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CONDITIONS OF THE QUALITY OF RELATIONSHIPS WITH REGARD TO PARTICIPANTS OF THE QUADRUPLE HELISE

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Purpose: The purpose of the article is to compare the attitudes of representatives of innovative enterprises toward the strength and importance of relationships in relation to different groups of participants in the quadruple helix (groups of enterprises, local government organizations, scientific organizations and business environment institutions).
Design/methodology/approach: The presented analyses are concerned with the determinants of the quality of relationships of innovative enterprises in the quadruple helix. The research was conducted on a sample of 200 innovative enterprises using the CATI method. Four relationship constructs were studied – trust, commitment, satisfaction and communication.
Findings: The results indicate that the most significant, both within strength and importance, are relationships with other enterprises, followed in turn by those with institutions of the business environment, local government and the scientific sphere. With respect to all participants in the quadruple relationship, the validity of the constructs is as follows: trust, satisfaction, commitment, communication (with commitment and communication being equally important in the case of business environment institutions). Analysis of the discrepancies in the responses indicated that the most statistically significant differences exist for the relationship with local government units.
Research limitations/implications: The main limitation is the research sample and the limitations of the relationships established, especially with regard to scientific/research institutions and business environment institutions.
Practical implications: The article indicates which constructs of relationship quality should be paid attention to by representatives of the various helix in managing relationships with innovative enterprises, and identifies which characteristics generate differences in their perception.
Originality/value: The article undertakes to analyse the quality of inter-organizational relations through the prism of its constructs. The article is addressed to both representatives of enterprises and other participants in the quadruple helix.

Keywords: quadruple helix, relations, relationship quality.

Category of the paper: research paper.

1. Introduction

Cooperation, due to the enormous turbulence of the environment, is an essential action taken for development. It facilitates access to information and knowledge by constantly offering new opportunities. Combining the potentials of partners is the key to successful development. Despite the awareness of the role and importance of cooperation, the relationships taking place between entities are often weak and unsustainable, and there are often attempts to exploit the partner (Nowak, 2015).

The quadruple helix (QH) model explains the essence and principles of cooperation using knowledge, mutual learning and synergy of resources in innovation processes. Relationships between the entities of each of the mentioned spheres have a slightly different nature and significance. An attempt is made in the article to analyse them.

The main goal of the article was to compare the attitudes of representatives of innovative enterprises toward the strength and importance of relationships with regard to the various groups of participants in the quadruple helix. Accordingly, the following research questions were posed:

Pb1. What is the importance of relationships, as measured by their strength and importance, in relation to the various addressees of the quadruple helix?

Pb2. Are there differences in the perceived importance of individual relationship quality constructs depending on their addressees?

Pb3. Do company characteristics differentiate perceptions of the components of individual relationship quality constructs depending on their addressees?

2. The importance of cooperation in the quadruple helix

The QH model is a significant concept in the development of cross-sector cooperation. The foundation of QH was the Triple Helix (TH) model, from 1995 (Mendel, Matzko, 2013; Etzkowitz, 1993; Etzkowitz, Leydesdorff, 1995; Leydesdorff, 2000) depicting different network behaviors. TH involves an arrangement of links between representatives of three sectors – scientific, private and public (Lącka, 2018) – at a certain level with a condition of mutual learning (Etzkowitz, Leydesdorff, 2000; Hilarowicz, 2017). Relationships occurring between spheres can take different forms, as illustrated by popular models (Etzkowitz, Leydesdorff, 2000, Etzkowitz, Zhou, 2007; Bednarzewska, 2016; Tomaszuk, Wasiluk, 2021):

1) an etatistic model of university-industry-government relations model, in which the public power sector embraces the scientific and business communities and directs their interactions;

2) a "laissez-faire" model of university-industry-government, consisting of three separate sectors, in which there are clear boundaries between them and relations are limited;
3) the Triple Helix Model of University-Industry-Government Relations, in which the three sectors maintain a relatively independent status, but there are advanced interactions between them.

In addition, a considerable number of concepts have been proposed in the literature for modeling the processes that take place in the three-sector system (Bednarzewska, 2016).

Thus, in the TH model, there can be both interpenetration of institutions from the three sectors (interchangeable playing of roles originally assigned to another sector) and the emergence of intermediate organizations located in the functional space between sectors (Hilarowicz, 2017). The concept of the QH (Carayannis et al., 2012) is linked to the concept of the knowledge economy, in which the structure of society is undergoing a continuous transformation derived from technoscience (Leydesdorff, 2012; Etzkowitz, Leydesdorff, 2000; Bojar, Machnik-Słomka, 2014).

An extension of the TH spiral is the concept of the quadruple helix (QH), whose model incorporates the media and civil society into the innovation system, which allows the formation of relationships based on the knowledge of society and democracy (Carayannis et al., 2012; Sick, 2016; Carayannis, Campbell, 2011; Bojar, Machnik-Słomka, 2014; Carayannis, Campbell, 2009; Colapinto, 2011), and creates a framework for innovation (Kopeć, 2020; Park, 2014).

The QH model, describing the new economic environment, allows analysis of the interaction of all actors, and indicates the involvement of the whole society in continuous innovation, which is the result of co-creation between all helixes connected by a network of partnerships, cooperation and relationships (Afonso et al., 2012; Bojar, Machnik-Słomka, 2014).

As in the case of TH, different concepts of helixes can also be found in QH (Macełko, Mendel, 2011; Lindberg et al., 2010):

1) the triple helix model with an additional element – the social sector, whereby civil society is not an equal partner in innovation development processes;
2) the quadruple helix model, in which the business sector plays the most important role, being responsible for commercializing products and services, utilizing expert and user knowledge, and systematically collecting information on user needs and experiences;
3) the quadruple helix model, in which the most important role is played by the public sector responsible for developing public services, stimulating and supporting citizen involvement, and systematically collecting information about the needs of innovation recipients;
4) the quadruple helix model, in which the most important role is played by the social sector responsible for creating innovations and deciding which innovations are priorities and should be developed.

Cooperation in QH is a source of many important benefits for the individual parties – both to increase the efficiency of operations and improve competitive position (Sudolska, 2011). The main objectives of business cooperation can be considered (Doz, Hamel, 2006; Yu, Lee, 2017):

1) joining forces to build a coalition to achieve mutual goals or turn potential rivals into allies in a common cause;
2) combining complementary elements to achieve synergistic effects;
3) jointly acquiring hard-to-reach knowledge and learning both with and from the partner.

By intensifying knowledge flows, inter-organizational cooperation reduces uncertainty and provides better adaptation to changes in a turbulent environment (Wściubiak, 2019). An important motive for cooperating partners is also the desire to share between them the costs and risks of ongoing activities, especially R&D work, which is characterized by both soaring costs and a significant percentage of projects ending in failure. Increasing pressure from competitors and the shortening of the life cycle of most products are also important impulses for cooperation. These are forcing companies to accelerate the pace of development of new solutions, resulting in the need to innovate ever faster. Achieving this goal is possible through cooperation with other entities (Gorbatyluk et al., 2016).

3. Methodology

The strength and importance of the relationship from the point of view of representatives of innovative enterprises with business partners, which were classified according to the concept of the quadruple helix, were examined. An innovative organization was considered to be one that integrates employees around shared innovation-oriented values and creates conditions for reporting and implementing innovations, based on trust (Krot, Lewicka, 2016) and nurturing an organizational climate that provides employees with a framework for making important decisions.

Due to the lack of an explicit quality of relationships (Skarmeas, Robson, 2008; Kumar et al., 1995; Ahamed, Skallerud, 2013; Lages et al., 2005), for the purposes of the study the concept was treated as a metaconstruct (Holmlud, 2008; Tomaszuk, 2022). Being aware of the fact that there are different sets of components of relationship quality in the literature, three constructs considered key – trust, satisfaction and commitment – were used to create the research tool (Hennig-Thurau et al., 2002; Ulaga, Eggert, 2006; Barry, Doney, 2011; Tung, Carlson, 2013; Leszczynski, 2014; Walter, 2003; Ahamed, Skallerud, 2013; Hajli, 2014; Vieira et al, 2008; De Wulf et al., 2001; Skarmeas, Robson 2008; Liang et al., 2011; Chu, Wang, 2012) and communication (Jiang et al., 2016; Heroux, Hammoutene, 2012; Whipple et al., 2010, Athanasopoulou, 2009; Fynes et al., 2005; Mohaghar, Ghasemi, 2011; De Bürca et al., 2011).

Regardless of the addressee of the relationship, given the complex nature of the constructs under study (Blunsdon, Reed, 2003; Sankowska, 2011; Lewicka et al., 2016), the list of items examining the quality of the relationship was optimized and formulated universally. It ranged from 3 (for satisfaction) to 5 (for the other constructs) (Table 1).

Table 1.
Identified dimensions of relationship quality

Construct	Items
Trust	T1) We are convinced that organizations we work with are fair.
	T2) We believe that organizations we work with know what they do.
	T3) We trust organizations we work with because they have trusted us.
	T4) We believe that cooperation with organizations will be beneficial for us.
	T5) Organizations usually keep their promises to our company.
Commitment	C1) We believe that organizations treat cooperation with us as an element of long-term relationships.
	C2) We believe that organizations prefer long-term cooperation with us over short-term profits.
	C3) We believe that organizations we work with would not do business with others at our expense.
	C4) We believe that organizations we work with are ready to invest time and resources in developing relationships with us.
	C5) From time to time we are ready to make sacrifices to help organizations.
Satisfaction	S1) Taking into account all aspects of cooperation, our experience with organizations is very Satisfactory.
	S2) Our relations with organizations have positively surprised us.
	S3) We are very pleased with the cooperation with organizations.
Communication	CM1) The contents of messages from organizations are clear to us.
	CM2) Organizations communicate with us in an open manner.
	CM3) Our contacts with organizations are very frequent.
	CM4) Our contacts with organizations are very often direct.
	CM5) Organizations make efforts to better understand us and our needs.

Note. As organization can be meant: 1. other enterprises, 2. local/government units, 3. scientific/research institutions, 4. non-government organizations.

Source: own study based on Lages et al., 2005; Walter, Ritter, 2003; Ryciuk, 2013; Stach, 2013; Woo, Ennew, 2004; Roberst et al., 2003.

For each statement in the questionnaire, the respondent was asked to indicate his or her position by marking the category on a five-point Likert scale, from 1 (strongly disagree) to 5 (strongly agree). The reliability of the created scale was checked using Cronbach's alpha coefficient. The calculated statistics (Table 2) indicate a high consistency of the items included in the created scale.

Table 2.
Cronbach's alpha coefficient for the tested constructs

		Alfa Cronbach			
		trust	**commitment**	**satisfaction**	**communication**
Relations with:	Enterprises	0.7617	0.7971	0.7137	0.7935
	Scientific institutions	0.8751	0.8949	0.9225	0.8504
	Local government units	0.8806	0.8900	0.9242	0.8000
	Non-government organization	0.8669	0.8816	0.8821	0.7831

Source: own study.

The survey was conducted with a sample of 200 innovative companies in the last quarter of 2021 using the CATI method. This made it possible to achieve a high level of standardization, to reach respondents in high positions, and to be anonymous (Malhotra, 2010). The characteristics of the companies are illustrated in Table 3.

Table 3.
Research sample characteristic

Characteristic		**%**
Industry	trade	29%
	production	26%
	service	19.5%
	construction	16.5%
	transport	9%
Enterprise size	10-49	57%
	50-249	34.5%
	>249	8.5%
Activity on the market	up to 1 year	0%
	1-3 years	0.5%
	4-9 years	5.5%
	more than 9 years	94%
Operations range	local	21%
	regional	18%
	domestic	31.5%
	international	29.5%
Established relationships	with other enterprises	98%
	with administration units	38%
	with research and development units	22.5%
	with business environment units	33%
Implemented innovations	product	64,5%
	service	39,5%
	process	34,5%

Source: own study.

4. Analysis of research results

Questions about relationship constructs preceded those about the strength and importance of relationships with individual participants (Table 4).

Table 4.
The power and validity of relationships with QH participant

Relations with:	**Enterprises**			**Local government units**			**Scientific institutions**			**Non-government organization**		
	$\bar{x}$	M_e	D	$\bar{x}$	M_e	D	$\bar{x}$	M_e	D	$\bar{x}$	M_e	D
Power	4.12	4	4	3.49	4	4	3.38	3	3	3.52	4	4
Validity	4.23	5	5	3.73	4	5	3.71	4	4	3.74	4	4

Source: own study.

The analysis of respondents' indications allows us to clearly state that the strongest relationships are those established with other companies, they also have the most significant importance, with a low coefficient of variation maintained. Next, rank the strength and importance of relationships with NGOs and with local government units. The least important are relationships with representatives of science (this is also confirmed by the number of established relationships – Table 3).

Respondents, when asked directly about the relevance of a given construct of the relationships formation (Table 5) for all partners of the QH, considered the following in order: trust, satisfaction, commitment (only in the case of NGOs commitment and satisfaction have received the same score) and communication.

Table 5.
Importance of individual constructs in shaping relationships with individual members of the QH

Meaning of the construct in relation with:	Enterprises			Local government units			Scientific institutions			Non-government organization		
	$\bar{x}$	M_e	D	$\bar{x}$	M_e	D	$\bar{x}$	M_e	D	$\bar{x}$	M_e	D
Trust	4.37	5	5	4.04	4	W	4.27	4	4	4.02	4	4
Commitment	4.17	4	4	3.95	4	4	3.93	4	4	3.95	4	4
Satisfaction	4.24	4	4	3.97	4	4	3.95	4	4	3.95	4	4
Communication	4.08	4	4	3.89	4	4	3.87	4	4	3.92	4	4

Source: own study.

Representatives of the surveyed companies were asked to respond to individual statements reflecting the characteristics of the constructs (Table 6).

Table 6.
Assessment of respondents' agreement with statements reflecting particular constructs of relationship quality

Statement	Enterprises			Local government units			Scientific institutions			Non-government organizations		
	$\bar{x}$	M_e	D	$\bar{x}$	M_e	D	$\bar{x}$	M_e	D	$\bar{x}$	M_e	D
T1	4.16	4	4	4.01	4	5	4.33	4	5	4.06	4	4
T2	4.43	5	5	3.78	4	4	4.33	4	5	4.20	4	4
T3	4.34	4	5	3.93	4	4	4.24	4	4	4.02	4	4
T4	4.60	5	5	4.20	4	5	4.44	5	5	4.11	4	4
T5	4.03	4	4	4.13	4	5	4.13	4	4	3.85	4	4
C1	4.31	4	5	3.66	4	4	3.84	4	W	3.70	4	4
C2	3.90	4	4	3.32	3	3	3.62	4	3	3.65	4	4
C3	3.57	4	4	3.23	3	3	3.42	4	4	3.38	3	3
C4	3.78	4	4	3.33	3	3	3.44	3	3	3.61	4	4
C5	4.00	4	4	4.03	4	4	3.84	4	4	3.76	4	4
S1	4.10	4	4	3.77	4	4	4.04	4	4	3.85	4	4
S2	3.78	4	4	3.41	4	4	3.60	4	4	3.64	4	W
S3	4.03	4	4	3.70	4	4	3.93	4	4	3.77	4	4
CM1	4.16	4	4	3.79	4	4	3.93	4	4	3.94	4	4
CM2	4.02	4	4	3.75	4	4	3.98	4	4	3.95	4	4
CM3	4.28	4	5	3.36	3	3	3.20	3	3	3.43	4	4
CM4	4.16	4	5	3.71	4	4	3.58	4	4	3.61	4	4
CM5	3.53	4	4	3.09	3	3	3.20	3	3	3.40	3	4

Source: own study.

As in the case of the importance and relevance of relationships overall, the highest agreement with the statements occurred with regard to relationships with other companies, followed (which does not coincide with respondents' answers regarding the strength and importance of relationships) with the scientific sphere, business environment institutions and local government units. Respondents' answers according to the arithmetic mean range from 3.09 for CM5 with regard to government units to 4.60 for T1 with regard to other companies. The largest difference according to the arithmetic mean occurred for statement CM3 (1.08 – 4.28 for companies and 3.20 for academic units); the smallest for T5 (0.18 – 4.13 for local government and academic units and 3.85 for NGO's). The median indicated differences for seven constructs (two for trust – T2 and T4; three for commitment – C2, C3 and C4; and two for communication – CM3 and CM5); while the dominant indicated differences for twelve (differences did not occur for the satisfaction constructs, and partially for commitment (C5) and communication (CM 1 and CM2)).

The Kruskal-Wallis test (Table 7) was used to test whether the parameters of companies (industry, size, scope of operations and period of operation in the market) differentiate perceptions of relationship components.

Table 7.
Differences in ratings of relationship constructs according to the characteristics of the analysed entities

		Industry	**Enterprise size**	**Activity on the market**	**Operations range**
Relations with:	Enterprises	-	-	-	-
	Local government units	x	x	-	x
	Scientific entities	-	-	-	x
	NGOs	-	-	-	x
$p < 0.05$					

Source: own study.

The most statistically significant differences are found in the case of perceptions of the constructs of the quality of relationships with local government units, and relate to the following, respectively:

- in the case of the industry represented – perceptions of commitment (for the statement "We believe that the local government institutions we work with would not do business with others at our expense" and "We believe that our local government partners are willing to invest time and expense in developing relationships with us") and communication ("Our contacts with local government institutions are very frequent");
- in the case of company size – perceptions of commitment (for the statement "We believe that local government institutions view cooperation with us as part of a long-term relationship");
- for operations range – perceptions of trust ("We believe that the local government units we work with know what they are doing") and commitment ("The commitment of local government institutions significantly influences the formation of relationships with them").

For scientific institutions, statistically significant differences in relationship perceptions were noted by:

- company size – perception of trust ("We believe that the scientific/research institutions we work with are honest"; "We believe that the scientific/research institutions we work with know what they are doing" and "We believe that working with scientific/research institutions will be beneficial to us”);
- range – perception of satisfaction ("Considering all aspects of cooperation, our experience with scientific/research institutions is very satisfactory"; "We are very satisfied with cooperation with scientific/research institutions").

In the case of business environment institutions, there were statistically significant differences in perceptions of the relationship due to the range for trust ("We believe that cooperation with NGOs will be beneficial to us"; "NGOs usually keep their promises to our company") and communication ("NGOs communicate with us in an open manner").

5. Conclusion

The results of the study clearly indicate that innovative companies in Poland shape their relationships based on the QH model, in which the business sector plays the most important role. The role of the public sector is to support and finance development, the scientific sector is responsible for creating new knowledge and intellectual capital, and the social sector is responsible for participating in idea generation and development (Lindberg et al., 2010). This is indicated both by the strength and importance of the relationships, which are significantly higher than those with the other three groups of participants, and by the sheer number of relationships established (only 22.5% of units declared cooperation with the scientific and research sphere, 33% with the business environment sphere, 38% with the administrative sphere). This shows that the importance of both cooperation and relationship management is far underestimated, which is covered in the research of other authors (Tomaszuk, Wasiluk, 2021).

Deepening the analysis to the level of relationship quality constructs, it can be seen that they are treated in a similar way regardless of the addressee of the relationship. The most important component of them is trust, the least important is communication.

However, slight differences were noted in the perception of the components of the various constructs depending on the parameters of the enterprise – especially with regard to local government units. In the author's opinion, this may be due to the fact that, unlike the other participants in the QH, these are relationships whose establishment was due to coercion. Differences were noted with regard to the industry represented, the size of the company and the

scope of operations. They did not occur with regard to the length of operation in the market, which may mean that the opinions of company representatives do not change.

The analysis and conclusions presented here can inspire further research, but it is important to point out the limitations of the research sample. Despite the fact that 200 innovative companies were surveyed, a significant number of them, due to the lack of established relationships with scientific and research institutions, the public and the administrative sector, did not comment on them.

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