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MANAGEMENT SYSTEM FOR INNOVATIONS CREATED IN THE OPEN MODEL (WITH MANAGERIAL TOOLS)

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Purpose: The main objective of the article was to defined an innovation management system, which consist of:

1. Subsystem for managing their own innovative maturity.
2. Subsystem for managing the processes of obtaining product innovations from suppliers.
3. Subsystem for innovative maturity management of suppliers from the supply chain and networks of cooperating companies.
4. Subsystem for innovation performance management.

The results of the literature and empirical research formed the basis for the development and test of two subsystems:

- Subsystem for managing their own innovative maturity.
- Subsystem for innovative maturity management of suppliers from the supply chain and networks of cooperating companies.

Design/methodology/approach: The main objective of the literature study was to prepare tools to review the elements, with consist of the innovation management subsystems. The main objective of the own research was to compare the elements of innovation management used by the three automotive concerns that produce propulsion systems in Poland. Comparing the elements used allowed the defined a complex model of a network and supply chain innovation management system (especially the two subsystems and propose to retrofit them). The proposed research tools can too be used to assess the maturity for managing innovations arising in collaboration. The tools will also serve as an inspiration (for manager R&D) for supplementing a functioning system with missing elements.

Findings: The first chapter presents the importance of developing a system from a theoretical, methodological and empirical point of view. The second chapter presents reserch methodology. The appendices 1 and 2 present the author's managerial tools for evaluative assessment of the two subsystems belong to innovation management system. The third chapter presents the results of surveys conducted using the developed managerial tools.

Research limitations/implications: Research limitations/implications: The main purpose of the work was to develop a systemic innovation management model for the supply chain in the automotive industry and to assess the possibility of its implementation in business practice. This goal was partially achieved. The possibility of implementing a systemic model only at car manufacturers was examined. The enterprises cooperating in the supply chain (suppliers, customers) were not examined. In connection with the above, it can be stated that two subsystems have been verified (subsystem for managing their own innovative maturity;

subsystem for innovative maturity management of suppliers from the supply chain). The others will be the subject of further research.

Keywords: Innovation management, OI Open innovation model.

Introduction

A management system is a collection of roles, methods, managerial tools, related processes, with specific properties and evaluations. Such a collection can be called a system if it also fulfils the other requirements (rigours) of systemicity: the orderliness of the collection; the coherence of the collection; the boundaries of the collection; the interaction with the environment; the ability to perform a given function or achieve a given goal (Bertalanffy, 1984).

In innovation science, a balance between control and freedom is required (Foster, Kaplan, 2001). Therefore, researchers are still reluctant to deal with innovation management systems and practitioners are not in favour of them, claiming that when implementing innovation processes, it is difficult to behave strictly according to decisions and guidelines.

An innovation management system has been defined as a set of interrelated or interacting organisational elements as well as processes that enable the achievement of innovation goals. An innovation management system is thus made up of two groups of elements (Checklist, 2020). The first includes those fostering the development of innovation within the company (roles, methods, managerial tools). The second includes innovation processes (including the process of generating ideas, processes of acquiring innovative solutions from outside), methods of evaluating and analysing its individual sub-processes, methods of indicating possibilities for their improvement.

The implementation of an innovation management system into an enterprise brings a specific range of benefits for companies. Among the benefits are (Standard CEN/TS 16555-1:2014 - Part 1: Innovation Management System):

- increased profits from innovation,
- a change in approach to problem solving and a new/different set of values,
- ease of identifying areas of risk and mitigating its impact,
- increased creativity and intelligence of the organisation,
- increased value from collaborating with business partners on innovation development,
- greater employee involvement, fostering teamwork.

An innovation management system encompasses all the activities that are necessary to generate innovation on a continuous basis, regardless of the size of the organisation. An innovation management system consists of all the elements that are essential to the innovation process, including: organisational conditions, leadership in the area of strategy and innovation, planning of activities to increase the market success of innovations, development

of enablers and drivers of innovation, the innovation management process, tools to assess the performance of the innovation management system, activities to improve the innovation management system, innovation management techniques (Standard CEN/TS 16555-1:2014 - Part 1: Innovation Management System). The foundations for configuring innovation management systems were laid by European Standards established by CEN - the European Standardisation Organisation. The established technical committee CEN/TC 389 - Innovation Management, established six standards with the status of technical specifications.

- CEN/TS 16555-1 Innovation Management - Part 1: Innovation management system.
- CEN/TS 16555-2 Innovation management - Part 2: Strategic intelligence management.
- CEN/TS 16555-3 Innovation Management - Part 3: Innovative thinking.
- CEN/TS 16555-4 Innovation Management - Part 4: Intellectual property management.
- CEN/TS 16555-5 Innovation Management - Part 5: Collaborative management
- CEN/TS 16555-6 Innovation Management - Part 6: Creativity management.

The standards developed are designed to provide methods, processes and tools aimed at: improving the competitiveness of organizations, enabling the emergence of innovative ventures, ensuring the optimization of the effects of inter-organizational cooperation. The first document was released in July 2013. Important for this study is: CEN/TS 16555-5: 2014 Managing Innovation - Part 5: Managing Collaboration. This document describes variants of cooperation in different circumstances and different ways and possibilities of managing cooperation. It provides guidance on managing cooperation between individuals, teams and different organizations, as well as the difficulties and benefits of cooperation. It gives guidelines for actions conducive to significantly improving the organization's innovative performance resulting from cooperation.

The literature distinguishes between two types of innovation management systems: independent (systems of R&D departments aimed at increasing innovative performance) and integrated (whose elements co-create the management system of the whole enterprise). The set of elements developed for innovation management can also be an inter-organizational system (if its elements are implemented in the systems of cooperators). Independent systems can evolve from independent to inter-organizational. Inter-organizational systems in which innovations are created can be called the OI open innovation model (Chesbought, 2006). Virtually every organization has certain elements of an innovation management system, with the larger the organization, the more of these elements are in place. If the innovation management system is to operate effectively and efficiently, it is necessary to review, organize, document the elements currently in use and supplement them with missing elements (and those operating in competing companies). When supplementing the management system for the development of innovation in the open model, the first step should be to assess its state of maturity (maturity to work in the IO). In the next step, supplement the system with elements supporting its own and cooperators' innovativeness (i.e.: methods of initiating innovation in

IOs, processes of acquiring innovative solutions, methods of protecting its own and cooperators' intellectual property, methods of identifying risks arising in jointly conducted innovation processes, drivers of change in innovation processes, introduce ICT infrastructure into the innovation management system). Figure 1 shows a model of an innovation management system aimed at developing innovation in an open model. The figure is meant to suggest that supplier portfolio management, along with strategy, knowledge flow organization structure, culture, standardization of the innovation process, are key success factors in innovation management (Cooper, 2004).

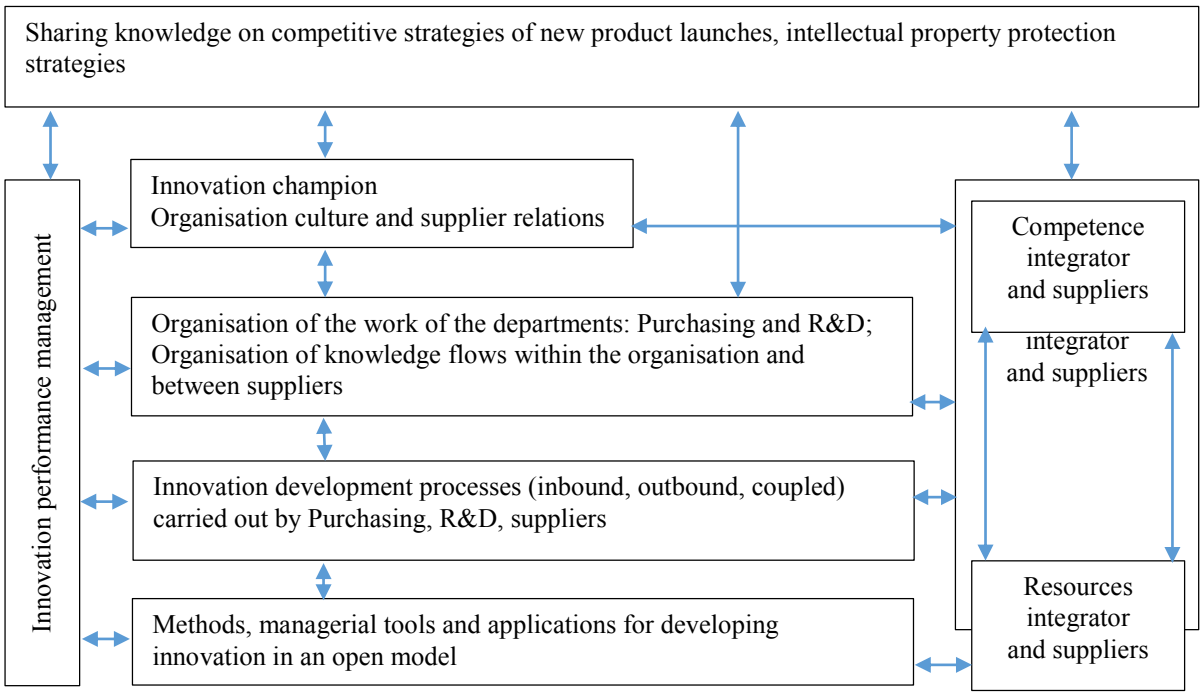

Figure 1. Innovation management system prepared for the development of innovation in the open model.

Source: Own elaboration based on: Cooper, R.G. (2004). *Product Leadership: pathways to profitable innovation*. New York: Basic Books.

As can be seen from the argument above, it is in the first instance within one's own organisation that the innovation capacity required to perpetuate work in the OI model should be assessed. Lamberti et al (2017) have developed scorecards with a set of indicators that give R&D managers a quick and holistic view of an organisation's capacity to work in an open innovation model. The paper goes on to present another managerial tool, e.g., the Smart Gird Maturity Model, which can be used to assess the innovation maturity of an organisation's own, as well as that of its collaborators to work in OI. Companies need to learn how to source innovation from a variety of internal and external sources using business models (Piller, West, 2014). Based on literature studies, it has been inferred that there is an ongoing intensification of conceptualisation, operationalisation, testing and implementation of innovation management systemów in companies across industries (Afuach, 2014). A body of researchers believes that innovation growth should be systematically monitored, preparing qualitative and quantitative

measures for this purpose (Forslund, 2007; Ryan, 2010). Following the guidance of these researchers monitoring areas have been selected. These areas were named innovation management subsystems. Listed:

1. subsystem for managing their own innovative maturity,
2. subsystem for managing the processes of obtaining product innovations from suppliers,
3. subsystem for innovative maturity management of suppliers from the supply chain and networks of cooperating companies,
4. subsystem for innovation performance management.

The results of the literature research formed the tools for all the subsystems mentioned. In this work, two subsystems in particular have received attention:

1. subsystem for managing their own innovative maturity,
2. subsystem for innovative maturity management of suppliers from the supply chain and networks of cooperating companies. Figure 2 shows an exemplary model of system innovation management that could be computerized.

Literature study has shown that managing: innovation in an own organization, supplier organizations and innovation processes translates into an increase in the innovation performance of the leader (Stawiarska, 2019). Systemic model of innovation management may consist of four applied subsystems i.e.: 1. Management subsystem of own innovation maturity; 2. Management subsustem for the processes of acquiring product innovations from suppliers; 3. Subsystem of managing the innovative maturity of suppliers from the supply chain; 4. Subsystem for innovation performance management (marked with different shades in Figure 2). The practical message of the implement systematic model of innovation management is an increase in innovation efficiency of liders supply chain and their supplyers. Practical usefulness of the model may be used in supply chains and network different industries.

System of innovation managementwas described and presented to the respondents in a graphic form (Figure 2). The respondents - managers of the surveyed concerns, employees of purchasing and R&D departments, gave their opinions on the system of innovation management. Supply chain leaders/surveyed companies expressed interest in the systemic model. The respondents believed that in the future it is worth using a computerized, system of innovation management.

The versatility of the proposed system innovation management enables supply chain leaders from different industries to put it into practice. Conversations with experts, which indicated possibility to integrate models and create one 'systemic model of innovation management' on an IT platform were held as well. Activities tests, interviews with managers of the studied organizations confirmed, giving the green light to development of the concept of system of innovation management.

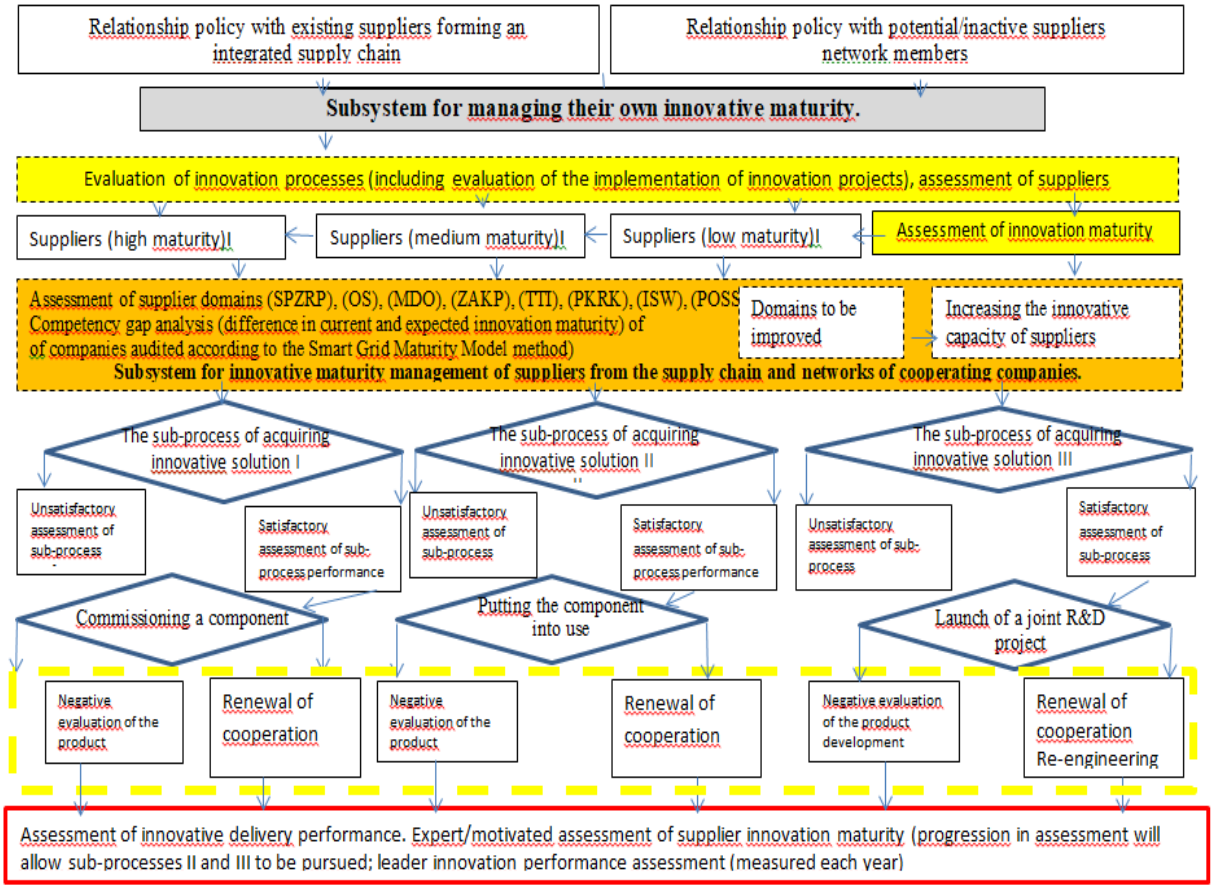

Figure 2. The system innovation management in supply chain and network.

Source: own study.

Using information from different sources makes it possible to substantiate the need to create systemic model of innovation management, and the collected empirical material (obtained with the use of complex set of tools) made it possible to propose integration of the tested models.

When implementing whole system of innovation management (each subsystem), one may expect growth in innovation efficiency of a leader and collaborating enterprises. Test only two subsystems was support users in increasing innovation efficiency. The study of only two subsystems authorizes the research hypothesis that "there are competence gaps in the pro-innovation performance of the surveyed enterprises. Periodic assessment of the competency gap (its own and that of its cooperators) will contribute to the growth of innovation".

Subsystems study has its own subject of research, method and technique and research tool. Developed an innovation management system give contribution to development of management science in the following area: The development of the innovation management concept towards a systemic innovation management.

1. Literature review

The elements of the innovation management system that foster the development of innovation in the open model are: roles, methods, managerial tools. Researchers have given these and other elements an assessment in the context of developing open model innovations, among the many elements of the system, as highly assess competences, leadership, information level, organisational culture, set of managerial methods and techniques, technology (Sopinska, Mierzejewska, 2017). In preparation for the description of the subsystem for managing one's own innovation maturity and the subsystem for managing suppliers' innovation maturity in the supply chain, the importance of the following elements was traced in the literature.

Leaders/managers play ten distinct roles. These roles fall into three categories: interpersonal, informational and decision-making (Griffin, 2012). One of the informational roles is played by the promoter (also called the innovation champion), who presents the action plan to the co-operators, develops and sends reports, periodicals and letters. The propagator in the following is also referred to as the innovation champion. Beltz (2011) explores how organisational structure theories can be linked to the development of innovation in an open model. He makes an attempt to answer: the question: which traditional concepts of organisational structure meet the needs of open innovation. The author believes that decentralisation, formalisation and specialisation in co-operation with suppliers should be introduced because they positively influence the innovation performance of co-operators.

Deal and Kennedy (1982) define **organisational culture** as 'an integrated pattern of human behaviour' including thoughts, words, actions and artefacts. The pattern depends on the leader and the ability of the members of the organisation to learn and transfer knowledge within the organisation and to collaborators. Organisational culture is to be adhered to and visible to the supplier at three levels: artefacts (including at the level of organisational structure and processes), beliefs and values (exhibited in strategy, mission, functional missions, intra- and inter-organisational interpersonal contacts), basic assumptions (taken for granted in the organisation and therefore extremely difficult to change in a clash with a different culture of the co-operator). In building an organisational culture that remains in line with the IO concept, the right balance must be found between fostering the creativity and inventiveness of suppliers and the right and control of suppliers.

TOM (Tools Organisation Management) methods and management tools. Methods are ways of proceeding, leading to the solution of a given problem and the achievement of a defined objective. Methods consist of specific and repeatable steps (Schuman, 2013). Without going into the differences and similarities between terms such as management methods and techniques, it is assumed that they are instruments in the hand of the manager to facilitate the solution of management problems. The managerial methods and tools that support the OI concept, can be defined as a combination of routines, practices and incentives that enhance

an organisation's innovation performance (Giannopoulou et al., 2011). Adopting the OI concept can threaten conventional managerial methods and tools practised in the company and vice versa (Ollila, Elmquist, 2011). The literature identifies reviews of formal, institutionalised methods and tools that are used to enhance self-innovation and that of suppliers and other collaborators (Aloini et al., 2017). Researchers believe that there is a need to develop new methods and tools for innovation management that also impact beyond the boundaries of one's own organisation.

Figure 3 shows the methods used to source innovation from outside the automotive industry.

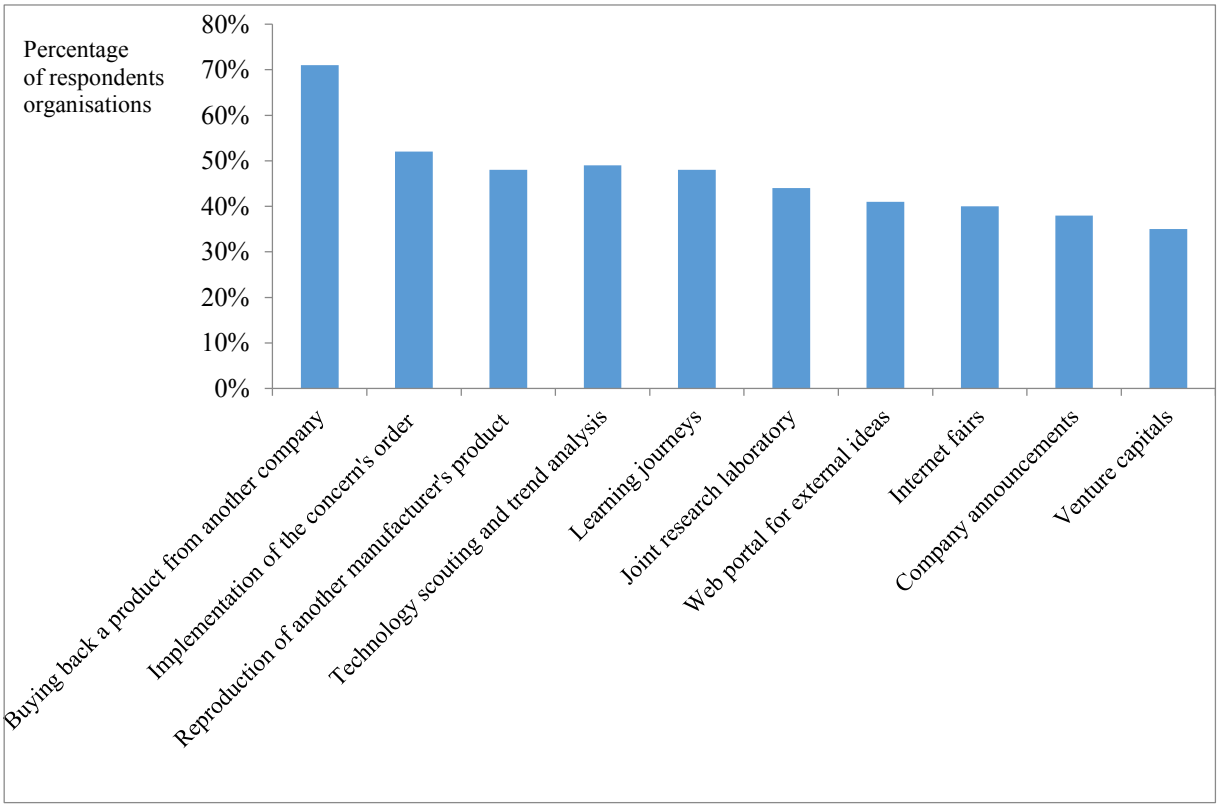

Figure 3. Use of external innovation sourcing methods in the automotive industry in % of organisations surveyed (selected from 45 suggested methods).

Source: Slovakia, J. (after) Chesbrough, H.W. (2003). *Open Innovation: The New Imperative for Creating and Profiting from Technology.* Boston: Harvard Business School Publishing, pp. 35-41.

Information technology, resource databases and collaborative capabilities are tools to support the transition from a closed to an open model of innovation development. The first desirable tool is an idiosyncratic resource base (Dougherty, Dunne, 2011); (Zott, Amit, Massa, 2011) and methods for managing non-owner resources. Supplier resource management methods in the automotive industry have been developed by researchers: (Aggarwal, Hsu, 2009; Lee, Cavusgil, 2006). Other researchers recommend the use of ICT with embedded methods for sustainable value creation, supported by the principles of equitable value capture from co-operators (Afuah, Bogers, 2016; Wang, Rajagopalan, 2015). The following are methods that support the management of innovations developed in an open model in the automotive industry. In describing them, an attempt has been made to provide literature that defines them more

broadly and gives examples of their application in the industry. Attention was drawn to the fact that the methods listed are applicable at different stages of the innovation process. For some of the listed management methods, tools have already been developed. For the automotive industry, selected management methods and tools are recommended for the management of innovations arising in an open model:

- **The Smart Gird Maturity Model** is a method, based on the concept of the Smart Gird Maturity Model, that can be used to self-assess and evaluate the innovation maturity of co-operators. If the tool is implemented in the innovation management systems of co-operating companies it will be easier to manage resources for innovative projects (Katz, Allen, 1985). In order to successfully implement an IO strategy, organisations need to develop a range of cooperators' capabilities. The SGMM tool can be used to identify the competence gap of suppliers in developing innovation in an open model (measure the state of progress in OI from the perspective of the expected state). After modifications, the tool can be used to periodically assess different groups of suppliers segmented e.g. based on the criterion of the degree of involvement in R&D activities in selected research areas. The author's SGMM tool is presented in the appendix of this thesis (the tool can be informative). Respondents considered the SGMM as a tool that could complement their innovation management system.
- **Learnig trip/Learnig journeys** a method based on scautig theory, involves continuous exploration and idea generation (Ili et al., 2010). The basic steps are: participation in trade fairs (not only industry trade fairs), organisation of innovation days, technical meetings with selected suppliers, informal events on dedicated topics, invitations to innovation projects from meeting and trade fair participants. The learnig trip method is used by Volkswagen with benefits translating into the number of ideas acquired.
- **Short-term employee exchanges** between links in the supply chain for innovation development are not common in the automotive industry, and there is a lack of procedures and guidelines for employee protection of intellectual property (Husanudin, 2018). Employee exchanges between network and cluster companies are more common. The transfer of innovative knowledge is more effective if it takes place at all stages of the innovation process (Torre, 2008; Torre, Rallet, 2005). Staff exchanges are supported by the EU Commission by launching sectorally dedicated programmes such as the Research and Innovation Staff Exchange - Maria Skłodowska-Cure Actions and highly valuing this activity for the innovation performance of companies. Methods of proceeding in organising staff exchanges have already been prepared in many EU countries (www.cedr.eu/...).
- **Strengthening personal ties.** The personal aspects of cooperative business relationships have received increasing attention in recent years and have been conceptualised as the foundation of supply chain relational capital (Cousins et al., 2006), particularly in the context of product innovation (Lawson et al., 2015). The importance

of building inter-organisational relationships through interpersonal ties has not only been suggested by empirically grounded research in Eastern business cultures (Michailova and Worm, 2003), but also in Western cultures. Japanese corporations (Toyota and Honda) are leading the way in developing bonds between employees of collaborating organisations in the automotive industry. Ties intensify especially during the R&D project phase (Stawiarska, 2016).

- **Finding affinities between firms and combining them for innovation development**. The method is recommended by Mitrega and Pfajfar (2015) Research (Mitrega et al., 2017) shows that searching for affinities in innovation activities improves the innovation performance of leaders in the Indian automotive industry from the idea generation stage through to the prototyping stage. The authors suggest sharing the experiences of members of collaborative groups. Bendkowski (2016) believes that good results for the innovation performance of an organisation/integrator can be achieved by connecting specialists in so-called informal communities of action. Searching for experts and specialists can be done through portals e.g. Linked-in or professionally as Tesla does - using the IT integration platform Jabil (Wincewicz-Bosy et al., 2017).
- **Training, continuous education and supplier incentives strengthen existing relationships.** Training is where new product concepts are born and incentives are the catalyst for working through the next stages of product development. One-size-fits-all educational and motivational activities do not fit all suppliers, especially those from different cultures, as GM found out when it tried to apply the Toyota Production System to its US supply chain. Motivation can be achieved through three types of action: rewarding innovative suppliers and organising events dedicated to innovation for selected suppliers, asking for innovation suggestions. All these activities motivate suppliers to develop specific knowledge. Also important are annual meetings (in the presence of the purchasing director), where companies exchange results and present prospects for innovation solutions. All the above-mentioned activities are practised by Volkswagen.
- **Routine activities like audits**, assessment of specific resources and processes dedicated to relationships, request for self-assessment. The mentioned activities are described by (Jean et al., 2014). The FCA asked for periodic supplier self-assessments for the development of socially responsible supplier businesses. The enhancement of the environmental value of the components put into production is acknowledged by the FCA , suppliers are willing to self-assess via a supplier IT portal. The assessments are averaged and presented, the supplier in a dedicated portal can easily identify a competence gap and an area worth improving (Stawiarska, 2014).
- **Monitoring the relationship dedicated to the development of innovation projects** - the automotive industry pursues breakthrough (radical) and incremental projects. Kastensson's (2014) research shows differences in the approach to innovation projects

between the two car manufacturers. Saab focuses on radical product development, building collaborative supplier structures from scratch. Volvo focuses on incremental development based on a fixed structure of strategic suppliers who undertake short-term component modification. Volvo's body technology also makes it difficult to implement radical component changes. Kastensson draws the paradoxical conclusion that both highly regarded automotive manufacturers, fail to effectively monitor projects and supplier relationships, which undermines innovation performance to date. Monitoring can include: project duration/co-operator time, value-added contribution, financial contribution (Gutiérrez, 2012). Researchers argue that appropriate calibration and monitoring of these three dimensions will allow one to determine whether the relationship with the supplier was strong, medium or weak (to assess the commitment to the project implemented in the IO model). Long-term use of a project monitoring system (even radical ones that use R&D suppliers from outside the integrated chain), measuring the strength of the relationship, will allow the integrator to more accurately assess suppliers, managing the relationship towards increasing their innovation and alignment with the integrator's needs. All automotive concerns use project monitoring. R&D and Purchasing departments - participate in each monthly innovation project evaluation committee (at FCA). They have validation and veto rights at every stage of the project involving external partners (suppliers or research consortia). However, according to research, project monitoring in automotive corporations does not affect their innovation performance equally.

- **Supplier portfolio management and relationship termination mechanisms**. Until recently, the literature did not suggest the implementation of systematic measures at the company level to help end unfavourable supplier relationships (Dyer, Singh, 1998). "Unrecoverable investments" in a certain group of suppliers have prompted managers and researchers (Tähtinen, Halinen, 2002; Moeller et al., 2006) to make analyses related to this issue. Other researchers have shown that innovation performance declines from mature supplier relationships as well as from mature supplier portfolios (Wagner, 2006; Capaldo, 2007). The process of ending relationships with suppliers that inhibit innovation is linked to the need for a systematic reconfiguration of firms' strategic resources. Zaefarian et al (2016) consider relationship termination to have two components: final preparation using routines and relationship termination. The aim is to identify ineffective supplier relationships by assessing their innovative performance and establishing procedures to end the collaboration (perhaps only at the level of new product development) and to bring the relationship down to transactional levels. Innovatively inefficient supplier relationships tie up resources that could be used more optimally for innovation. For this to happen, it is necessary to monitor inactive/potential suppliers operating in the network as well as those with whom relationships have been terminated. Wagner (2006) tells us to assess the cost of terminating the relationship and

to prepare resources for activities that end the relationship. The end-of-relationship assessment should be prepared as a document and kept, as well as provided to the supplier. Rather, it should be a document that motivates suppliers to improve their performance for future relationships (Yam, Chan, 2015). When dissolving collaborations, it is important to remember to safeguard one's intellectual property and recover resources located in the relationship that can be used in alternative supplier relationships. A portfolio of innovative suppliers is managed by Toyota.

- **Innovation champion**. A person whose role is to get suppliers to work in an open innovation model. The concept of the innovation champion was introduced by Schon (1963). Subsequent researchers have addressed the champion's involvement in innovation activities (Chakrabarti, 1974; Frost, Egri, 1981; Howell et al., 2005; Kratzer et al., 2010; Mansfeld et al., 2010). Markham's (2013) study showed that the champion specifically supports early stage R&D projects for which there is no support from other parts of the organisation, and is therefore involved in the process of sourcing innovative solutions from suppliers. The innovation champion role has been introduced by Volkswagen into its structures.
- **Outsourcing the role of innovation champion**. Supplier relationship management should be learned and institutionalised internally or outsourced. The literature suggests that the management of relational activities can be moderated by external organisations (external purchasing execution companies, information brokers or cluster coordinators) because of the need to eliminate dominant organisational attitudes (Henneberg et al., 2010). An external company may be more effective in shaping the network (configuring the supplier portfolio). The external innovation champion delegates project management to the leader - the producer of the strategic good.
- **A computerised project vision for which talent is recruited.** The vision document defines the overall scope and purpose of the programme, product or project. Clearly articulating the problem, proposing a solution, helps to set expectations and reduce risk. Using IBM's Knowledge Center platform, for example, a product vision document can be presented and talent can be recruited for the automotive industry. The platform is used by Volkswagen.
- **Control of communication with and between suppliers**. Strategic integration with suppliers has been discussed by (Johnson, 1999), supplier development programmes (Wagner, 2006), and team control of supplier communication (Joshi, 2009). All these researchers are of the opinion that communication is very important for the development of a joint product (at each stage of this development). The researchers have developed tools to control communication at each stage of the collaboration. Volkswagen, PSA have specific communication interfaces for collaboration with suppliers to monitor and evaluate the contact of each party in the relationship.

- **Formal mechanisms for managing investment in an innovation project.** The main formal mechanisms are the estimation and valuation of the investment input and the regular updating of innovation processes, general agreements, non-disclosure agreements for engineering research. These formal mechanisms strengthen supplier relationships and have a positive impact on innovation performance (Lawson et al., 2015). In new product development, there are often unforeseen and additional inputs. Acquisition, transfer of assets, requires effective control, communication and reporting related to their funding (Eckerd, Hill, 2012). Smart Contract (blockchain technologies) in automotive is intended to be used by Toyota. The Toyota Research Institute (TRI) has officially stated that it will apply it to each of the following stages of the product lifecycle: concept development, design, product distribution, trade finance, retail sales and use of the product, product recycling and aftermarket and parts operations. Smart contracts and custom code support the security and compliance of multi-party contracts at any level of the supply chain, speeding up reconciliations, transactions, money and asset transfers between parties (https://www.bloomberg.com/...).
- **Building trust between employees of collaborating companies and educating in the area of relational competence**. Cheng and Huizingh (2014), Dyer and Hatcha (2006), and Ryciuk (2017) presented mechanisms for building inter-organisational trust in the automotive industry. They showed that manufacturers who provide more assistance in innovation projects reap more benefits from their supply chain relationships. Jean et al. (2014) demonstrate that, stimulating co-operators' procedural adaptations, an appropriate partnership approach to jointly develop new procedures through structured socialisation, translates into innovation performance of co-operating parties. By building strong ties within the supplier association, Toyota develops a strong network identity, and this overcomes the constraints of knowledge preservation bias.
- **Analysing purchasing practices**, auditing purchasing reports in the areas of: sourcing strategy, supplier management, material category management, inventory and procurement, ICT in purchasing, is routine in the automotive industry and generates many ideas for bringing suppliers together in R&D research groups (https://www.apqc.org/...).
- **Crowdsourcing is public brainstorming aimed at finding a solution to a specific problem**. The object of crowdsourcing can be knowledge. InnoCentive is an example of an online platform that gives entrepreneurs the opportunity to formulate tasks and seek their solution among ideas from a large number of originators. Associated with the solution of a task is, a monetary reward. Obtaining the solution is in line with intellectual property law. Among the companies using the platforms are Ford and Toyota. Ford's 'Your Idea' platform, has already received more than 3000 ideas from customers. Toyota has developed the Prius using the platform. An analysis of the various

implementations of crowdsourcing allows the following classification of their operating models to be proposed: exchange, competition, collaboration, exchange.

- **Innovation competitions are possible with tools for initiating, implementing and monitoring product development**. They are organised among an established project group (e.g. supply company engineers). Ferradasa et al. (2017) show that innovation competitions are an excellent tool to seek external knowledge, e.g. among next-tier suppliers. The authors advise on how to prepare and run a competition. In their research, they show that SME companies threatened by market and technological turbulence are keen to enter competitions organised by corporations. FCA, Volkswagen organise innovation competitions for students in Poland. A common practice in the automotive industry are competitions organised by first-tier suppliers for next-tier suppliers. Organisers of high-profile competitions are the companies: AC S.A., Kongsberg Automotive, Valeo Innovation Challenge. Competitions in the automotive industry are also organised by external companies e.g.: Microsoft Imagine Cup and state authorities (the Polish government is organising the InnoMoto competition for the second time).
- **Collaboration with research centres** (universities and research institutions, scientific government agencies) is carried out in accordance with standards for identifying resources (technological, human, financial) needed in the development of the spin-off organisation, and measured by spin-off performance indicators. Examples of cooperation between automotive concerns and universities come from Poland. FCA Group plants located in Poland and Opel Manufacturing Poland Sp. z o.o. cooperate with the Silesian University of Technology.
- **Recombinant models of knowledge management** Bessant and Trifilovwj (2017) and Aloini (2018) focus on 'recombinant' models of knowledge management, in which knowledge learned and successfully implemented in one domain can be transferred to another'. The authors highlight that managerial tools for knowledge transfer hold promise for IOs. The content of the article can be associated with the concept of TRIZU.
- **A set of tools to support creativity and imaginative thinking called Theory of Inventive Problem Solving TRIZ** (Russian: Теория Решения Изобретательских Задач), TIPS. Altshuller and Shapiro's (1956) theory initially presented as a conceptual design method in engineering boiled down to a process. Nowadays, TRIZ tools are also applied in 'soft' non-technical areas (Zlotin et al., 2000), especially in innovation management (Sheu, Lee, 2011), supply chain management (Stratton and Warburton, 2006), knowledge management (Qi, Shangguan, 2008; Vezzetti et al., 2011) management of innovations arising in an open model (Biedenbach, Müller, 2012). The TRIZ process starts by describing the problem to be solved with an abstract model (function model, contradiction model, substance field model, etc.). Then one or more standard model transformation techniques can be applied (pruning, contradiction elimination rules, substance field model transformation standards, etc.). The usefulness

of the models is checked by means of specific indices, such as the concept of ideality, trends in the evolution of engineering systems. The best model presents an abstract (theoretical) solution. The final step in this process is to find a 'real world' phenomenon that could enable the implementation of this theoretical solution. For this purpose, TRIZ recommends the analysis of databases or physical and chemical phenomena, based on database functions or function-oriented search. TRIZ, being a complex instrument, provides a broad set of tools for idea generation, analysis and problem solving. In addition, a TRIZ knowledge base for various knowledge management tools has been adopted to facilitate patent search and analysis (Cong, Tong, 2008; Marcandella et al., 2009); The second set of TRIZ tools relates to product potential analyses. They can be used at the idea generation and internal R&D planning stages, as well as to facilitate collaborative activities by analysing the potential of external technology. TRIZ tools are used by Korean automotive companies, i.e. Hyundai and Kia. Existing technology from other industries is applied in these corporations. The analysis of contradictions and their elimination (using the classic Altshuller matrix) contribute to the exponentially increasing number of patented solutions. Separation principles are applied to supply chain design. TRIZ stimulates creativity and shortens the costly iterative process. TRIZ experts have worked with Hyundai and Kia corporations and suppliers for the adoption of new tools. TRIZ tools have been integrated into the innovation management system for several years, but there is a lack of research dedicated to the adaptation of TRIZ tools to supplier systems. Existing case studies of TRIZ use (Moehrle, 2005), suggest that: TRIZ tools can be used separately (that is, not necessarily the entire TRIZ set); the most commonly used TRIZ tools are contradiction elimination instruments; TRIZ does not have sufficient integration with IT tools; the most common problem with TRIZ is subjectivity and dependence on user experience and qualifications. The study shows that TRIZ-based methods are viable tools for innovation management and are able to provide support at all three stages of the innovation process (creation, implementation and diffusion of innovations).

- **QFD** (Quality Function Deployment). It is a method used to design and improve the quality of products or services. This method enables a customer requirement to be translated into the technical parameters of the final product through the successive stages of its design and manufacture and, as a result, to achieve greater customer satisfaction. For each customer requirement and technical parameter, a performance index is calculated. This makes it possible to identify priorities for improving product quality. Shigeru Mizuno and Yoji Akao are considered the forerunners of the method under discussion. The method was first used in 1972 at the Mitsubishi shipyard in Kobe. In the 1980s, it found widespread use particularly in automotive companies (Toyota, Ford, General Motors) (Wolniak, 2015). The basic tool of the method is the so-called 'House of Quality'. It is a matrix which is a combination of a diagram of the

interdependence of customer needs and technical requirements. QFD shows good complementarity with TRIZ-based methodologies. It is used as a problem-solving tool, e.g. to determine the purpose of an innovation (Hua et al., 2006). The QFD tool has IT software dedicated to the automotive industry (e.g. Edraw MaX Pro - platform for diagramming).

- **FMEA** (Failure Modes and Effects Analysis) or FMECA (Failure Modes and Criticality Analysis), this method is based on the analytical determination of cause-and-effect relationships of potential product defects and the inclusion of a criticality (risk) factor in the analysis. Its objective is to consistently and systematically identify potential product/process defects and then eliminate them or minimise the risks associated with them. With the FMEA method, the product/process can be continuously improved by subjecting it to successive analyses and, on the basis of the results obtained, introducing new corrections and solutions, effectively eliminating the sources of defects and providing new ideas to improve the product properties. The objectives of the method are: to reduce the probability of defects, to increase the detectability of defects arising, and to increase customer satisfaction with the product/service being purchased (Myszewski, 1994). This method was used as early as the 1950s in the United States and Japan to ensure the reliability of high-risk products, mainly in aviation, aerospace and military applications. In the 1970s, it spread to Europe and was mainly used in the electronics and mechanical engineering industries. Since the 1980s, it has been successfully used in the automotive industry. In February 2018, a group of international automotive companies signed an agreement on the use of FMEA in the automotive industry. The document places requirements on suppliers to assess the types and consequences of failure of their components. A common set of FMEA requirements/ expectations enables suppliers to run one business process and use one set of FMEA methods and tool, while satisfying the requirements of all their customers. In December 2018, the official AIAG-VDA FMEA industry manual was released . IT tools fully support the new harmonised AIAG VDA FMEA system, e.g. DataLyzer's FMEA software.
- **Self-assessment tool** - a scorecard, used to monitor whether the company is effectively and efficiently generating IO outputs. The charter shows the resources free and committed to projects. Lamberti et al. (2017) lists six indicators for self-assessment of innovation in the charter. Galankashia et al. (2014) more extensively described the application of the scorecard to multi-criteria supplier selection in the Iranian automotive industry.
- **Tools for imitation.** Some of the smaller Japanese car companies have a strategy of never introducing a new technology and commercialising new solutions first. They prefer to wait for other manufacturers, preferably Toyota, to establish the technology in the market, thereby reducing their own and their suppliers' risks. Keiretzu

does not expect high inovation performance from its group suppliers. Among these suppliers are many manufacturers of 'non-original' spare parts. General-purpose technology offers opportunities for imitation as well as the use of a variety of materials. Little is known about what business tools are used to copy technology in the automotive industry. There are publications that present a comprehensive proposal for developing a cost model for comparing diverse products from developed and emerging markets (Schleich, 2006). In the Western world, offensive, innovative manufacturers expect themselves and their suppliers to act independently and proactively and do not use the tools mentioned.

- **SGMM** - sub-system innovation management.

When analysing the above methods and accompanying managerial tools, SGMMs were looked at in particular, which should make up a future innovation management system. Rudkowski (2014) recommends a systematic assessment of supplier innovation using SGMM in eight management areas. The author follows the model developed at Carnegy Melon University - the SGMM (Smart Grid Maturity Model). The SGMM provides a framework for transforming suppliers from the supply chain and network to their innovation maturity. The SGMM consists of eight domains and six levels of maturity assessment. The SGMM provides a common language for comparing and improving areas of innovation management. It gives suppliers and potential suppliers/network members, guidance on activities, investments and best practices for engaging in open integrator R&D activities. As an IT-based expert system, the SGMM, based on knowledge and collaboration with the innovation champion, can provide guidance on technological, regulatory and organisational issues. The model has eight main domains to monitor and these are:

1. Strategy, governance and regulatory oversight, planning, decision-making, strategy implementation, disciplines, regulation and investment.
2. Organisation and structure-communication, culture, knowledge management, training and education.
3. Technology-information, engineering, integration of information and operational technologies, standards and business analysis tools.
4. Social and environmental and ecological initiatives, sustainability, economics and ability to integrate grid operations.
5. Grid operations - advanced grid observability, control, quality and reliability.
6. Labour and asset management - optimised resources (e.g. people and equipment).
7. Customer management and experience - retail sales, customer service, pricing options and controls, advanced services, visibility into usage, quality and performance.
8. Value chain integration - enables demand and supply management, distributed generation and load management and exploitation of market opportunities.

The APQC organisation, in collaboration with Carnegie Mellon University's Software Engineering Institute, has developed software tools for SGMM (i.e.: tools for capturing and maintaining data collected from organisations in the energy industry). There is nothing to prevent SGMM from being modelled for use in automotive supply chain and network development. For the purpose of the research work, a tool was prepared to survey the innovation maturity of automotive suppliers (Appendix 3), and an Excel-based IT tool was prepared to collect and process the data obtained in the supplier surveys. The SGMM model can also be used to self-assess the innovation maturity of any organisation that is: at any level of the supply chain, a member of a formal or informal supply network or a non-networked enterprise. The SGMM can become an important element of an innovation management system. Its implementation in an organisation does not complete the work on the innovation management system.

2. Research methodology

The main objective of the literature study was to prepare tools to review the elements, with consist of the innovation management subsystems. The main objective of the own research was to compare the elements of innovation management used by the three automotive concerns that produce propulsion systems in Poland. Comparing the elements used allowed the definied a complex model of a network and supply chain innovation management system (especially the two subsystems and propose to retrofit them).

The proposed research tools (Appendix 1, Appendix 2) can too be used to assess the maturity for managing innovations arising in collaboration. The tools will also serve as an inspiration (for menager R&D) for supplementing a functioning system with missing elements.

Achieving the aims required applying research methodology which meant operating according to stages: analysis of the literature on the subject; determining the research gap; initial (praxeological) research; conceptualization of four podsystem; preparation of research tools and gathering of data - conducting relevant research; data analysis; formulation of practical recommendations for the researched enterprises; indication of limitations of the conducted research; indication of the rationale for further research.

Combination of various research methods, corresponding to subsequent research stages, have been applied. Grouping the methods according to the tested models was found significant. Details related to the research methodology are presented in table 1.

Table 1.
Research methodology

Innovation management system	Research methodology			Research Subject Matter	Sample size
	Critical analysis of the literature on the subject	**Quality methods**	**Quantity methods**		
Subsystem for managing their own innovative maturity	•	The SGMM expert method Individual in-depth interviews Survey *Appendix 1,2*	-	Corporations: VW, Toyota, FCA	3
Subsystem for managing the processes of obtaining product innovations from suppliers	•	Individual in-depth interviews Survey *The results of the study are not presented in this article*	-	Plants manufacturing engines that belong to the corporations VW, Toyota, FCA	3
Subsystem for innovative maturity management of suppliers from the supply chain and networks of cooperating companies	•	The SGMM expert method Individual in-depth interviews Survey *Appendix2*		Plants manufacturing engines that belong to the corporations VW, Toyota, FCA	3
Subsystem for innovation performance management	• Financial document analysis	Survey *The results of the study are not presented in this article*	Statistical analysis - correlation analysis - regression analysis		3
System management model	•	Interview	-	Implementer of IT solutions for business	-

Source: own study.

Tests of research tools preparation for subsystems analysis were conducted in three automotive corporations (producing drives in Poland).

3. Research findings

Tabela 2.
Tools used by the company (concern) in its relations with suppliers (case of Toyota, VW, FCA)

Management tools	Use of		
Concern	T	V	F
Individual meetings with suppliers	✓	✓	✓
Participation in dedicated discussion forums	✓	✓	✓
Requests for information and technical dialogues	✓	✓	✓
Standard in communication with suppliers e.g., developed RFI process	✓	✓	✓
Dedicated teams to solve problems arising in cooperation with suppliers	✓	✓	✓
Conduct supplier assessments as part of development programmes and identify potential for improvement	✓	-	-
Secondment of staff to the supplier to exchange knowledge	✓	-	-
Adoption of seconded staff from the supplier to share knowledge	✓	-	-
Cyclical meetings of inter-organisational working groups	✓	-	-
Cooperation and exchange of experience not only with suppliers but also with subcontractors	-	-	-
Innovation days organised to communicate development and innovation needs to suppliers	✓	✓	✓
Learnig trip/ Learnig journeys	-	✓	-
Strengthening of inter-organisational personal links between R&D, Purchasing employees	✓	-	-
Finding commonalities between supplier companies and combining them for innovation development	✓	-	-
Continuous training or education and incentives for innovative suppliers	✓	-	-
Innovation audit as a routine activity/identifying specific resources and processes dedicated to the relationship/asking the supplier for a self-assessment	✓	-	-
Monitoring of relations dedicated to the development of innovative projects	✓	-	-
Supplier portfolio management and relationship termination mechanisms	-	-	-
Appointment of "Innovation Champions"	✓	✓	✓
Hiring an innovation champion	-	-	-
Computer vision of the project to which talent is recruited	-	-	-
Formal mechanisms for managing investment in open innovation	✓	✓	✓
Building trust between employees of cooperating companies and education in the area of relational competence	✓	-	-
Analysis of purchasing practices, audit of purchasing reports	✓	✓	✓
Innovative competitions	-	✓	✓
Use with suppliers of tools to support creativity and imaginative thinking developed by TRIZ (Theory of Inventive Problem Solving)	-	-	-
Use of QFD (Quality Function Deployment) tools with suppliers	-	-	-
Use of FMEA (Failure Mode and Effects Analysis) tools with suppliers	✓	✓	✓
Using "Procurement engineering" with suppliers to improve product performance to meet changing customer expectations	-	-	-
Use of "Reverse engineering" with suppliers to study the product to design a counterpart	✓	✓	✓
Use of "Reverse engineering" with suppliers to study the product in order to design an equivalent	✓	✓	-

Source: own study, base on Appendix 1 (in January 2021 FCA I PSA joined and created concern Stellantis. Data refer to the period 2020)

Using the Smart Grid Maturity Model, lider of suplly chain can assess the innovation maturity of cooperators and prepare measures to improve their competence for R&D cooperation.

The proposed comprehensive method, is a multidimensional set of precise instruments for measuring and assessing the maturity of activities carried out in cooperation. The SGMM model lists six levels of maturity assessment of activities carried out in 8 domains of the organization. An example matrix for assessing innovation maturity is shown in the table below.

Example of innovation maturity matrix to work in the OI open innovation model.

Table 3.
Research methodology in SGMM

5								
4								
3								
2	X	X		X	X		X	X
1			X					
0						X		
	SPZRP	OS	MDO	ZAKP	TTI	PKRK	ISW	POSS

Source: http://www.sei.cmu.edu/library/assets/brochures/sgmm-1010.pdf.

The eight enterprise domains rated on a six-point scale are[1]:

1. Strategy, Management Processes and Regulation (SPZRP),
2. Organization and Structure (OS),
3. Matrix of Operational Activities (MDO),
4. Asset Management and Employee Competence (ZAKP),
5. Technology and Information Technology (TTI),
6. Customer Needs and Customer Relationships (PKRK),
7. Integration of Value Networks (ISW),
8. Processes in the Social and Environmental Area (POSS).

Based on the Smart Grid Maturity Model method, using the Analytic Hierarchy Process (AHP), the domains most relevant to cooperation in IO with first-tier and next-tier suppliers and idle suppliers were selected. Using the article by (Motyka, 2012), in which the author juxtaposes the AHP method with the Strategic Scorecard method, component weights are assigned to the eight domains of enterprises. The leader can build the innovation maturity of suppliers in different areas of operation. Assessing the level of innovation maturity and identifying the competency gap, if any, is necessary in the effort to improve supplier innovation. The competence gap of suppliers of the three concerns was examined and is shown in the following radar charts. Respondents/employees of the concerns were asked to give a rating for their suppliers (engine component suppliers). The ratings were averaged and shown in the figures below.

[1] Domain evaluation criteria and complete domain evaluation form see: (Stawiarska, 2019).

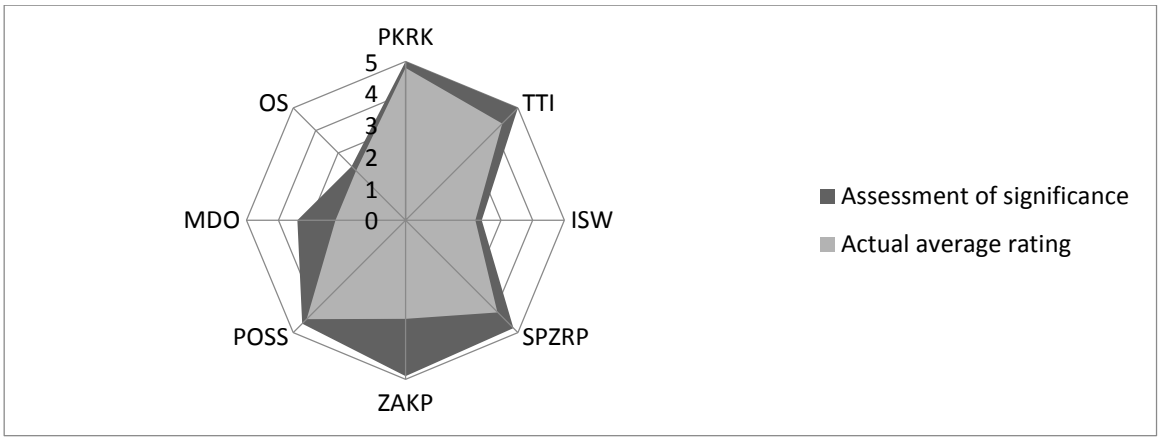

Figure 4. Competency gap analysis of Toyota suppliers' innovation maturity.

Source: own study, base on Appendix.

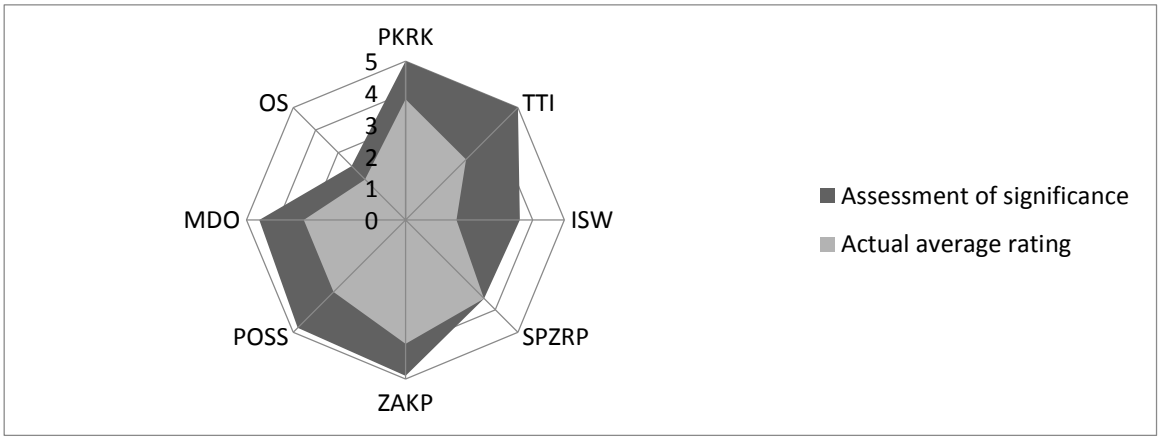

Figure 5. Competency gap analysis of Volkswagen suppliers' innovation maturity.

Source: own study, base on Appendix.

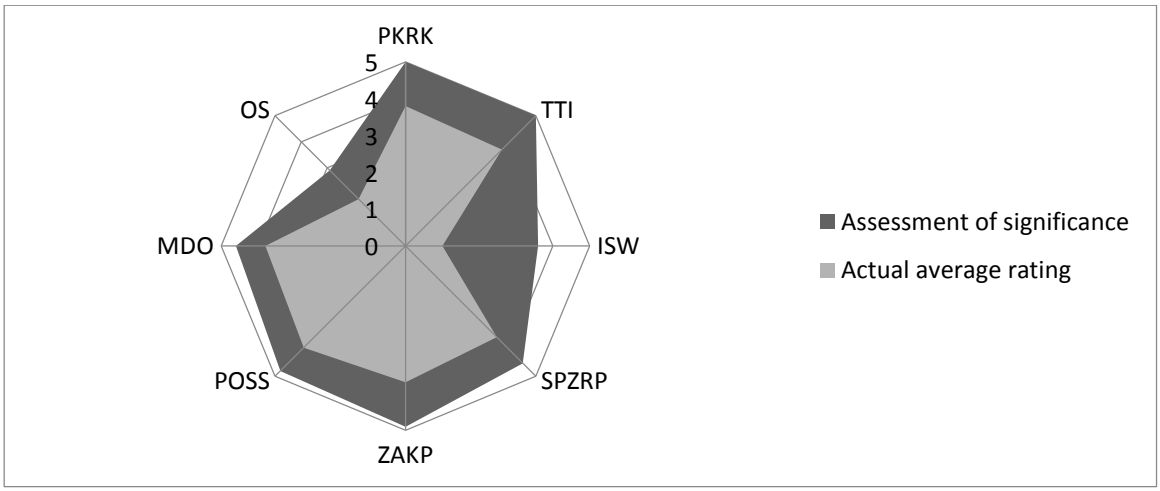

Figure 6. Competency gap analysis of FCA suppliers' innovation maturity.

Source: own study, base on Appendix.

The enterprise domains listed in the figures play a key role in developing organizations to work in an open innovation model OI. A high rating of the domains is a guarantee of the ability to collaborate on innovation in cooperation with the chain leader. The averaged assessment conducted by the respondents showed that suppliers have competence gaps in innovation maturity. Looking at the charts above, it can be concluded that Toyota suppliers show the smallest competence gap in maturity to work in an open innovation model. The figure shows that Volkswagen sees a larger supplier competency gap. Perhaps this is why it is still skeptical about the open innovation development model. The above graphical analysis proves hypothesis 3: Implementation of the supplier's innovative maturity assessment model / Managing the innovative maturity of suppliers results in an increase in the innovativeness of the supply chain leader (measured by the number of patents obtained).

Recognizing the domains of suppliers supporting and assessing them, results in an increase in the number of patents developed in cooperation (see Table 3), this relationship is particularly well demonstrated at Toyota.

4. Discussion

Researchers are building and testing innovation management systems (Cooper, 2004), (Forslund, 2007), (Ryan, 2010) that can be applied to supply chains and networks. The systems being implemented take into account inter-organisational R&D collaboration in the automotive industry (Afuach, 2014). Most of the innovation management systems in operation require digitisation (Stawiarska et al., 2001). Chapter one presents the author's model of a complex innovation management system. The proposed model consists of subsystems, and these subsystems consist of elements identified in the literature. The research work resulted in analyses of two innovation management subsystems operating in the three automotive concerns studied. The results of the subsystem studies are presented in Chapter Three. The presented results of the comparative empirical research suggest the following cognitive conclusions:

1. The conglomerates studied often lack the competences of their competitors, which are necessary for innovation activities in the IO model.
2. The studied corporations implement an innovation management system, but this system cannot be called complex. The closest sophisticated system to support the development of innovation in IO is that of Toyota. Toyota among keiretsu suppliers builds a specific organisational culture, applying the philosophy: challenge, kaizen, genchi genbittsu, mutual respect, teamwork, Toyota Production System, quality circles. The innovation management system among suppliers implemented by Toyota is a perfect exemplification of the Japanese approach to work. Product development decisions do not come suddenly, they are worked out over many meetings, discussions, collective

consultations in a group of managers of cooperating companies. Even if Toyota's activities are not explicitly referred to as an innovation management system - they de facto form an integrated set of principles, procedures and methods oriented towards the creation, dissemination and use of innovation knowledge.

3. Corporations do not build a culture of innovation among suppliers, they do not require creativity, they do not measure the innovation maturity of suppliers. They use supplier databases prepared for their use, where they store information about innovations developed by suppliers. Volkswagen has the most advanced tool for monitoring suppliers and their innovations. A supplier can log on to the VW portal, becoming an 'inactive' supplier, and submit information about a proposed innovation. Volkswagen declares that the knowledge deposited here contributes to the supplier relationship and is used to develop new technologies, products, services.
4. The case studies reveal clear difficulties related to the process of changing the supplier base and reconnecting the resources of new suppliers.

Chapter three also shows an assessment of the innovation maturity of suppliers. It is presented in radar charts as a competence gap in the eight domains of IO work. Toyota suppliers are the most mature for IO work. Only by having a complete picture of the competences of suppliers and potential suppliers can the conglomerate join forces with suppliers in developing new innovationsolutions. The results of the study provide evidence that there is still a lot of work to be done in the systemic innovation management of automotive suppliers. The development of four innovation management sub-systems by the supply chain leader creates an opportunity for their integration. It is therefore worth formulating practical conclusions precisely for purchasing and R&D managers in automotive corporations. The basic practical conclusions are:

1. An innovation management system among suppliers developed centrally and locally, i.e. in the countries of location of production plants, is desirable.
2. All the subsystems and elements of the innovation management subsystem architecture mentioned are equally important. However, there is one that should be singled out - this is a common culture of innovation among co-operators.
3. It is worth implementing innovation management tools and applications in an open innovation model. The supplier innovation management model could be implemented in an IT system and serve as a tool to support innovation development. The idea of implementation was discussed with a specialist from SAP (responsible for cooperation with automotive companies) and met with interest and confirmation of feasibility. An IT-based supplier innovation management system could be classified as an integration platform for innovation. This platform could integrate so-called 'active' and 'inactive' suppliers, concerns and cluster animators. The tool could support the innovation process and consist of different procedural elements. The first element would serve to self-assess innovation maturity. Equipped with artificial intelligence,

the platform would analyse the supplier's declared innovation maturity in the self-assessment, identify competence gaps in the domains subject to self-assessment. At the end of the research periods, the platform would be able to display the average ratings of suppliers by group (by row or segment related to a specific technology). The platform, by detecting competency gaps in specific domains of the surveyed company, could generate action plans for their improvement, identify incentives that will result in closing the gap/resolving the problems. Big data technology will collect and analyse data on supplier assets and pinpoint their location in a timely manner. It seems that corporations still have an indifferent attitude towards new ICT used in supplier relations for innovation development, so they do not invest in modern ICT systems, and this delays organisational change in innovation development processes in open models. Education and promotion of the platform will therefore be necessary. However, looking at what is happening in the automotive software supplier market, it is becoming clear that in the future all automotive suppliers will develop innovations based on open source software. There will come a time when all automotive innovations will be the result of collaboration on open source platforms.

Research on building an innovation management system will continue. The goal of the research will be achieved after testing further tools to identify elements of the next two subsystems, i.e.

- Subsystem for managing their own innovative maturity.
- Subsystem for innovative maturity management of suppliers from the supply chain and networks of cooperating companies.

Although there are problems in the automotive industry in obtaining and analysing data for research, it must be said that a new look at the area of open innovation is needed. The aim of future projects is to develop software, processing data on supplier potential. Artificial intelligence algorithms will be used to find the best suppliers, identify their resources and simulate efficient and effective innovation processes. The undertaking is important for the sustainability of suppliers and the growth of innovation for all companies in the supply chain. The fact that there is a growing demand for eco-innovation, as well as the projected possible crisis in the automotive market, remains an important context for future research.

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Appendix 1

Survey of international automotive companies

Dear all, I would like to request an interview questionnaire on innovation capacity building and cooperation among companies in the automotive industry. The research is being carried out for an academic thesis.
The research aims to identify supplier innovation management methods in the context of the effectiveness of new product implementation in your company.
Innovation is key to the success of companies. Despite the announcement of multi-million-pound innovation implementation programmes in the economy, a significant challenge remains in how to source innovation. The R&D function and the Purchasing function have an important role in developing innovation. The work of those employed in these departments involves co-creating and sharing knowledge with strategic suppliers, as well as purchasing innovative solutions, including early-stage development. Given the existing challenges, it was decided to carry out a diagnosis of innovation in the purchasing of innovative solutions. The research was conducted in both the R&D and Purchasing departments of car manufacturing companies and suppliers. The questions concern stimulators and barriers to innovation procurement, solutions to support the development of innovations in an open model, ICT tools used in the innovation procurement process.
I ask for truthful information and honest answers.

Part 1

Interview questionnaire

Supplier innovation management

Kindly answer the following questions to understand your supplier innovation management model.

1. Does your company (concern) have an innovation strategy? yes no
   If yes, does this strategy have a separate strategy for the area of Purchasing? yes no
   Is there a policy for managing the innovation of 1st tier suppliers? yes no
   Is there a policy for managing the innovation of 2nd tier suppliers? yes no
2. What percentage of innovation (concern)

develops in-house R&D and then subcontracts to suppliers (process I)	……%
sources to suppliers by purchasing/licensing the finished solution (process II)	……%
sources externally through coupled project collaboration with suppliers (process III)	……..%
other what.....	……..%
	100%

3. Does this percentage pattern hold in relation to previous years
   - increases in favour (I) yes no
   - increases in favour (II) yes no
   - increases in favour (III) yes no
   - Does the change affect the efficiency of innovative solutions? yes no
4. Does the company purchase all components also innovative? yes no
   If yes then:

Does the company strive to increase the number of first-tier suppliers tier suppliers cooperating in R&D? yes no

Does the company strive to increase the number of second-tier suppliers cooperating in the R&D area? yes no

5. Does the company (concern) manage R&D contracts with second-tier suppliers? yes no

Does the company (concern), in the execution of R&D contracts with suppliers, use the processes developed? yes no

Does the company (concern) manage the risk of purchasing innovative solutions? yes no

6. On the basis of which criteria does the company (concern) segment (group) active suppliers with whom it develops R&D projects?

with whom it develops R&D projects? .....

7. On the basis of which criteria does the company (concern) segment (group) inactive suppliers, with which it wants to develop R&D projects?

.....

8. Is controlling implemented for the distinguished categories of suppliers with whom the company (concern) develops R&D projects? (insert "x" in the table below)

Organisation of purchases							Controlling	Strategic Operational Tactical
Active suppliers				No-active suppliers			Area strategy	
Category …… …….	Category …… ……	Category …… …….	Category …… ……	Category …… ……	Category …… ….	Category …… ….		
							Market analysis	
							Category strategy	
							Category innovation strategy	
							Supplier and contract management	
							Process preferences (I), (II), (III)	
							Risk management in processes	
							Negotiations	
							Order processing/verification	

9. Does the company (concern) use an ICT tool, Business Intelligence? e.g. K-Monitor to:

- supplier grouping, yes no
- strategic controlling of suppliers, yes no
- operational controlling of suppliers, yes no

10. What are the specific criteria for evaluating a supplier with whom the company (group) is developing/intends to develop innovative component projects?

.....

Are these criteria:

- formulated/written down yes no
- neasurable yes no
- communicated to suppliers yes no

11. Are the following managerial tools used in the company (concern) in relations with suppliers (insert "x" in the column on use)

Management tools	use of
Individual meetings with suppliers	
Participation in dedicated discussion forums	
Requests for information and technical dialogues	
Standard in communication with suppliers e.g., developed RFI process	
Dedicated teams to solve problems arising in cooperation with suppliers	
Conduct supplier assessments as part of development programmes and identify potential for improvement	
Secondment of staff to the supplier to exchange knowledge	
Adoption of seconded staff from the supplier to share knowledge	
Cyclical meetings of inter-organisational working groups	

Cooperation and exchange of experience not only with suppliers but also with subcontractors	
Innovation days organised to communicate development and innovation needs to suppliers	
Learnig trip/ Learnig journeys	
Strengthening of inter-organisational personal links between R&D, Purchasing employees	
Finding commonalities between supplier companies and combining them for innovation development	
Continuous training or education and incentives for innovative suppliers	
Innovation audit as a routine activity/identifying specific resources and processes dedicated to the relationship/ asking the supplier for a self-assessment	
Monitoring relacji poświęconych rozwojowi projektów innowacyjnych	
Supplier portfolio management and relationship termination mechanisms	
Appointment of "Innovation Champions"	
Outsourcing the innovation champion	
Computer vision of the project to which talent is recruited	
Formal mechanisms for managing investment in open innovation	
Building trust between employees of cooperating companies and education in the area of relational competence	
Analysis of purchasing practices, audit of purchasing reports	
Innovative competitions	
Use of creativity and inventive thinking tools developed by TRIZ (Theory of Inventive Problem Solving) with suppliers	
Use of QFD (Quality Function Deployment) tools with suppliers	
Use of FMEA (Failure Mode and Effects Analysis) tools with suppliers	
Using Procurement engineering with suppliers to improve product performance to meet changing customer expectations	
Using Reverse engineering with suppliers to study the product to design an equivalent	
Crowdsourcing of innovations (ideas from "ordinary" people)	

12. What barriers (including communication) and risks does your company (Polish branch) face in developing innovation with suppliers?

.....
.....

13. What kind of stimulators (including communication) for the development of innovations with Polish suppliers are distinguished by the company?

.....
.....

Part 2

Questionnaire survey

Supplier innovation management - self-assessment of activities

1. are the following sentences about the company (concern) close to the truth:
(1 - completely disagree 5 - fully agree) (insert "x" in the chosen column 1 - 5)

Supplier innovation management	1				5
We periodically monitor the internal causes of potential inefficiencies in purchasing processes					
We periodically monitor external causes of potential inefficiencies in purchasing processes					
We measure the value generated by purchases, e.g., impact of purchases on sales performance, operating costs by purchasing category					
We cyclically observe the trends evident in the market among purchasing organisations and consider their relevance to our organisation					
We periodically monitor external suppliers (not currently affiliated with our organisation) in order to acquire their innovative solutions through purchase/licensing					
We periodically monitor external suppliers (not currently associated with our organisation) in order to develop innovative projects with them					
We fear the complexity of buying innovation, preferring to co-create it in the development process with the supplier					
Our structures allow us to be fast and agile in our new solution development projects with suppliers, we have an open book policy in place)					
We audit our own company, analysing: Strategy, Management Processes and Regulations (SPZRP) in order to be more open to innovative solutions from outside					
We audit our own company, analysing: Organisation and Structure (OS) in order to be more open to innovative solutions from outside					
We audit our own company, analyse: Measures of Operations (MDOs) to be more open to innovative solutions from outside					
We audit our own company, analyse: Technology and Information Technology (TTI) in order to be more open to innovative solutions from outside					
We audit our own company, analysing: Level of Customer Service and Customer Relationships (PKRK) in order to be more open to innovative solutions from outside					
We audit our own company, analyse: Value Network Integration (ISW) opportunities, in order to be more open to innovative solutions from outside					
We audit our own company, analysing: Social and Environmental Area Processes (POSS) in order to be more open to innovative solutions					
We apply risk management to innovative projects with suppliers					

2. Does developing R&D cooperation in an open model with suppliers increase the number of innovative solutions implemented? yes no

Appendix 2

Survey of international automotive companies
Interview questionnaire
Managing the innovation competence of suppliers

Please use the tool prepared below to provide an expectation and rating towards the innovation maturity of the suppliers (1st tier, 2nd tier and 'idle/networked) with whom you are collaborating in the development of the engine. Please give an importance rating to each domain (5 - domain important/desirable, 0 - domain not important/not required). Please average the rating of the engine's parts/software suppliers (5 - very high rating of suppliers' cooperation in engine development, 0 - critical rating of suppliers). Please use the form below.
Supplier innovation maturity analysis form

Analysis of supplier innovation maturity - questionnaire		Group suppliers Tier I		Group Tier II suppliers and subsequent		Group suppliers idle networked	
		Assessment of importance	Assessment	Assessment of importance	Assessmen	Assessment of importance	Assessmen
		Scale 0-5	Scale 0-5	Scale 0-5	Scale 0-5	Scale 0-5	Scale 0-5
1	**Strategy, Management Processes and Regulations (SPZRP) - vision and mission, governance , stakeholder cooperation**	**Sum of products**		**Sum of products**		**Sum of products**	
	Skills in strategic market analysis/technology monitoring						
	Organisation/membership in a network, exploiting opportunities from the network						
	Presentation, vision, strategy, development directions to next level suppliers						
	Cooperation with suppliers of innovative solutions is regulated by law						
	Ability to create relationships with innovation suppliers, speed of execution of purchase transactions						
	Patent activity for self-created and networked innovations						
	Defined policy of innovation and support for investment decisions in new solutions						
	Innovation strategy integrates all five areas of innovation management (ideas, priorities, implementation, people and strategies)						
	Diversified portfolio of innovation processes (I, II, III)						
	Working with stakeholders ensures investments that sustain growth						

2	**Organisation and Structure (OS)**	**Sum of products**		**Sum of products**		**Sum of products**	
	The organisational structure enables collaboration with other network stakeholders to optimise network performance and security						
	Ability of the structure to adapt to market changes						
	The organisation is able to adapt easily to support new ventures, products and services that emerge as a result of collaborative networking of relationships						
	Using structured methods to create innovation: morphological method, focal object method, designe thinking, brainstorming, synectics						
	Using complex systems (as opposed to ad-hoc solutions) to generate, test and evaluate innovation ideas						
	Stosowanie procesu priorytetyzacji w celu wyboru projektów zgodnie ze strategią innowacji						
	Products and services are more competitive thanks to innovative processes						
	Effective internal and external information flow						
	Speed and efficiency of decision-making						
	The organisation supports the collection of ideas e.g. (from network links)						
	A clear, common and comprehensible system of risk assessment for the development of innovations - which allows projects to be analysed objectively						
	Project management skills						
	Possession of management certification (e.g. ISO 9001)						
3	**Operational Measurement Matrix (MDO)**	**Sum of products**		**Sum of products**		**Sum of products**	
	Decisions are made quickly in the company based on analysis and are often automated						
	Operational management is based on real-time data extracted from the relationship network						
	Preparation time for innovative components is competitive/design time						
	The R&D/purchasing and production cell is involved in coordinating the development and testing of prototypes between downstream suppliers						
	There is an automated innovation development process						
4	**Asset and Employee Competence Management (ZAKP)**	**Sum of products**		**Sum of products**		**Sum of products**	
	Management of staff development						
	Effective incentive system						
	Kompetencje pracowników						
	Use/exchange of staff resources/knowledge within the organisation and between companies in the network (key staff from R&D, purchasing and production)						
	Employee autonomy in problem solving						
	An organisational culture that supports innovative company and network activities						
	The company has a complete picture of cooperators' assets based on information, databases and connectivity						
	General climate of the organisation supporting the idea generation process						
	Promoting opportunities to learn and share experiences with other organisations						
	Audit of operations, performance and trend analyses are available to collaborating organisations						

5	**Technology and Information Technology (TTI)**	**Sum of products**		**Sum of products**		**Sum of products**	
	The quality of the IT infrastructure (hardware, network) supports innovative activities IT compatibility allows for the implementation of joint projects						
	Purchasing systems support the development of innovation						
	Design systems support the development of innovation						
6	**Customer Needs and Customer Relationships (PKRK)**	**Sum of products**		**Sum of products**		**Sum of products**	
	Mutual relationship management						
	Mutual understanding of business needs						
	Building lasting business relationships						
	Relationship enhancement applications are plug-and-play						
7	**Integration of Value Networks (ISW)**	**Sum of products**		**Sum of products**		**Sum of products**	
	Level of joint investment in research and development activities						
	Number of new joint products and services launched annually						
	Number of patents filed as a result of cooperation						
	Optimisation of assets throughout the value chain, assets are automatically adapted to the needs of the innovation process						
8	**Processes in the Social and Environmental Area (POSS)**	**Sum of products**		**Sum of products**		**Sum of products**	
	A trustworthy corporate image						
	Network cells control their activities in the context of environmental burdens						
	Strategic, tactical and operational objectives are aligned with local, regional, national and international development goals						
	The organisation cooperates with external actors on environmental and social issues						
	Innovation maturity score (sum of products from eight domains)	total		total		total	

Source: own elaboration.