

# DIFFERENTIATING CRITERIA FOR HIGH-TECH COMPANIES

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**ABSTRACT**

Manufacturing companies operating within the high-technology sector are of interest to science, industry and national authorities because of the special economic importance attached to them. However, in order to investigate the condition of those companies, support their growth and monitor the effects of the aid awarded to them, it is first necessary to properly identify the business entities belonging to that sector. To identify the entities belonging to the high-technology industry, it is necessary to perform a sequence of activities which form the procedural algorithm. Usefulness of the algorithm has been verified using the example of a group of Warsaw high-tech companies which were subject to investigation under the European project Warsaw Entrepreneurship Forum. The algorithm could be used as the basis for the implementation of an IT tool for the identification and description of high-tech businesses.

**KEYWORDS**

high technology, PKD classification, algorithm, identification of entities, defining of research group.

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## Introduction

Manufacturing companies operating within the high-technology sector (HT) are of interest to science, industry and national authorities because of the characteristics ascribed to them. From the macroeconomic perspective, the sector is important for several reasons. First, its condition is viewed as a reflection of the level of competitiveness and innovativeness in an economy [1, 2]. As proof of this, it should be noted that the increase in production and particularly in exports of high-tech goods (from 3% of the export value in 2009 to a minimum of 15% in 2030) was mentioned in the government's strategic documents as one of the levers (and simultaneously a metre) of Poland's medium and long-term growth.

Secondly, studies have shown that HT companies are highly productive and competitive, they stimulate the growth of export and increase the level of technology in the entire economy [3]. Thirdly, high-tech companies create well-paid jobs for the most

highly-skilled workforce, which, ultimately, stimulate the domestic demand and encourage savings. An important ingredient of functioning of those companies is their cooperation with science, which contributes to quicker commercialization of scientific research and transfer of technological knowledge [4].

Moreover, the companies provide an excellent space for research on the latest trends in technologies, management and marketing [5]. An important consideration here is the accelerating trend towards the reindustrialization of cities, which has also reached the capital of Poland [6]. The "purity" of technologies which come under the "high-technology" heading has a beneficial effect on the increase of employment rates among the most highly-skilled workforce, especially among young people. This is a strong case for an active reindustrialization policy with respect to the development of the high-tech sector in metropolitan areas. An incentive here would be the fact that the sector already has a significant presence in Warsaw, which is particularly visible in the central districts of the city [7].

All this creates a chance of dynamic development in this direction for other city districts and provides an opportunity for those enterprises which see their opportunity for market expansion in the revival of production (rather than in the services sector only).

In view of the above, it is essential to know which entities are high-tech and which are not. However, an attempt to apply a generally accepted sectoral classification has proved to be ineffective. Use of this classification has resulted in qualifying as high-tech those entities which do not meet the basic classification criteria (e.g. pharmacies instead of drug manufactures, or optical shops instead of companies producing optical equipment) and in omission of important entities which have been assigned to another PKD<sup>1</sup> section, but which are in fact high-tech (e.g. innovative pharmaceutical companies which, due to the high share of trade in medicine in their revenue, are defined as commercial rather than manufacturing companies).

### Formulation of the problem and research objectives

Verification of the distinguishing features of HT companies, supporting their development and monitoring the effects of the aid granted to them will only be possible if the manufacturing companies belonging to that sector are correctly identified. Studies carried out for this purpose on a population of Warsaw companies have shown that the task is not as easy as it appears at first glance. The initially identified group of 1363 entities (representing the entire population of Warsaw HT companies), classified as high-tech due to their PKD code denoting the type of business activity was, after a closer examination reduced to 137 entities (10% of the initial population) which with certainty meet the HT criteria. This is indicative of the seriousness of the problem and its importance for research performed on manufacturing companies. Therefore, the following research questions (RQ) have been formulated:

RQ: *What methods should be used in order to ensure a reliable and correct classification of the HT entities?*

To identify the entities belonging to the high-tech industry, it is necessary to perform a sequence of activities to verify the basic PKD classification. The activities, arranged in a logical sequence, form the procedural algorithm for verification of criteria and classification of business entities as high-tech. Therefore the objective of this paper (OP) is:

OP: *Define the method for verifying the PKD classification and correct identification of HT entities.*

The above objective has been achieved through analysis and discussion of the results of the currently applied HT verification methods (Sec. 3), proposal of an alternative method implemented based on the entire population of Warsaw HT companies (1363 entities, Sec. 4), verification of its usefulness based on the selected group of Warsaw high-tech companies (137 entities, Sec. 5) and discussion of the results obtained (Sec. 6).

### Methods applied in the identification of High-Tech

High Technology refers to areas of manufacture and products which are highly science-intensive, i.e. are characterized by a high level of R&D intensity [8]. There exists a commonly applied criterion to distinguish companies operating in the high-tech sector from other companies. The OECD and Eurostat, based on the ratio of research and development expenditure to sales revenues (or value added), distinguish four categories of the manufacturing industry, one of them being high technology [9, 10]. The high-tech category comprises three branches: pharmaceuticals, manufacture of electronics, aviation and space industry. Thus, HT companies are identified based on the assumption that all entities performing the listed types of activity qualify as high-tech.

The second criterion is related to the type of manufactured products. Based on this criterion, nine groups of products which qualify as high-tech can be distinguished: products related to aviation and space industry, computers, electronic and telecommunication products, pharmaceuticals, research and development equipment, electrical machinery, chemicals, non-electrical machinery, weapons and ammunition [9]. This criterion is not commonly used due to the lack of statistical data in this area. The situation is similar for the third criterion which proposes to classify as high-tech those entities which own patents for the products related to the listed categories of products.

In view of the arguments pointing to the lack or restricted access to adequate data, the widest definition of the high-tech industry is applied according to which the HT industry includes all those entities which carry out their activity in the three listed categories: pharmaceuticals, electronics, aviation and aerospace (each of these categories corresponds to

<sup>1</sup>PKD – Polish Classification of Business Activity.

specific codes under the PKD classification – Polish Classification of Business Activity). This approach is most commonly used by researchers, who refer to large statistical samples or whole populations, e.g. [5, 11, 12].

Following the above guidelines, a study was carried out to identify and analyze the high-tech manufacturing sector located in Warsaw. To this end, the REGON register database (as on December 2012) was obtained from the GUS (National Office of Statistics). The database contained 1363 business entities conducting activity in HT industries together with a list of attributes describing those entities. Even a rough analysis of the obtained database of businesses allowed us to make the following assumptions:

- some of those businesses are probably inactive,
- some of them do not in fact belong to the high-tech sector.

Additional studies were conducted which confirmed the above hypothesis. The research made use of secondary data provided by the report by the PwC consulting firm of September 2011 entitled: “Impact of the innovative pharma industry on the Polish economy” [13]. The report contains a detailed analysis of the pharmaceutical market in Poland. A characteristic feature of the market is the clear division into those companies which work to develop new medication (innovative companies) and those which produce the substitutes of the existing drugs (generic companies). According to the report, there are two manufacturing plants producing innovative medication in Warsaw. It has been established that the companies which own those plants have their registered office in Warsaw. However, they were not included in the database of high-tech companies since they defined their main type of activity as commerce rather than manufacturing. This is yet another proof of uselessness of the sectoral classification according to PKD codes.

This brought about a need for developing an alternative method which would enable more accurate and reliable identification of the high-tech sector.

### Hybrid method for High-Tech enterprise identification

In order to make the PKD classification more credible, it was deemed necessary to complement the data obtained from the GUS<sup>2</sup>. The complementary information came from two sources: Business

Activity Indicator (the database run by the ZUS<sup>3</sup>) and companies’ private websites. On this basis, a hybrid method of high-tech enterprise identification was proposed which combines the PKD classification with the company’s activity as recorded by the ZUS and the information available online. The high-tech sector identification method which was used to investigate the population of Warsaw companies comprised four steps (Fig. 1):

- Step 1 – to extract from the REGON register the entities which are classified as high-tech on the basis of the sectoral criterion (PKD: 21, 26, 30.3);
- Step 2 – to verify the activity of those entities using the Activity Indicator based on the data provided by the ZUS (Business Activity Indicator = 1);
- Step 3 – to identify the entity’s own website;
- Step 4 – to verify the conformity of the offer published online with the declared type of sectoral activity conducted within the high-tech industry.

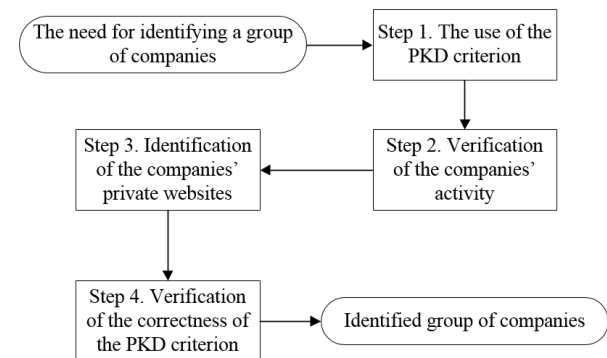


Fig. 1. Hybrid method for high-tech enterprise identification (own research).

#### STEP 1.

The analyzed entities were identified based on the main type of activity declared by them which was expressed by the PKD classification code contained in the REGON register. Thus, the first step in the identification process of the population of high-tech companies was to identify those companies which meet the requirement:

$$PKD_i \in \{21, 26, 30.3\},$$

where  $i$  is the  $i$ -th entity in the database, 21, 26 and 30.3 are PKD classification codes assigned to three areas of business activity: pharmaceuticals (21), electronics (26), aviation and aerospace (30.30).

#### STEP 2.

The first step in “purification” process of the database was to eliminate the inactive entities. For

<sup>2</sup>GUS – the National Office of Statistics

<sup>3</sup>ZUS – the Polish National Insurance Company

this purpose, the Activity Indicator was applied (based on the ZUS database) which limited the list of companies to 558 (41% of the REGON register database). However, additional information had to be obtained in order to conduct further analysis.

#### STEP 3.

This additional information was obtained from Internet resources where the companies operating in the high-tech sector should publish information on their own websites. To this end, all entities were analyzed and a set of 266 high-tech entities was obtained (48% of all active entities) which were active and had an own website.

#### STEP 4.

The information obtained from companies' websites was used to verify the conformity of the offer published on the website with the declared type of activity in the GUS database. It was surprising to find that only in 137 cases (51.5% of active entities with an own website) the analysis produced positive results, meaning that a particular company could be classified as actually belonging to the high-tech manufacturing sector.

Based on the above, it can be assumed that classification of a company as high-tech based on the type of activity expressed by the PKD classification code may be subject to substantial error in at least half of the cases (Fig. 2). In light of these findings, unverified (declaratory) PKD classification cannot be a reliable criterion for qualifying a company as high-tech.

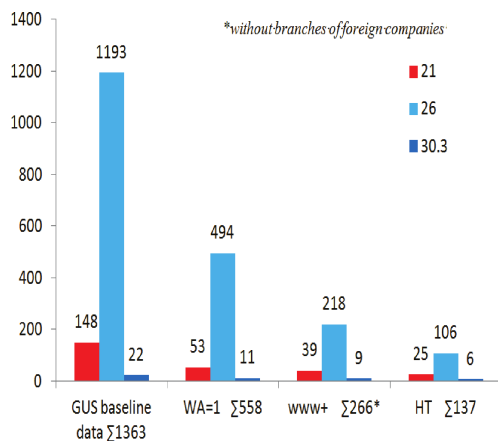


Fig. 2. Structure of the number of companies during particular steps of the study according to the PKD type of business activity (own research).

## Verification of the method usefulness

The new method increases the reliability of both the identification process and analysis of companies in terms of their high-tech characteristics distinguishing them from other companies.

As regards verification of the correctness of identification, there are examples of companies which were eliminated during particular steps of “purification” of the Warsaw high-tech companies population. In step 2, those companies were eliminated which are not registered as active payers of the mandatory contributions to national insurance (the ZUS). Those companies were deemed inactive, and so were the companies which did not employ a single person throughout the year 2012. Step 3 eliminated companies which did not have their own website. It was concluded that the lack of a website is another sign of (market) inactivity of a modern company, especially one operating in the field of advanced technologies. There is of course the risk that such an approach will result in the omission of certain entities. However, in the authors' view, this approach is not affected by a significant error. Step 3 eliminated those entities whose declared PKD was different from the basic type of activity conducted by them.

As regards analysis of the entities in terms of characteristics distinguishing high-tech ventures, it was found that private websites represent a valuable source for enrichment of the data contained in the REGON database. Thus, the next step in the research was to examine the websites of all 137 companies qualified as high-tech in order to provide an in-depth description and identify those characteristics which distinguish the companies from other business entities. The list of those characteristics follows the structure shown in Table 1.

Figure 3 presents the characteristics of the analyzed population based on the number of companies having particular features.

An in-depth analysis suggests that high-tech businesses differ from other companies with respect to the following features: conducting business to business (B2B) activity, export activity and searching for new employees. Certain ambiguity arose with respect to some activities related to science: cooperation with research centres, patents and obtaining certification. On the one hand, these seem to be the most important features of the companies associated with high technologies; on the other hand, the number of companies which confirm conducting this type of activity is relatively low. To verify those assumptions, a segmentation analysis of the set was performed using two analytical methods: 1) Ward's clustering method by means of which 3 segments were identified and 2) Kohonen's self-organizing map (SOM) where 4 segments were identified. Segmentation carried out by means of two different methods confirmed that there is considerable variation between the criteria distinguishing particular sub-groups of entities within the high-tech population.

Table 1  
Classification attributes in the internet dataset (own research).

Name	Description
EMPLOY	Does the company employ workers?
AKTIV	Is the company active? Is the data on the website up-to date?
SOCIAL	Does the company have social media accounts?
PATENT	Does the company hold a patent or trademark registration?
SCIENCE	Does the company cooperate with research centres? Does it have own research laboratories?
LANG	Does the company have a website in a foreign language?
B2C	Does the company sell to individual customers?
B2B	Does the company sell to other companies?
EXPORT	Does the company export?
CERT	Does the company have certificates?
INNOV	Does the company describe itself as innovative?

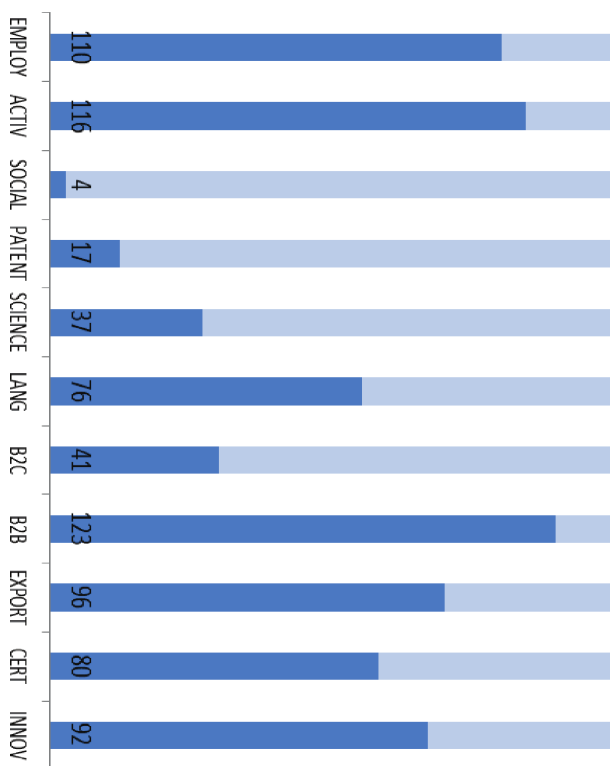


Fig. 3. Number of companies possessing attributes from the internet dataset (own research).

Segmentation by means of Ward's method produced a visible gradation of companies in terms of their export activity and scientific activity understood as: patenting, obtaining certification and cooperation in the field of research (or running own laboratories). On the basis of this segmentation, two growth segments were distinguished containing the exporting companies and the scientifically active companies (the segments differ in their level of development). The third segment includes companies which maintain their status quo rather than develop.

Using the self-organizing map, four segments were distinguished. This type of segmentation also distinguished between companies with a lower and a higher level of export and scientific activity. However, this description was enriched by adding new distinctive features. Thus, segment 1 included companies which were active in terms of exports and scientific research, but did not hold patents. Segment 3, on the other hand, comprises companies which are active in terms of exports and hold patents. Segment 4 whose characteristics are very similar to segment 1 has the biggest foreign capital share of all groups. Segment 2, whose specification is similar to that of segment 3 based on cluster analysis, does not compare favourably with other segments. It contains companies which currently do not have many features conducive to development.

In summary of the obtained results, it should be concluded that the strongest criteria differentiating Warsaw high-tech companies are, in the order of importance:

- export activity,
- scientific activity, understood as: obtaining certification, cooperating with research centres (or running own laboratory) or holding patents,
- searching for and employing new workers,
- share of foreign capital in the form of ownership,
- preference to B2B sale over B2C sale.

## Conclusions

The studies, whose initial purpose was to provide material for the description of the Warsaw high-tech sector, revealed that there was a major difficulty identifying the entities which qualify as high-tech. As has been found, the basic criterion for qualifying companies as high-tech which is based on the PKD declared by the companies, is not reliable. Therefore,

a need arose to define a new method that would provide an unequivocal answer to the question about which companies should and which should not be regarded as high-tech.

Implementation of this method brought two benefits: it verified and restricted the set of entities selected by means of the sectoral criterion (PKD) as well as ensured the enrichment of the analytical dataset. As a result, after subjecting high-tech entities to the four-stage verification process, it was possible to elaborate an in-depth description of those companies, using data obtained from websites. Segmentation performed on the basis of this data demonstrated that the companies considerably differ in their level of development. Therefore, further research will focus on finding additional criteria which could be used to identify the high-tech companies with the highest development potential.

In this context, one needs to highlight the significant role of exports which, in the course of the research, proved to be the key feature distinguishing developing business entities. There is a reference here to the “hidden champions” concept (HCh) which has been developed by H. Simon since the mid-1990s [14, 15]. HCh is a special group of businesses which are characterized by: high level of exports, competing on a global scale and a very narrow (and simultaneously profound) specialization of their offer. There are three reasons why those ventures form a valuable part of the economic ecosystem. First, compared to other companies, they are more resistant to negative changes in the economic situation. Secondly, they create new jobs which are characterized by stability and a relatively high level of remuneration. Thirdly, it has been demonstrated that the risk of failure of such companies is much lower than the average level in a given economy. This concept is viewed by the authors as a potential source distinguishing the most promising high-tech businesses and, at the same time, a direction for further research aiming at identifying companies with the highest market potential.

Main limitation of the method is the necessity to use the information placed by the company on the website. The obvious assumption, which is done and cannot always be met, is accuracy, timeliness and reliability of such information. It is also assumed that the person completing the survey on the basis of the website is able to correctly interpret and evaluate the content presented there. This is not an easy task, even for people who are experts in the field of entrepreneurship and management. However these limitations are only handicaps in using of the method, but does not deny its usefulness, especially in the context of large size of research sample.

To sum up the findings of the study, we must conclude that the objective set at the beginning of the research project, i.e. elaboration of a reliable and correct method to verify whether a company belongs to the high-tech sector, has been achieved. The method is of a general nature, which means it can also be used to identify other groups and sectors of business entities. Inclusion of the internet data in the presented cycle suggests the need for automation of the process in which the proposed method may provide the basis for designing an IT tool. This will enable further extension of the method by adding elements of quality management of the enriched data, which is essential when using data acquired online.

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