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Sources of Intellectual Capital Acquisition

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Abstract: Research related to intellectual capital (IC) concerns its use and impact on the selected results achieved by enterprises. IC is analysed as a single stream of enterprises' internal resources. Since IC is used in the business activities of enterprises, it must also be acquired. However, research conducted so far does not cover the area of IC acquisition. The purpose of this paper is to present the results of research undertaken in a relatively new area of IC acquisition that has not been scientifically explored over a research period of several years. The research covered innovative small and medium enterprises (SMEs) that were developing software in Poland from 2005 to 2019. The data series allowed the use of dedicated analysis tools, including the dynamic changes over time, multidimensional comparison and cluster analysis. The primary conclusions revealed that the acquisition of IC is a process that takes place simultaneously and continuously in two independent streams—internal and external—and that the external sources of IC were more important for SMEs covered by the research. Continued research will allow comparative analyses between various branches or sectors of the economy to bring new knowledge about the importance of IC to the business activities of enterprises.

Keywords: O34 Open Intellectual Capital; O30 Intellectual Capital Acquisition; L25 Empirical Analysis of open intellectual capital acquisition

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1. Introduction

In knowledge-based economy, it has been noted that intangible resources are essential in maintaining an enterprise's continuous development [1–3]. In the extensive subject literature, intellectual capital (IC) is treated as part of these intangible resources of enterprises [4]. Many researchers of IC indicate that it is a strategic factor for enterprises in achieving success [5–11]. Hence, the operational needs of enterprises result in the use of individual components and their elements belonging to the IC structure. The transfer of IC (including knowledge and technology) refers to both the internal and external environment of enterprises [12–17]. However, the research on IC to date has focused on its use in various business activities [18–24]. Similar to other resources, IC, which is considered a key resource for business development, is subject to limitations. First, IC in enterprises is not a self-renewable resource—it is not born by itself. It requires active acquisition and development, whether it is acquired from external or internal sources (such as cooperation with other enterprises or its own research and development department). It requires targeted actions and the appropriate funds to be allocated for this purpose. This means that both the use and acquisition of IC should be treated as equally important and as key strategic processes in the operational activities of not only large enterprises but also small and medium enterprises (SMEs). The first requirement of IC is its acquisition—to the extent necessary—to ensure the continuity of operations. Thus, it can be assumed that the acquisition of IC is a systematic and continuous process related to a company's operational activity. This is a relatively new area of research; there is a lack of research in the literature about the acquisition of IC by innovative software-producing SMSs over several years. Therefore, to conduct research, it was necessary to decompose IC into two independent streams of simultaneous acquisition. The decomposition into independent streams led to the proposal of a new concept: Open

IC (OIC). In the OIC concept, two streams of simultaneous acquisition were considered: internal and external.

The primary purpose of this paper is to present the results of research undertaken regarding OIC acquisition and to answer the research questions formulated based on the decomposition of this acquisition into two separate streams. First, is OIC acquired simultaneously and continuously in two separate streams (internal and external) over the entire research period? Second, which OIC acquisition sources (internal or external) are most important for the surveyed SMEs, considering the level of acquisition over the entire research period?

2. Literature Review

The interest of enterprises in IC can be noted in the literature over the last few decades. Over this considerable length of time, IC concepts have evolved. The use of IC in business activities, the related analyses and evaluations and the necessity of reporting the effects of its use led to two emerging trends in current scientific considerations regarding IC. The first trend was related to IC structure and concepts. The studies defined the list of components and their elements that make up the IC structure, and which are usually related to enterprise strategy. However, over time, the expansion of the IC research spectrum was observed [25,26]. Over several decades, the amount of research about IC concepts and issues related to them, including issues related specifically to enterprise strategy, has grown [27–31]. IC has also been studied in a holistic context [32–34]. A vast amount of research is dedicated to individually selected IC components and elements [35–39]. A very important issue taken by researchers is the knowledge transfer performed within inter-organisational networks [40–42]. The research has also covered the use of IC in developing value and competitive advantage in enterprises [43–48]. Increasingly, the research has covered the issue of the use of IC in the innovation process [49–54]. However, the research presented in the literature clearly indicates that the use of IC occurs in every enterprise, not only in innovative enterprises. Thus, the use of IC is not limited to the innovation process; it has a broader context related to the business activities of all enterprises. On the other hand, IC acquisition is usually researched as one of the elements composing the IC management process [55]. There is very limited research strictly dedicated to the acquisition of IC by SMEs over a period of several years. There are studies dedicated to the IC used by SMEs but only based on one-time surveys [56–60]. The disadvantage of such research is that it cannot show the dynamic change in IC usage, or even acquisition, over several years.

The second trend concerned the application of accounting principles and reporting methods of IC measurement and evaluation in enterprises. Similar to the concepts, the methods of analysis and evaluation of IC are widely discussed in the subject literature. The differentiation concerns the evaluative tools applied and the variables used. The subject literature lists over 40 methods of analysis and evaluation. New proposals and modifications to existing methods still arise. For obvious reasons, it is beyond the scope of this paper to discuss all the IC concepts and methods used. Presently, it can be said that it is not a closed set. IC has been analysed and evaluated as a single stream of enterprises' internal resources. Studying the acquisition of IC over several years requires conducting research with decomposition into two streams: internal and external. The necessity of decomposing IC into two streams is an assumption, since no studies have proven that companies acquire IC simultaneously from internal and external environments over several years.

The subject literature led to the conclusion that, until now, there has been a deficiency in research providing a dynamic comparative evaluation over several years between the acquisition of IC in two parallel and symmetric streams. Thus, the two streams of acquired IC being compared must be described with the same component structure to perform such an evaluation.

The concepts of IC presented in the available literature differ in terms of the number of components included in the IC structure and their definitions and contents. The consequence is that there is no single, universal concept of IC. The scientific debate on this

subject continues. However, one of the most frequently cited approaches was proposed by Karl Sveiby [61]. It describes the IC structure which consists of the most extensive number of unique components. Thus, based on the above-mentioned approach, the IC structure used in this research consist of the following unique components and their elements:

- Human capital consists of knowledge (tacit and explicit), competencies, commitment, cooperation, professional development, values, predisposition and experience.
- Organisational capital consists of structural capital, organisational culture, strategies, decision-making systems and job style.
- Relational capital consists of clients, partners, reputation, internal and external relations, trust, image and brand.
- Project capital consists of operational and supporting processes, employee programs and project management techniques and methods.
- Innovation capital consists of intellectual properties, intangible properties, intangible assets and innovations that have been developed.
- Information capital consists of information systems, formal (descriptive) documentation and information-sharing rules and databases.
- Technological capital consists of technological infrastructure, internal computer networks and technologies that have been developed.

This concept of IC acquisition consists of two levels. The first level consists of the seven components listed above. The second, more detailed level consists of the elements belonging to those components. This IC structure does not pretend to be universal and comprehensive. It is an open concept, which means that new elements can be added in the future, but only in compliance with the principles of the uniqueness of components and their contents. Both internal and external streams of IC acquisition consist of the same structure of components. Thus, the research described in this paper was conducted with the decomposition of simultaneous and symmetric IC acquisition streams into internal and external. In the internal stream, the IC was acquired based on enterprises' own resources. In the external stream, the IC was acquired from the external environments of the enterprises covered by the research. Thus, the developed concept of IC acquisition is broad enough to perform comparative analyses between the two streams.

3. Materials and Methods

The common and well-known opinion is that enterprises currently acquire IC from both and external environments. Nevertheless, the acquisition of IC has not been researched. Thus, the acquisition of IC constituted a new and unexplored area. To research this new area, it was necessary to decompose it into two separate streams of IC acquisition.

3.1. The Concept of Open Intellectual Capital Acquisition

There is no universal and commonly accepted concept of IC presented in the available literature. Thus, in the analysis conducted, the concept of IC acquisition described in the previous chapter was used. The availability of empirical data allowed research to be conducted at the IC components level: human capital, organisational capital, information capital, relational capital, project capital, innovation capital and technological capital. The research was conducted by separating IC acquisition into two streams: internal and external. The internal stream consists of the IC acquired internally based on the resources within the individual enterprises surveyed. The external stream consists of the IC acquired from environments external to the enterprises surveyed. Each stream is described by the structure of the seven components in IC acquisition. This solution allows comparative analyses of the IC acquisition in each stream. Additionally, using the same symmetrical IC structure in both streams ascertains which components are acquired from internal sources and which are acquired from external sources. The decomposition into these two independent, simultaneous streams is a novel approach for research of this type conducted over several years. Using the same IC structure in both internal and external streams of acquisition allows for the comparison of acquisition by SMEs. This is why this concept

can be called Open IC (OIC). The overall OIC acquired by enterprises represented in this research contains both internal and external streams. The research questions in this paper will be answered using the above-mentioned proposition.

3.2. Empirical Data, Research Period and Enterprises Included in the Research

This research covered innovative SMEs that develop software in Poland, which is a knowledge-intensive sector. Today, SMEs producing software, not only in Poland but also in other countries, use project management techniques based on the Agile Manifesto that belongs to the family of software developing Agile Project Management techniques [62]. SMEs producing software in Poland are examples of such business activities. The innovative SMEs in the current research that are developing and improving software primarily on individual orders of customers are enterprises that are operating in other branches and industries of the economy. The above-mentioned project management techniques assume the participation and cooperation of customers with programmers in software that are producing and improving projects. This is the reason why respondents identified the list of enterprise customers as an internal source of OIC acquisition. Therefore, the customers are good examples of IC acquisition in the business operations of software production. The study covered 15 years from 2005 to 2019 and was determined by data availability. The empirical data were obtained from Statistics Poland based on an individual agreement. Statistics in Poland conducts regular surveys designated for innovative enterprises only. Each year, the number of software-producing innovative SMEs is different. Detailed specifications of the questions were required to represent the answers in time series. Fourteen sets of time series describing the acquired components of OIC (separately for internal (s_1–s_7) and external (s_8–s_{14}) streams) were obtained and are presented in Table 1.

Table 1. Time series of OIC acquisition variables. Source: prepared by the author.

Component Stream	Description of Variables Characterizing the Acquiring of OIC
Streams of components forming the entire internal stream of acquired OIC, variables s_1–s_7	
s_1	Stream of human capital component
s_2	Stream of organisational capital component
s_3	Stream of relational capital component
s_4	Stream of technological capital component
s_5	Stream of information capital component
s_6	Stream of project capital component
s_7	Stream of innovation capital component
Streams of components forming the entire external stream of acquired OIC, variables s_8–s_{14}	
s_8	Stream of human capital component
s_9	Stream of organisational capital component
s_{10}	Stream of relational capital component
s_{11}	Stream of technological capital component
s_{12}	Stream of information capital component
s_{13}	Stream of project capital component
s_{14}	Stream of innovation capital component

Table 2 presents the time series of variables that describe the acquisition of each OIC component from internal and external sources identified by the SMEs in this research. Each time series presented in Tables 1 and 2 consists of 15 annual observations.

Table 2. Time series of OIC acquisition sources. Source: prepared by the author.

OIC Sources	Description of OIC Acquisition Sources
	External sources of OIC acquisition, variables s_{15}–s_{30}
s_{15}	Cooperation with software companies belonging to the same industry
s_{16}	Other companies in the same industry
s_{17}	Suppliers of equipment, materials, components and standard software licenses
s_{18}	Competitors
s_{19}	Consulting firms, consultants, commercial laboratories, private R&D institutions
s_{20}	Cooperation with Polish Academy of Sciences (PAS)
s_{21}	Cooperation with other national research institutes
s_{22}	Cooperation with foreign institutions
s_{23}	Cooperation with national universities
s_{24}	Conferences, fairs, exhibitions
s_{25}	Scientific, technical and commercial journals and publications
s_{26}	Other scientific, technical and professional societies and associations
s_{27}	Purchased licenses (excluding licenses for standard computer software)
s_{28}	Purchased results of external R&D
s_{29}	Purchased consulting services
s_{30}	Other external sources
	Internal sources of OIC acquisition, variables s_{31}–s_{36}
s_{31}	List of enterprise customers
s_{32}	Product development achieved based on own research and resources
s_{33}	Managers
s_{34}	Sales department
s_{35}	Marketing department
s_{36}	Other departments of the enterprise

The specified variables characterise issues directly related to the acquisition of OIC necessary in the iterative processes of software development and improvement in the SMEs. Sources presented in Table 2 belong to external and internal streams. Each OIC component can be acquired from each source. Each source was identified once by participants if IC was acquired. Thus, the aggregated number of SMEs in each source signifies the level of acquired IC in each year of the research period. The external sources comprise streams of IC acquisition, and internal sources comprise internal streams. Both external and internal sources were chosen by SMEs covered in the research. The external sources characterise interactions with the external socio-economic environment. The internal sources represent the developers working in the project-oriented source (s_{32}) and are well-known in the subject literature as functional departments [62–64]. Table 3 contains the number of SMEs used in this research.

The research covered innovative SMEs employing 10–49 employees and 50–249 employees. The comparative analysis and evaluation of OIC acquisition required appropriately selected statistical tools. These tools are described in the next subchapter.

Table 3. SMEs covered by the research. Source: prepared by the author.

Year	Number of SMEs
2005	213
2006	228
2007	247
2008	278
2009	291
2010	269
2011	306
2012	314
2013	347
2014	338
2015	345
2016	352
2017	367
2018	382
2019	403

3.3. Characteristics of the Statistical Tools Used in Quantitative Analysis

Since the research presented in this paper is based on one of the first studies performed on OIC acquisition for a period of several years (2005–2019), the statistical tools were carefully selected so that they constituted a coherent whole, and simultaneously allowed for various analyses and evaluations of IC acquisition. For this reason, the use of these tools in this study was described thoroughly.

The identification of the structure of internal and external sources of OIC acquisition required the use of cluster analysis with Ward's agglomeration method, preceded by data standardisation [65–67]. Ward's method was chosen because the complex cluster structure of the OIC acquisition sources could be obtained with the most accurate representation of the original (empirical) data. This analysis was performed with the use Equations (A8)–(A10) described in Appendix A. All evaluation results are presented in the next chapter.

4. Results and Discussion

The results of Equations (A1) and (A2) indicate the level-of-acquisition share of OIC components. The calculation results reveal a significant differentiation in OIC component acquisition during the research period (Figure 1). The results obtained reveal that the component technology capital was acquired only in the external stream of OIC acquisition throughout the research period (100% of share). This component consists of technological infrastructure, internal computer networks, computer equipment and other equipment such as hardware. Although used in the software development process of the SMEs researched, they are not the results of operational activities. SMEs covered by the research produce software, not hardware. Therefore, the respondents identified that hardware is obtained through external streams (100%). This result was only possible to identify because the OIC concept was used in this research.

The next example of OIC acquisition differentiation is the relational capital component (71.9% external and 28.1% internal). This component consists of clients, partners, reputation, internal and external relations, trust, image and brand. After all, the software development projects that are performed on individual orders of external enterprises require a high level of trust, a good reputation and the ability to establish and maintain permanent relationships with customers. Thus, the result obtained confirms that such components are closely related to the external socio-economic environment of innovative SMEs that are developing software in Poland. The organisational capital was also acquired mostly in the external stream (66.3% external and 33.7% internal). This component consists of structural capital, organisational culture, strategies, decision-making systems and job style. It is closely related to the project capital component, which contains operational processes, employee programs and project management techniques and methods (18.4%

external and 81.6% internal). Knowledge of IT project management techniques based on the Agile Manifesto is primarily acquired in the external stream. These techniques are then adapted to each enterprise's conditions so that the software development and improvement processes are managed with the greatest possibility of generating added value, as expressed in innovative products. Therefore, the innovation capital component of the OIC was generated mostly in the internal steam (83.5% internal and 16.5% external stream). From an economic point of view, these results allowed us to conclude that an internally managed innovation process requires more financial resources and it is much more important for generating added values and innovations in SMEs. The information capital is the OIC component that is acquired most in the internal stream (72.5% internal and 27.5% external). This component consists of information systems, formal (descriptive) documentation, information sharing rules and databases. When documentation about the innovation of developed software, dedicated information systems and sharing rules for developers and clients (users) is considered, this component is generated in the internal stream of OIC. The remaining solutions are acquired in the external stream. The direct and iterative involvement of programmers in generating added value means that the level of the human capital component in acquiring OIC was similar in both the internal (57.7%) and the external (42.3%) streams. The human capital component consists of knowledge (tacit and explicit), competencies, commitment, cooperation, professional development, values and experience. Generating added value in the processes of software development and improvement taking place inside SMEs directly involves programmers as part of an iterative teamwork, while obtaining knowledge from external sources (in the external stream of OIC acquisition). The results indicate that human capital, similar to the other components (except technological capital), is obtained simultaneously in both internal and external streams, which confirms that it is necessary to analyse and evaluate OIC acquisition with decomposition in two streams. Figure 1 also revealed that OIC acquisition, in the internal and external streams, is diverse and complementary in terms of the components of this capital in innovative SMEs that are developing software in Poland.

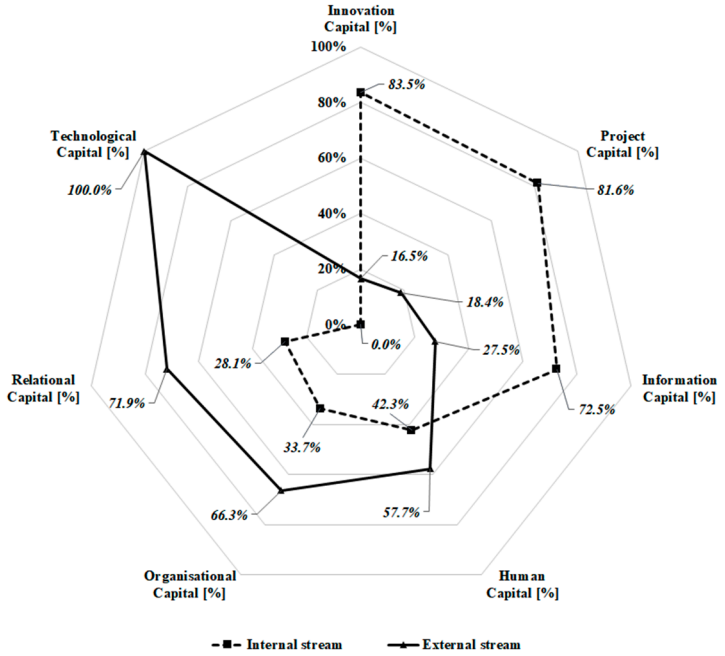

Figure 1. The value of OIC component acquisition. Source: prepared by the author.

Results of the calculated dynamic rate-of-change in the internal and external streams of acquiring OIC are presented in Table 4.

Table 4. The dynamic rate-of-change. Source: prepared by the author.

Indicator/Stream	Internal Stream	External Stream
Dynamic rate-of-change	3.21%	7.45%

The calculation results indicate that the level of IC acquisition in the internal and external streams increased year-on-year by an average of 3.21% and 7.45%, respectively, over the entire research period for the SMEs surveyed. The results also reveal that OIC acquisition from external sources (in external streams) increased at twice the rate of acquisition from internal sources (in internal streams) over the entire research period. This signifies that external sources of OIC were more important for surveyed SMEs over the entire research period.

Results of the calculated dynamic rate-of-change in the level of acquiring OIC components are presented in Table 5.

Table 5. The dynamic rate-of-change n the level of acquiring OIC components. Source: prepared by the author.

OIC Components	Internal Stream	External Stream
Human Capital	8.53%	16.74%
Innovation Capital	6.05%	6.76%
Project Capital	5.83%	9.61%
Information Capital	4.78%	11.23%
Relational Capital	2.61%	3.81%
Organisational Capital	1.28%	5.02%
Technological Capital	0.00%	7.58%

The results indicate that in the processes of software development and improvement taking place in the SMEs researched, the importance of human capital increased the most. This relevance relates to the added value generated in these iterative processes as part of the developers' teamwork. Additionally, the relevance of the human capital acquisition in the external stream increased over time by an average of 16.74%, while in the internal stream, it increased by an average of 8.53%. Similar situations were identified for the following components: information capital (increased by an average of 11.23% in the external stream and 4.78% in the internal stream) and project capital (increased by an average of 9.61% in the external stream and 5.83% in the internal stream). The lowest increase in the level of acquisition recorded, apart from technological capital, was for organisational capital in the internal stream (by an average of 1.28%) and relational capital in the external stream (by an average of 3.81%). As previously noted, relational capital is closely related to the clients, partners, reputation and trust of an enterprise. Increasing the level of OIC acquisition in clients' trust and enterprise reputation is one of the most difficult tasks and requires prolonged effort. From a managerial point of view, these elements are easy to lose but very difficult to increase, which is reflected in the results. Organisational capital is primarily acquired when needs related to computer equipment and infrastructure maintenance arise.

The results of the calculated taxonomic indicators are presented in Table 6. The values of taxonomic indicators allow us to compare many time-series variables (OIC components) by considering their mutual and multidimensional relations. Thus, the values of the taxonomic indicators bring more accurate comparisons between the two separate internal and external streams of OIC acquisition levels composed of OIC components. The interpretation is that the greater the value of the indicator, the higher the level of OIC acquisition.

As seen in the calculated values presented in Table 6, the taxonomic indicators of the OIC acquisition level in the internal and external streams in each year are greater than zero, which means that the OIC was acquired continuously in both streams. The values of subtracting the taxonomic indicators in the internal and external stream in each year are

presented in Figure 2. If the values of the OIC acquisition levels in each year are different in the overall internal and external streams, then the calculated value will not be zero (Figure 2).

Table 6. Values of taxonomic indicators. Source: prepared by the author.

Year	It_{in}—Internal Stream	It_{out}—External Stream	$It_{in} - It_{out}$
2005	0.3154	0.2665	0.0489
2006	0.3448	0.3430	0.0017
2007	0.3724	0.4016	−0.0293
2008	0.4042	0.4169	−0.0127
2009	0.4176	0.4077	0.0098
2010	0.3560	0.3516	0.0044
2011	0.3881	0.3910	−0.0028
2012	0.3977	0.4172	−0.0195
2013	0.4417	0.4704	−0.0287
2014	0.4366	0.4561	−0.0195
2015	0.4496	0.4786	−0.0291
2016	0.5061	0.5579	−0.0519
2017	0.5427	0.6176	−0.0749
2018	0.5710	0.6351	−0.0641
2019	0.6160	0.7419	−0.1259

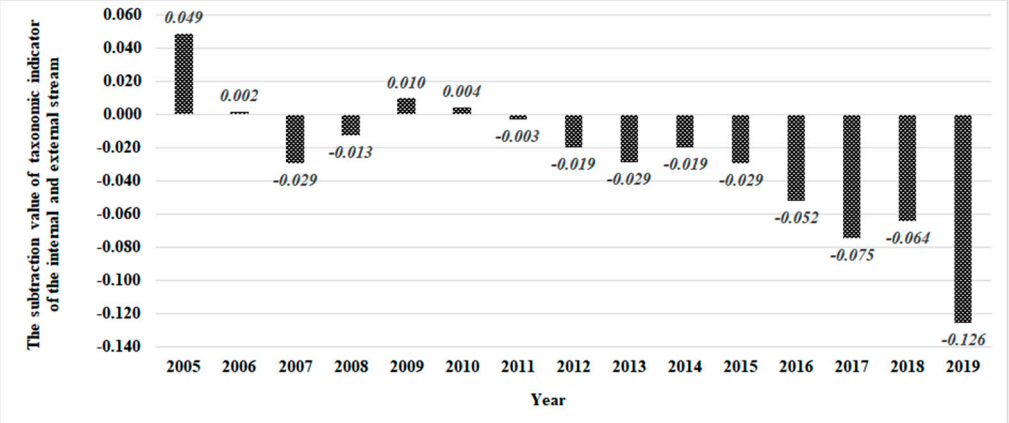

Figure 2. The value of subtracting the taxonomic indicators. Source: prepared by the author.

The results presented in Figure 2 are greater than zero in each year, which means that the levels of OIC acquisition by the innovative SMEs are different in the internal and external streams. The results also reveal that the values of the taxonomic indicators of the OIC acquisition levels in 2005, 2006, 2009 and 2010 were higher in the internal than the external stream. In the remaining years of the research period, from 2007 to 2008 and 2011 to 2019, the opposite situation was observed. In these periods, the values of the taxonomic indicators of the OIC acquisition levels were higher in the external than in the internal stream. In conclusion, the level of OIC acquisition in the external stream became more important than the level of acquisition in the internal stream. These results also led to the conclusion that from an economic and managerial point of view, the external sources of OIC acquisition became more important for the SMEs.

As a part of the taxonomic indices' calculation procedure, the level of OIC acquisition was used to calculate the stimulants' weights; thus, determining the impact of the level of each component's acquisition on the entire level of OIC acquisition by the innovative researched SMEs. The results are presented in Table 7.

Table 7. The weights of stimulants. Source: prepared by the author.

Component/Weight	Human Capital	Organisational Capital	Relational Capital	Technological Capital	Information Capital	Project Capital	Innovation Capital
ω_i	0.193	0.178	0.140	0.104	0.129	0.133	0.122

The calculations indicate that the weight (ω_i) of each component is greater than zero, meaning that all OIC components were acquired throughout the research period. The lowest value of the weight was 0.104 for the technological capital component. Thus, the impact of the level of technological capital acquisition on the level of the overall OIC acquisition by the SMEs was the lowest in the entire research period. Alternatively, the greatest impact on the level of the entire OIC acquisition was recorded for human capital (with a weight of 0.193).

The OIC was acquired from different internal and external sources. The dynamic change rate of the OIC acquisition from different external and internal sources is presented in Table 8.

The results reveal that during the research period, the SMEs did not acquire OIC in the external stream from the licenses purchased (excluding licenses for standard computer software), the results of external R&D purchased, consulting services purchased or other external sources. The results indicate that cooperation in software development projects with software companies belonging to the same industry of innovative SMEs—that are developing software in Poland—provided the largest increase in OIC acquisition year-on-year by an average of 12.98%. The second most important external source is other companies in the same industry, where the OIC acquisition level increased year-on-year by an average of 10.87%. In this case, the informal contacts of developers are very important (for example, social media dedicated to exchanging technical thoughts and ideas). Interesting results have been seen in cooperation with the Polish Academy of Sciences (PAS) and competitors, where OIC acquisition levels decreased year-on-year by an average of 6.77% and 8.64%, respectively. This empirically shows that differentiation from competitors in business activities (e.g., strategy differentiation) becomes less important than the benefits of cooperation, and even coopetition. Decreased cooperation with the PAS could indicate that OIC acquisition for SMEs is more important in developing practical solutions than the theoretical aspects of software creation. This conclusion can be supported by the fact that cooperation with national universities other than the PAS significantly increased year-on-year by an average of 8.08%. In other words, the OIC acquisition of innovative SMEs developing software in Poland is related more practically than theoretically to software creation. In the internal stream, the cooperation with customers and an enterprise's own research and development resources were the most increased sources of OIC acquisition, year-on-year, by an average of 13.04% and 10.89%, respectively. Although the researched SMEs did not conduct their research and development activities in separate departments, this work was performed in software development projects by software developers and software laboratories during the testing of newly created or improved software. Table 9 contains the calculation results of the cluster analysis.

The values of the cophenetic correlation coefficient, calculated independently for internal (0.937) and external (0.934) streams, prove to be a very good match between the structure of the OIC acquisition sources constituting the empirical input data and the structure of clusters obtained from the cluster analysis.

The graphical representation of the structure of sources of OIC acquisition in the external stream is presented in Figure 3.

Table 8. The dynamic rate-of-change of OIC acquisition. Source: prepared by the author.

OIC Sources	Sources of OIC Acquisition/Stream	Internal Stream	External Stream
s_{15}	Cooperation with software companies belonging to the same industry	-	12.98%
s_{16}	Other companies in the same industry	-	10.87%
s_{23}	Cooperation with national universities	-	8.08%
s_{24}	Conferences, fairs, exhibitions	-	8.01%
s_{21}	Cooperation with other national research institutes	-	7.96%
s_{26}	Other scientific, technical and professional societies and associations	-	7.06%
s_{25}	Scientific, technical and commercial journals and publications	-	5.08%
s_{22}	Cooperation with foreign institutions	-	4.48%
s_{19}	Consulting firms, consultants, commercial laboratories, private R&D institutions	-	−2.03%
s_{17}	Suppliers of equipment, materials, components and standard software licenses	-	−4.27%
s_{20}	Cooperation with Polish Academy of Sciences (PAS)	-	−6.77%
s_{18}	Competitors	-	−8.64%
s_{27}	Purchased licenses (excluding licenses for standard computer software)	-	0.00%
s_{28}	Purchased results of external R&D	-	0.00%
s_{29}	Purchased consulting services	-	0.00%
s_{30}	Other external sources	-	0.00%
s_{31}	List of enterprise customers	13.04%	-
s_{32}	Product development achieved based on own research and resources	10.89%	-
s_{34}	Sales department	7.75%	-
s_{35}	Marketing department	6.84%	-
s_{33}	Managers	1.93%	-
s_{36}	Other departments of the enterprise	1.57%	-

Table 9. The distances of cluster. Source: prepared by the author.

IC Acquisition Stream/Nodes	1	2	3	4	5	6	7	8	9	10	11
External stream	15.17	6.82	5.75	2.85	2.35	1.44	1.34	1.00	0.93	0.84	0.52
Internal stream	11.56	3.40	1.65	1.26	0.59	-	-	-	-	-	-

The cluster analysis indicates the following structure of OIC acquisition sources in the external stream:

- cluster 1: s_{15} represents the OIC acquisition cluster that consists of a single source: cooperation with software companies belonging to the same industry;
- cluster 2: s_{16} represents the OIC acquisition cluster containing a single source: other companies in the same industry;
- cluster 3: s_{17} represents the OIC acquisition cluster that consists of a single source: suppliers of equipment, materials, components and standard software licenses;

- cluster 4: s_{21} and s_{23} represent the OIC acquisition cluster containing two OIC acquisition sources: cooperation with other national research institutes and cooperation with national universities, respectively;
- cluster 5: s_{24} and s_{25} represent the OIC acquisition clusters that consist of two OIC acquisition sources: conferences, fairs and exhibitions and scientific, technical and commercial journals and publications, respectively;
- cluster 6: s_{18} and s_{20}, and s_{22} and s_{26} represent two clusters of OIC acquisition, with only 0.31 distance from each other (distances between the two clusters are 0.84 and 0.52, respectively) and s_{19}, with a distance of 0.93. These clusters consist of the following OIC acquisition sources: coopetition and cooperation with the PAS; cooperation with foreign institutions and other scientific, technical and professional societies and publications; consulting firms, consultants, commercial laboratories and private R&D institutions.

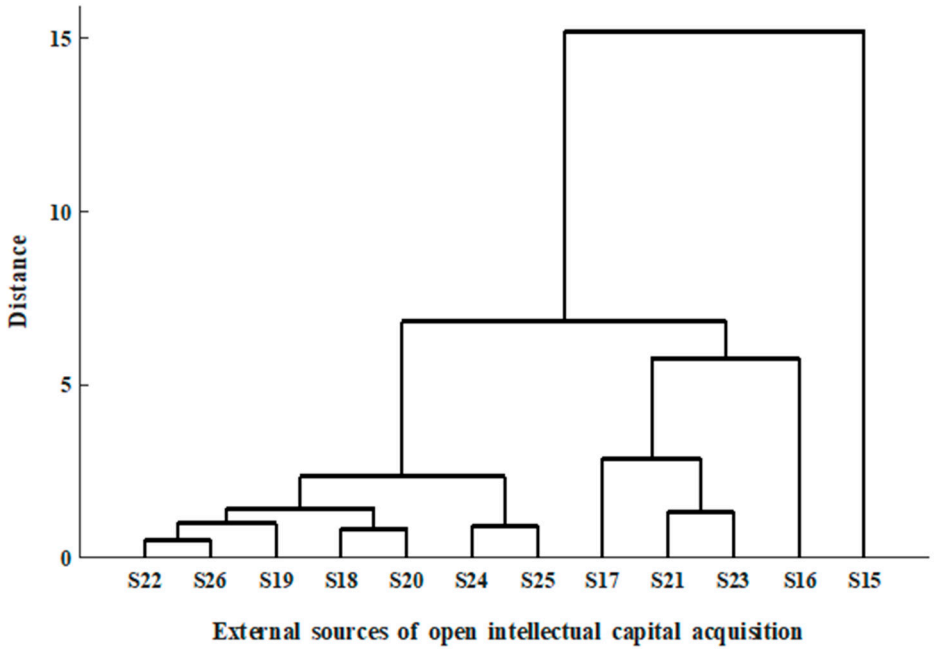

Figure 3. The structure of sources of OIC acquisition in the external stream. Source: prepared by the author.

The structure of the sources in the external stream consists of six clusters. These clusters represent a significant differentiation in terms of the OIC acquisition level. A comparison of the results presented in Table 7 with the identified clusters reveals that cooperation with software companies belonging to the same industry and cooperation with national universities and companies in the same industry were the most important sources of OIC acquisition in the external stream. Thus, it can be concluded that these sources are most important in OIC acquisition and in achieving business success by innovative SMEs developing software in Poland.

The graphical representation of the structure of sources of OIC acquisition in the internal stream is presented in Figure 4.

The cluster analysis indicates the following structure of OIC acquisition sources in the internal stream:

- cluster 1: s_{31} and s_{32} represent the OIC acquisition cluster that consists of two OIC acquisition sources: a list of enterprise customers and product development achieved based on an SME's own research and resources;
- cluster 2: s_{34} and s_{35} represent the OIC acquisition cluster that contains sales and marketing departments;

- cluster 3: s_{33} and s_{36} represent the OIC acquisition cluster that consists of managers and other departments in the enterprise.

The structure of the sources in the internal stream also represents differentiation in terms of the OIC acquisition level. A comparison of the results presented in Table 7 with the identified clusters reveals that cooperation with customers and an SME's own product development were the most important sources in the internal stream. The results lead to the conclusion that innovative SMEs developing software in Poland—primarily on individual orders of customers, which are enterprises operating in other branches and industries of the economy in close cooperation with them in IT projects—develop and improve their own software to sell on the market.

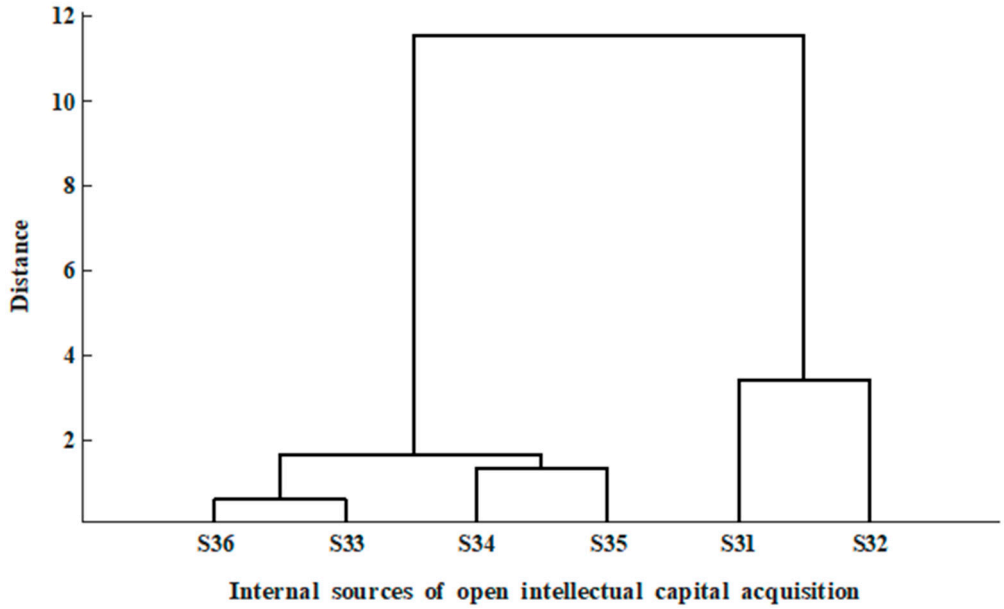

Figure 4. The structure of sources of OIC acquisition in the internal stream. Source: prepared by the author.

5. Conclusions

Many valuable studies have examined IC. Most of them have reviewed different aspects of the usage of IC obtained both internally and externally by SMEs (such as management issues, impact on output effects, added value, market value of enterprises and so on). However, for software-developing innovative SMEs, OIC usage is different from OIC acquisition. Today, not only technology is transferred to software-developing innovative SMEs, but any kind of knowledge the company finds useful in its business activities. This has been the case for many years, leading to the conclusion that it has become common knowledge. Researching the acquisition and usage of IC in the SMEs without separating them is an oversimplification of the phenomenon of the OIC's role. Different knowledge is acquired rather than implemented in the software produced by innovative SMEs. Between acquisition and usage, there is an adaptation process, which requires time and both technological and financial resources. These arguments are why the proposal formulated in this paper is different. Such SMEs do not acquire knowledge that is not necessary for their business. Thus, it is wise to investigate the two major subjects, which have been formulated into the research questions of this paper.

The primary purpose of this paper was to answer the following research questions: First, was OIC acquired simultaneously and continuously in two separate streams (internal and external) over the entire research period? Second, which OIC acquisition sources (internal or external) are most important for the surveyed SMEs, considering the level of acquisition over the entire research period? These research questions are unique and have not yet been researched.

The first conclusion is that OIC acquisition took place as a continuous and simultaneous process in independent internal and external streams of the SMEs developing software in Poland. Thus, analyses and evaluations of OIC acquisition over several years should be performed by decomposing the acquisition of this capital into two streams: internal and external. Since the research results have proven the accuracy of the OIC concept with the same IC component structure—that was decomposed into internal and external streams of acquisition—a new concept of (OIC) can be considered to be proposed, where the same OIC structure will be used to analyse and evaluate internal and external streams simultaneously. Future research can lead to a new model proposal of OIC acquisition, where the decomposition into two streams of the same IC structure is described.

The second conclusion revealed by the results of the study is that external sources of OIC acquisition were more important than internal sources for surveyed SMEs over the entire research period. This conclusion determined that OIC acquisition through external streams in many forms, such as cooperation or usage of open sources in OIC acquisition, has become more important for SMEs producing software than internal sources.

The research questions have been answered, but there are additional, more detailed conclusions drawn from this research.

The third conclusion is that there was a significant differentiation of OIC acquisition at the components level; the OIC component acquisition in both the internal and external streams was complementary. It can be assumed that the differentiation of OIC acquisition depends on different industries. This assumption can be verified by future research using comparative analyses of OIC acquisition between enterprises belonging to different industries. The results also identified that the level of OIC acquisition increased for all components, which empirically proves the increased importance of OIC acquisition for the SMEs researched. The most relevant increase was denoted for the human capital and the information capital components in both the internal and external streams. The lowest impact of the entire OIC acquisition of the SMEs studied was the level of technological capital component acquisition, whereas the greatest impact was recorded for the level of human capital.

The fourth conclusion was based on the level of OIC acquisition, where components belonging to the internal stream were more significant than in the external stream. However, the evaluation of dynamic change and the values of taxonomic indicators revealed that the acquisition of OIC components in the external stream became more relevant for the business activities of the SMEs in the research.

The fifth conclusion is that the differentiation of business activities from competitors was less important than cooperation and coopetition. The evaluation of the structure of OIC acquisition sources revealed that cooperation with software companies belonging to the same industry and cooperation with universities and companies in the same industry were the most important sources in the external stream, while cooperation with customers and an SME's own product-development team were the most important sources in the internal stream. The conclusions presented above prove that differentiation and competitive strategy in current-day business activities of the SMEs belonging to the software industry are not sufficient to achieve success. The roles of cooperation and coopetition have become the most important factors and driving forces in achieving business success.

6. Future Research

Using this approach to research OIC acquisition creates the possibility and indicates the necessity to continue more detailed research on acquiring OIC in enterprises belonging to other branches and industries. Further research will allow us to obtain new knowledge about the diversification of OIC acquisition by enterprises of various sizes and conducting business in different branches and industries, among other things. It will be possible to make comparative analyses between groups of enterprises from various industries and to propose a new model of OIC acquisition. Finally, new knowledge about IC acquisition can help in

planning and implementing OIC acquisition strategies, not only for different businesses and industries, but also for enterprises developing software in a multi-project environment.

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Appendix A

The level-of-acquisition share of the OIC at the individual component in the entire internal stream was calculated according to Equation (A1).

$$Sc_i = \frac{\sum_{t=2005}^{2019} s_{it}}{\sum_{t=2005}^{2019} \left(s_{it} + u_{jt}\right)} \times 100\%, \ \left(\forall t = 2005, \ldots, 2019;\ i = 1, \ldots, 7; j = 8, \ldots, 14\right) \quad \text{(A1)}$$

where:

t = the subsequent year in the time series;

i = the index of each variable from s_1 to s_7 (see Table 1), describing the subsequent component of IC in the internal stream;

j = the index of each variable from s_8 to s_{14} (see Table 1), describing the subsequent component of OIC in the external stream;

s_{it}—the acquisition level of the subsequent component i, belonging to the entire internal stream of OIC by the SMEs surveyed in the subsequent year t of the research period;

u_{jt}—the acquisition level of the subsequent component j, belonging to the entire external stream of OIC by the SMEs surveyed in the subsequent year t of the research period;

Sc_i—the level-of-acquisition share of the subsequent component i, belonging to the entire internal stream of OIC acquired by the SMEs surveyed over the entire research period.

The level-of-acquisition share of the OIC at the individual component in the entire external stream was calculated according to Equation (A2).

$$Uc_j = \frac{\sum_{t=2005}^{2019} u_{jt}}{\sum_{t=2005}^{2019} \left(s_{it} + u_{jt}\right)} \times 100\%, \ \left(\forall t = 2005, \ldots, 2019;\ i = 1, \ldots, 7; j = 8, \ldots, 14\right) \quad \text{(A2)}$$

where:

t = the subsequent year in the time series;

i = the index of each variable from s_1 to s_7 (see Table 1), describing the subsequent component of OIC in the internal stream;

j = the index of each variable from s_8 to s_{14} (see Table 1), describing the subsequent component of OIC in the external stream;

s_{it} = the acquisition level of the subsequent component i, belonging to the entire internal stream of OIC by the SMEs surveyed in the subsequent year t of the research period;

u_{jt} = the acquisition level of the subsequent component j, belonging to the entire external stream of OIC by the SMEs surveyed in the subsequent year t of the research period;

Uc_j = the level-of-acquisition share of the subsequent component j, belonging to the entire external stream of OIC acquired by the SMEs surveyed over the entire research period.

The theoretical description of dynamic rate of change was adopted to analysis in this research [68]. The dynamic rate-of-change in each component of the acquired OIC was calculated according to Equation (A3).

$$\overline{T}_{ck} = \left(\left(\sqrt[N-1]{\prod_{t=2}^{N} \frac{z_{ck(t)}}{z_{ck(t-1)}}} \right) - 1 \right) \times 100\%, \ \left(\forall c = 1, \ldots, 7; \ k = 1, 2 \right) \tag{A3}$$

where:

t = the subsequent year in the time series;

N = the number of annual observations in the time series of the subsequent components included in the OIC acquired by the SMEs surveyed over the entire research period;

c = an index ranging from one to seven, denoting subsequent components included in the OIC acquired by the SMEs surveyed over the entire research period;

k = index one or two, indicating, respectively, the entire internal or external stream of OIC acquisition by SMEs included in the research;

$\frac{z_{ck(t)}}{z_{ck(t-1)}}$ = another value of a chain index in the time series of the acquisition level of the subsequent component c, included in the OIC acquired by the SMEs surveyed in the subsequent year t of the research period;

$\overline{T}_{ck}$ = the dynamic rate-of-change in the acquisition level of component c, included in the OIC acquired by the SMEs surveyed over the entire research period, separately in the internal and external stream k.

Analysis of the taxonomic indicator was performed according to following procedure:

1. Each of the seven components of the IC constitutes one diagnostic variable of the OIC acquisition at the components level, separately in the entire internal and external stream.
2. The level of acquisition of each diagnostic variable is the number of acquired components belonging to individual OIC components in each year of the research period, as identified by the SMEs in the study. The higher the level of acquisition of the diagnostic variable, the higher the acquisition level of OIC in the entire internal and external stream. Therefore, each of the seven components constituting the seven diagnostic variables stimulates the entire internal and external stream of OIC acquisition separately. Neither the entire internal nor external stream contain destimulants.
3. Standardised values of stimulants in each year of the research period were calculated based on Equation (A4).

$$Ms_{\bullet,j} = \frac{Md_{\bullet,j}}{max\left(Md_{\bullet,j}\right)} \tag{A4}$$

where:

$Md = \left[d_{ij}\right]$—matrix of stimulants describing two entire streams of OIC acquisition: internal and external k, where d_{ij} is the level of OIC acquisition of stimulant j, where $i = k \times (modulo) \times n$, where n is the number of streams of IC acquisition covered by the analysis. Thus, $i = k + n \times r$ (where $r = 0$ for first year, $r = 1$ for the second year, ... , $r = l$ for the subsequent year l). Hence, the Md matrix consists of $l \times n$ rows (where l is the number of years in the research period), and j is the number of columns representing stimulants (diagnostic variables) that describe IC acquisition;

Ms = a matrix of standardised values of the stimulant's matrix Md, taking values in the interval <0, 1>. The following transformation was used in the standardisation process: for matrix $M = \left[m_{ij}\right]$, notation $M_{\bullet,j}$ means next j column of this matrix, and j is also the next standardised stimulant.

4. Selection of the weight estimation method for diagnostic variables and calculation of the value of the taxonomic indicator. The value of the taxonomic indicator was calculated based on Equation (A5).

$$It_i = \omega_1 \times Ms_{i,1} + \omega_2 \times Ms_{i,2} + \ldots + \omega_j \times Ms_{i,j} \quad \text{(A5)}$$

where:

It_{in} = the calculated value of the taxonomic indicator of the OIC acquisition level in the entire internal and external stream k (where $i = k \times (modulo) \times n$) in each year of the research period.

Ms = the matrix of the standardised level of diagnostic stimulants (components of the OIC acquisition);

ω = the vector stimulant weights (diagnostic variables): $\omega = (\omega_1, \omega_2, \ldots, \omega_j)$, such that $\forall i = 1, 2, \ldots, j\ \omega_j \in (0, 1) \wedge \sum_{i=1}^{j} \omega_j = 1$ and the function presented in Equation (A6) achieved the highest value (for $M = [m_{ij}]$ and $N = [n_{ij}]$, where $M * N$ means matrix multiplication).

$$F(\omega) = \sum_{j=1}^{7} cor\left(Ms_{\bullet,j}, Ms * \omega\right), \left(\sum_{j=1}^{7} \omega_j = 1\right) \quad \text{(A6)}$$

where:

$F(\omega)$ = a function that determines the value of the weight ω for each stimulant j in each year of the research period. The sum of the values of weights ω_j of all stimulants is equal to 1.

The taxonomic index, belonging to the group of taxonomic methods, enables comparative analyses and evaluations between objects described by many different types of variables [69–72]. In this research, the value of the taxonomic indicator is used to compare the level of OIC acquisition between two overall streams, internal and external, in each year of the research period. The interpretation of the value of the taxonomic indicator in this research is as follows: the higher the value of the indicator (closer to one), the higher the level of acquiring OIC in a given overall stream, which means the greater importance of this stream for the processes of software development in the innovative SMEs in each year of the research period. A value of the taxonomic indicator greater than zero means that the OIC was acquired continuously by the SMEs covered by the research. For example, if in a particular year, the value of the indicator is greater in the external stream than in the internal stream, then the OIC acquired in the overall external stream is more important in that year than in the overall internal stream for the SMEs.

The value of weights (ω_i) was numerically determined using the Monte Carlo method to obtain the maximum sum of Pearson's correlation coefficients between the value of the taxonomic indicator It_i and the standardised values of stimulants, described by the Ms matrix, in each year of the research period. The values of this indicator belong to the interval <0, 1>.

The value of weights (ω_i) allows the measurement of the impact of each IC component acquired for an entire research period. This measure is related to the components level throughout the research period, as follows: the greater the weight value, the greater the impact of the acquisition level of a given component on the level of OIC acquisition in both streams (external and internal). Thus, the greater the value of the weight of a given component, the greater the importance of this component in acquiring OIC, and therefore, the greater the importance of the software development processes taking place in the SMEs throughout the entire research period.

To calculate the dynamic rate-of-change of internal and external use of sources of OIC acquisition, Equation (A7) was used, respectively, for variables s_{15}-s_{30} and s_{31}-s_{36} (Table 2).

$$\overline{T}s_{ck} = \left(\left(\sqrt[N-1]{\prod_{t=2}^{N} \frac{s_{ck(t)}}{s_{ck(t-1)}}} \right) - 1 \right) \times 100\%, \ \left(\forall k = 1, \ldots, 22;\ c = 1, 2\right) \quad \text{(A7)}$$

where:

t = the subsequent year in the time series;

N = the number of annual observations in the time series of the subsequent components included in the OIC acquired by the SMEs surveyed over the entire research period;

k = an index ranging from one to twenty-two, denoting subsequent sources of OIC acquisition from s_{15} to s_{30} for external sources and from s_{31} to s_{36} for internal sources over the entire research period;

c = index one or two, indicating, respectively, the entire internal or external stream of OIC acquisition by the researched SMEs;

$\frac{s_{ck(t)}}{s_{ck(t-1)}}$ = another value of a chain index in the time series of the OIC acquisition level from subsequent source k, by the SMEs surveyed in each year t of the research period;

$\overline{T}s_{ck}$ = the dynamic rate-of-change in the OIC acquisition level from source k by the SMEs surveyed over the entire research period, separately in the internal and external stream c.

The identification of the structure of internal and external sources of OIC acquisition required for the use of cluster analysis with Ward's agglomeration method are performed with the use of Equations (A8)–(A10).

$$d_{(r,s)} = \sqrt{\sum_{k=1}^{p}(r_k - s_k)^2} = \|r_k - s_k\|_2 \quad \text{(A8)}$$

where:

$d_{(r,\,s)}$ = the Euclidean distance between the centroids of the each two clusters;

p = the number of attributes, equal to the number of the standardised variables which describe each generic group (here p = 2);

r_k, s_k = the successive generic groups of answers with the number of answers;

k = the successive number of generic group of answers.

$$dist_{(r,s)} = \sqrt{\frac{2n_r \times n_s}{(n_r + n_s)}} \times \|r_k - s_k\|_2 \quad \text{(A9)}$$

$dist_{(r,\,s)}$ = the sum of squares measured as the equivalent of distance (Ward's method);

$\|r_k - s_k\|_2$ = the Euclidean distance;

r_k, s_k = the centroids of clusters r and s;

n_r, n_s = are the number of elements (generic groups of answers) in clusters r and s.

The correctness of the created dendrograms was verified based on the cophenetic correlation coefficient shown in Equation (A10) [73].

$$c = \frac{\sum_{i<j}(x(i,j) - \overline{x})(t(i,j) - \overline{t})}{\sqrt{\left(\sum_{i<j}(x(i,j) - \overline{x})^2\right)\left(\sum_{i<j}(t(i,j) - \overline{t})^2\right)}} \quad \text{(A10)}$$

where:

c = the value of cophenetic correlation coefficient;

$x(i,j)$ = the value of the Euclidian distance between the input values i and j;

$t(i,j)$ = the value of the distance between the clusters of a hierarchic dendrogram;

$\overline{x}$ = the arithmetic mean of Euclidian distances between the values i and j;

$\overline{t}$ = the arithmetic mean of the distance between the clusters of a hierarchic dendrogram.

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