

## FOOD CHEMISTRY PATENTS INFLUENCE ON PRODUCTIVITY: A CASE STUDY OF A SECTORAL APPROACH IN VARIOUS OECD COUNTRIES

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**Abstract:** The effects of Intellectual Property Rights (IPRs) is one of the economic mysteries of the current literature. However, at sectoral-level, it has still failed to provide any obvious empirical evidence regarding any direct link between patents and productivity. The chief contribution of this research paper is to provide empirical evidence on how chemistry patents relate to productivity growth in the case of a low-tech intensive industry (Food, Beverage and Tobacco). In order to support both the theoretical and empirical findings of the literature a dynamic regression model is tested and found a valid representation of the negative relationship between food chemistry patents granted and productivity growth in the long run. Subsequently, some conclusions and policy implications are suggested in order to support the enhanced productivity growth performance of these food industries, highlighting the importance of changes in current property protection systems

**Key words:** sectoral approach, patents, labor productivity

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### Introduction

The main objective of intellectual property rights (IPRs) is to stimulate innovation by enabling inventors to appropriate the returns on their investments. The changing economic background of innovation, the globalization tendencies of markets, and the fragmentation of sectoral production are changing the way actors utilize and understand the role of properties. The slow and steadily growth in agricultural productivity allowed for a sustained decrease in real agricultural commodity prices, and contributing to a decreasing share of food in the overall consumer expenses. In this context, the systems in which these rights operate vary from those of previous decades and are continuously changing, in order to optimize their benefits so as to contribute to enhanced productivity growth (OECD, 2013).

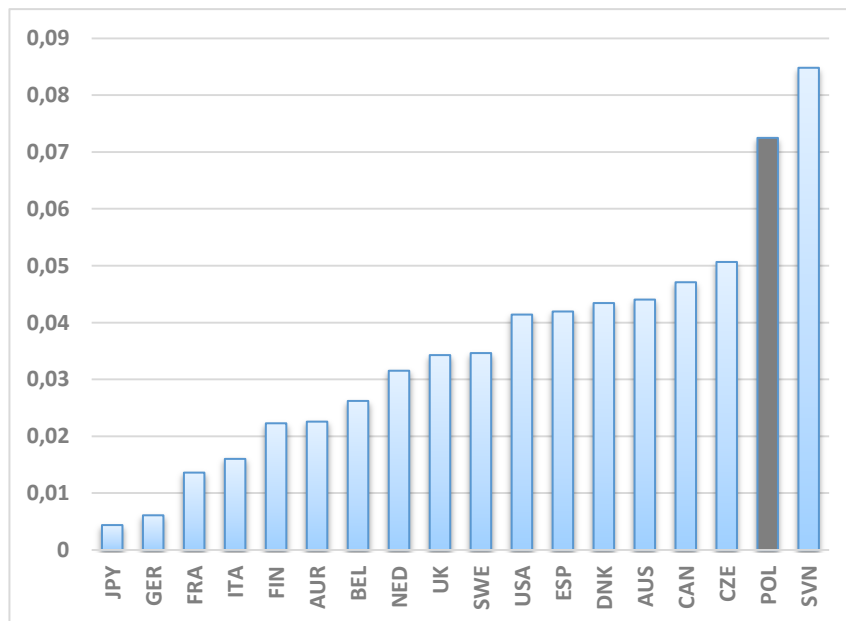
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Earlier, Wijnands et al. (2008) calculated the growth of labour productivity in the food industries in a sample of (18) OECD countries, and indicated that Brazil had the lowest, and the USA had the highest indicator. Thus, there are correspondences in time patterns in ‘traditional’ non-ICT (Information and Communications Technology) industries, such as food, drink and tobacco, leather, fabricated metals and hotels, and other services with declining productivity growth rates over time in both regions (Ark et al., 2008).



**Figure 1. The average productivity growth (%) in Food, Beverage and Tobacco industries between 1995-2014 in various OECD countries (Jäger, 2016)**

There are also country-specific sectoral differences in the sources of changes in productivity (Figure 1). This is one of the possible reasons, why economies with higher incomes are better suited to expand coverage and maintain a relatively greater capacity to innovate in more differentiated level of inventions. From this perspective, the relevant legal authorities accommodate an increasing demand for patent protection in the growing number of fields or industrial sectors. The increasing number of countries with memberships of international agreements and enforcement mechanisms are key sources of change in patent rights, while increases in duration are a limited source of enhanced productivity (Park, 2008).

Given this, researchers are commonly interested in examining the impacts of these IPRs on productivity. Consequently, the rest of this paper is structured as follows. In the following sections, we will briefly describe the theoretical background and the datasets with the methods applied to determine the main features of the relationship between output per capita growth and patents in the case of Food,

Beverage and Tobacco industries. Because of the lack of measurement data relating to patents, hardly any clear evidence has been presented in the literature. Our research questions focus directly on how patents are related to productivity. The results of dynamic regression models, based on an augmented Cobb-Douglas production function with (cross-country and industry specific) panel data from various OECD countries, will be able to demonstrate the effect of food chemistry patents on productivity growth in the long run in a sectoral approach (Pham, 2017). At the end of this paper, conclusions and policy implications are suggested in order to support enhanced productivity growth performance in these food industries, highlighting the importance of changes in current property protection systems.

### **The Background to Patents and Productivity Relations in a Sectoral Approach**

One of the major mysteries of new manufacturing processes in modern economic history was the industrial revolution, which began in the period from about 1760 and caused relatively rapid and sustainable economic growth to spread from Britain around the world. A. Smith, exploring the primary sources of persistent economic development, highlighted the protection of intellectual properties to facilitate trade and innovation (Smith and Haakonssen, 2002). The concept of intellectual property rights benefited inventors by preventing the unrestricted copying of inventions, and stimulated the birth of new ideas and inventions (Jones, 2000). Caselli (1999) also defined technology as a combination of machines and equipment of a certain type and their skilled operators. The New Institutional Economics perspective distinguished such institutions as formal rules (created by entities such as the government and public services) and informal constraints (customs, beliefs or behaviour patterns), which affect economic, social and political relations North (1991). However, there is no consensus in the literature regarding the direct channels through which these IPRs affect innovation mechanisms. Sectoral analysis attempts to account for why various industries exploit different levels of technology and employ different levels of skilled labour. A patent is a script, issued by a government or regional office, which describes an invention and creates a legal condition in which the patent can only be exploited with the authorization of the owner of the patent. An invention may relate to a product or a process, and the protection conferred by the patent is limited in time. Patents are frequently referred to as 'monopolies', but they do not give the inventor the exclusive right to make, use or sell the patented article (Ngaini et al., 2014).

Moreover, the use of patents varies heavily across industries, and the introduction of patent laws may alter the direction of technical changes, as patent laws raise the productivity of inventions in industries that depend on them, relative to other industries (Moser, 2007). There are too few observations to compare patenting rates broadly across industries and confirm that machinery innovations have been more frequently patented, while chemicals, food processing, textiles, and scientific instruments have been patented less frequently. The industries in which patents are

a more important means of protecting innovations are more responsive to any strengthening of protection. For instance, the pharmaceutical industry, which depends extensively on patents to defend its branded knowledge, should exhibit a higher rate of growth in response to stronger patent protection than the food and beverage industries, where patents are less essential in adopting the returns from innovations (Hu and Png, 2013). However, at sector-level, there is still a lack of any obvious empirical evidence regarding the link between patents and productivity. This lack of any relationship is consistent with Boldrin and Levine's (2013) view on the use of patents, either as a defensive, or as a rent-seeking instrument. Concentrating on various manufacturing industries in the OECD countries, both productivity and R&D expenditure increased with patents (Park, 2003). Others also found that in those countries that have stronger patent rights the more patent-intensive industries grow relatively faster than those where there is a lower concentration (Hu and Png, 2013). On the other hand, academic studies have found no evidence that patenting is essential to protect and motivate innovations in machinery industries (Boldrin and Levine, 2008). At sectoral level Boldrin et al. (2011) found the same disconnect between patenting activity and productivity. Kinsella (2013) also criticizes utilitarian arguments in favour of intellectual property as being fallacious in terms of ethics, methodology, and economics. The academic scepticism of Boldrin and Levine (2002) went even further by suggesting that market mechanisms would be more efficient in allocating resources without patent systems. Consequently, the patent rights granted to investors in certain industries do not necessarily indicate productivity growth.

#### **Data and Methodologies**

The EU KLEMS Project describes a new set of Productivity and Growth Accounts with data up to 2014 for major European economies (i.e. Austria, Belgium, the Czech Republic, Denmark, Germany, Finland, France, Italy, Netherlands, Spain, Slovenia, Sweden, and the United Kingdom) and other OECD countries (Australia, Canada, Japan, and the USA). The latest release of KLEMS in 2016 was created for the analysis of productivity (output per capita) in the framework of detailed growth accounts, such as gross value added (GVA), numbers of engaged employees, capital formation etc. at the ISIC (Indicators of activities for Industry and Services) Rev. 4 industry level for various OECD countries from 1970 onwards (Jäger, 2016). Gross Value Added is a measure used in economics as the value of goods and services produced in an area, industry or sector and is also equivalent to output (GDP) less intermediate consumption. Although each of the selected industries was separated according to the United Nations Statistic Division, this research concentrated only on the Food, Beverage and Tobacco (10-12) subdivisions. According to the taxonomy of Hatzichronoglou (1997), the food cluster under examination belongs to the low-tech intensive group.

In our dynamic model specification, we also need a unique dataset to examine the extent to which patents might explain productivity growth. In this case, the

historical patent publications categorised by technology are based on the Statistics Database (WIPO, 2017) of the World Intellectual Property Organization (WIPO) in the food industries, as counted by the filing office. Food chemistry is the study of matter, including its composition and structure, its physical properties, and its reactivity. Overall, we have an unbalanced panel data for each industry group of the listed 17 OECD countries to measure the relationships existing between food chemistry patents granted and output per capita in a sectoral approach between 1995 and 2014. According to the theoretical background of growth economics, it should be highlighted that the neo-classical models do not respect the role of patents. In the 1950s Solow was a pioneer, identifying that it was not only fluctuations in the amounts of physical and human capital accumulation which affected output growth (Solow, 1956). Although, this ‘unexplained’ residual, labelled Total Factor Productivity (TFP), could not be measured directly, it allowed the introduction of institutions such as property rights to be incorporated into new theories dealing with economic growth. Thus, TFP cannot be classified among the traditional (capital, labour) factors that determine production, as it either stems from improving technological quality or management skills, and changes in the organization of production etc. Another way is to increase the technical efficiency of output per capita by better applying existing technologies (catching-up) through better management techniques (Latruffe, 2010).

Hence, our estimations are based on an augmented Cobb-Douglas production function (Mankiw et al., 1992), in which income (Y) at time (t) is expressed as:

$$Y_t = K_t^\alpha (A_t L_t)^{1-\alpha-\beta} \quad (1)$$

where:

(K) is the physical capital and (L) is labour accumulation, ( $\alpha$ ) and ( $\beta$ ) are their output elasticities. Separately, these values are constants determined by the available technologies. (A) denotes Total Factor Productivity (TFP).

In this model, TFP is assumed to be the ‘residual’ component of output growth. However, this residual is not only attributed to institutional effects, but also associated with IPRs. Hence, the impact of patents granted on productivity through their effects on the technical efficiency of production is seen as the primary engine of growth. So, substitute A in the following:

$$A_t = A(IPR)_t = aIPR_t^\gamma \quad (2)$$

where:

IPR denotes intellectual property rights, and ( $\gamma$ ) is the elasticity of technical efficiency with respect to the level of IPRs.

Subsequently, divide each side of Equation (2) with L:

$$y_t = k_t^\alpha (IPR_t)^{\gamma(1-\alpha-\beta)} \quad (3)$$

where:

(y) is labour productivity (output per capita Y/L); (k) is expressed in terms of efficiency labour units (K/L).

The equation of motion is now:

$$\dot{k} = i_k + (n + g + \delta)k \quad (4)$$

where:

(g) is the growth rate of technical efficiency, (n) is the growth ratio of the labour force, ( $i_k$ ) is the investment rate, and  $\delta$  is the geometric rate of depreciation. Let  $i_k = s_k y$ , where ( $s_k$ ) symbolizes the respective savings frequency from output. Substitute ( $i_k$ ) with the savings rate and take the logs (ln) of both sides of Equation (3).

After reordering each of (2) and (3), the economy tends toward a long run equilibrium, and the extent of economic growth affects the rate at which per capita output approaches its steady state level ( $y^*$ ). Consequently, the logs of productivity at a given time (t) are equal to the following formula:

$$\ln(y^*)_t = \frac{\alpha}{1 - \alpha - \beta} \ln(s_k)_t - \frac{\alpha + \beta}{1 - \alpha - \beta} \ln(n + g + \delta)_t + \gamma \ln(IPR) \quad (5)$$

The relationship between intellectual property rights and output per capita is analyzed in a panel regression model to ensure the consideration of the contribution of productivity in various food sectors. In an attempt to confirm the endogenous growth theories dynamic, GMM (Generalized Method of Moment) estimations are calculated, developed by Arellano and Bond (1991), to determine how patents might affect productivity growth in the long run. The subsequent dynamic models contain the lagged dependent variables among the repressors. These model specifications require exceptional instrumentation to employ lagged levels of dependent and predetermined independent variables, likewise the differences among the exogenous variables. Only the first lags of the dependent variables were used as instruments in our models. After taking the first difference of the dependent variable  $\ln(y^*)$  of Equation (5), the following regression method was tested in the Food, Beverage and Tobacco sector:

$$\Delta \ln y_{it} = \beta_0 + \beta_1 \Delta \ln y_{it-1} + \beta_2 \ln(s_k)_{it} + \beta_3 \ln(n + g + \delta)_{it} + \beta_4 \ln(patent)_{it} + e_{it} \quad (6)$$

where:

( $\Delta$ ) signs variables in the first difference, and ( $y_{i,t}$ ), substituted by the ratio of real GVA per capita of country (i) for the period (t) at current prices (Jäger, 2016), ( $y_{i,t-1}$ ) is the lagged productivity growth. The ( $n+g+\delta$ ) variable is equivalent to the average growth rate of employment (n) and a constant (0.05), as proposed by Mankiw et al. (1992). Thus, the investment ratio (sk) is replaced by a proxy of gross fixed capital formation (GFCF) measured in real terms.

As defined by the OECD (2017), GFCF is measured by the total value of a producers' acquisitions, less disposals of fixed assets during the accounting period, together with the value of non-produced assets, such as improvements in the quality of productivity, research etc. The (patent) variable is the total number of

patents granted as counted by the filing office in the case of food chemistry (WIPO, 2017). Finally, (e) is the error term.

### Results of Analyzing the Relation Between Food Chemistry Patents and Productivity in a Sectoral Approach

Table (1) shows our regression results. In this table, the long run effects of investment, employment and patents on productivity growth is summarized. In our analyses the so-called two-step Generalized Method of Moments (GMM) estimators are preferred in order to handle the proposition of downward biased standard errors (Windmeijer, 2005). Although, the effects of the lagged GVA per capita ( $y_{i,t-1}$ ) are robust in the examined branches, the share of investment ratio ( $s_k$ ) indicated no significant z-statistics. The lack of significance in these cases only means that changing investment does not indicate productivity growth in these branches at a given level of other determinants. Meanwhile, as predicted by growth theories, employment growth attainment ( $n+g+\delta$ ) is negatively related to productivity growth in both (1 and 2) models. However, the coefficient values do not seem to be large in these models, indicating a valid representation of the negative relationship between food chemistry patents granted and productivity growth in the long run. In other words, assuming continuous time, a one unit increase in the number of patents may negatively affect productivity growth in food industries.

**Table 1. Results of the regressions based on Equation (6)** (Authors' own estimations based on (Jäger, 2016) and (WIPO, 2017))

Independent variables	Model 1	Model 2
constant	0.258 (2.17)**	0.266 (2.11)**
$\ln(y)_{i,t-1}$	-0.122 (-4.46)***	-0.117 (-4.44)***
$\ln(sk)_{i,t}$	-0.062 (-1.65)	-0.055 (-1.64)
$\ln(n+g+\delta)_{i,t}$	-0.754 (-16.95)***	-0.781 (-21.16)***
$\ln(\text{patent})_{i,t}$		-0.007 (-2.78)***
Number of Observations	238	212
Number of Countries	17	17
Wald test	287.56***	561.14***
AR(1) test	(-2.543)*	(-2.459)*
Sargan test	15.681	11.717
Heteroscedasticity robust z-statistics are in parentheses. *** significant at 1%, ** 5%, * 10%, respectively. P-values without an index mean that the coefficient is not significant even at the 10% level		

In the bottom section of Table (1) the significant Wald tests suggest that the dynamic specification should be preferred in all model specifications. Thus, the substantial AR(1) tests, derived by Arellano and Bond (1991), indicate the lack of autocorrelation in the first differenced errors. Thus, according to the Sargan tests (Hansen, 1982), the null-hypothesis of over-identifying the validity of restrictions can be rejected, as well. Although these findings contradict the results of Park (2003), who pointed out that protection of patents positively affects productivity in manufacturing growth, a substantial number of research studies have yielded different conclusions about the role of IPRs at sector level. Meanwhile, Moser (2007) confirmed distinct inter-industry differences in patenting. However, the direct negative effects of food processing patents were not significant on output in his research. In spite of some methodological critiques related to the validity of our regression results is limited by the bias caused by the exclusion of the omitted variables of our models, we can demonstrate the predicted negative correlation between food chemistry patents and output per capita in various OECD countries. Thus, additional research directions have emerged in this study and general conclusions are drawn only if further types of patents are taken into consideration to determine their effects on productivity

### Conclusions

The chief contribution of this research paper is to provide empirical evidence as to whether patents can reduce productivity growth in low technology intensive industries. However, lately there have been intense theoretical and policy debates which have attempted to understand the influence of these institutions. So far, no clear agreement has emerged and common questions remain. As explained in the introduction, productivity improvements can be realized either through application of better technologies or through some of the factors for farm managers depend on their management skills, such as efficiency of improvements, natural environment, investment in R&D, infrastructure, availability of similar farms, value chains and applied policy framework etc. (European Commission, 2016). However, in order for new food technologies to be selected by farmers and applied to their intended use, not only their management practices are important. Essentially the number of engaged patents can also reduce the productivity growth in some cases.

Measuring TFP allows for a comprehensive tool of productivity change over time to monitor the reaching of a viable food production. However, scholars are frequently involved in observing exactly how TFP matter, as far as the restricted usage of econometric methods and datasets allows. Hence, our results have contributed to a public policy debate regarding the role of intellectual property rights in economic growth and development. One of the limitations of our findings is that this research has demonstrated only one characteristic of the relation between intellectual property rights and productivity growth. Essentially, it is not only the examined patents granted, but also other IPRs, such as trademarks, utility models, industrial designs etc., which can also be related to output per capita,



among other determinants in the long run. Moreover, others (Kot, 2015; Kadłubek and Grabara, 2015) have also emphasized the additional role of transportation, logistics functions etc. in the production of enterprises. Hence, the major conclusion of our results is the extent to which food chemistry patents, *ceteris paribus*, negatively correlate with output per capita in the Food, Beverage and Tobacco industries. This study was not intended to disapprove the utility of intellectual property rights. The complexity of innovation processes which patents intend to achieve has had a long historical evolution, and their economic effects are extremely hard to observe. Although, preventing or weakening the influence of patents has been an essential part of decision making for management, distinctive conclusions cannot be drawn in respect of the economic effects of patents. Despite some of the recent tendencies in outcomes, substantial institutional reforms are expected to be required in the future.

One of these reforms supports the greater independence and improved efficiency of the European Patents Office (EPO), which is essential to secure trust and confidence in order to maintain its sustainability in the long term. Besides, the adoption of new legislation systems are required that would allow third parties to inspect appropriate reports. Hopefully, the 2013 framework of uniform patents and court decisions which was developed by the Unified Patent Court (UPC) will be accepted beyond the 25 member states and thus became a part of their judicial systems. The unitary characteristics will make it possible to cancel more easily any patents granted by mistake or to non-practicing entities, and there will be no need for additional time for parallel litigation. Thus, a third party will not have to wait for the outcome of opposition procedures at the EPO when bringing a withdrawal action before the UPC. In our opinion, the instant elimination of the legacy of the existing patent systems is not advisable, but a reduction of the validity length periods and a better quality of patents seem to be a desirable development.

Consequently, it is also recommended that agricultural policies should be more conducive to innovation, and to granting patents in order to develop long-term and sustainable productivity growth and reduce policy uncertainties. Moreover, we believe that a better understanding of property features is one of the essential elements in the success of taking managerial decisions to enhance productivity performance in these sectors.

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### WPLYW PATENTÓW W CHEMII SPOŻYWCZEJ NA PRODUKTYWNOŚĆ: STUDIUM PRZYPADKU PODEJŚCIA SEKTOROWEGO W RÓŻNYCH KRAJACH OECD

**Streszczenie:** Skutki funkcjonowania Prawa Własności Intelektualnej (PWI) są ciągle jedną z tajemnic gospodarczych w obecnej literaturze. Jednak na poziomie sektorowym wciąż nie udało się dostarczyć żadnych oczywistych dowodów empirycznych dotyczących jakiegokolwiek bezpośredniego związku między patentami a produktywnością. Głównym wkładem tego artykułu badawczego jest dostarczenie empirycznych dowodów na to, w jaki sposób patenty dotyczące chemii wpływają na wzrost produktywności w przypadku przemysłu o niskim poziomie zaawansowania technologicznego (żywność, napoje i wyroby tytoniowe). Aby wesprzeć zarówno teoretyczne, jak i empiryczne ustalenia zawarte w literaturze, przetestowano model regresji dynamicznej i stwierdzono, że jest to prawidłowa reprezentacja negatywnego związku między przyznawanymi patentami na chemię spożywczą a wzrostem produktywności w długim okresie. Następnie sugeruje się wnioski i implikacje polityczne, aby wesprzeć zwiększony wzrost wydajności w gałęziach przemysłu spożywczego, podkreślając znaczenie zmian w obecnych systemach ochrony dóbr.

**Słowa kluczowe:** podejście sektorowe, patenty, wydajność pracy

#### 食品化學專利對生產率的影響 – 一個經合組織國家部門方法的案例研究

**摘要:** 知識產權 (Intellectual Property Rights, 簡稱 IPR) 是當前文獻的經濟奧秘之一。然而, 在部門層面上, 關於專利與生產率之間的直接聯繫仍然沒有提供任何明顯的經驗證據。本研究論文的主要貢獻是為低技術密集型產業 (食品, 飲料和煙草) 的化學專利與生產率增長之間的關係提供經驗證據。為了支持文獻的理論和實證結果, 對動態回歸模型進行了檢驗, 並且發現了長期得到的食品化學專利授權與生產率增長之間負相關的有效表示。隨後, 為了支持這些食品工業的生產率增長表現, 提出了一些結論和政策建議, 強調了現行財產保護製度變化的重要性

**關鍵詞:** 部門方法, 專利, 勞動生產率