The Internationalization of High-Tech Firms

The Internationalization of High-Tech Firms:

Patterns, Innovation and Research and Development

Edited by Nelly Daszkiewicz

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INTRODUCTION

NELLY DASZKIEWICZ

Along with extremely rapid development of new technologies, in economics and management studies we can observe an increase in the research and publications devoted to high technology industries and firms.

The analysis of the world literature of the subject shows that high-tech firms positively influence economic growth and the acceleration of innovation speed and contribute to raising the competitiveness level of a country or a region.

Moreover, high-tech firms are characterised by a relatively higher level of expenditure on research and development (R&D), higher innovativeness, and higher propensity to the internationalisation of activities in comparison with enterprises from traditional industries (low-tech).

It has been also observed that high-tech firms, more often than traditional (low-tech) ones, begin the internationalisation process at inception or soon after it and, what is more, it runs faster. It is caused by high innovativeness and their possession of state-of-the-art technologies and products with short lifecycle.

Unfortunately, findings of a lot of research show that, in spite of the dynamic development of the Polish economy since 1989 followed by the growing engagement of Polish firms in international activity, their internationalisation level, measured, for example, by the share of exports in sales, is still low in comparison with firms from other European Union countries. Unfortunately, the innovativeness of Polish firms does not compare favourably with foreign firms, either.

However, the world output on the internationalisation of firms from high technology sectors suggested that Polish firms also belonging to this group are more internationalised than traditional firms, and the process of their internationalisation can run differently.

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Therefore, it was assumed that it was worth conducting research into the internationalisation of Polish firms from high-tech industries as comprehensive research in this area in Poland had not been conducted before.

The aforementioned premises became the inspiration for the undertaking of research within the research project entitled "Internationalization Patterns of Small and Medium-Sized Enterprises Operating in High-Tech Industries", financed by the National Science Centre¹. The effects of the research in the first stage of the implemented project have already been described in the book by N. Daszkiewicz *Internationalization of Enterprises Operating in High-Tech Industries*, Wydawnictwo Naukowe PWN, Warszawa, 2016 and in several articles written by Nelly Daszkiewicz, Faculty of Management and Economics, Gdansk University of Technology and Krzysztof Wach, Faculty of Economics and International Relations, Cracow University of Economics.

This monograph is the result of work by the extended research team on the second stage of this project and presents problems we have not addressed before or, in comparison with previous publications, have since been updated and are described from a different perspective.

The monograph consists of six chapters.

Chapter One, *The concept of high-tech firms and their role in the contemporary economy* (Agnieszka Głodowska), provides the overview of the basic terms, particularly terminology related to high technologies and high technology sectors, and then it presents the essence and the characteristics of high-tech firms and their classifications. The overview is very important from the point of view of the problems discussed later on as, in the literature, there is no unambiguous and commonly accepted definition of the high technology sector or a definition of a high-tech firm. In the latter part of the chapter, the author focuses on the role of knowledge and innovation in a high-tech firm. Next, a *high-tech* enterprise is presented from the perspective of the growth theory and as the source of technological convergence. Chapter One ends with the

¹ Research project 0PUS 6, entitled "Internationalization of small and mediumsized enterprises operating in high tech industries" No 2013/11/b/hs4/02135 financed by the National Science Centre, 2014-2018, and managed by Nelly Daszkiewicz, Faculty of Management and Economics, Gdansk University of Technology.

description of the functioning and development of high-tech firms in the light of the existing research.

Chapter Two, *The internationalisation of high-tech enterprises* (Nelly Daszkiewicz), starts with a short explanation of the term of internationalisation, and then it concentrates on the problems related to early and rapid internationalisation of high-tech firms. It also explores terminology problems as, in the literature of the subject, we find a lot of definitions of firms early and rapidly internationalised. In the next part, the author describes the factors involved in the early internationalisation of high-tech firms' internationalisation. It is followed by the presentation of the links between entrepreneurial orientation and the theory of internationalisation, which brought about the emergence of the international entrepreneurial orientation concept. In the last section of the chapter the evolution of the directions of research into born globals and technology-oriented firms is presented.

In Chapter Three, *Innovation and internationalisation of high-tech firms* (Krzysztof Wach), the author presents definitions of the basic terms, such as innovation, innovativeness, innovation potential, innovation process, and innovation management. This is particularly important because these terms are sometimes misunderstood as synonyms which they are not. Moreover, the issue is of key significance because high technology firms are innovative firms. The chapter goes on to discuss the innovativeness factors, both internal and external. Then, the author concentrates on innovation intermediaries and innovation diffusion and discusses the problem of the transfer and diffusion of innovation from research centres to firms. He also describes the links between innovation and internationalisation of firms. In the final part of the chapter the author presents a fragment of the findings of the research carried out within this project concerning the innovative behavior of high-tech firms.

Chapter Four, *The internationalisation of research and development activities of high-tech firms* (Małgorzata Kosała), is of special significance because the internationalisation of firms can be also implemented in another dimension, namely in the research and development sphere. Owing to that, a company gains the ability to search globally for highly specialised resources which are necessary to conduct works leading to the achievement of original results. The author presents the essence and types of research and development activity, typologies and strategies of research and development internationalisation, and motives for the internationalisation

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of research and development activity. Then the author discusses the significance of transnational corporations in global research and development activity and, at the end of the chapter, an overview of research into R&D internationalisation is provided.

Chapter Five, *The impact of financial innovations on the internationalisation of enterprises* (Adam Marszk), discusses a still novel problem regarding the significance of financial innovations in the firm internationalisation process. The problem did not exist in the theories of internationalisation for a long time. Even now, the issue is poorly studied, and financial innovations are mentioned among both the internal and external factors of internationalisation. Chapter Five begins with an explanation of financial innovations and their categories. Then the author focuses on the socio-economic impact of financial innovations and potential links between financial innovations and internationalisation of firms. At the end of the chapter the author presents the survey of empirical research on the economic role of financial innovations.

The last chapter, Chapter Five, *The results of empirical research* (Nelly Daszkiewicz, Krzysztof Świetlik), presents the empirical analysis of the internationalisation of firms operating in high-tech sectors. The main goal of the research was to identify the patterns and mechanisms of the internationalisation of Polish firms functioning in high-tech industries. Additionally, five detailed goals were set:

G1: Determining and estimating the intensity and level of the internationalisation of Polish firms operating in high-tech industries.

G2: Determining the influence of the internationalisation pace on the intensity of the internationalisation of high-technology firms.

G3: Determining the influence of innovativeness on the intensity of the internationalisation of high-technology firms.

G4: Determining the strategies and instruments of the internationalisation of the studied enterprises of high-tech industries.

Then, based on the analysis of approaches in the literature of the subject, five research hypotheses were formulated:

H1: The size of a firm is positively correlated with the intensity of its internationalisation.

H2: Innovativeness of a firm contributes to the intensification of the internationalisation process of firms functioning in high technology industries.

H3: An increase in the expenditure on R&D activities contributes to the intensification of the internationalisation process of firms functioning in high technology industries.

H4: The internationalisation pace of firms (belonging to the group of born globals) contributes to the intensification of the internationalisation process of firms functioning in high-technology industries.

H5: Internationalisation intensity is positively correlated with the use of high control modes (firms with higher internationalisation intensity measured by TNI index are more likely to use high control modes).

CHAPTER ONE

THE CONCEPT OF HIGH-TECH FIRMS AND THEIR ROLE IN THE CONTEMPORARY ECONOMY

AGNIESZKA GŁODOWSKA

1.1 The essence and the characteristics of high-tech firms

There are a lot of firm typologies developed based on a variety of criteria, such as: the size, the ownership structure, the scope of activities or industry in which they operate. Recently, more and more attention has been paid to the recognition of firms according to the level of their technological advancement. On this basis, we can isolate so-called hightech firms, also defined as high technology firms. "High-tech" is a commonly used name - a loanword which has become a kind of internationalism. These firms stand out from others in terms of specific characteristics, which is the reason why their definition requires a multifaceted and multi-dimensional approach. What is more, the complexity of the problems is increased by the lack of explicitness in defining the hightech category itself, the conceptualisation of which is the starting point in defining the essence of firms belonging to this sector. Joseph (1988) paid attention to the fact that the "high-tech" term is not very precise, and its proper meaning can vary depending on the context in which it has been used. Taking this into consideration, Steenhuis and Bruijn (2006) proposed four dimensions of the use of the high-tech technology: (i) Industry based, (ii) firm based), (iii) product based and (iv) life-cycle based. Therefore, we can talk about the high-tech industry, high-tech firms and high-tech products and the categories are interrelated and imply each other. The broadest term is high-tech industry, which according to Malecki (1985) stands for the industry related to innovations. The determinants of the high-tech industry are research and development intensity, the share of R&D expenditure in sales, or the ratio of technical workers to the total workforce (Malecki, 1985). Tether and Storey (1998) present a relative, although not very precise attitude to the high-tech industry, defining it as

an industry in which investments in scientific and technological activities are proportionally higher in comparison with other industries. On the other hand, the American National Science Foundation specifically defines a high-tech industry as one in which R&D expenditure is not lower than 3.5% of the net sales value, whereas employment in this activity is larger than 25 people per 1,000 workers (after: Zakrzewska – Bielawska, 2011). A comprehensive definition of the high-tech sector is presented by Świdurska (2009), who recognises it as a sector with a high level of employment of scientific and technical staff, intensely cooperating with scientific and research entities, characterised by a fast process of the ageing of products and technologies developed, dynamically exchanging resources in terms of technical infrastructure and the effects of innovative activity (patents, licences) (Świdurska, 2009). This definition can be supported, and at the same time supplemented, by the set of characteristic features of the high technology industry as given by Zakrzewska -Bielawska (2011). They are: (i) A high level of innovations and their fast diffusion. (ii) the fast process of the ageing of the developed products and technologies and, at the same time, fast use of knowledge in practice in the form of new patents and licences, (iii) a high level of hiring scientific and technical employees, (iv) high capital expenditures and a high level of the rotation of technical equipment, (v) high investment risk and fast investment devaluation, (vi) intensive cooperation with domestic and foreign entities from the high-tech sector and R&D area, (vii) increasing competition in international trade (Zakrzewska - Bielawska, 2011).

The high-tech industry term determines the essence of high-tech products. As above, their typology takes place by estimating the content of technology, research and development outlays in a product (Hansen and Serin, 1997). What is more, they are characterised by a short lifecycle, meaning a dynamic rotation of products and their modernisation. The product-based approach is very useful for the classification of the hightech industry and firms (more on that in section 1.2.). Defining high-tech industry and goods is very significant from the point of view of high-tech firm conceptualisation. To put it simply, we can claim that these are all firms operating in the high-tech industry, firms manufacturing high-tech goods or providing technologically advanced services. Such an approach is presented in numerous works (Malecki, 1985; Steenhuis and de Bruijn, 2006). However, it is not deprived of limitations. The high-tech industry is so broad that it can include enterprises at various levels of technological advancement. Moreover, businesses from traditional industries can also have the properties of high-tech firms (Ratajczak - Mrozek, 2011). This is similarly the case in the identification of high-tech firms based on the

production of high technology goods. High-tech firms do not always only produce high-tech goods, they can also create goods with low technological and innovative saturation, and vice-versa (Steenhuis and de Bruijn, 2006). Another limitation of this approach can also lie in the size of firms included in the industry and, as a result, the share of small and mediumsized enterprises may be highly underestimated (Baldwin and Gellatly, 1998).

Bullock (1983) defines high-tech firms based on the same features that identify high-tech industry, applying them to the level of firms. Thus, these are: the intensity of outlays on research and development in a firm, as well as the size of technical employment (Bullock, 1983). This is similar to Mohrman and von Glinow (1990), but they pay attention to the dynamics of changes in the environment of enterprises. They acknowledge that a high-tech organisation is one which operates in an environment where all spheres undergo permanent changes. Such an organisation has to reveal a lot of flexibility and constantly adapt to the changing conditions of the environment (Mohrman and von Glinow, 1990). The European Commission (2002) defines high-tech firms as highly innovative and/or with great research and development intensity and/or using a complex and specialist technology in the manufacturing process.

The essence of high-tech enterprises is superbly reflected by the specific features of these firms, distinguishing them from others. Ratajczak -Mrozek (2011) divides these features into two groups: primary (causative) features and secondary (consecutive) features. The primary features of high-tech businesses include: (i) The use of a complex production technology, (ii) innovativeness and fast diffusion of innovations, (iii) functioning in the research and development area, (iv) short product lifecycle, (v) homogenous demand for products and activities in niche industries (Ratajczak - Mrozek, 2011). The author regards the following as secondary features: (i) High qualifications of the workforce, (ii) high investment risk, (iii) high capital expenditures, (iv) inclination to internationalisation (Ratajczak - Mrozek, 2011). On the other hand, Zakrzewska - Bielawska (2010, 2011), when defining high-tech firms, pays attention to three important characteristics of these enterprises. She indicates that they play a role of innovative, knowledge-based and using ICT technologies enterprises. Each of these areas is distinguished by its characteristic properties which are the obligatory components of high-tech firms.

A high-tech enterprise as an	A high-tech enterprise as a	A high-tech enterprise as an as a
innovative enterprise	enterprise	enterprise
A firm conducting research and development works, allocating relatively large funds on R&D activities. A creative firm, capable of constant creation of innovation. A firm consistently implementing new scientific and technical solutions, introducing innovations to the market, adapting innovation from the outside. An enterprise possessing a large share of new products or services in its portfolio. A flexible enterprise, thinking strategically, universally and competitively. A firm based on the innovative potential of the team, fully using the team's work.	A firm based on the application of technology, information, and knowledge, creating and disseminating new knowledge and skills. A firm based on intellectual capital, constantly developing this resource. A progressive, flexible firm, constantly adapting to the market conditions. A firm using experience to create new knowledge, constantly updating it, supporting new concepts and experiments. A firm accepting high uncertainty, volatility, cooperation in full trust, collective learning, sharing knowledge, accepting criticism. A firm characterised by organisational values such as quality, customer service, diversity, professionalism, innovativeness, relations. A firm that flexible, dynamic, and open, and grants a lot of freedom and autonomy to its team of employees	A firm having new IT infrastructure at its disposal. A firm using the state-of-the art ICT technologies. A firm enhancing its effectiveness, flexibility, productivity through the use of ICT solutions. A firm eliminating mistakes, reducing costs, owing to the application of ICT technologies. A structurally and functionally flexible firm. A firm which employs ICT specialists or cooperates with them.

Table 1. The characteristics of innovative, knowledge-based and technological firms as components of a high-tech firm

Source: Own study based on Zakrzewska - Bielawska (2010, 2011).

High-tech enterprises, as modern, innovative organisations, use the latest ICT solutions and, therefore, can be defined as technological enterprises. They have adequate IT infrastructure and know how to use it. Moreover, they are characterised by high knowledge and science absorption. In accordance with the paradigm of the knowledge-based economy we can call them knowledge-based enterprises. The aforementioned three components of a high-tech enterprise are closely related to each other and mutually imply one another. To define a firm as technologically advanced, all these components must occur since every high-tech firm is innovative, knowledge-based, and technological.

1.2. The classification of high-tech enterprises

The classification of high-tech enterprises, just like their conceptualisation. requires a multi-dimensional approach. There is no uniform taxonomy of high-technology businesses. As Pera (2013) claims, the most active international organisations in terms of developing the classification of activities and high-technology goods include ONZ, OECD, and Eurostat. In works, product-based and service-based approaches prevail. One of the first attempts to systematise high-tech industries, made on the basis of international comparative analysis, is the classification proposed by the OECD. The categorisation is based on the criterion of outlays on R&D in relation to value added. On this basis, four groups, characterised by a varying degrees of technological advancement, are identified (OECD, 2011): (i) Low technology – research and development intensity below 1%, (ii) medium-low technology – research and development intensity 1 - 12,5%, (iii) medium-high technology – research and development intensity 2.5 - 7%, (iv) high technology – research and development intensity above 7%. Industries classified to the last group, with the highest research and development intensity, underwent a number of changes over the studied years under the influence of technical progress and market conditions, this is highlighted by Daszkiewicz (2016a).

There are some popular and standard qualifications referring to high-tech industries and products on the international, regional (European) and domestic level. These are interrelated. It is presented in Figure 1.

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Explanations of abbreviations:

ISIC – International Standard Industrial Classification of all Economic Activities; CPC –Central Product Classification;

HS -Harmonized Commodity Description and Coding System;

SITC -- Standard International Trade Classification;

NACE – Statistical Classification of Economic Activities in the European Community);

CPA – Classification of Products by Activity; PRODCOM – Products of the Community; CN –Combined Nomenclature; PKD – Polish Classification of Activity; PKWiU – Polish Classification of Goods and Services; PRODPOL – List of Polish Industrial Products/ Source: Pera (2013, p. 54).

The most recommended typology of business activity is the International Standard Industrial Classification of All Economic Activities (ISIC), identifying high-tech industries based on the OECD definition. According to the latest version, these are the following sectors (Romo, Villalobos and Toriz, 2015): (i) Manufacturing of aircraft and spacecraft (Group 303), (ii) manufacturing of office, accounting, and IT equipment (Division 26), (iii) manufacturing of radio, television, and communications equipment (Group 263), (iv) the pharmaceutical industry (Division 21), (v) manufacturing of medical, optical, and precision instruments (Division 26X). The European Classification NACE is based on ISIC classification, but it proposes, not only the aggregation of sectors manufacturing high-tech goods, but also providing so-called knowledge intensive services. In the first group it includes (Eurostat, 2014): (i) Manufacturing of basic pharmaceutical products and pharmaceutical preparations (21), (ii) manufacturing of computers, electronic and optical products (26). Knowledge based services, according to NACE classification rev. 2, are as follows (Eurostat, 2014): (i) water and air transport (50 to 51), (ii) publishing activities, telecommunications, programming and broadcasting, and information service activities (58 to 63), (iii) financial and insurance activities (64 to 66), (iv) legal and accounting activities, malls and shopping centres activities, consulting and management activities, architectural and engineering activities, technical testing and analysis, scientific research and development, and advertising and market research (69 to 75), (v) employment related activities (78), (vi) security and investigation activities (80), (vii) public administration and defence and compulsory social security (section O), education (section P), human health and social works activities (section Q), arts, entertainment, and recreation (section R) (84 to 93). The Polish Classification of Activity is conceptually and methodologically coherent with the European classification.

In the product-based approach, the recommended classification on the international level is the Central Product Classification (CPC), its European equivalent is the Classification of Products by Activity (CPA),

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and its Polish one is the Polish Classification of Goods and Services (PKWiU). The groupings at the class level (4 characters) are compliant with the classifications of economic activities, but the transfer from CPC to ISIC requires the use of the conversion table (Pera, 2013). According to those classifications, the following are technologically advanced products (Pera, 2013): (i) Basic pharmacological substances, medications, and other pharmaceutical products (21), (ii) computers and electronic and optical products (26), (iii) aircrafts, spacecrafts, and similar optical machinery (30.3).

For the purposes of the analysis of the international trade of high-tech goods, this group of goods was also identified with the use of appropriate classifications applied in trade (CN, SITC, HS). On the basis of SITC typology rev. 4, we can distinguish a few hundred goods of high and ultrahigh technology (Daszkiewicz, 2016a): (i) Space and aeronautic equipment, (ii) computers and office machinery, (iii) electronics and telecommunications, (iv) pharmaceutics, (v) scientific and research instruments, (vi) electric machinery, (vii) non-electric machinery, (viii) chemicals, (ix) arms and ammunition. According to CN nomenclature, high-tech goods are in the following divisions (Pera, 2013): (i) Organic chemicals (CN 29), pharmaceutical products, (CN30), nuclear reactors, boilers, machinery and mechanical appliances, and parts thereof (CN84), electrical machinery and equipment and parts thereof, sound recorders and reproducers, television image and sound recorders and reproducers, and parts and accessories of such articles (CN 85), aircraft, spacecraft, and parts thereof (CN 90), clocks and watches and parts thereof (CN 91), toys, games and sports requisites, and parts and accessories thereof (CN 95). Another example of product classification is the EU list, PRODCOM. It is a list between production (CPA) and foreign trade (CN) statistics.

In the proposed taxonomies of high-technology, both industries and products line up because the classifications are not autonomous but codependent. What is more, they are cyclically updated, changes in one classification determine changes in others. Moreover, the presented classifications do not exhaust the problem, since there are other standards proposed, for example in other parts of the world or countries (North America Industry Classification System (NAICS) or Standard Industrial Classification (SIC)). On the basis of the proposed grouping, we can classify high-tech enterprises, but we have to remember about the limitations of both the sector-based and product-based approach (Daszkiewicz, 2016a). Therefore, we can also come across other, alternative attempts to systematise the categories of high technologies (Baldwin and

Gellatly, 1998; Wojnicka, Klimczak, Wojnicka and Dąbkowski, 2006; Kile and Philips, 2009; Skala, 2014).

1.3. The role of knowledge and innovation in a high-tech firm

The functioning of high-tech enterprises and the building of their competitive advantage depends on exogenous and endogenous factors (Zakrzewska - Bielawska, 2014a). In accordance with the positioning approach, it is the sector and position of a firm in the region that determines its effectiveness and the successes achieved. As progressive and flexible organisations, high-tech firms operate reactively in a turbulent environment and their advantage is often determined by the use of opportunities arising from the external environment of the firm. This is only possible when they have adequate internal resources. The Resource-Based View emphasises the significance of unrepeatable and unique features, properties, resources of the firm, and their structure as the factors determining the company performance (Cavusgil and Knight, 2009). In the case of high-tech firms, these are knowledge, innovations, and their derivatives which constitute the main indicator and determinant of their functioning. High-tech firms are defined as enterprises based on knowledge, technology, and innovation. The starting point, however, is knowledge, as a resource necessary in creating the remaining key features of a high-tech firm. Knowledge forms as a result of data and information processing. Data are raw and not analysed facts, events, numbers, and statistics. They become the basis of information which, in turn, is defined as real or conceptual, registered, and interpreted events (Kłak, 2010). Daszkiewicz (2016a) pays attention to the multitude of the classifications of knowledge. We can talk about the epistemological and ontological approach to knowledge. There is a division into explicit and tacit, basic, advanced or innovative knowledge (Daszkiewicz, 2016a). From the microeconomic perspective, knowledge is understood as information used in action, or information used to solve a specific problem (Drucker, 1994; Applehansa, Globe and Laugero, 1999). Turban (1992) believes that knowledge consists of the philosophy of life, ideas, truths, ideology, opinion, vision, and know-how. In accordance with Lundvall's concept (2006), knowledge is divided into individual components: (i) Know- what - part of knowledge, referring to the familiarity with facts and events taking place in an area or society; (ii) know – why – part of knowledge, referring to the understanding and interpretation of truths and principles prevailing in a given area or society; (iii) know - how - part of knowledge, referring to the ability to perform a specific action; (iv) know - who - part of knowledge, referring, in a sense, to the combination of the three aforementioned elements, namely the information about how and who can perform specific actions (Lundvall, 2006). Thus, acquiring knowledge consists in collecting information, data, facts and skills, and the capabilities of theoretical and practical reasoning. The elements are accumulated and developed in the process of learning, educating, and achieving experience (Głodowska and Wydymus, 2013). According to the knowledge-based economy concept, knowledge is treated as another factor or production, in addition to the traditional ones such as land, natural raw materials, labour and capital. What is more, it is indicated that it is the most important factor of production as, owing to it, the combination and reconstruction, to an extent possible of the other factors of production, takes place. In itself, it does not contribute to growth, only when it is applied in the production of goods and services - this is where the special role of knowledge-based enterprises in economy comes from (Makulska, 2012). In order to define a firm as high-tech, it must have the properties of a knowledge-based enterprise and a learning enterprise. A knowledgebased enterprise was characterised in Table 1. We can add here that it is an enterprise which combines all components of knowledge in the process of management and development, which requires a very efficient IT system and adequately educated personnel of the firm. It is an enterprise which offers knowledge-based products and services, this factor determines their competitive advantage (Tong, 2013). A high-tech enterprise has the qualities of so-called learning organisation, that is, one which is focused on the constant development of new qualifications and abilities of its members. Consequently, a new awareness and sensitivity of the perception of the environment occurs, which leads to permanent development. The effect of the permanent concentration on the acquisition and development of knowledge of high-tech enterprises is research and development activity and innovativeness (Flaszewska and Zakrzewska - Bielawska, 2013).

Innovations are a derivative of knowledge. According to Couros (2003), knowledge is the first element making up the innovative process. The conceptualisation of the term innovations cannot omit the classical approach created by Schumpeter (1960), the author of one of the most famous theories of entrepreneurship, in which innovation is presented as the crucial element of economic development. According to Schumpeter (1960), innovation is every new, unique solution applied in the economic life sphere. He mentions five dimensions of innovativeness (Schumpeter, 1960):

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- 1. Introducing new goods to production or improving the existing ones;
- 2. Introducing a new production method or improving the existing one;
- 3. Opening a new market;
- 4. Introducing a new method of sales or purchase;
- 5. Introducing a new organisation of production.

Thus, we can talk about technological, process, organisational and marketing innovations, and the key term seems to be the term "new", which stands for the application or implementation of a given solution for the first time. On the other hand, Drucker (1992) paid attention to the strong connections between innovative activity and entrepreneurship. He defined innovation as a special tool of entrepreneurship (Drucker, 1992). There are numerous definitions and classifications of innovations, developed by different authors (Freeman, 1994; Haffer, 1998; Rogers, 2003). Hightech enterprises, due to their specific properties and resources, are characterised by a distinctly higher level of innovativeness than others. They put special pressure on research and development activity, which is the basic source of innovation. It is in the high-tech industry companies where the highest level of integration of the research and development sphere with production, the employment of highly qualified scientific and technical staff, and intensive cooperation with other high-technology organisations are observed. Consequently, state-of-the-art products, with a strong saturation of technology are created (Baruk, 2006). Innovations also contribute to the creation of new knowledge, thus, relations between knowledge and innovations have the character of feedback loops. From the definition of high-tech firms itself, it is highlighted that the essence of those firms is modern technology, which is the manifestation of the skilful and practical application of knowledge, particularly scientific and technical, in the production process.

In the empirical papers verifying the significance of individual resources for the activity of high-tech firms, the special role of knowledge and innovation is confirmed (Cross, Borgatti and Parker, 2002; Kelley and Rice, 2002; Cloodt, Hagedoorn and Van Kranendburg, 2006; Zakrzewska – Bielawska, 2014a). One of the highly valued resources is knowledge, and competencies of staff and innovations and technological knowledge are more appreciated in firms characterised by a relatively higher ability to create and commercialise innovations. Similar dependencies have been observed with regard to research and developmental activities (Zakrzewska – Bielawska, 2014a). The significance of cooperation and strategic alliances in the creation of innovative solutions are also indicated (Cross, Borgatti and Parker, 2002; Kelley and Rice, 2002; Cloodt, Hagedoorn and Van Kranendburg, 2006).

1.4. A high – tech enterprise from the perspective of the growth theory

The significance of high-technology, including high-tech enterprises, for the economic growth of a country is quite obvious. In the literature of the subject there is a common agreement that innovativeness, knowledge, technologies, human capital, and specifically, the fundamental elements making up the core of high-tech enterprises, are causative forces of longterm changes in economy (Nadiri, 1993; Coe and Helpman, 1995; Bassanini, Scarpetta and Hemmings, 2001; Khan & Lunitel, 2006). The relationship can be described from two perspectives. Firstly, we can look at an overview of common economic growth models, indicating what role high-tech enterprises or their attributes played in them. Secondly, attention should be paid to the role of high-tech firms in the economy from the perspective of the entrepreneurship theory.

A typical approach to the economic growth model is their division into classical, neoclassical and contemporary ones. In classical theories, the leading role in the economic process was played by land, capital, and work. Classical economists either did not notice the role of the fourth factor of growth, which is knowledge, or treated it ambiguously. Smith (1904) believed that the wealth of a nation depends primarily on the manufacturing power of labour, which in turn, is determined by the division of labour. The importance of knowledge, or rather a kind of innovative activeness improving production techniques, was perceived by him as a result of the division of labour, owing to which an employee focusing attention on one activity, as a result of time saving, could focus his or her thoughts in order to improve the work performed (Żelazny, 2006a). Although Ricardo noticed the existence of technical progress in economic processes, he did not associate it with innovative abilities differentiating enterprises and entrepreneurs (Żelazny, 2006a). In classical theories we can see authors assessing, ambiguously and indirectly, the impact of innovations on economic growth through the impact on growth factors (e.g. division of labour). Say (1855) was the first to identify intangible capital in addition to tangible capital, that is, the one arising from knowledge, and he perceived an entrepreneur as a creative innovator (Lipiński, 1968). According to Say (1855), innovations affecting the

market do not bring any harm due to the fact that markets are flexible and adapt to new situations. On the other hand, Stueart (1767) believed that mechanisation, as an effect of technical progress, does not affect positively the reduction of prices and, what is more, it has a negative influence on employment. The main factor influencing an increase in the economic growth rate is an increase in global demand and a decline in unemployment. The representatives of classical economics did not attach any special role to high-tech firms or related factors in the process of economic growth and development. Rather, technical development was discussed from the perspective of its social effects, for example, mechanisation depriving people of work.

The first formalised model looking at scientific and technical knowledge as a factor of long-term changes in the economy was the neoclassical Solow growth model. However, the factor in neoclassical theories was not defined precisely and constituted so-called Solow residual (Denison, 1985; Jorgenson, 1990). Technical progress included all those factors which influence economic growth except for the size of workforce and tangible capital. Therefore, it was broadly understood as the Total Factor Productivity. Moreover, it had the character of a commonly-available public good, thus, there is no explanation for its differentiation on the micro level (Nowak, 2007). Treating scientific and technical knowledge as an exogenous factor of growth in neoclassical models became the contribution to the research into its endogenisation and, thus, the creation and evolution of endogenous growth theories, in which knowledge and innovation are the starting point for the discussion (Wojtyna, 1995). It arose from the need to find out the sources of the productivity of factors determining economic growth, and thus responding to the question regarding what makes up the Solow residual, and what significance technology, knowledge, and technical progress have. Subsequent models have tried to recognise inventions, innovations, research and development activity, and human capital as new factors of the economic growth (Liberda and Maj, 2009). As Romer (1986) observes, the endogenous growth theory assumes that the formation of new knowledge in one enterprise creates positive external effects for the whole economy via the improvement in the capacities in other enterprises. Knowledge, as the only factor of production, is characterised by the growing economies of scale. It occurs as a result of the diffusion of knowledge, as it is not protected with patent rights and cannot be kept secret. According to Romer (1986), the state policy can contribute to a more optimum level of the accumulation of knowledge. In the next model, Romer (1990) pays attention, not only to knowledge, but also to research and development activity and technological

progress. He introduces three sectors into the model: (i) Manufacturing finished goods, (ii) manufacturing intermediate goods, (iii) research and development: and four factors of production: (i) capital, (ii) labour, (iii) human capital, (iv) technology. Between individual factors of production and sectors, there is a strong relationship. Human capital used by the research and development sector creates new technologies which, in turn, are utilised by the intermediate goods sector. Intermediate goods are used for the production of finished goods. An increase in production, and therefore the growth of GDP, depends on the human capital resources. outlays on research, and development (Romer, 1990). Additionally, Lucas (1988) pays attention to the significance of human capital for the economic growth. He believes that the development of an economy takes place mainly as a result of the growing rate of the accumulation of human capital. It influences the growth of the productivity of the workforce and contributes to the better use of the other factors of production. The process of human capital accumulation takes place via the education process and learning by doing. Moreover, the so-called spill over effect occurs, specifically its flow between firms and economies. Therefore, a firm is a place of creating and diffusing knowledge. The effect of knowledge diffusion is also recognised in the theory of entrepreneurship (Daszkiewicz, 2016a). Audretsch and Lehmann (2013) proved that people become entrepreneurs if they have the potential to achieve benefits from knowledge diffusion. Through the commercialisation of knowledge and ideas, which arise in a given firm, an entrepreneur contributes not only to the diffusion of knowledge but also to the initiation of further entrepreneurial ideas and the improvement of economic results, not only in the firm itself but also in the development of regions and economies (Daszkiewicz, 2016a; Audretsch and Lehmann, 2013). The concept is developed within the so-called knowledge spill over theory of entrepreneurship (Daszkiewicz, 2016a).

Wach (2015) observes that endogenous theories of growth became a contribution to the development of knowledge-based theories in which entrepreneurship is linked to the economic growth. Theories of entrepreneurship are the second perspective on the assessment of the cause and effect relationship between high-tech enterprises and the economic growth. There are numerous theories of entrepreneurship, and among them knowledge-based theories deserve special attention, - considering specifically the discussed problem (Wach, 2015). In the search for the relationship between entrepreneurship and economic growth, these theories play a crucial role. A new competitive dynamic makes firms attach more and more weight to knowledge and intellectual resources,

acknowledging that knowledge and science, and their effective development, are the key factors of production, which ensure the achievement and maintenance of competitive advantage, thus replacing traditional factors (Galende, 2006; Diaz - Diaz, Aguiar - Diaz and DeSaa - Perez, 2008). An economy in which a lot of firms operate basing their competitive advantage on knowledge and science according to Koźmiński (2001) is defined as a knowledge-based economy. There are numerous definitions of a knowledge-based economy in which high-tech firms are indicated as its key determinants (Fazlagić, 2000; Kukliński, 2003; Chen and Dahlman, 2005). A knowledge-based economy is a new phase of the development of civilisation in which the fundamental role is played by science, information, and knowledge (Żelazny, 2006b). It is about both individual and collective knowledge. Individual knowledge is a set of experiences, information, and personal skills (tacit knowledge) whilst collective knowledge is subject to collective and institutional verification made by science (codified knowledge) (Sadowski, 2007). In this approach, these are high-tech firms which are the basis for the functioning and growth of economy. According to Tong (2005), the high-tech industry has two specific properties which are important to the economy. Firstly, it engages modern technological thought, thus combining science, technology, and industry. In other words, these are firms which need technical progress, which determines the progress of scientific knowledge, which in turn has a partially public character. Secondly, firms in the hightech industry are characterised by great technological capabilities and high intensity of research and development works and usually expenditure on the financing of research and development (R&D) (Tong, 2005). Considering the fact that technological capabilities are not evenly distributed in firms or branches of industry, it is the high-tech industry which becomes the central point of the research and development potential and efforts in the whole economy, which has an unquestionable influence on innovations. Technological progress, as an effect of the intended activeness of private firms in the area of research and development leads to innovations, which has also been proven in the growth concepts based on research and development. Besides, the supply and demand character of innovation, strictly connected with entrepreneurship, was already indicated in Schumpeter's (1942) and Drucker's (1976) works.

The influence of high-tech enterprises on economic growth seems obvious, however, indicating a direct cause and effect relationship is not that simple. Theoretical models of economic growth, as well as theories of entrepreneurship, concentrate on knowledge, innovations, and technologies in the context of their significance for economy. Undoubtedly, these are

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attributes of high-tech enterprises, therefore, we can assume that these are the enterprises which commercialise knowledge, create innovations, and generate technological progress - they are the driving force of the contemporary economy. Besides, we should remember that the basis, and at the same time the measure of the accuracy of theoretical approaches on various levels of aggregation, is determined by decisions of firms whose conceptual sum defines the effects related to such notions as science, progress, innovativeness, information, namely the basic elements constituting the core of the contemporary economy (Głodowska and Wydymus, 2013).

High-tech firms as the sources of technological convergence

The deliberations conducted in the area of economic growth, and on the role of high-tech firms in this process, are closely connected with the problem of economic convergence. The search for the relationship between high-tech firms and economic growth ultimately serves as an explanation of differences in the level of the incomes of economies. In consequence, it may contribute to an answer to the question as to what makes some economies develop faster than others, and what conditions must be fulfilled for underdeveloped countries to catch up with countries on a higher level of development? These issues are at the core of economic convergence as it is a process of concurrence and convergence of countries in various spheres of the economic life. There are many ways of approaching convergence within economic theories. We can talk about its broader dimension, in which the convergence of economies can concern a broad spectrum of changes undergoing in individual countries: Construction, style of living, living standard, systems, markets, etc. In a narrower approach, economic convergence concerns the concurrence of the level of income. The economic convergence concept was formed on the grounds of neoclassical theory, according to which, convergence is a natural and autonomous consequence of the economic development. Countries on a lower level of economic development, and thus having a smaller resource of real capital, are characterised by higher productivity, which results from the neoclassical assumption about the decreasing productivity of the real capital. As a result, the dynamics of growth in poorer countries are relatively higher than in richer countries, and the dispersion of incomes decreases in the long term (Kusideł, 2013). In the course of the development of research into convergence and the evolution of neoclassical theories, different kinds of convergence and ways of quantifying them were formed. A new theory of the endogenous growth,

initiated by Romer (1987, 1990) and then developed by Grosmann and Helpmann (1991), made long-term economic growth dependent on technical progress, technology, and human capital. It means that the new theories perceived the process of the convergent growth differently than neoclassical ones, indicating that it is knowledge, technology, and progress which were of exogenous character in the neoclassical models, are key factors for convergence. The technological convergence term was created. which means economies becoming similar in terms of technological potential. The potential is most often expressed by the Total Factor Productivity (Islam, 2003). The technological convergence term is also used in the context of income convergence, when the measure of technology in economy is adopted as a variable explaining the economic growth. We can talk about technological convergence in regard to countries, regions, or industries. The literature of the subject is rich in works discussing the dominants of high-tech firms and their impact on the process of equalising developmental disproportions. Firstly, attention should be drawn to the fact that knowledge resources are available in the economy as a result of education, learning by doing, and research and development works. The acquisition and absorption of knowledge resources determine the level of efficiency and technological change (Berman, Bound, and Griliches, 1994; Murphy, Riddell, and Romer, 1998). Secondly, it is assumed that the efficiency level, reflecting the technological advancement of an economy and its growth determined by the intensive development of knowledge, leads to an increase in income. The assumptions were also positively verified in numerous empirical works (Verspagen, 1993; Amable, 1993; Keller, 2001; Howitt and Mayer-Foulkes, 2002; Lee, Lim, and Song, 2005; Stokke, 2008).

Regardless of the approach to technological convergence, and the level of disaggregation adopted in a study, a firm is always the starting point and the source of changes. The convergence of economies in terms of technology, or their dynamic development as a result of technology, arises from the activities on the micro level, whose sum means measurable changes on the macro level. The high-tech industry is particularly significant in this case. The literature recognised a positive relationship between the high-tech specialisation and the convergence process. Mora (2008) identified a positive correlation between the share of the high-tech industry in the region structure and the level of the income and employment growth. Cook (2005) indicated that these are high-tech industry firms which, to the greatest extent, use opportunities arising from the liberalisation of markets and globalisation, contributing to the intensification of growth in the region. The acceleration of growth as an

effect of high-tech specialisation is also recognised in the models of new economic geography, according to which, in consequence of the effective reduction of transaction costs and economic integration, differentiation of the level of growth in economies or regions takes place. It means that high tech industry firms, their concentration and dispersion, can cause convergence or divergence processes. Closing the technological gap between countries can be also analysed from the perspective of knowledge diffusion via the foreign trade of technologically advanced goods (Maciejewski, 2010; Pera, 2014; Kubielas, 2009). Piątkowski and von Akr (2004) indicated directly that the Information and Communication Technologies (ICT) industry plays the most important role in decreasing productivity dispersion in Europe and the United States.

1.5. The functioning and development of high-tech firms in the light of the existing research

An analysis of the literature of the subject indicates that the subject matter of high-tech firms is rich and multifaceted. They are the object of research in various scientific disciplines: Economics, international business, management, entrepreneurship, biotechnology and engineering. The research scope and the perspective of the analysis of high-tech firms are also varied. There are a lot of publications on high-tech enterprise management, its marketing aspects, the environment or internationalisation. The results of the cursory and formulaic revision of databases are presented in Table 2. The aim of this overview of databases was to indicate the number of available publications in the configuration of a given key word and the "high-tech firm" term. The indicated databases were searched through in the time frame 1960/1985 – 2017, depending on a given base. All categories of scientific publications were considered: Articles, books, chapters in monographs, post-conference publications, papers, reports. Chapter One

Table 2. The number of publications on high-tech firms according to different databases

				Databases*			
Key words	EBSCO Host	Emerald	JSTOR	ScienceDirect	SCOPUS	Springer	Web of Science
High-tech industry	2 214	107 221	20 635	112 970	10 057	789 944	3 722
High-tech firms	1 577	74 761	17 344	61 179	2 761	427 010	2 277
Entrepreneurship: High – tech firms	262	7 285	3 187	3 854	861	17 313	252
Definition: High – tech firm	27	57 001	16 020	22 352	39	160 469	38
Forms: High – tech firms	116	61 288	17 831	51 922	187	355 226	155
Knowledge, innovation: High – tech firms	196	22 097	7 035	13 697	316	58 004	513
Clusters: High – tech firms	110	9 081	1 459	10 945	179	59 742	179
Marketing: High – tech firms	149	62 772	7 526	14 800	243	201 305	884
Management: High – tech firms	564	67 646	13 676	31 460	262	215 509	616
Internationalisation: High – tech firms	49	4 368	281	453	72	10 581	19
SMEs: High – tech firms	9	9 370	437	2 460	36	4 958	48
Environment: High – tech firms	187	54 375	10 199	32 863	319	193 290	293
Development: High - tech firms	484	90 979	13 926	46 499	1 028	300 152	1 009
*ac of 15 Amount 2017							

*as of 15 August 2017. Source: Own study based on databases shown in Table 2.