Coopetition as a factor in the development of innovative and technologically advanced firms: an example of the high-tech sector

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ABSTRACT

Coopetition is a relatively new and still incompletely understood economic phenomenon. It is made notable not only by the simultaneous cooperation and competition between firms, but also by the fact that coopetitive relations are increasingly often becoming a factor in development in a highly turbulent environment. Coopetition takes on particular importance in the case of technologically advanced, innovative and knowledge-based firms, such as those in the high-technology sector. The pressure to innovate and create new knowledge in this sector compels firms to spend large sums on research and development; and the high costs of R&D, investment risk, restrictedness of resources and the ever shorter life-cycle of high-tech products provide strong reasons to enter into cooperation with entities in the business environment, including even direct competitors. This paper considers the factors influencing the development of high-tech firms, in the context of their specific features. Research carried out on a sample of 61 medium and large high-tech companies, based in Poland and operating either in Poland or in the global marketplace, showed that coopetition at a mesoeconomic level is a stimulator of development for high-tech firms, and that cooperation with competitors leads to an increase in a firm's innovativeness, the development of patents and licences, and the diffusion of innovations.

Keywords: coopetition, determinants of development, innovation, high-technology

1. Introduction

A knowledge-based economy is one in which knowledge is created, assimilated, transferred and used more effectively by firms, organizations, individuals and communities, favouring the rapid development of the economy and society (OECD, 1996; OECD, World Bank Institute, 2001). In the European Union, a strategy intended to lead member countries to a knowledge-based economy was the Lisbon Strategy, adopted in 2000 and updated in 2005 (Lisbon European Council, 2000; Commission of the European Communities, 2005), and now the Europe 2020 strategy (European Commission, 2010). The fundamental goal of these strategies is to increase the innovativeness of the European economy so that it can develop effectively. One of their key objectives is appreciation of the role of science and technological progress in economic development, and consequently recognition that development of the research and development (R&D) sector and support for the innovativeness of firms are fundamental challenges for economic policy. According to these guidelines, the high-technology (high-tech) sector, which contains innovative, technologically advanced and knowledge-based firms (Zakrzewska-Bielawska, 2010), is expected to expand continuously in member states, since it is the foundation for a competitive

knowledge-based economy. In this regard the question arises of what factors control the development of high-tech firms, and whether they act as stimulators or barriers to that development.

There are many studies reported in the literature concerning factors behind the development of firms, including both innovative and knowledge-based firms (Probst, Raub, Romhardt, 2002; Tidd, Bessant, Pavitt, 2005). All of these factors also control the development of high-tech firms, but not all of them are of the same importance. Undoubtedly the newest technologies require close cooperation, since nowadays the success of a single product depends on contributions from specialists in various fields. Readiness and ability to cooperate is a necessary condition for the creation and functioning of an effective system of innovation. Efficiently cooperating partners from industry and the social and public sectors create new solutions, thus contributing to the development of country and of the region.

A particular type of cooperation is *coopetition*, which denotes cooperation between firms that are simultaneously in a competition relationship (Bengtsson, Kock, 2000). Coopetitive relationships are a relatively new type of relations between firms, although as research shows (Chin, Chan, Lam, 2008; Hoover, 2004; Kitchen, Snow, Mariani, 2007) they are of huge significance for firms' development. In the high-tech sector, simultaneous cooperation and rivalry between competitors is becoming increasingly important, owing to the intensity and technological advancement of that sector.

This paper aims to make an assessment of the importance of coopetition as a factor in the development of high-tech firms, based on research carried out on a sample of 61 medium and large high-technology companies based in Poland that operate either in Poland or in the global marketplace.

The organization of the paper reflects its goal. First a definition is given of a high-tech firm and determinants of its development. Secondly the phenomenon of coopetition is defined, along with the opportunities and dangers associated with it. Thirdly, research results are given concerning evaluation of coopetition in comparison with other factors affecting the development of high-tech firms in Poland.

2. Determinants of the development of high-tech firms

When considering the problem of how to define the high-tech sector, the question arises of whether the sector is a producer and creator of advanced technology, or rather a user commonly applying such technology.

According to the National Science Foundation, there is no single preferred method for identifying high-technology industries (Grudzewski, Hejduk, 2008). It is most frequently assumed that the high-tech sector represents industries that spring up at the meeting point of science and industry, and which involve the processing of the results of scientific research in industry (Bessant 2003).

The OECD (Organisation for Economic Co-Operation and Development) methodology is used in EU national statistics to define high-tech industries and products. This is based on a sectoral approach by economic sectors (ISIC/NACE) and product approach by product groups (SITC) (Eurostat, 2011; OECD, 2009). In both approaches, the main factor deciding whether a given sector or product is placed in the high-tech category is the intensity of R&D expenditure. Under such an approach, high-tech is a relative category. It encompasses sectors or products which fulfil certain quantitative criteria in a given period, by contrast with sectors or products that do not fulfil those criteria. It should be noted, however, that in the literature, apart from

indicators of R&D intensity [more than 8% of the value of sales (OECD, 2009)], a number of other features are also stated to be defining for that category of firms, including (Davis, 2003; Glasson, Chadwick, Lawton Smith, 2006; NewCronos, 2009):

- a high level of innovation and rapid diffusion of technological innovations;
- a rapid process of obsolescence of products and technologies;
- a high level of employment of scientific and technical personnel;
- high capital expenditure and high rotation of technical equipment, which is replaced by more modern and innovative devices;
- high investment risk and fast devaluation of investments;
- intense strategic domestic and international cooperation with other high-technology enterprises and scientific and research centres.

It follows that a high-tech firm is an innovative and knowledge-based firm which is active in research and development and is open to cooperation with its surroundings, creating various kinds of network links (Bonardi, Durand, 2003; Czakon, 2012; Kodama, 2009; Mukkala, 2010) and clusters with other organizations (Braunerhjelm, Feldman, 2006; Bresnahan, Gambardella, 2004; Feser, Goldstein, Renski, Renault, 2002; He, Fallah, 2011). It is also expected to make use of modern information and communication technologies (ICT); these provide a foundation for a knowledge management system which at the same time facilitates the process of creating innovations and supports R&D activity.

Considering the above-mentioned features, the most typical examples of high-technology sectors are the aerospace sector, computing, telecommunication equipment and technologies, the advanced technologies sector based on CAM, CAD and CIM, optical equipment, the biotechnology sector, pharmaceuticals, laser devices, the nuclear industry, power generation and technical machinery and equipment, etc. [OECD, 2009]. However, it should be emphasized that defining the boundaries and size of the sector is a challenge in itself, and the issue of defining a high-technology sector is one that is complex, encompasses multiple aspects, and in a sense remains open to new, more precise approaches and classifications which will undoubtedly emerge in the future.

The development of the high-tech sector is very important for any country's economy, since it reflects that economy's competitiveness and modernity. Such development results both from a firm's own needs and initiatives, and also from development having its source in science, market needs, links between market players, and technological or social networks (Office for Official Publications of the European Communities, 2004). It is thus controlled by numerous factors, both internal and external.

In considering the external factors, it should be noted that the development of the high-tech sector ought to be a basic goal of a nation's economic policy, since it is that sector which brings about long-term economic growth. The sector is most highly developed in the world's most developed countries, such as Japan, the United States and the countries of Western Europe. In Poland the development of the high-tech sector is treated as a priority, as is shown by the undertaking of various types of initiatives at both central and local government level. The most important of these include the Innovative Economy 2007–2013 operational programme, programmes entitled "Technological Fishing Rod", "Patent Plus", "Technological Initiative", "System for Support for Key Investment for the Polish Economy" and "EQUAL Community Initiative", the Regional Innovation Strategies (RIS) and others (Polish Ministry for the Economy, 2005–2011). Under these programmes, technologically advanced firms can obtain financial and substantive support aimed at increasing their

innovativeness and contributing to the development of new technologies. Other significant external factors affecting the development of high-tech firms include (Zakrzewska-Bielawska, 2011):

- national R&D potential, including in particular R&D expenditure and the availability of scientific and research staff;
- R&D infrastructure (clusters, technological incubators, science parks, centres of technology transfer);
- a system for financing R&D activity (EU and domestic programmes, venture capital, business angels, banks, etc.);
- foreign investment, particularly in research and development centres;
- patent policy and protection of intellectual property;
- the rate of technical and technological development;
- the intensity of competition;
- customer requirements.

Since high-tech firms operate at the boundary between science and industry, a significant factor in their development is the existence of *technopoles*. A technopole is an area with a concentration of scientific institutions working on innovative technologies. They include technology parks and science parks, and the dominant branch of industry is the high-tech sector. Factors influencing their location and operation are above all access to highly qualified staff and good infrastructure, the closeness of scientific and research institutions, and high expenditure on innovative research (Postman, 1993). The greatest number of technopoles can be found in the United States. There are also a significant number in Europe and in south-east and eastern Asia. There are virtually none in Africa and South America. The world's best-known technopoles are Silicon Valley in San Francisco, Orange County in Los Angeles, Silicon Plains in Dallas; Silicon Island Kiusiu in Japan, which includes the technopoles of Kumamoto, Oita Kagoshima, Miyazaki and Kurome-Tosu; and in Europe – Silicon Glen in Edinburgh, Silicon Fen in Cambridge, South Paris, Silicon Bavaria in Munich, and Taguspark in Lisbon. These centres are characterized by a well-developed network of formal and informal links, both between firms and with the scientific research sector, which favour the creation and spread of knowledge and innovation. In Poland, interest in technological parks increased significantly when Poland joined the European Union, mainly as a result of access to structural funds. Although the technological parks currently functioning in Poland are an example of how it is possible effectively to overcome problems, create a climate and activate various key partners on the path to ultimate organizational success (Marciniec, 2007; Oleksiuk, 2009), they still represent an incompletely exploited opportunity to build new economic structures based on knowledge, national resources and human potential. The development of high-tech firms is also conditioned by many factors of an internal nature. These are most often connected with the firm's potential, its culture and management methods (Zakrzewska-Bielawska, 2011).

The potential of a firm derives from its resources, their structure, features and quality characteristics, and the ability to create these in optimum combinations (Barney, Delwyn, 2009; Sanchez, Heene, 2004). Resources include everything possessed or controlled by a firm and constituting a basis for its business activity, as a result of which usable things of value are produced for specific customers (Hunt, Morgan, 1995; Lin, Lin, Bou-Wen, 2010). Various ways of classifying firms' resources can be found in the literature. The most common typology is based on a division into material, human, financial and information resources (DuBrin, 2012; Griffin, 2001). A more extensive classification is also often encountered, including financial, physical

(material), human, organizational, relational and intellectual resources (Barney, Delwyn, 2009; Grant, 2010; Hill, Jones, 2010). Significant internal factors in the development of high-tech firms as regards the firm's potential include its resources – assets – and in particular:

- financial potential, namely all of the firm's own financial resources and those offered by institutions supporting the high-tech sector. These determine to a large extent the intensity of a firm's R&D activity, and consequently also its innovativeness;
- material potential, namely the material technology used by the firm, its R&D base, geographic location, access to raw materials, its buildings, machinery, equipment, etc. This determines the modern character of the firm and affects its ability to produce high-quality innovative products;
- market potential, namely brand, loyal customers, reputation, channels of distribution, etc. This is the potential which an organization possesses thanks to its connections with the market and with customers;

in addition to resources of knowledge and skills, in particular:

- human potential, namely the number and structure of staff employed, their experience and skills (particular creative thinking and problem-solving abilities, and entrepreneurial and managerial skills) and motivations. This is a foundation for the development of a firm's competences;
- intellectual potential and technical/market information potential, namely the firm's accumulated technological, economic and commercial knowledge, including know-how, databases, patents, copyrights, quality and environment protection standards, hidden knowledge, competitive advantage, etc.;
- relational potential, namely connections with the outside, expressed in the ability to promote, neutralize or otherwise influence elements of the firm's external environment. This includes all types of relations with business-related institutions, including with financial institutions, scientific and research centres, trading partners and so on.

The resources that a firm possesses within the scope of the aforementioned types of potential determine the sources of its competitive advantage and its development in the long term.

Another important internal factor in the development of high-tech firms is their organizational culture, which is understood to include social norms and value systems stimulating staff, appropriate organizational atmosphere, shared meanings and symbols, cognitive schemes, behavioural requirements, and a system of models of thinking and acting which are grounded in the organization's social environment and are of importance for the attainment of its formal goals (Schein, 2004). Organizational culture has a strong impact on the development of high-tech firms, since the system of beliefs, values and opinions of a firm's staff affects their attitudes and behaviours (Arad, Hanson, Schneider, 1997; Martins, Terblanche, 2003). In high-tech firms it is necessary to create an appropriate level of organizational culture, basic elements of which will include knowledge, openness and good communication; this will favour creativity and innovativeness.

Other important internal factors for the development of high-tech firms include partnership-style leadership (Evans, 2003), talent management (CMA Management, 2007; Vaiman, Vance, 2008), and the flexibility of the enterprise (Boyle, 2006; Schmenner, Tatikonda, 2005).

The development of the high-tech sector is influenced by another very significant factor, which is a result of interaction between the internal and external factors

previously listed. This factor is *coopetition*, which is a combined product of competitive pressure and the desire for cooperation, given the resources possessed by the firm (Bengtsson , Kock 2000; Lado, Boyd, Hanlon, 1997).

3. Coopetition: competition and cooperation

The term *coopetition* was first used in 1989 by Ray Noorda, CEO and co-founder of Novell Inc. (Gomes-Casseres, 1996). Its provenance is therefore practical rather than theoretical. The concept is regarded as having been popularized by A.M. Brandenburger and B.J. Nalebuff (1996), who made the assumption that firms may on the one hand cooperate and share the uncertainty resulting from the behaviour of their environment, while on the other hand remaining competitors in other areas of their activity. They may therefore simultaneously build and maintain competitive advantage resulting from cooperation and also from competition. Cooperation allows firms to integrate their actions so as to achieve intended mutual benefits, while at the same time acting as rivals striving to attain individual strategic goals. Hence coopetition is not a development of either the theory of competition or the theory of cooperation, but is interpreted as a system of actors acting on the basis of a partial concordance of interests and goals (Dagnino, Yami, Le Roy, Czakon, 2008).

The theoretical foundations for coopetition are based primarily on game theory (Brandenburger, Nalebuff, 1996), resource theory (Chen, Su, Tai, 2007), the theory of social capital (Inkpen, Tsang, 2005; Tura, Harmaakorpi, 2005), and interorganizational dynamics (Tidstrom, 2008). These theories contribute to the concept of coopetition by indicating the motives for establishing relationships of this type and identifying their potential benefits.

The convergent interests that lie behind parallel competition and cooperation relate primarily to mutual learning and stimulation of innovativeness, improvement of technological solutions, reduction of costs of R&D work, and better coordination of supply chains (Bengtsson, Ericsson, Wincent, 2010; Bonel, Rocco, 2007; Dagnino, Rococo, 2009; Gnyawali, Park, 2009). Coopetition undoubtedly requires a part to be played by knowledge, which is the source of competitive advantage. Knowledge acquired within a framework of cooperation can also be used for competing (Levy, Loebbecke, Powell, 2003). Moreover, coopetitive relations stimulate technological development and firms' innovativeness (Nemeh, Yami, 2012), particularly as regards open innovation (Grimpe, Sofka, Peters, 2012). The complementarity of resources, including technological ones in particular, and jointly conducted R&D work, make it possible to spread the costs and risks of introducing new technologies between coopetitors, while at the same time reducing the time required to create technological innovations. The benefits of coopetition include among others: synergy effects, specialization, advantages of scale, reduced transaction costs, fuller exploitation of market opportunities, expansion of the scale of operations, and access to new markets (Bigliardi, Dormio, Galati, 2011; Kotzab, Teller, 2003; Pangarkar, Klein, 2001).

On the other hand, coopetitive relationships are also accompanied by specific dangers, including above all the risk of leakage of knowledge and know-how out of the firm and the opportunistic behaviours of coopetitors, this being described as *coopetitive tension* (Bengtsson et al., 2010; Gnyawali, He, Madhavan, 2008).

Other dangers include asymmetry of the arrangement, which may result from errors at the stage of creation of coopetitive relationships or may arise in the course of those relationships, conflicts between competitors, organizational disharmony resulting from differences in culture and organizational structures, and the possibility of the

transformation of a cooperating firm into an even stronger rival (Ritala, 2012; Tjemkes , Vos , Burgers, 2012).

The literature contains various classifications of coopetitive relationships. Based on the levels of competition and cooperation, the following types of coopetition are distinguished: alienator (low cooperation and competition), contender (high competition and low cooperation), partner (low competition and high cooperation), and coopetitor (high cooperation and competition) (Luo, 2004). Other criteria have been used to produce the typologies described below (Cygler, 2009; Dagnino, Padula, 2002; Donaldson, O'Toole, 2007; Jankowska, 2012):

- based on goal: type A coopetition (the goal and duration of cooperation are predetermined, and the duration is short or medium), type B coopetition (the duration of cooperation is undefined, with an awareness that it is finite, and firms undertake cooperation with one rival in order to defeat another, usually stronger competitor), and type C coopetition (characteristic of firms in danger of being forced out of the marketplace, with a hard-to-define duration of cooperation);
- based on the number of firms and level of value chain: simple dyadic coopetition, complex dyadic coopetition, simple network coopetition, and complex network coopetition;
- based on the number of competitors involved and the geographical reach of the relationships: separational, distributed, geocentric and network coopetition;
- based on level of analysis: micro coopetition (between employees), microeconomic coopetition (between departments in a firm), mesoeconomic coopetition (between firms in an industry), macroeconomic coopetition (between industries, clusters, etc.), and global coopetition (between economies);
- based on economic commitment and social bonds: discreet coopetitive relations (low commitment and weak bonds), periodic coopetitive relations (low commitment and strong bonds), coopetitive relations of a dominant partner (high commitment and weak bonds), and intimate coopetitive relations (high commitment and strong bonds).

The issue of coopetition takes on particular importance in the high-tech sector. High-tech firms compete for the position of technological leader and for innovative leadership within the industry (Zakrzewska-Bielawska, 2012). Through intensive innovative activity they aim to create new products which satisfy customers' current needs, but also use their products to create new needs. The desire to attain the position of technological leader is conditional on patent policy and intellectual property protection, which provide a guarantee of the ability to profit from new technologies, inventions or research results. Competition in the high-tech sector also results from the need to earn back investment costs through sales over shorter and shorter time frames.

On the other hand the high complexity of products, the high level of technological advancement, and the heterogeneity and uniqueness of resources which could not be produced independently within the time necessitated by the dynamics of the environment (Bengtsson et al., 2010) stimulate high-tech firms to enter into cooperation with their competitors. Coopetition enables these firms to create, within the field of their activity, unique advantages in such areas as specialization, information, communication and the use of a specialized labour market (Adamik, 2008), where the resulting benefits come from synergy and the accumulation of

features of competitiveness, such as renowned brands, refined technology, joint financing, joint marketing, and expanded channels of distribution.
With regard to the foregoing considerations, the following hypothesis was posed: *High-tech firms perceive coopetitive relations as a stimulator of their development.*
In order to test what factors affect the development of high-tech companies and to verify the above hypothesis, a survey was conducted of 61 selected firms in Poland between 1 September 2010 and 31 January 2011. The following section describes how the data were collected.

3. Research methodology

Respondents were selected on the basis of two criteria: (1) that the firm belongs to the high-tech sector, and (2) that the firm is classified as a medium-sized or large enterprise (over 49 or over 249 employees respectively, as defined in the Polish *Act on freedom of economic activity* (2004). The high-tech sector was defined according to the sectoral approach of the OECD classification. Under this approach, high-tech industries include manufacturers of basic pharmaceutical products and pharmaceutical preparations, manufacturers of computers, electronic and optical products, and manufacturers of aircraft, spacecraft and related machinery, whereas high-tech knowledge-intensive services are telecommunications, computer programming, consultancy and related activities, information service activities, and scientific R&D (high-technology and knowledge-based services aggregations based on NACE Rev. 2, 2011) .
Out of 180 firms invited to take part in the survey, 61 firms agreed to participate: 24 from the IT and telecommunications industries, 13 from the pharmaceutical industry, and 24 from other segments in the high-tech sector. They included 47 classified as medium-sized enterprises and 14 as large enterprises. All 61 firms were based in Poland during the study period; 29 operate solely in Poland and 32 operate globally.
Among the participating firms, the ratio of R&D expenditure to revenue was more than 8% in 19 cases, less than 6% in 20 cases, and between 6% and 8% in 22 cases. All of the firms had an R&D department, and new technologies were acquired using both their own R&D potential and external sources. The sources most often indicated were contacts with other centres engaged in R&D activity (56 firms), purchase of licences and know-how (41 firms), and technology transfer (40 firms). Less frequently used were contracting and strategic partnership in R&D, and in only a few cases had a firm been purchased together with its technology or a joint venture been set up with a technology provider. A clear majority (43) of the responding firms strive for innovative and technological leadership by developing new technologies and introducing innovative products to the market. Imitation is declared as an innovation strategy by 18 of the 61 firms, the most often indicated type being creative imitation, based on the use of the experience of an innovator and its new product to launch one's own enhanced or substitute products.
The monographic method was applied, with the standardized interview technique. This made it possible for the researcher and survey participants to come to a common understanding of the meaning of particular development factors. The respondent firms were represented by their CEOs.
The interview questionnaire included several questions concerning the following areas: (1) the characteristics of the firm as a high-tech enterprise; (2) assessment of the factors influencing its development; (3) identification of coopetition relationships.

The interviews conducted with the questionnaire resulted in the accumulation of qualitative data that were subsequently organized, grouped, and analysed. Statistical factors and descriptive statistics, as well as Kruskal–Wallis tests were used as methods of analysis; these made it possible to identify significant differences in responses between different high-tech industries and differently sized firms.
It should be noted that the reliance on respondents' subjective assessments constitutes a certain limitation on the interpretation of the results obtained. However, because the respondents were CEOs, it is reasonable to assume that their responses reflect the situation in their respective firms to the greatest extent possible.

4. Results and discussion

Respondents were first asked to evaluate how particular features of the high-tech sector relate to their firms, using a scale from 0 to 5, where 0 denotes absence of a feature, 1 denotes that it is very weakly applicable, and 5 denotes that it is very strongly applicable. The results are given in Table 1.

Table 1
Evaluation of selected features of high-tech enterprises as they relate to the firms participating in the survey

Selected features of high-tech enterprises	Total (all firms)			
	N	$\bar{x}$	M	IQR
Innovativeness	61	3.80	4	1
Diffusion (spread) of technological innovations	61	3.54	4	1
Obsolescence of developed products and technologies	61	2.84	3	2
Level of employment of scientific and technical staff	61	3.25	3	1
Level of replacement of technical equipment with more modern and innovative devices	61	3.05	3	0
Investment risk	61	2.93	3	0
Development of patents and licences	61	2.0	2	2
Ability to accumulate, effectively use and share knowledge, and team learning ability	61	3.16	3	1
Communication supported by modern information technologies	61	3.51	4	1

N = no. of firms $\bar{x}$ = mean M = median IQR = interquartile range

All of the CEOs stated that the listed features applied to their firms. It is a cause for concern, however, that their level of applicability was assessed at a not especially high level (with an average of 4), considering that it is firms from this sector which ought to display those features to the greatest degree. The highest scored features were innovativeness, diffusion of technological innovations, and communication supported by modern information technologies. This is evidenced by the median values of 4, which mean that 50% of the respondents consider these features strongly or very strongly applicable to their firm. The low values of interquartile range (IQR=1) confirm that the responses were not highly differentiated.
The levels of replacement of technical equipment with more modern and innovative devices, ability to accumulate, use and share knowledge, and employment of scientific and technical staff were found to be applicable to the respondent firms to a moderate

degree. This is confirmed by the values of the mean scores given for those features (from 3.05 for replacement of technical equipment to 3.25 for employment of scientific and technical staff), as well as the value of the median (M=3). The feature assessed as most weakly applicable to the respondent firms was development of patents and licences (M=2), although responses here were quite highly differentiated (IQR=2). This is a cause for concern in that it is high-tech firms that are the source of new knowledge and inventions, which is expected to be reflected in patents and licences. Moreover, out of the 29 firms which gave the lowest score for that feature, 13 rated their innovativeness as good or very good. It would therefore appear that those firms concentrate to a greater extent on organizational, marketing or process innovations than on product innovations. It should also be noted that among the firms which rated their ability to develop patents and licences at the lowest level, the majority are firms with low expenditure on R&D.

The respondent firms also gave relatively weak scores for the features of obsolescence of developed products and technologies (mean score 2.84) and investment risk (2.93).

To test for statistically significant differences ($p<0.05$) in the scores given for individual features depending on the particular high-tech industry, the number of employees and the ratio of R&D expenditure to revenue, a Kruskal–Wallis test was performed. The results of this test lead to the following conclusions:

- obsolescence of developed products was scored most highly in the ICT industry, probably because of the specific features of that industry. The life-cycle of IT and telecommunications products is becoming ever shorter, and new solutions in this area are appearing on the market at an increasing rate. Communication based on modern information technologies was rated higher in the pharmaceuticals industry and ICT than in the other high-tech industries;
- activity relating to the development of patents and licences differs significantly depending on the number of a firm's employees. Scores for this feature were highest among the group of the largest firms (with more than 500 employees), and lowest among the smallest firms (with 51 to 100 employees), which means that as the number of staff increases, including in the R&D area, there is an increase in the level of inventiveness among the analysed firms;
- the most differences in the scores given by respondents for particular features were recorded with respect to the ratio of R&D expenditure to revenue. Firms for which this ratio had the highest values (8% and over) returned significantly higher scores for innovativeness, development of patents and licences, and level of employment of scientific and technical staff. Among firms for which the ratio was lower (up to 8%) these features were given lower scores. This therefore confirms the rule that the more a firm spends on R&D, the more it becomes an innovative and knowledge-based enterprise.

All of the respondent firms enter into coopetition relationships on a mesoeconomic level, which confirms that coopetition is an important element of the strategy of high-tech firms. In the analysis, coopetitive relationships were identified on the basis of the two criteria of economic commitment and social bonds (Donaldson, O'Toole, 2007). Economic commitment is reflected in jointly undertaken or planned investments and in the sharing of resources, while social bonds reflect the level of trust between partners and the openness and bilateral nature of communication. The distinguishing of two levels – weak and strong for social bonds, and high and low for economic commitment – leads to four types of relationships: discreet, periodic, dominant-partner and intimate.

A clear majority of participating firms (Figure 1), regardless of their size or the industry in which they operate, have relations of the discreet type with their competitors, which means that they are oriented more towards competition than cooperation. The low degree of cooperation characteristic of this group is linked to limited trust and low economic commitment. Periodic relationships were reported by 8 of the 61 responding firms, primarily those of medium size and representing various high-tech industries, particularly the production of consumer electronics. Only in isolated cases, and only in the ICT sector, were dominant-partner and intimate relationships reported. The first type was entered into by a medium-sized firm, whose stronger (dominant) partner determined the time and nature of the cooperation. Strong relations with competitors, reflected both in the sharing of resources and in trust between rival firms, were reported only by one large firm with international operations, which was also rated as highly innovative.

Social bonds	Economic commitment: low	Economic commitment: high
strong	Periodic relationships (8 firms)	Intimate relationships (1 firm)
weak	Discreet relationships (51 firms)	Dominant-partner (hierarchy) relationships (1 firm)

Figure 1. Coopetitive relationships of firms participating in the survey

It can thus be concluded that the analysed firms do enter into coopetitive relationships, but do so with a certain amount of caution, with a relatively low level of commitment, both social and economic.

The functioning and development of high-tech firms is controlled by numerous exogenous and endogenous factors. They may have a positive effect on a firm and increase its chances of development, or have a negative effect and hamper or slow down that development. Respondents were asked to evaluate selected external and internal factors from the perspective of their influence on the firm's development. The evaluation used a scale from –5 to +5, where if a factor was deemed to have a positive influence (increase the chances of the firm's development) it was given positive score from +1 to +5 (where 1 denotes a very small influence and 5 a very large influence), and if the factor was deemed to have a negative influence (hamper or slow down the firm's development) the score was from –1 to –5 (where –1 denotes a very small influence and –5 a very large influence). A score of 0 meant that the factor had no influence on the firm's development. Table 2 gives the results of the evaluations made by the respondents.

A large majority of respondents stated that the listed factors had a positive influence on their firms' development. Among the external factors, the one with the strongest influence is the rate of technical and technological development (M=4), although six respondents reported that this factor somewhat hampers their firms' development (this factor was given a score of –1 by five respondents, meaning that it very weakly hampers development, and a score of –2 by one person, meaning that it weakly hampers development). Initiatives at central and local government level, and R&D

infrastructure, are considered by approximately 70% respondents to stimulate the development of high-tech firms, although the strength of their influence was assessed as fairly low, and almost 30% firms said that these factors do not have any influence on their functioning and development. Customer requirements were assessed as stimulators with moderate influential strength, although it was in this case that respondents' opinions were most differentiated (IQR=3). This means that some respondents believe that this factor strongly or very strongly favours their firms' development, while others found its influence to be weak or very weak. A differentiation in respondents' views is also found in the case of their evaluation of intensity of competition as a determinant of development: 70.5% regard competition as a stimulant to the firm's development, while 29.5% see it as a barrier. Foreign investment, patent policy and the system of R&D financing are reported to have only a weak influence on respondents firms' development, irrespective of whether that influence is declared to be positive or negative.

Table 2. Determinants of development for the firms participating in the survey[1]

No.	Determinants of the development of high-tech firms	negative influence				no influence	positive influence			
		N	$\bar{x}$	M	IQR	N	N	$\bar{x}$	M	IQR
1	Domestic R&D potential (R&D expenditure, number of scientific and research employees, etc.)	2	-	-	-	**0**	59	1.85	1	2
2	Initiatives at central and local government level	0	-	-	-	**16**	45	1.98	1	2
3	R&D infrastructure (clusters, technological incubators, science parks, etc.)	0	-	-	-	**17**	44	2.86	3	2
4	System for financing R&D activity (EU programmes, venture capital, business angels, etc.)	6	-	-	-	**2**	53	1.75	1	1
5	Foreign investment, particularly in R&D centres	18	-1.44	-1	1	**4**	39	1.85	2	1
6	Patent policy and intellectual property protection	11	-1.36	-1	1	**4**	46	2.0	2	2
7	Rate of technological development	6	-	-	-	**0**	55	3.07	4	2
8	Intensity of competition	18	-1.61	-1	1	**0**	43	2.88	3	2
9	Customer requirements	2	-	-	-	**0**	59	2.79	3	3
10	Financial potential	16	-1.5	-1	1	**0**	45	2.75	3	1
11	Material potential	2	-	-	-	**0**	59	2.79	3	2
12	Market potential	0	-	-	-	**0**	61	2.97	3	2
13	Human potential	1	-	-	-	**0**	60	3.02	3	2
14	Intellectual potential and technical/market information potential	0	-	-	-	**0**	61	2.62	3	1
15	Relational potential	0	-	-	-	**0**	61	2.16	2	2
16	Organizational culture	0	-	-	-	**0**	61	2.28	2	2
17	Method of management (leadership)	0	-	-	-	**0**	61	2.80	3	2
18	Talent management	3	-	-	-	**13**	45	2.27	2	2
19	Firm's flexibility	3	-	-	-	**0**	58	2.53	3	2
20	Coopetition	0	-	-	-	**0**	61	2.77	3	2

N = no. of firms $\bar{x}$ = mean M = median IQR = interquartile range

Analysing the strength and direction of the influence of internal factors, it can be noted that all respondents consider that market potential, intellectual potential, relational potential, organizational culture and method of management contribute to

[1] Because of the small number of firms declaring a negative effect for certain factors, it is not correct from a methodological point of view to calculate means and medians. In these cases only the number of firms is given. Moreover the calculation of a mean for ranks enables only the ordering of objects in terms of average rank value.

the development of their firms. Insufficient financial potential was indicated by 16 persons as a barrier to this process, and material potential, human potential and the firm's flexibility were indicated as barriers in individual cases. The most differentiated opinions were expressed with regard to talent management: at 13 firms it was stated that no action is taken in this area, so the factor does not influence their development. At more than one half of the firms the nature of this activity was assessed positively, and at three firms it was assessed negatively. However regardless of whether talent management favours or holds back a firm's development, 50% of respondents stated that its influence is weak or very weak (a median of 2). It can therefore be concluded that endogenous factors have a greater influence on the development of the analysed firms than exogenous ones.

None of the respondents assessed coopetitive relations as a factor which hampers or has no influence on the development of a firm, and the strength of its influence was scored higher than the firm's relational potential, namely its ability to create relationships with the business environment, broadly interpreted. However respondents' opinions showed differences depending on R&D expenditure, approach to innovation and evaluation of social bonds with competitors. A Kruskal–Wallis test ($p<0.05$) showed that:

- the greater a firm's R&D expenditure, the more strongly coopetitive relations stimulate its development;
- the more a firm concentrates on innovative imitation, the more weakly it identifies coopetition as a factor in its development;
- the more relations with competitors are based on trust and open communication, the more strongly coopetition influences the firm's development.

In order to test whether there exist significant relationships between determinants, a Spearman correlation was carried out (Table 1 in the appendix). The results of the analysis showed that very many of the relationships are significant ($p<0.05$) and positively correlated. The strongest correlations are found for human potential with relational potential ($R=0.76$) and with organizational culture ($R=0.75$), and also for material potential with market potential ($R=0.75$). It should also be noticed that all of the relationships between internal factors, except for the correlation of market potential with talent management, are statistically significant. This means that if a given factor is regarded as having a strong influence on a firm's development, then a factor correlated with it was also regarded as having a strong influence. Among the external factors the strongest correlations are found for rate of technological development with intensity of competition ($R=0.68$) and with customer requirements ($R=0.67$). Technological progress brings changes in customers' tastes as well as more intense competition, and this may undoubtedly stimulate or hold back the development of high-tech firms.

It is no surprise that coopetition, as a factor in the development of high-tech firms, is correlated most strongly with relational potential ($R=0.59$). This means that if relations with business institutions stimulate a firm to develop, then cooperation with competitors does so also. Quite strong and significant relationships can be noticed between coopetition and a firm's resources, which confirms the significance of the interrelation of resources in the creation of coopetitive relationships and their effect on its development (Chen et al., 2007; Hamel, Doz, Prahalad, 1989). Among external factors, coopetition is most strongly correlated with the rate of technological development ($R=0.40$), which also allows confirmation of the influence of

technological changes on the creation of coopetitive relationships for the purpose of developing the enterprise (Guidice, Vasudevan, Duysters, 2003).

To test whether there are significant relationships between particular determinants of high-tech firms' development and their characteristic features, correlation was carried out using Spearman's rank correlation coefficient. First a separate computation was made of the correlations between features of high-tech firms and the determinants indicated by respondents respectively as stimulators and as barriers to development. The results of these computations are given in Tables 2 and 3 in the appendix. It should be noted that correlations for barriers were computed only when the samples were sufficiently large. Next an 11-point scale[2], used for evaluation of the factors in the development of high-tech firms, was changed into the 5-point scale for the purposes of the calculations (Table 4 in the appendix). Analysis of the results shows that:

- the more strongly a firm's development is stimulated by internal factors (particularly the various types of resources, organizational culture, leadership and flexibility), the greater the extent to which the firm is characterized by innovativeness and the associated development of patents and ability to accumulate and share knowledge;
- domestic R&D potential, central and local government initiatives supporting high-tech firms, and R&D infrastructure, by stimulating a firm's development, contribute to its innovativeness and its level of employment of scientific and technical staff;
- rate of technological development, customer requirements, intensity of competition and a firm's financial potential contribute to greater replacement of technical equipment with more modern and technologically advanced devices;
- the greater the influence of coopetition on a firm's development, the greater are its innovativeness and ability to develop patents and diffuse innovations.

It should also be noted that some of the significant correlations are only of an apparent nature, and are difficult to interpret in the context of the current research.

Based on the results of the research as presented above, the proposed hypothesis can be considered to be confirmed. Coopetitive relations influence the development of high-tech firms, acting as a stimulator to that development. All of the firms analysed entered into coopetitive relationships at the mesoeconomic level, and none of them considered such relationships to be a barrier to development. However the dominance of discreet types of relationships is evidence that the analysed high-tech firms compete more than they cooperate. Coopetition as a stimulant of the development of high-tech firms depends on a firm's relational potential, its level of R&D expenditure and the rate of technical and technological progress, which lead to changes in customer requirements and the intensity of competition. The role of coopetition as a factor in the development of innovative and technologically advanced firms increases as a firm strives for innovative leadership, since cooperation with competitors leads to an increase in the firm's innovativeness, its development of patents and licences, and the diffusion of innovations.

[2] Various scales were used in the questionnaire. The 11-point scale made it possible to formulate more detailed conclusions concerning the determinants of high-tech firms' development.

5. Conclusion

Coopetition has become the subject of intensive research in recent years, and the concept of coopetition is itself used to explain the economic and social consequences of networking in various sectors and countries (De Ngo, Okura, 2008).
Simultaneous cooperation and competition is particularly characteristic of the high-tech sectors, which operate in networked and hypercompetitive conditions. At the level of the firm, a decisive factor for the development of high-tech enterprises is the firm's attitude to its competitors and its ability to cooperate with them in order to improve innovative processes. Innovations are produced through cooperation between organizations, and can also be jointly marketed; complementarity of resources and jointly conducted research and development work make it possible to spread the costs and risk of introducing new technologies between coopetitors.
Coopetition is therefore an important factor in development, not only for firms in the high-tech sector, but also for firms that are less technologically advanced but are nonetheless innovative and knowledge-based. It therefore seems appropriate to conduct further research into the nature and dynamics of this phenomenon. Research to date has concentrated primarily on identifying the phenomenon of coopetition and its forms, but without deeper analysis of the development trajectories (dynamics) of particular relationships. Another interesting direction of research would seem to be the identification and evaluation of factors determining coopetitive relationships in terms of the resources, size and phase of development of coopetitors. However, in view of the widespread existence of interorganizational networks and the continuous creation of new forms of such structures, there is a need for research and the development of knowledge concerning coopetitive relations in network systems of firms. It therefore seems that the phenomenon of parallel competition and cooperation will continue to be investigated by researchers worldwide.

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APPENDIX

Table 1. Correlations between determinants of development for the firms participating in the survey

Determinants of development	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	**0.48**	**0.37**	0.16	0.12	0.16	-0.15	-0.08	0.12	0.12	0.23	**0.29**	**0.41**	**0.38**	**0.35**	0.24	0.16	-0.08	0.10	0.25
2		**0.39**	0.02	0.00	0.23	0.12	0.02	0.11	0.21	0.22	**0.26**	**0.31**	**0.38**	**0.33**	0.19	0.24	0.23	0.18	**0.29**
3			**0.28**	**0.39**	**0.29**	0.14	0.20	**0.26**	0.02	0.16	0.11	0.14	0.15	0.23	0.23	**0.45**	**0.25**	**0.27**	0.14
4				0.14	**0.50**	0.23	**0.34**	**0.29**	0.02	**0.31**	0.21	0.24	**0.33**	0.24	0.22	**0.28**	0.11	-0.02	0.22
5					0.18	**0.31**	**0.31**	**0.30**	0.17	0.11	0.12	0.04	0.11	**0.26**	0.24	0.23	0.20	0.18	0.12
6						**0.34**	0.25	**0.30**	**0.41**	**0.33**	**0.37**	**0.42**	**0.43**	**0.40**	**0.34**	**0.42**	0.23	0.22	0.19
7							**0.68**	**0.67**	**0.55**	**0.46**	**0.48**	**0.36**	**0.48**	**0.39**	**0.52**	**0.48**	**0.51**	**0.41**	**0.40**
8								**0.64**	**0.32**	**0.32**	**0.33**	0.25	**0.40**	**0.30**	**0.50**	**0.38**	**0.49**	**0.43**	**0.32**
9									**0.46**	**0.43**	**0.40**	**0.36**	**0.54**	**0.40**	**0.58**	**0.57**	**0.59**	**0.55**	**0.34**
10										**0.66**	**0.64**	**0.61**	**0.51**	**0.50**	**0.56**	**0.43**	**0.36**	**0.38**	**0.34**
11											**0.75**	**0.72**	**0.70**	**0.67**	**0.70**	**0.53**	**0.32**	**0.34**	**0.43**
12												**0.73**	**0.57**	**0.64**	**0.63**	**0.42**	0.23	**0.30**	**0.55**
13													**0.68**	**0.76**	**0.75**	**0.55**	**0.40**	**0.37**	**0.49**
14														**0.68**	**0.63**	**0.60**	**0.47**	**0.42**	**0.51**
15															**0.72**	**0.50**	**0.32**	**0.33**	**0.59**
16																**0.62**	**0.49**	**0.57**	**0.44**
17																	**0.64**	**0.58**	**0.28**
18																		**0.72**	0.15
19																			**0.26**

Note: R ≥ 0,25 is essential with min. p<0,05

Determinants of development for the high-tech firms:

1 Domestic R&D potential
2 Initiatives at central and local government level
3 R&D infrastructure
4 System for financing R&D activity
5 Foreign investment, particularly in R&D centres
6 Patent policy and intellectual property protection
7 Rate of technological development
8 Intensity of competition
9 Customer requirements
10 Financial potential
11 Material potential
12 Market potential
13 Human potential
14 Intellectual potential and technical/market information potential
15 Relational potential
16 Organizational culture
17 Method of management (leadership)
18 Talent management
19 Firm's flexibility
20 Coopetition

Table 2. Correlations between the features of high-tech firms participating in the survey and their determinants that stimulate their development

	Determinants of development for the high-tech firms																			
Features of high-tech firms	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
A	**0.41**	**0.42**	**0.42**	0.23	0.11	0.18	**0.34**	0.28	**0.30**	0.13	**0.36**	**0.39**	**0.48**	**0.40**	**0.38**	**0.41**	**0.30**	0.13	**0.28**	**0.37**
B	**0.42**	0.22	-0.02	0.10	-0.14	0.01	0.16	0.14	0.15	0.09	**0.29**	**0.37**	**0.35**	0.21	0.18	0.22	-0.03	-0.09	**0.29**	**0.34**
C	**-0.31**	-0.06	0.05	-0.06	0.02	0.20	0.20	0.23	**0.40**	0.28	0.08	0.14	0.14	0.17	0.09	0.07	0.21	**0.34**	0.25	-0.05
D	**0.27**	0.25	0.22	0.11	0.17	0.25	**0.34**	0.11	0.16	0.29	**0.41**	**0.49**	**0.35**	**0.27**	**0.45**	**0.46**	0.18	0.14	**0.28**	**0.46**
E	0.13	**0.31**	0.27	0.18	0.30	0.13	**0.50**	**0.40**	**0.61**	**0.48**	**034**	**0.45**	**0.29**	**0.31**	**0.35**	**0.37**	**0.30**	**0.30**	**0.26**	**0.32**
F	-0.12	-0.05	0.02	0.07	-0.19	0.00	0.06	-0.18	0.02	-0.04	0.09	-0.07	0.13	-0.08	-0.07	0.09	0.09	0.20	015	-0.08
G	**0.26**	**0.48**	**0.48**	0.26	**0.35**	**0.51**	**0.49**	0.27	**0.42**	0.26	**0.44**	**0.51**	**0.52**	**0.51**	**0.57**	**0.40**	**0.46**	**0.49**	**0.45**	**0.46**
H	0.12	0.23	0.14	0.11	0.10	0.18	**0.33**	0.19	**0.41**	**0.30**	**0.29**	**0.30**	**0.41**	**0.30**	**0.33**	**0.44**	**0.30**	0.15	**0.38**	0.24
I	-0.11	0.00	0.05	0.12	0.14	0.09	**0.35**	0.18	0.12	0.06	0.23	0.24	0.17	0.13	0.08	0.20	0.05	0.16	0.15	0.12

Note: R ≥ 0,26 is essential with min. p<0,05

Determinants of development for the high-tech firms:

1 Domestic R&D potential
2 Initiatives at central and local government level
3 R&D infrastructure
4 System for financing R&D activity
5 Foreign investment, particularly in R&D centres
6 Patent policy and intellectual property protection
7 Rate of technological development
8 Intensity of competition
9 Customer requirements
10 Financial potential
11 Material potential
12 Market potential
13 Human potential
14 Intellectual potential and technical/market information potential
15 Relational potential
16 Organizational culture
17 Method of management (leadership)
18 Talent management
19 Firm's flexibility
20 Coopetition

Features of high-tech firms:

A Innovativeness
B Diffusion (spread) of technological innovations
C Obsolescence of developed products and technologies
D Level of employment of scientific and technical staff
E Level of technical equipment
F Investment risk
G Development of patents and licences
H Ability to accumulate and share knowledge
I Communication supported by modern information technologies

Table 3. Correlations between the features of high-tech firms participating in the survey and their determinants that inhibit their development

Determinants of development for the high-tech firms	Features of high-tech firms								
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Foreign investment, particularly in R&D centres	-0.36	0.12	0.01	-0.46	**-0.49**	0.12	**-0.59**	**-0.62**	-0.01
Patent policy and intellectual property protection	0.03	-0.13	0.39	-0.31	-0.12	0.17	0.13	-0.09	0.47
Intensity of competition	-0.40	-0.10	-0.01	**-0.64**	-0.40	0.42	**-0.65**	-0.27	-0.12
Financial potential	-0.50	-0.20	-0.16	0.34	-0.17	-0.41	-0.22	-0.33	0.06

Note: R ≥ 0,49 is essential with min. p<0,05

Features of high-tech firms:

- **A** Innovativeness
- **B** Diffusion (spread) of technological innovations
- **C** Obsolescence of developed products and technologies
- **D** Level of employment of scientific and technical staff
- **E** Level of technical equipment
- **F** Investment risk
- **G** Development of patents and licences
- **H** Ability to accumulate and share knowledge
- **I** Communication supported by modern information technologies

Table 4. Correlations between the features of high-tech firms participating in the survey and their determinants of development according to the revised scale form the 11-point to 5-point.

	Determinants of development for the high-tech firms																			
Features of high-tech firms	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
A	**0.31**	**0.36**	0.23	-0.01	0.08	**0.25**	0.24	**0.29**	**0.28**	**0.39**	**0.32**	**0.32**	**0.36**	**0.30**	**0.30**	**0.45**	**0.35**	0.21	**0.28**	**0.38**
B	0.18	0.20	0.19	-0.15	-0.08	0.07	0.07	0.18	0.08	**0.26**	0.16	**0.28**	0.25	0.05	**0.26**	**0.33**	0.06	0.03	0.21	**0.26**
C	-0.17	-0.09	-0.20	-0.07	0.17	-0.02	0.16	**0.32**	0.24	**0.30**	0.02	0.13	0.09	0.19	0.05	0.07	0.13	**0.31**	0.18	-0.09
D	0.10	023	0.01	0.19	0.01	0.24	0.21	0.10	0.17	**0.39**	**0.33**	**0.33**	**0.28**	0.06	**0.47**	**0.56**	0.25	0.00	0.22	**0.35**
E	0.11	0.19	0.16	0.11	**0.36**	0.19	**0.45**	**0.43**	**0.44**	**0.40**	**0.33**	**0.38**	0.15	**0.27**	0.16	**0.34**	0.23	**0.27**	0.23	**0.27**
F	**-0.28**	-0.23	-0.02	0.23	-0.04	-0.06	0.06	0.12	0.12	0.07	0.10	0.03	0.13	-0.04	-0.14	0.07	0.05	**0.28**	**0.30**	-0.17
G	**0.28**	0.21	0.14	**0.28**	0.12	**0.30**	**0.34**	0.24	**0.44**	**0.36**	**0.41**	**0.50**	**0.42**	**0.43**	**0.44**	**0.38**	**0.44**	**0.27**	**0.40**	**0.41**
H	-0.08	0.05	019	0.11	0.13	0.10	0.39	**0.38**	**0.36**	**0.39**	**0.29**	**0.27**	**0.28**	**0.28**	**0.29**	**0.39**	**0.35**	**0.37**	**0.30**	**0.26**
I	-0.23	-0.01	-0.05	-0.02	0.09	0.09	**0.29**	**0.26**	0.11	0.16	0.16	0.17	0.21	0.13	0.06	0.22	0.18	0.15	0.07	0.08

Note: R ≥ 0,26 is essential with min. p<0,05

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