International Journal of Managerial Studies and Research (IJMSR)
Volume 2, Issue 7, August 2014, PP 125-136
ISSN 2349-0330 (Print) & ISSN 2349-0349 (Online)
www.arcjournals.org

Technological Innovation Paths in European Bio Ethanol Industry

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Abstract: *The companies innovate by adjusting, improving and changing of complex technical and organization systems, which are characteristic for a certain industry. The known determinants of innovations indicating the trajectory of technical transformation of the companies in a certain industry are generalized, based on the data of separate innovative companies. Taking into account integration of the companies producing bioethanol into general corporative structures of multinational companies, we found out that the technological trajectory of innovative companies do not depend on certain sector, but are built with the deep orientation on general corporate innovation policy of the companies. The determinants of the innovations have been identified based on the statistic analysis of 35 producers of bioethanol in the EU taking into account the influence and interconnections of the companies inside the group, the number of which made up 645 companies.*

Keywords: *Innovation; technological path; bioethanol.*

1. INTRODUCTION

The rapid development stage of conventional bioethanol has moved to the mature phase. Competition between manufacturers, economic environment where everyone is in single economic and legal space, e.g. what is the European Union, has aggravated so much, that weaker players in addition to the annual balance of cash losses, have started closing productions and leaving the industry with great losses. Since the production of conventional bioethanol is based on almost identical technological processes and parameters, it becomes obvious that every effective change or development of technological innovation process in bioethanol industry must give producers a distinction, contributing to the development of long-term competitiveness. Additional threat to producers of bioethanol using conventional manufacturing processes is created by the developing second-generation technology, which allows converting lignocellulosic materials into bioethanol. This situation forces the companies to change in terms of technology - to create and introduce new innovative technical processes to ensure the ability to compete.

Innovation requires changes in the operation of technical and organizational systems. These changes are not an instant process. The process of transformation involves trial and learning. These processes are path-dependent, with the directions of search strongly conditioned by the competencies accumulated for the development and exploitation of their existing product base (Tidd, et al., 2005). Proceeding from the sectoral differences there have been developed classifications of taxonomies (see Pavitt, 1984), which allow to identify tasks contributing to defining of the innovative strategies of the companies. The indicators of innovations in taxonomies have become the data of certain activities of innovation companies acting in different sectors. Consequently, we have to admit that the companies working even in the framework of one sector are different, use different technologies and have different levels of complexity. Besides not all the companies belonging to the same industry are innovative. Moreover, necessary scientific knowledge is not always accumulated in those organizations which produce final products. Due to growing globalization and integration of the companies, the knowledge in the form of patents and other determinants of innovations can be concentrated in a separate structural division of the company that has interconnections with the company producing innovative products/processes and that is why they are not accounted in research. In parallel the accumulation of knowledge inside the whole group can allow to adjust and transform the knowledge of one discipline to another. Thus the received knowledge and technologies can become new sources of innovations for the companies.

In this article, we will consider the influence and delivery of the accumulated inside of the whole companies' structural group determinants on the separate industry, with the help of which (determinants of innovations) the trajectory of technical change of the companies providing technological innovations is identified.

2. THEORETICAL BACKGROUND

It is generally considered, that creating new products, processes and services is recognized as a major source of competitive advantage and technology is often the enabler of such innovations (Chiesa, 2001). The existing point of view is that those technological innovations bringing the main input into industrial competitiveness have major support from the scientific community (Zaltman et al., 1973; Tidd, 2001). It is also known that in a long run companies are forced to innovate or to perish (Freeman, 1982; Archibugi, 2001). It is important to notice that certain companies innovate more often than others.

Consistency in innovations is necessary, as it is believed that innovation offers only a temporary monopoly (Dodgson, et al., 2008), because there are many fast followers: killed competitors able to overcome leaders by copying or by drawing on assets on those first markets which do not have them. Innovators may control access to markets, taking up 'shelf space' and limiting opportunities for successful entry by competitors (Shapiro & Varian, 1998). Companies becoming aware of the necessity to innovate try to adjust their strategy of development so that the chosen trajectory secured sustainable innovativeness. However as Tidd et. al. (2005) noticed, firms' strategies are strongly constrained by their current position and by the specific opportunities open to them in future: in other words, they are path-dependent.

Companies cannot change immediately their technological trajectory, as for that a number of interconnected resources and procedures contributing to transformation of knowledge, experience, and competences are necessary. Moving from one path of learning to another can be costly, even impossible, given cognitive limits (Tidd, et al., 2005). It is also necessary to take into account the fact that modern production is often complex with the usage of several technologies at the same time. Each technology has their own models of development, requiring a number of specific competencies and strategic decisions. Moreover, technical transformation of the companies is strongly dependent on the character of the industry in which the company works.

As noted by Tidd et. al. (2005), there are differences amongst industrial sectors in the sources and directions of technological change, which can be summarized as follows:

Size of innovating firms: typically big in chemicals, road vehicles, materials processing, aircraft and electronic products; and small in machinery, instruments and software. Type of product made: typically price sensitive in bulk materials and consumer products; and performance sensitive in ethical drugs and machinery.

Objectives of innovation: typically product innovation in ethical drugs and machinery; process innovation in steel; and both in automobiles.

Sources of innovation: suppliers of equipment and other production inputs in agriculture and traditional manufacture (like textiles); customers in instrument, machinery and software; in-house technological activities in chemicals, electronics, transport, machinery, instruments and software; and basic research in ethical drugs.

Locus of own innovation: R&D laboratories in chemicals and electronics; production engineering departments in automobiles and bulk materials; design offices in machine building; and Systems Departments in service industries (e.g. banks and supermarket chains).

Each of the above mentioned variables influences in a certain way the innovative activity of the company. We can assume that the groups of interconnected variables only increase diversified influence. Diversity of the influence causes the disability of companies to self-identity with a concrete profile of variables and by this it excludes the possibility to study systematically the influence of certain groups of variables on innovation activity of the companies. In other words we can say that the absence of systematization of the mentioned-above variables decreases the probability of correct choice of the trajectory according to which they should change technologically to provide the expected result - sustainable innovation.

The most famous systematization of trajectories that takes into account sectoral peculiarities is presented by Pavitt (1984). Source of innovation, expressed through technology (see Table 1) as shown by the research of Pavitt (1984) varies depending on the sector in which the company operates. Pavitt (1984) identified four major technological sources in different industrial sectors. Later the fifth sector was added dealing with information technology.

Table1. *Five major technological trajectories*

	Supplier-dominated	Scale-intensive	Science-based	Information-intensive	Specialized suppliers
Typical core products	Agriculture; Services; Traditional manufacture;	Bulk materials; Consumer durables; Automobiles; Civil engineering;	Electronics; Chemicals;	Finance; Retailing; Publishing; Travel;	Machinery; Instruments; Software;
Main sources of technology	Suppliers; Production learning;	Production engineering; Production learning;	R&D; Basic research;	Software and systems departments	Design; Advanced users;

Source. *adopted from Tidd, (2005)*

Identification of sectoral diversity allowed Pavitt to offer the trajectories of strategic decisions providing innovations. The taxonomy of Pavitt (1984), was widely used in the empirical studies Cesaratto and Mangano (1993), De Marchi, Napolitano and Taccini (1996), and was used in the manuals of the company's proxy authentication and the attractiveness of the country as well (Malerba, 2005).

However, according to the research of Archibugi (2001) the presented innovative trajectories have certain drawbacks. Firstly, this classification was created based on the innovative firms though in the industries both innovative companies and those not using innovations are present.

Secondly, there are some limiting factors and one of them should be admitted: the fact that the trajectory and the source of innovations are determined in the light of industries and not companies. It is known that the companies belonging to the single sector or industry have a different technological provision despite the fact that they belong to the factually similar product group. Additionally Marsili and Verspagen (2001) noticed that the classification was not based on the consideration of the knowledge base of the firm. On the basis of the taxonomy of Pavitt, Marsili and Verspagen (2002) suggested using in the classification technological regimes described as an "intellectual framework" for interpreting the variety of innovative processes observed across the industrial sectors.

Mersili and Verspagen's (2002) classification distinguishes five regimes: 1) *science based*, associated with knowledge base in life science and physic science; 2) *fundamental processes*, associated with chemistry-based technologies, in chemicals and petroleum industries; 3) *complex (knowledge) system* regime presents a knowledge base that combines mechanical, electrical/electronic and transportation technologies; 4) *product-engineering* regime, which relies on mechanical engineering technologies 5) *continuous-processes* regime includes a variety of production activities such as metallurgical process industries - metals and building materials, chemical process industries – textiles and paper, food and tobacco.

Marsili and Verspagen (2002) note that their classification in comparison with Pavitt's taxonomy, distinguishes industries with a chemistry-knowledge (fundamental processes regime) base from those with a life-science knowledge base (pharmaceuticals in the science based regime). The typology of regimes was derived as a summary of the empirical evidence from a combination of data sources (patents, R&D statistics, scientific inputs, innovation surveys, and so on).

We should pay attention to the fact that the presented research while developing taxonomies are concentrated on the basis of separate companies. The research does not take into account the influence of integration and vertical integration in particular. In the framework of quickly developing globalization separate groups, alliances of multi-companies represent whole industries where technological trajectories are oriented not only at the industry but also they reflect development tendency inside the group. In this case while considering a separate industry we come across the open assumptions: 1) The activity of enterprises belonging to the same group is complex, they interweave among industries. The product produced by the companies can be not only one product but several. At the same time the production can represent different industries; 2) The size of the companies or their groups carrying out activity in the same industry vary in a very wide range.

These discrepancies make self-identification of the companies difficult, as the discrepancy of the technical and financial abilities between the companies inside of the industry causes different origin of determinants of innovations. The necessary competences and sources of innovation inherent to certain technical changes in the companies of the industry do not correspond to each other. In this case cultivation of the competences does not have an identified trajectory, thus the possibility of purposeful accumulation of the necessary knowledge and experience is excluded.

Without doubt the presented technological classifications of Pavitt (1984) and Marsili and Verspagen (2002) have contributed a lot to the determination of the technological trajectories of the industry. On the other hand, we have to admit that almost all classifications including the described above are mostly static and not dynamic (Archibugi, 2001). Due to growing technological intensity there appear companies and industries having different aggregate features of technological trajectories enveloping at once several industries. Consequently, in such cases technological change has its own unique aspect which has its own determinants of innovations.

3. INNOVATION PATH IN BIO ETHANOL INDUSTRY

Development of bioethanol industry in the EU was stimulated not with the appearance of new innovation product or process, but in the framework of biofuel directive adoption in 2003. Rapid development of the industry caused a number of peculiarities of this industry. Despite the fact that the product bioethanol produced by an enterprise is standardized and has registered quality, the status of the enterprises producing bioethanol is very diverse. The producers of bioethanol are companies or groups of companies that have very diverse profiles of activity. In the industry there both companies, which are specialized only on bioethanol production and agro-industrial groups representing several directions of activity at the same time, exist. Correspondingly, development of technological innovation of each of the companies is presented by different trajectories influenced by specific determinants of innovations having interconnections with different industries.

In the following chapters we shall identify the indicators reflecting technological determinants of innovations in bioethanol industry. Suggesting that the quantitative expression of the power of relationship between the variables and determinants of technological innovations reflects the ability of the companies to carry out technological innovations, we can explain the trajectory of technological changes of the companies and by following them the possibility of achieving of sustainable technological innovativeness in bioethanol industry increases.

4. METHODOLOGY

4.1. Technological Innovation Measurement

First of all, the variables must be measured in order to assess the degree in which the chosen variables influence the technological innovation. However, as noted by researches (Dodgson, et al., 2008, Smith, 2005) one of the greatest challenges to managing innovation is its measurement. According to Souitaris (2003) nowadays there is no such approach, which would allow measuring the innovation. Furthermore, there are known to be controversies about the correlation of variables and their relation to the rate of innovation (Downs & Mohr, 1976; Wolfe, 1994). Innovation is difficult to measure for a number of reasons. Dodgson, et al. (2008) points out the 4 main reasons: 1) some time is necessary for benefits appearing, 2) term of innovation, 3) some measurement systems measure inputs to the innovation, while others only measure outputs the benefits of an innovation often do not appear until sometime after its introduction, 4) ascertaining the source of an innovation may be complex.

This situation of emerging issues in the measurement of the determinants of innovation in the research described Souitaris (2003). The researcher argues that due to the difficulty in measuring the parameters of innovation we should pay attention to the factors that affect the discrepancy between the determinants of innovation and the degree of innovation, respectively. This situation can be subject to the origin, definition and measurement of innovation itself. In the studio, the researcher draws attention to items such as the differentiation of lineages innovation (differentiation by the nature of innovation) such incremental vs. radical innovation or high-cost vs. low-cost innovation. The author points out that the determinants for each of the presented types of innovations are different.

Another problem is being caused by the lack of a standard definition of technological innovation (Garcia & Calantone, 2002). The different definitions and interpretations of technological innovation have led to variations in the identified determinants. The problem is the definition of itself and the determinants of innovation. This refers to the two main types of determinants of innovation. Found that the components of the innovation of the first type, the measurement of which can produce using actual quantitative indicators is easily transportable (Souitaris, 2003). They fit together in various studios and measurement of the types of parameters is uncomplicated. For example, a standardized measurement of the value of companies through a quantitative indicator of existing staff in the company (Kimberly & Evanisko, 1981) can be attributed to that of the first type. By the second type is the data that is built on the perceptions and attitudes of the respondents. According to Souitaris (2003) and it is possible to carry such data such as perceptions of the intensity of competition or attitudes towards risk-taking, as well as general and usually subjective concepts (like centralization of power or complexity of knowledge). Although the data of the second type refers to the so -called soft variables type of their importance in determining the innovation capacity is not less important than the first type, the so -called hard variables. By the way, Souitaris (2003) also notes that the data of the second type - soft variables, often there is no unified definition. In this case, the definition is often subjective and depends's perceptions. This author also notes that the differences in the dimensions of technological innovation arise from the fact that the studies carried out between: a) different types of companies active in various sectors of economic activity, and b) the different stages of the innovation process, and c) in regions that produce empirical research.

Despite the above mentioned uncertainties in the measurements of innovation is still possible to identify the trend towards the use of certain conventional key variables with which it is possible to carry out the measurement of indicators on companies' ability to innovate.

According to Dodgson, et al. (2008) and Smith (2005) basic indicators when measuring innovation are R&D statistics, patent data, innovation surveys, and product announcements. This statement coincide with the choice of Pavitt (1984) in his research relies on patents, R&D statistics, scientific inputs, innovation surveys.

Tidd (2001) draws attention to the fact that other attributes are frequently measured also, such as research funding budgets, number of researchers, number of significant inventions, number of new products, amount of published research, etc. Nelson and Winter (1982) point such factors as increased productivity and growth or lower costs. Andrew et. al (2007) provide a range of common measures related to technological innovation. These include inputs such as financial resources and people; processes such as resource efficiency, actual versus planned time to market, and milestone compliance; and output measures such as number of new products and services launched, market share growth, new product success rates, number of patents filed, and publications written.

In the Carayannis, et al. (2003) publication is presented a rather wide scope of variables that are aimed to measure the innovation. Apart from identification of the variables, the publications also suggest the typology and classification of these variables.

According to Smith (2005), there are three other important classes of indicators:

1) techno metric indicators, which explore the technical performance characteristics of products
2) synthetic indicators developed for scoreboard purposes mainly by consultants
3) databases on specific topics developed as research tools by individuals or groups.

Table 2 presents the variables that measure the degree of company's innovativeness.

Table2. *The variables that measure the innovation*

Source	Variables	
Oslo manual, 1997	R&D, Performance, new and improved products and processes	
Souitaris, 2003	Number of incrementally innovative products introduced in the past 3 years; Number of radically innovative products introduced in the past 3 years; Number of innovative manufacturing processes introduced in the past 3 years; Percentage of current sales due to incrementally innovative products introduced in the past 3 years; Percentage of current sales due to radically innovative products introduced in the past 3 years; Expenditure for innovation in the past 3 years over current sales. Number of patents acquired in the past 3 years.	
E. G. Carayannis, et al. 2003	Hard measurables	Patents, R&D Budget, New Products, R&D Staff, Publications, R&D, Incentives, New Features, Inventions, New Markets, Product Extensions, Conferences, CRADAs, Partnerships
	Soft measurables	Productivity, Growth, Lower Costs, Flexibility, Supply/Demand, Firm Size, Market Influence, User Benefits, ,Lower Prices, Social Enablers, Time Savers
Dodgson, et al., 2008	R&D statistics, patent data, innovation surveys, product announcements	

Source. *By author, based on sources indicated in table*

As some authors of empirical researches often underestimate the complexity of innovation, it is reasonable to reconsider measuring innovation determinants only upon a certain variable.

The author of paper consider that possibility to materialize technological innovation is the company performance level leading to technological innovations and influenced by many interlinked internal and external variables forming company innovation ecosystem, which requires effective management. This fact forces cast the only definitive indicator of measurement. Instead, use of several indicators together, has filed a full measure of the ability of companies to be innovative. This assumption coincides with the assumption Souitaris (2003) on the feasibility of the use of certain portfolio of indicators to identify the general ability of companies to be innovative.

Taking into account the specifics of innovations in bioethanol industry, would be logical to take into consideration the variables that are typical for this industry and that indicate the opportunity to create innovations in comparison to other companies of the same industry. Further in the text there are given and explained the dependent and independent variables that are presented in this study.

4.2. Innovation Variables in Bio Ethanol Industry

The study covers all the bioethanol industry in Europe. The list of the companies producing bioethanol and the data concerning the production capacities in Europe were gathered from the database of an organization ePure (2012) and can be found in appendix I. The publication of the list of participants on which the study was based is dated January 2012. ePURE represents and supports companies that produce renewable ethanol in the EU for all end-uses, i.e. fuel, potable and industrial uses. ePURE also represents companies that have an interest in ethanol production. Currently, ePURE's membership accounts for 80% of the installed renewable ethanol production capacity in Europe. This information implies that the data presented in the databases of ePure is a reliable source.

This research is based on the quantitative data describing the following variables: declared production capacity of bioethanol in the world, quantity of plants in the EU belonging to each producer of bioethanol in the EU, quantity of plants in the world belonging to each producer of bioethanol in the EU, quantity of companies being a part of companies producing bioethanol in the EU, the general quantity of patents and quantity of patents belonging to class Y2E50/-00, -16,

-17 produced by all the companies participating in the research. More detailed variables are presented further in this article.

The suggested factors that are aimed at estimation of what percentage of the company's turnover is invested into R&D, does not seem to be applicable: a) Data is confidential; b) R&D, often, is a rather general field where, among those related to bioethanol, are researched very diverse technologies.

Other variables were eliminated as not appropriate for this study and not available because of data confidentiality or evaluated as not significant.

4.2.1. Patents

There are number of reasons why bioethanol industry cannot be evaluated by commonly accepted variables, which were mentioned above. For example, many authors suggest measuring the ability to produce innovations by the output of products for a certain period of time. However, in bioethanol industry, like in many other large-scale industries, competition mainly occurs on the scale of economy as a whole and is based on cost of leadership strategy. The novelty in this industry is improving or creating a new process, which allows reducing expenditure of operating costs or improving the quality of the collateral, or in some cases, by-products. That is why, it is more reasonable in bioethanol industry to measure the technological processes developed leading to the technological innovation.

Nevertheless, the speed of implementation of those technological processes is still a question. Bioethanol production process involves many interrelated technological processes. Trying to improve the process in the event of failure must stop the entire plant indefinitely. According to this, development and testing of new processes take a long time, because there have been cases where this turns company in a bankruptcy. Therefore, evaluating the number of the patents implemented in a certain period, would be a doubtful approach. The author of the study as the most reasonable, consider the approach for technological innovativeness measurement in bioethanol industry, where the number of the patents (variable is coded as *Patent* in results) would be measured regardless of the fact whether the patent is actively implemented already or not, the knowledge acquired during the period of invention phase can be efficiently applied in practice on later stage of technology development. At the same time the number of patents that belong to Y02E50/00 class - Technologies for the production of fuel of non-fossil origin (coded as *Patent_00*), according to Cooperative Patent Classification, as well as the patents that have direct relation to the bioethanol industry will be measured. In this case the research stipulates division to 2 additional groups: 1) the patents classified by group Y2E50/16 belonging to inventions connected with production of bioethanol from lignocellulose raw material (coded as *Patent_16*) and patents stipulating the use of convectional raw material – grain while producing bioethanol at classification number Y2E50/17 (coded as *Patent_17*). Garcia-Vega (2006) noticed that a higher technological diversity leads to more innovation. Distinguishing the patents is an important aspect, as the total number of patents shows all the ongoing activities of the company or group of companies, but the patents chosen according to the classification mentioned above will directly reflect the R&D activities in a particularly chosen industry's sector.

Grounding on the described above notes we can suppose that:

H1: *Ability of the companies to produce innovations in a certain industry has dependency on the general potential to innovate by the whole group of companies independently on the direction of activity of the companies that are included into the group.*

Since the patents are one of the main indicators determining innovation output (Kemp, et al., 2003), we can suppose that the strength of influence of other variables studied in this work on issue of patents will become an indicator pointing at the trajectory of origin of the innovations in the EU bioethanol industry. Data concerning the patents are gathered resorting to the database of European Patent Office.

4.2.2. Performance

This study also includes such term as company's performance expressed in production capacity (Coded as *Volume*). This figure is the expression of an almost linear dependence of the companies' turnover and thus this variable distinctly reflects company's innovation capabilities (Tidd, et al., 2005). Performance reflects summary quantity of bioethanol produced by the company and its group. Belonging of these companies to a certain group is explained in the chapter describing the variable – the quantity of the companies. We take into account all the production capacities of the companies or their groups irrespectively of their location. Supposing that the number of production capacities of bioethanol production reflects the potential of innovations creation in a certain sphere of activity, we can state that:

H2: *The production capacity in bioethanol industry influences the issuing of patents.*

4.2.3. Competence

In the research there was introduced the variable reflecting the number of plants units belonging to companies or their group. This variable reflects technical competence in bioethanol industry. We can assume that each plant has its own technical parameters the exploitation of which requires certain competencies and knowledge, which are accumulated together with the increase of quantity of the units produced as each of them has their peculiarities. For example, in Brazil the source of raw material is sugar cane, and in Europe raw material is grain cultures as well as sugar beet. Correspondingly, sharing of experience and knowledge which takes place at the existing differences between technical and organization parameters stimulate the growth of competencies, which in the end influences the ability to improve or to produce a new process/product. Thus, we state that:

H3: *the number of production units with a separate location having an identical profile of activity increases the innovative ability of the companies.*

4.3. Quantity of Companies

The number of companies comprising the alliance or other structure forming the company indicates relative diversification available within the group. We can suppose that together with the growing number of companies the spectrum of knowledge and experience increases. The industries where the researched companies are active are not identified as the spectrum of actions of the companies belonging to the consolidation of companies is so diverse that relying on the preliminary analysis it became obvious that the selection of activities would not have statistic significance. This variable reflects the general quantity of companies comprising the group, alliance or other structural division uniting the companies. Since the participation of the companies has different percentage share of participation in business, entrance into its composition is possible only in case when the share of participation of parent company or its influence through the daughter company makes up 50% and higher on all levels. If the daughter company belongs to a company or companies share of which makes up 50% and higher the number of companies was summarized. This assortment was taken from the assumption that share participation lower than 50% does not give the full-fledged right as to the managing of the activity of the company, correspondingly the knowledge and competences may be spread without participation and control of a minor share-holder. In this way we grouped all the 35 producers of bioethanol active in the EU. The general quantity of the researched companies, taking into accounts all the described above, made up 645.

Descriptive statistics of the researched variables is present in table 3.

Table3. *Descriptive statistics*

Variables	Range	Min	Max	Mean	SE	SD
Capacity Total	3094.6	5.4	3100.0	329.1	111.0	656.8
Plant numbers EU	7.0	1.0	8.0	1.9	0.3	1.7
Plant numbers World	14.0	1.0	15.0	2.5	0.6	3.5
Companies Number	122.0	1.0	123.0	18.4	4.9	29.1
Patent Total	3539.0	0.0	3539.0	191.7	113.7	673.0
Patent class Y2E50	32.0	0.0	32.0	2.5	1.1	6.4
Patent class Y02E50/16	11.0	0.0	11.0	1.0	0.5	2.8
Patent class Y02e50/17	16.0	0.0	16.0	1.1	0.5	2.9

Source. *By author, 2014*

To determine the active interconnections between the determined above variables the analysis of correlation coefficients was used. The interpretation of the received results is presented in the next chapter.

5. Results

The data reflecting the volume of interconnections between the determined by us variables presented above are shown in table 4.

Table4. *Correlation coefficients of variables in analyses*

	Variables	1	2	3	4	5	6	7	8
1	Capacity Total	-							
2	Plant numbers EU	.711**	-						
3	Plant numbers World	.917**	.887**	-					
4	Companies Number	.902**	.711**	.903**	-				
5	Patent Total	.386*	.024	.251	.354*	-			
6	Patent class Y2E50	.487**	.144	.389*	.434**	.766**	-		
7	Patent class Y02E50/16	.332	.151	.266	.300	.155	.688**	-	
8	Patent class Y02e50/17	.427*	.152	.373*	.398*	.805**	.958**	.507**	-

Source. *By author, 2014*

***Correlation is significant at the 0.01 level (2-tailed)*

**Correlation is significant at the 0.05 level (2-tailed)*

The interconnection was determined between all the patents independently of their belonging to a certain classification (hereinafter All the Patents) and the patents getting into the classification Y02E50/17 describing the patents produced of grain (hereinafter Patents Class 17) has a meaningful correlation coefficient 0.805. Coming back to the first stated by us hypothesis we can affirm that this result indicates that the ability of a company to generate patents in a certain fields strongly depends on the general quantity of patents produced. It is obvious that the companies which have accumulated considerable quantity of knowledge, despite the fact that accompany others independent of each other sectors of activities, having knowledge easier transform it into different knowledge in other fields. Naturally this phenomenon is observed in companies comprising big groups, such as Cargill, Roquette or Dong Energy, having a large portfolio of patents of different profiles.

According to the research the relationship between the production volumes and patents in the field of production of grain bioethanol is reflected by a correlation coefficient, which equals to 0.427 at $p<0,05$. Although this relationship corresponds to the statement that the size of the company is one of the determinants of bioethanol industry innovations, this category does not influence that much the output of innovations.

Several reasons can be connected with this phenomenon. Firstly, not all companies working in the bioethanol industry concentrate their technological line on innovative production. Some of the representatives of bioethanol industry concentrate their attention not at the development of technological processes ensuring the best conversion of raw material, but at the raw material production, in this case the cereals. This tendency is observed in large agro-industrial groups, for example such as Cristal Union, one of the biggest producers of bioethanol in Europe. In such cases the technologies of production are bought from the suppliers of equipment. The trajectory of developments is concentrated not on the technological change of companies but on the acquiring cheaper raw material source. Consequently, the output of innovations is absent. Secondly, some of bioethanol producers concentrate their developments on the production processes on the production of bioethanol of the second generation, such as Inbicon. Since the technologies of the production of the second generation bioethanol have not been completely commercialized but are at the stage of development, the production capacities of such plants are respectively poor. On the other hand, the new generation of production is always connected with scientific inventions and developments. This phenomenon causes the situations when small capacities are connected with the big number of inventions. Such situation strongly contributes to decreasing of the value of relationships between the variables discussed. Consequently, our second hypothesis, supposing that there exist the relationships between the capacity of the plant and the output of innovations in the form of patents, is confirmed only partially.

The supposition that together with the growing number of production units the output of innovations is stimulated was not confirmed by this study. The correlation coefficient between these variables is insignificant. Such insignificant influence has similar trajectory of circumstances as well as in case of relationship between the output of technological innovations and the size of production capacities. As it turned out some companies having only one production unit, such as Roquette or Dong Energy for instance, are more productive in the sphere of innovations than the companies having among their assets several units of bioethanol. Consequently, the statement of the third hypothesis in the present form is to be considered as having no significance.

6. DISCUSSIONS

The main studied question of this article is to figure out the trajectory of technological way of the company contributing to acquiring of technological advantage in bioethanol industry of the EU, with taking into account of integrations. By this study we were determining three set input determinants of innovations – accumulated summary potential inside the whole group to generate knowledge, the size of production, and quantity of separate production units. If previously the research (Pavitt 1984, Marilisi and Verspagen 2002) in the field of sectoral technical trajectories showed clearly designated limits with the available sources of innovations corresponding to the industry of sectoral development, the current research points out that the main source of innovation independently on the profile of the whole group of companies is the accumulated aggregate scientific basis. Neither the specialization nor the competence of an enterprise, nor the size of the company has such strong influence on innovative ability of the company as the created/available certain inside the group resources contributing to the production of innovations. As an example we can mention such companies as Roquette and Dong Energy having in their assets only one production unit, but generating more interim products of innovation than large companies specializing in the sphere of bioethanol.

It is important to underline the fact that the similarity as to the activity of the companies inside the group is not an important factor stimulating production of patents in bioethanol industry. A more important factor here is the general critical mass of innovation output which is transmitted to a certain, in this case - bioethanol industry. Thus we can state that belonging to a certain industry is not a determinant predictor while choosing and determining of the innovative strategy of companies. If in generally acceptable known technological trajectories the strategy has well-known features/framework, in bioethanol industry innovating companies follow different technological trajectories. If the general direction of the group of companies, which is comprised by a bioethanol company, sticks to the strategies that are concentrated on growing of cereals and the production of bioethanol is only a means of utilization of raw material with added value, then the innovative strategy of the enterprise has the signs characteristic for technical trajectories of agricultural sector. In cases when companies are specialized in technologies of lignocellulose materials, sectoral signs of science based industries are typical for them.

On the basis of the information received in this study we can state that the technological trajectory of innovating companies does not depend on a certain sector, but has only certain characteristic signs. The technical trajectory of innovating companies is built with a deep orientation at the general corporate innovative policy of the companies. This concerns those companies that are innovative and that have innovation output. Here we should state that the innovative companies have their own technical trajectory which in higher degree depends on cumulative *technical background* than on industrial characteristics. Having a unique complex of worked out inner procedures and resources contributing to accumulation and transformation of knowledge inside the companies allows creating their own unique trajectories contributing to technical transformation of innovative companies. With the help of the study conducted we can make sure that each industry has their own differences, thus we should not follow one of the five generally accepted technological trajectories without deep analysis of industrial differences. Although the carried out analysis gives us the right to underline the importance of technical basis of the companies at certain technical changes with the help of innovations, to confirm the assumptions arisen from this study we should conduct identical research in other industries and sectors.

REFERENCES

Andrew, J. P., Sirkin, H. L., Haanaes, K. & C, M. D., 2007. Innovation 2007: A BCG Senior Management Survey, Boston: Boston Consulting Group.

Archibugi, D., 2001. Pavitt'S Taxonomy Sixteen Years On: A Review Article. Economics of Innovation and New Technology, 10(5), pp. 415-425.

Carayannis, E. G., Gonzalez, E. & Wetter, J., 2003. The Nature and Dynamics of Discontinuous and Disruptive Innovations from a Learning and Knowledge Management Perspective. In: L. R. Shavinina, ed. The International Handbook on Innovation. s.l.:Elsevier Science Ltd., pp. 115-138.

Cesaratto, S. & Mangano, S., 1993. Technological Profiles And Economic Performance In The Italian Manufacturing Sector. Economics of Innovation and New Technology, 2(3), pp. 237-256.

Chiesa, V., 2001. R&D strategy and organisation. Managing Technical Change in Dynamic Contexts. London: Imperial college press.

De Marchi, M., Napolitano, G. & Taccini, P., 1996. Testing a model of technological trajectories. Research Policy, 25(1), pp. 13-23.

Dodgson, M., Gann, D. & Salter, A., 2008. The Management of Technological Innovation: Strategy and Practice. New York: Oxford University Press Inc..

Downs, G. W. & Mohr, L. B. J., 1976. Conceptual issues in the study of innovation.. Administrative Science Quarterly, Volume 21, pp. 700-714.

ePure, 2012. [Online] Available at: http://epure.org/statistics/info/Productioncapacityinstalled [Accessed 23 01 2012].

Freeman, C., 1982. The Economics of Industrial Innovation. London: Pinter.

Garcia, R. & Calantone, R., 2002. A critical look at technological innovation typology and innovativeness terminology: a literature review. The Journal of Product Innovation Management, Volume 19, pp. 110-132.

Garcia-Vega, M., 2006. Does technological diversification promote innovation?: An empirical analysis for European firms. Research Policy, 35(2), pp. 230-246.

Kemp, R. G. M., Folkeringa, M., de Jong, J. P. J. & Wubben, E. F. M., 2003. Innovation and firm performance. Research Report H200207, Zoetermeer: SCALES.

Kimberly, J. R. & Evanisko, M. J., 1981. Organisational innovation: The influence of individual, organisational and contextual factors of hospital adoption of technological and administrative innovations. Academy of Management Journal, 24(4), pp. 689-713.

Malerba, F., 2005. Sectoral Systems. How and why innovation differs across sectors. In: The oxford handbook of innovation. New York: Oxford University Press Inc., pp. 380-406.

Marsili, O. & Verspagen, B., 2001. Technological Regimes and Innovation: Looking for Regularities in Dutch Manufacturing.[Online] Available at: http://www.druid.dk/conferences/nw/paper1/MarsiliVerspagen.pdf s[Accessed 10 08 2014].

Marsili, O. & Verspagen, B., 2002. Technology and the dynamics of industrial structures: An empirical mapping of Dutch manufacturing. Industrial and corporate change, 11(4), pp. 791-815.

Nelson, R. & Winter, S. G., 1982. An Evolutionary Theory of Economic Change. Cambridge: The Belknap Press of Harvard University Press.

Pavitt, K., 1984. Sectoral Patterns of Technical Change: Towards a Taxonomy and the Theory. Research Policy, Issue 13, pp. 343-373.

Shapiro, C. & Varian, H., 1998. Information Rules: A Strategic Guide to the Network Economy. Boston, MA: Harvard Business School Press.

Smith, K., 2005. Measuring Innovation. In: J. Fagerberg, D. Mowery & R. R. Nelson, eds. The Oxford handbook of Innovation. New York: Oxford University Press Inc., pp. 148-177.

Souitaris, V., 2003. Determinants of Technological Innovation:Current Research Trends and Future Prospects. In: L. V. Shavinina, ed. The International Handbook on Innovation. s.l.:Elsevier Science Ltd., pp. 513-528.

Tidd, J., 2001. Innovation management in context: Environment organizational and performance. SPRU Science and Technology Policy Research, Volume Working paper no. 55.

Tidd, J., Bessant, J. & Pavitt, K., 2005. Managing Innovation: Integrating Technological, Market ad Organizational Change. Haddington: John Wiley & Sons.

Wolfe, R. A., 1994. Organisational innovation: Review, critique and suggested research directions. Journal of Management Studies, 31(3), p. 405–431.
Zaltman, G., Duncan, R. & Holbek, J., 1973. Innovations and organizations. New York: John Wiley.

Appendix1. *List of companies' producing bioethanol in EU with belonging production units and number of integrated companies; un., un., 2014.*

Nr.	Company group	Bioethanol plant, un.	Number of integrated companies, un.	Nr.	Company group	Bioethanol plant, un.	Number of integrated companies, un.
1	Abengoa	15	123	19	Interagro	1	26
2	ABF	1	40	20	Jaunpagasts Plus	2	1
3	Acciona group	1	6	21	Komers International	1	2
4	Agrana	1	14	22	KWST	5	5
5	Alcobiofuel	1	1	23	Lantmännen	1	15
6	AWW	2	1	24	Marex	1	1
7	Bertolino Group	1	3	25	MG Baltic	1	12
8	Bioethanol AEG	1	1	26	Mullermilch	1	23
9	Carberry	1	1	27	Nordzucker	1	22
10	Cargill	8	69	28	PLP	1	1
11	Caviro	1	10	29	Roquette	1	30
12	Cristal union	4	39	30	Sekab	2	8
13	Destylacje Polskie	1	1	31	St1	4	10
14	Dong Energy	1	18	32	Suedzucker	5	31
15	Enviral	1	2	33	Tereos	15	113
16	ESP Chemies	1	1	34	Verbio AG	2	11
17	Ethanol Energy	1	1	35	Viva Agroteks	1	2
18	Hungrana	1	1				

Source: *adopted from ePure, 2012. Companies - N prior, Sobieski, Danisco, Euroethyl excluded from the list due to the discontinued operations, or lack of data.*