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TECHNOLOGICAL CHANGE IN A SMALL EUROPEAN COUNTRY: A PATENT- BASED ANALYSIS FOR GREECE

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─Abstract ─

The description of the development of the Greek technological change is the main aim of this paper. The analysis is based on the examination and elaboration of patent records and relies on the study of their technological content and their economic direction. Results show that technological change focuses on producing new technologies for the 'agricultural sector', 'food', 'pharmaceuticals', 'metal shaping-separation', 'rubber-plastic products', 'building-housing', 'instruments' and 'electricity'. These technological fields are related to the economic activities of 'food-beverages', 'chemicals', 'rubber-plastics' and 'metal products', 'machinery-equipment', and 'electronic-communication equipment'. Results also show that technological change follows two different but clear patterns. Based on the first pattern, technological change is directed to new economic sub- activities but inside the existing firm's production lines. Most firms of 'food-beverages', 'chemicals' and 'electrical machinery-equipment' are characterized by this pattern. Based on the second pattern, technological change is directed to new economic activities, outside the firm's production lines. Half firms of 'machinery-equipment' as well as several persistent Greek firm innovators follow this pattern. Results may have important implications for public innovation policy regarding targets, tools and particularly measures.

Key Words: *Greece, New technology, Patents, Technological change,*

JEL Classification: *O31, 033, 034, 052*

1. INTRODUCTION

Nowadays, there is a wide agreement on the importance of technological change and its contribution in economic growth and development. Whether interpreted as endogenous or exogenous and related to the process of knowledge creation, while being derived from the internal part of economy and society (classical theory), or as the result of continuous interactions and feedbacks among the different socioeconomic institutional agents (institutional-evolutionary theory), technological change is of central economic importance, leading both economy and society to a higher level of real product. This means that technological change, defined as a process of introduction and adoption of new processes and products, leads to an increase in productivity, which ends up to first product growth and finally to economic-social prosperity. Therefore technological change is a factor that makes the difference, leading to a new way of organization at political, economic and social level.

However, it is very difficult to understand and interpret technological change. Technological change relies on the progress of both science and technology, which inherently implies the central involvement of research (R&D). Therefore, a basic process and activity of technological change, is research (R&D). Consequently, technological change is only examined and described through R&D activities and more specific through the results of these activities. These results may have a quantitative or a qualitative form and content. However, there is one main problem with these results: They can't be measured by usual and traditional techniques of performance indicators. That's why empirical research suggests that it's better to measure the effects or outcomes of R&D activities, and this can only be done based on relative indicators. Empirical research so far has used such indicators, which can be grouped into two main categories and specifically to input or resources indicators and output or product indicators. Among input or resources indicators, those of expenditures for R&D, R&D personnel, fees and licensees are the most common used. On the contrary, the most important indicators of output or product are those of patent and publications indicators (OECD,2005). Patent indicators express the results of applied research and experimental development. They are the main result or product of R&D activities that are executed inside and outside firms.

This paper studies technological change in Greece through patent indicators. Results could be integrated into a wider discussion on developing a new innovation policy, promoting new forms of entrepreneurship and financing innovative actions towards that direction in Greece. The rest of this paper is structured as follows: Section two presents a literature review on the description and measurement of technological change based on patent data. Section three deals with some methodological issues and describes the data used for this paper. Section four analyzes the main trends of technological change in Greece, as these have been extracted from Greek patents. Section five presents some concluding remarks, while synthesizing and further discussing the main results.

2. LITERATURE REVIEW

Patent records have been used for the study and description of technological change in Greece. Empirical research has extensively explored patents, taking advantage of their important advantages. However, empirical research has also highlighted their limitations. In relation to their advantages, patents are linked to both inventions and innovations. Patents have a close (if not perfect) link to inventions (OECD,2009). Patents cover a broad range of techniques, extending now to biotechnology and software, with first extensions towards services-related inventions (so-called "business methods") (OECD,2005). Patents enable researchers to study different features of the innovative process. Some major research directions examined through patents, are those of the level of inventive activity (Griliches,1990; Lanjouw and Mody,1996; Cohen et al.,2000) and of the different types of innovation and technological competencies of organizations (Breschi et al,2003). Others, such as Marinova and McAleer (2003) focused on the technology strengths of nations, while one of the most ambitious research fields is perhaps the field that examines the emerging patterns of technology diffusion, knowledge relatedness and spillovers (Scherer,1982; Jaffe,1989; Engelsman and Van Raan,1994; Verspagen,2005).

However, patents also present strong weaknesses. Patents do not capture all innovations, but a restricted part of it. As a matter of fact, some innovations are not patentable (Levin et al.,1987) and, even when they are, patents are not considered by firms to be the most efficient way of protecting and of appropriating innovations (Crepon et al,2000). Moreover, firms are more likely to patent research that results in new products, rather than research that results in new processes. This means that patent data correspond to a biased sample of innovations since they only include technological innovations and tend to overestimate product innovations (Popp,2005). In addition, the rate at which new innovations are patented varies across industries, countries and patent offices, meaning that the propensity to patent differs. These significant differences, as Pavitt (1984) and Malerba and Orsenigo (1996) mention, are linked to both the types of innovations and the characteristics of technological regimes in terms of knowledge bases, cumulativeness of innovation and technological opportunities. The last weakness is the issue of their value, which depends on their contribution to the economy, in technological or in economic terms. There are patents of high value and those of very low value. However, patent offices don't discriminate among them and patents are usually treated equally, which could be a problem, as Guellec and van de la Potterie argue (2000).

3. METHODOLOGY AND DATA

Greek patent data has been used for the study of technological change. This means that the main data source is the Greek patent office and the main unit of analysis is the patent document. For methodology reasons it has been decided to first collect patent documents from the establishment of the respective organization (1988), second work with patent grants instead of simple applications and third focus on Greek firm patents instead of examining all firm patents. Therefore, this paper exploits first an initial patent database, which contains all patents that were granted in Greece during the period 1988-2010. Based on this data a second patent database has been constructed and elaborated, which contains Greek firm patents.

The analysis is based on the elaboration of the patent codes of each Greek firm, according to the structure and the rationale of the international technology classification (IPC). Five technological levels have been identified (sector, sub-sector, class, subclass and main group) for each patent code. The description of technological change is based on the examination of the technological and economic content of patents according to the IPC, which classifies patents according to their technological content into one or more of the 8 technology sectors, 20 sub-sectors, 118 classes, 623 sub-classes and more than 2200 main groups. The sample comprises of 1490 codes of Greek firm patents. One or more codes can be assigned to each patent. These 1490 codes are all codes, which have been assigned to each patent and not just first or main codes. The examination of all patent codes adds to the analysis more detail and reliability, as it contributes to the analysis of the complete technological content, also considering all possible technological directions and economic uses and all interconnections between different technologies.

In addition, technological change is further studied through the examination of three indicators, which have been constructed especially for this paper and aim at better describing the Greek technological change, at least qualitatively. The first indicator examines the coincidence between production and technology activities, when the latter are interpreted as production activities. The second investigates whether new technologies are placed inside or outside the main and total (main and secondary) production line. The third focuses on the economic direction of the recorded 'real new technology', which is a completely new term being introduced especially for this paper and further defined below. Regarding the first indicator, the 4-digit codes of production origin (based on each firm production) and technology- economic direction (based on each firm technology) are compared. The main argument behind this indicator is the following: Greek firms may or may not have developed patents placed along their main or their total production line. Therefore, the production origin of firms should be related more or less, or even should coincide, with the technology-economic direction of patents. The quantitative expression takes the form of a percentage for each firm based on its total patent activity. Two such percentages are presented, one for the main production and technology activities and a second for the respective total.

Regarding the second indicator, it is obviously related to the first in the sense that if there is coincidence between firm production and technology activities, then new technology is placed inside the production line. Six percentages for each firm have been calculated. According to results new technology could involve new economic activities at 2-digit level (new branch), 3-digit (same branch, new 3-digit activities) or 4-digit (same branch, new 4-digit activities). Regarding the third indicator, the 'real new technology' is defined as technology, placed only outside the firm's production line. New technology can be placed inside or outside the firm's production line, but 'real new technology' is only placed outside. The criterion used in order to sketch the economic direction of the above 'real new technology' is entirely qualitative and it further discriminates between 'total' and 'dominant' real new technology. The first indicates the presence of 'real new technology', while the second highlights its concentration. For instance if a firm has developed patents, of which the 75% is directed in 'machinery-equipment', being further specialized in 'agricultural machinery', then new technology is concentrated in this activity. However, as the main firm economic activity is the 'manufacture of metal products', this new technology is actually 'real new technology', which is placed outside the firm's production line. Based on this process for each firm, technological change can be better described, while aggregating further results at branch and sectoral level could be then extracted.

4. MAIN RESULTS

The analysis shows that technological change is widely dispersed into the eight technology sectors. However, eight main trends can be recorded: First 'horticulture and cultivations', second 'food', third 'preparations for medical or other purposes', four 'mechanical metal-working', five 'transporting', six 'building', seven 'instruments' and eight 'electricity'. The above main trends are related to the following economic activities: Pattern one leads to agricultural sector's activities, but based on the respective patent codes, a final link to 'agricultural and forestry machinery' is recorded. Pattern two leads to 'food-beverages', which is further specialized to the 'production of meat, poultry meat products, bread and related products'. Pattern three leads to 'pharmaceutical preparations, household and sanitary goods and toilet requisites'. Pattern five leads to 'rubber-plastic products', while pattern six leads to both 'basic metals' and 'metal products' (e.g. aluminium production, metal structures and parts of structures, builders' carpentry and joinery of metal, locks and hinges). Pattern seven leads to 'optical instruments'. Finally, the pattern of patents related to electricity is clear: they are all directly related to the 'electric distribution, control, wire and cable'.

Generally the coincidence between the production and technology activities at 4-digit level is small and accounts for 18.70% based on the main production and technology activities and 27.72% based on the respective total (mean values). Obviously for non-industrial firms the above coincidence is zero, while for the whole manufacturing sector is higher (27.56%). Absolute deviation (non-coincidence) between the main production and technology activities at 4-digit level is recorded in 'textiles', 'wood and products from wood' and 'other transport equipment'. On the contrary absolute coincidence is recorded in 'leather and related products' and 'measuring, testing, navigating and control equipment; watches and clocks'.

At branch level, firms in 'chemicals' as well as those of 'electronic-communication equipment' are separated between those developing new technologies inside the production line and those developing outside, as half new technology is placed along the 'main' and 'total' production activities. The indicator of coincidence account for nearly 35% for firms activated in 'non-metallic mineral products', 'metal products', 'machinery-equipment' and 'electrical machinery-apparatus'. Finally, firms in 'food-beverages', 'paper' and 'other manufacturing' exhibit very low levels of coincidence between the production and technology activities at 4-digit level. Focusing on firms that have mainly developed new technologies outside production, there are firms in branches mainly associated with new activities at 2-digit level ('basic metals', 'textiles', 'wood and products from wood', 'other transport equipment' and 'other manufacturing') or new sub-activities at 3- and 4- digit level, but along the production line ('food-beverages', 'non-metallic mineral products' and 'machinery-equipment'). In the remaining branches, the relatively new technologies are related to new 3- and 4-digit economic sub-activities. The firms of 'chemicals', 'plastic-rubber products', 'metal products' and 'electrical machinery-apparatus' are characterized by this behavior.

Last but not least, and assessing between the two kinds of technological change ('total' vs. 'dominant real new technology'), it seems that regarding the first kind, the 'real new technology' is directed either to a new economic branch, either to one or more new activities at 3- and 4-digit. There isn't any dominant pattern and the only safe derived conclusion is that most Greek firms with many patents are related to one or more new 3-digit activities, inside however their production line. In relation to the second kind of technological change, Greek firms are almost divided among two different but clear trends. According to the first trend, technological change leads to new economic activities, inside however production. Most firms in 'food-beverages', 'chemicals' and 'electrical machinery-apparatus' are characterized by this trend and pattern of behavior. Based on the second trend, technological change leads to new economic activities, outside however production. Half of firms in 'machinery-equipment' and most persistent firm innovators are characterized by this trend and pattern of behavior.

A further and deeper reading of the recorded technological change in Greece reveals some very interesting facts: Technological change is characterized by its traditional orientation, as a large part of new technology is related to the 'construction industry' and the 'agricultural sector'. Even technologies which seem to be more technologically advanced, such as those of 'instruments' and 'electricity', have a traditional nature if their technological content is further examined. Regarding the rest important new technologies, such as those of 'food', 'lighting' and the three patterns related to 'performing operations' (e.g. separation, mixing and transporting), these new technologies are the result of R&D activities entirely related to some persistent firm innovators in Greece. In fact each of these patterns may be nearly associated with the R&D activities of a single Greek persistent firm. Last but not least, there is also pattern three (preparations for medical, dental or toilet purposes). It can be argued that this is a completely different case as its patents mainly focus on 'pharmaceuticals', which are usually protected by this means of protection.

5. CONCLUSIONS

This paper examines technological change in Greece, based on the technological and economic content of patents, which have been developed during the period 1988-2010. Results show that technological change focuses on new technologies related to 'horticulture and cultivations', 'food', 'medical or other preparations', 'mechanical metal-working', 'transporting', 'building', 'instruments' and 'electricity'. Therefore, results show and confirm a dispersed landscape for technological change, but traditional enough in nature, origin and orientation. In fact there is strong interrelation between production, as expressed by the activities of Greek firms, and technological development, as represented by patents. Technological change and production activities move in parallel, with few 'old' and traditional industries playing a very important role.

Results may have important implications for public innovation policy regarding targets, tools and particularly measures. The Greek government has used several and different measures to promote technological change and innovation production since the 1980s. It is common belief that funding and assisting technological change through R&D activities is more likely to create persistent effects in the long term. The further provision of fiscal subsidies is rather useless, as their results are static, short-term and unlikely to change routines and accumulate knowledge. If a favorable industrial environment is the issue for Greece, and there is an unanimous agreement on this, then there is a need to focus on technological change, as behind it elements of path-dependence, innovation patterns and industrial dynamics are hidden, all necessary for building a sustained national growth and success. This paper is a first research effort to study and measure technological change in Greece. Obviously more research has to be done, in the direction of investigating its determinants and indicating its results on both Greek firms and the entire economy. Empirical research has identified so far many factors that encourage and promote technological change. Future research could be directed to this kind of analysis and next papers could show the first results.

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