pin down the product and market segments that a cluster might be missing.

At the time of analysis, the products of Silicon Saxony companies were mainly used in the automotive industry, robotics, communication systems, and energy. Industrial lasers, bioelectronics, and biosensors may become new segments of the Saxon microelectronics market. These potential areas have an impressive performance on key indicators, and experts expect them to grow in the future.

According to Strategies Unlimited, a world leader in market research in photonic devices, industrial laser production grew by 26% in 2017, and the market volume reached USD 4.3 billion[21] that year. In 2019, a 7% growth was expected in the market.

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[20] *Smart* Specialization Platform. URL: http://s3platform.jrc.ec.europa.eu (accessed: 24.01.2020).

[21] *Industrial* Laser Solution. URL: https://www.industrial-lasers.com/articles/print/volume-33/issue-1/features/2017-was-a-great-year-for-industrial-lasers.html (accessed: 16.03.2019).

Germany is a major centre for bioelectronics. Experts believe that the country will retain its share of the market over the next ten years.

The global bioelectronics and biosensors market was estimated at USD 17.5 billion in 2016. According to forecasts, the total annual growth rate will average 9.2%. Thus, the level of USD 41.9 billion will be attained by 2026.

The technology, logistics opportunities and human resources of Silicon Saxony are sufficient to ensure development in these segments of the microelectronics market.

Tool 8. Competitive position analysis

This tool outlines strategic paths to ensure cluster development. To this end, the volume and market share of the clusters as well as its products are compared to those of other players in the market.

The micro- and nanoelectronics industry is concentrated in Europe around regional design and manufacturing centres. We will consider two of them as competitors of Silicon Saxony: Minalogic,[22] a global innovation cluster in Grenoble (France), and Sicilian Technology District of Micro and Nano Systems[23] in Catania (Italy).

Both clusters have adopted a strategic model that has at its core anchor companies — leaders in the global microelectronics market. For Minalogic, these are ST, Soitec, and Schneider. All three are world leaders in the production of non-volatile memory chips. The anchor company of the Catania cluster is ST-Microelectronics (ST), which excels at making semiconductor technologies, devices, and solutions. Silicon Saxony stands out among other clusters because it emerged with public help from the state.

A comparison of the product portfolios of the three clusters shows that the Sicilian cluster manufactures robotic products using micro- and nanotechnologies, whereas Minalogic focuses on sales to the healthcare industry.

Figure 4 shows the results of a competitiveness analysis the three clusters, which was based on three parameters: product complexity (Y-axis), product range (X-axis), and annual cluster turnover (indicated by the circle size).

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[22] *Minalogic*. Global Innovation Cluster for Digital Technologies in Auvergne-Rhone-Alpes, France. URL: http://www.minalogic.com/en/home (accessed: 20.03.2019).

[23] *Microelectronics* Cluster in Sicily. URL: https://www.ice.it/it/repository/pdf/Biat_MC_Sicilia.pdf (accessed: 20.03.2019).

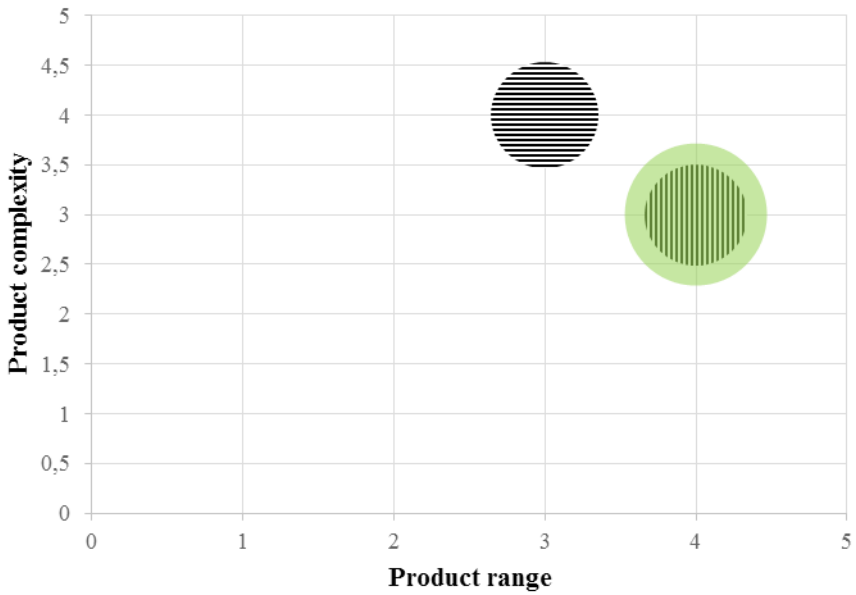

Fig. 4. Evaluation of the competitiveness of European microelectronics clusters: Silicon Saxony (horizontal hatching), Minalogic (vertical hatching), Micro and Nano Systems (grey)

Source: prepared by the authors based on the analysis of data from Silicon Saxony, Minalogic and Micro and Nano Systems.

Minalogic has the most members — over 400 (as compared to approximately 300 at Silicon Saxony and about 200 at Micro and Nano Systems). Micro and Nano Systems employs 43,200 people; Silicon Saxony, over 20,000; Minalogic, about 25,000. Micro and Nano Systems has the highest annual turnover, 7 billion euros; that of Silicon Saxony is 4 billion euros; of Minalogic, 3.6 billion euros.

The development strategy of Silicon Saxony can benefit from the best practices developed in Catania and Grenoble. In particular, it can increase its product range and complexity, reach out to new niches, encourage cross-company employee mobility within the cluster, and launch open innovation projects.

At policy level, the EU is encouraging transnational cooperation between regional clusters. It is not, therefore, completely accurate to consider the three clusters as competing.

Stage III. Institutional support assessment

Tool 9. Old and new institutions for collaboration

This tool is used to identify whether a cluster has institutional and/or social capital to sustain collective action.

Germany ranks 24th out of 190 countries on the World Bank's Ease of Doing Business; this means that its regulatory environment is favourable for creating and developing local companies. Table 5 shows Germany's rakings for each topics.

Table 5

Germany's performance on Ease of Doing Business

Topics	Rank
Overall	24
Starting a business	114
Dealing with construction permits	24
Getting electricity	5
Registering property	78
Getting credit	44
Protecting minority investors	72
Paying taxes	43
Trading across borders	40
Enforcing contracts	26
Resolving insolvency	4

Silicon Saxony enjoys significant investment support from the German government, with public investment reaching 5 billion euros in 2014. The German government plans to invest another 400 million euros in microelectronics until 2020. There are several cluster support programmes: the GA programme gives loans to startups; the German accelerator program, an initiative of the Federal Ministry for Economic Cooperation and Development, annually selects German startups for collaborations with leading US companies based in New York and California. Silicon Saxony is a member of the Go-cluster excellence initiative. Launched by the Federal Ministry for Economic Affairs and Energy, it covers more than 100 innovative clusters in Germany.[24] The program provides financial support for innovative services.

The main institution that supports and promotes clusters in the country is Germany Trade & Invest, the country's economic development agency.[25]

Silicon Saxony has support from external public and private institutions. These include European cluster support programmes (FP7, H2020, CIP / COSME, INTERREG) and national projects (EEAS - Energy Efficient Aviation Solutions, Network Management for Cool Silicon). Support for clusters focuses on new technologies, access to new markets, and new partnerships and projects.

[24] *Clusterplattform* Deutschland. URL: https://www.clusterplattform.de/CLUSTER/Navigation/EN/NationalLevel/go-cluster/go-cluster.html (accessed: 20.02.2019).

[25] *Germany* Trade and Invest. URL: http://www.gtai.de/GTAI/Navigation/EN/welcome-ru.html (accessed: 20.03.2019).

Stage IV. Process control

Tool 10. Monitoring and evaluation

This tool evaluates the progress of cluster initiatives, particularly, the performance of cluster members, investment, finances, ownership, and sustainability.

Cluster management quality monitoring is carried out in Europe by experts of the European Cluster Efficiency Initiative (ECEI) (www.cluster-excellence.eu), who give independent voluntary confirmation of cluster management effectiveness, recognised in Europe and around the world. Assessment is carried out based on 31 indicators. The ECEI gold label 'Excel in Cluster Excellence' is awarded to a cluster if it scores at least 80% of the maximum points on each measure.[26]

In 2012, Silicon Saxony received the gold label, which proves the efficiency of its management methods and systems.[27] In 2015, the cluster received the award once again.

Over the past twenty years, many semiconductor manufacturers (GlobalFoundries Dresden, Infineon Technologies, X-FAB) have invested heavily in Silicon Saxony. The cluster, in its turn, has used the money to finance its growth; for its members, this means a 10-15% increase in annual turnover.

Conclusion

To sum up, Silicon Saxony successfully adapts its internal structure to market scientific and production requirements. The cluster has forged network partnerships both in Germany and internationally. As the coordinator of the Silicon Europe Alliance, it has an important role in advancing Europe's semiconductor industry and creating the value chain.

To grow, the cluster can look for new niches. One of the options is participation in the Cool Chip international Symposium held annually since 1998. Silicon Saxony can strengthen its inter-cluster ties in Europe. For instance, its collaborations with the Russian cluster in Dubna may well develop into a new network of hi-tech coating manufacturers. Other growth opportunities lie with raising funds, including venture capital, and reducing costs to outperform Asian competitors.

Using the World Bank methodology to assess the competitiveness of Silicon Saxony made it possible to establish what advantages the cluster has over its competitors as well as to identify the elements of its success and understand how the business environment may impede quality development.

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[26] *Processes* of application, assessment and award — ESCA. URL: https://www.cluster-analysis.org/gold-label-new/processes-of-application-assessment-and-award (accessed: 05.04.2019).

[27] In order to qualify for the ECEI GOLD Label "Excel in Cluster Excellence", the cluster management organizations must meet certain criteria characterizing the quality of cluster management as a whole, the financing system, the strategies and methods used to promote services, and the level of public recognition.

The assessment could be more informative if there were tools to analyse the initial condition of the cluster (human, physical, and infrastructure factors), its competitive niches, and its life cycle stage. It seems appropriate to employ the Porter Diamond as an additional tool. It is also possible to use tools for measuring the effectiveness of government support in assessing cluster competitiveness: in some countries, including Russia, clusters are as a rule top-down initiatives[28] [27; 28].

The World Bank methodology made it possible to gain a deeper understanding of the role of microelectronic clusters in the German economy as well as on a global scale. The findings can be used in analysing the performance of leading innovation clusters in Russia.

This article was supported by the Erasmus+ programme of the European Union (Jean Monnet 586712-EPP-1-2017-1-RU-EPPJMO-MODULE)

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