The Relationship between State Aid to R&D and Patent Applications in the Context of the European R&D Expenditure

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\section*{ABSTRACT}

The present paper aims at providing a contribution to the literature on public expenditure on R&D. According to the assumption that state aid to R&D can represent a relevant incentive for developing innovative activities, measured by patent applications, the paper provides an empirical analysis of state aid in the context of public expenditure to R&D in the EU. Based on empirical findings, the paper also proposes to establish general policy guidelines designed to improve the economic impact of public policies on R&D.

\section*{Introduction}

According to the state aid literature, one of the most important rationales that can justify state aid granting refers to the possibility to correct or compensate for inefficient results in the functioning of the markets ("market failures"). From a theoretical perspective, literature mentions as main objectives envisaged by state aid policy maintaining an undistorted competition in the economic environment, increasing efficiency and economic competitiveness, as well as promoting economic and social cohesion. However, the main objective which was explicitly confirmed by the European legal framework is the undistorted competition in the EU (Negrescu and Oprescu, 2004).

Historically, state aid policy has gradually evolved from this “negative” perspective of prohibiting anticompetitive practices and reducing Member States’ capacity to subsidize their economy towards a more “positive” approach aiming at harmonizing national state aid policies through increasing efficiency and economic development (Blauberger, 2009). Based on this perspective, the European Commission has constantly highlighted the economic advantages of granting horizontal state aid for promoting sustainable economic development of the Member States. State aid to R&D, as a component part of horizontal state aid, represents one of the main instruments used by public policies in order to support research as well as innovative activities and to reach the targets specified by the European Commission in order to increase the international economic competitiveness of the EU on the global environment (European Commission, 2010).
The present paper is structured in the following manner: the second section explains the main methodological aspects proposed by the research; the third section provides a description of the related literature; the fourth section presents the empirical results of the paper, while the last section concludes.

**Methodology**

The fundamental objective of the present study is to provide a contribution to the related literature by establishing a possible relationship between state aid to R&D and patent applications in the EU. In this context, the research hypothesis considers that state aid, as a component of public funding of R&D, represents an active contributor to the development of patent applications in the EU. Although there is no universally accepted direct measure of innovative performance at a country level, patents statistics are generally used in the literature to evaluate the innovative performance of countries since they reflect in a significant manner the output of the research activities undertaken and the possibility to translate knowledge into potential economic development (Griliches, 1990, pp. 1661-1707, Jones, 1995, pp. 759-784, Lanjouw și Schankerman, 2004, pp. 441-465).

The main variables of this paper are state aid to R&D and patent applications in the EU Member States for the period 2001-2012. State aid to R&D was considered as a percentage of GDP, while patent applications were considered per million inhabitants of the Member States. The relationship between these variables has been estimated using a panel based on a SUR regression. In order to better understand the importance of state aid in the context of the European public policies for R&D, we have extended the utilization of this model by testing the potential relationship between patent applications, on the one hand, and gross domestic expenditure to R&D (GERD) and government expenditure to R&D, respectively, on the other hand. Taking into account the time between the financing of a new product or process through state aid and the introduction of the respective innovation through a patent, we have incorporated time lags in the panel.

**Literature Review**

The problem of governments granting state aid has been intensively debated in the related literature. While keynesist economists suggested the necessity of government support for business cycle stabilization, neoclassical economists considered the importance of maintaining the self-regulating capacity of the market and the possibility that government support should only complement this mechanism. In spite of different and even opposite responses, one of the most common conclusions of the literature was that the fundamental objective of state aid policy concerns the correction or compensation of “market failures” that might appear in the economy, targeting an undistorted economic competition in the internal market.

The role of public policies in supporting economic development through the effects on technological change and innovation has been offered mainly by the evolutionary theory. From a theoretical perspective, it considers that the economic development process is technologically driven and it includes a multifactorial model across time and geographical space (Chiaromonte și Dosi, 1993, pp. 39-63, Geels, 2004, pp. 897-920, Silverberg și Verspagen 1995, pp. 209-227).

During the 1980s, state aid granted to industry and services by EU Member States represented about 2% of EU GDP and gradually decreased to approximately 1% in the following decade (European Commission, 2011). This policy development has been highlighted by the Lisbon European Council of 2000 that suggests both the importance of reducing the general level of state aid and moving the priority from sustaining individual sectors or companies towards horizontal objectives of common interest (“less and better targeted state aid”).
The overall decreasing trend registered by state aid in the EU continued until 2007 when it reached the value of 0.4% of GDP. The quantitative amount of state aid granted by Member States increased in the context of the financial and economic crisis, reaching to a level of 0.6% in 2008, which represented a 50% higher value than the year before. These developments have proved that state aid tends to have a counter-cyclical component which is used by governments to subsidize their economies (e.g. Ouyang, 2011, pp. 542-553, Paunov, 2012, pp. 24-35). During the recession period, state aid has been granted under the Temporary Framework, which was intended to promote investment and facilitate the access to finance for companies facing difficult credit conditions.

State aid to R&D, as a component of horizontal aid, is considered more acceptable by the European Commission, because it does not have the potential to distort competition in the internal market and can stimulate innovation by addressing market failures that prevent markets from achieving the best results (European Commission, 2004). The government support for R&D in the EU has gradually developed across time, in line with general measures supporting horizontal policies designed to create potential incentives for a wide range of economic actors of the market, making several economists to suggest that European industrial policy is an essentially R&D policy (Van Pottelsberghe, 2008).

The importance of R&D investment for promoting sustainable development and making the EU more economically competitive at the international level has been emphasized by the Barcelona European Council of March 2002 by setting the objective for expenditure on R&D to 3% of GDP by 2010. In the context of this target not being achieved, the interest shown by the European Commission in the field of R&D investment has intensified after the financial and economic crisis with the focus largely maintaining on framework measures and innovation and has been further adopted by the Europe 2020 strategy (European Commission, 2010).
Empirical Analysis

The level of GERD was 266 898 million EUR in 2012, which increased with 2.9% from the year before and 42.9% more than in 2002, confirming an overall ascending trend in the EU. The R&D expenditure relative to GDP (R&D intensity) registered a small descending trend in the EU from 1.87% in 2002 to 1.82% in 2005. From 2006 it had an ascending trend and reached a value of 2.06% in 2012, after a small decrease in 2010.

Among the EU Member States, R&D intensity reached its highest values in 2012 in Finland (3.55%), Sweden (3.41%) and Denmark (2.99%). At the same time, the Member States which reported the lowest R&D intensities were the ones that joined the EU in 2004 or more recently, along with Greece, although it should be remarked that Slovenia (2.8%) and Estonia (2.18%) registered levels above the EU average, while the Czech Republic (1.88%) and Hungary (1.30%) registered levels above 1% (European Commission, 2013).

From the perspective of analysing the relationship between GERD and patent applications, we found a positive correlation, with a 0.79 R2 value, which means that the relationship between these variables is robust. This result confirms the fact that countries with higher R&D intensities reported a larger number of patent applications per inhabitants.

Table 1: The relationship between patent applications and GERD

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C(1)</td>
<td>-50.075</td>
<td>4.6143</td>
<td>-10.852</td>
<td>0.0000</td>
</tr>
<tr>
<td>C(2)</td>
<td>91.329</td>
<td>2.6401</td>
<td>34.592</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Weighted Statistics

<table>
<thead>
<tr>
<th>R2</th>
<th>Adjusted R2</th>
<th>F-statistic</th>
<th>Prob (F-statistic)</th>
<th>Mean dependent var</th>
<th>Sum squared resid</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.7931</td>
<td>0.7925</td>
<td>1196.6</td>
<td>0.0000</td>
<td>85.251</td>
<td>586652.6</td>
</tr>
</tbody>
</table>

Source: author’s own calculations based on data from Eurostat

From the perspective of the funding sources, R&D expenditure in 2011 reveals the fact that 54.9% of the total amount in the EU has been granted by the business sector, while 33.4% has been granted by the government sector and a further 9.2% from foreign sources. The relatively significant component of the business sector as a source of R&D financing in Finland and Germany is highlighted by the fact that business-funded R&D represents approximately two thirds of the total GERD in 2011. However, the government sector has granted the majority of the gross expenditure on R&D in Cyprus and Poland in 2011, while relatively important percentages of R&D funding from external sources has been registered in Latvia, Bulgaria, Lithuania, Luxembourg, Ireland, the Czech Republic, the United Kingdom, Austria and Malta (European Commission, 2013).

When analysing the relationship between government expenditure to R&D and patent applications, we found a positive correlation, with a 0.08 R2 value, showing a weak degree of correlation between these variables. Consequently, it appears that government sector supports the development of patent applications to a lesser extent than the business sector, which is in accordance with statistical data regarding the funding sources of R&D expenditure.

Table 2: The relationship between patent applications and government expenditure to R&D

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C(1)</td>
<td>26.697</td>
<td>12.244</td>
<td>2.1803</td>
<td>0.0300</td>
</tr>
<tr>
<td>C(2)</td>
<td>296.04</td>
<td>56.213</td>
<td>5.2664</td>
<td>0.0000</td>
</tr>
</tbody>
</table>
State aid, as a public component of GERD, represented about 4% of global R&D expenditure in 2011, equal to 10 billion EUR and 0.08% of the GDP in the EU. In 2001, more than 50% of total state aid for R&D was granted by Germany (about 3 billion EUR), France (1.9 billion EUR) and Spain (0.9 billion EUR). From a relative perspective, state aid to R&D represented about 18.9% of total aid to industry and services in the EU, while block-exempted state aid granted to R&D represented around 2.2 billion EUR in 2011, which was 21.8% of total horizontal state aid granted for the same objective. Germany (1.1 billion EUR), Italy (171.2 million EUR) and the United Kingdom (132.7 million EUR) are the countries that utilized the most this instrument (European Commission, 2013).

The relationship between state aid to R&D and patent applications appears to be positive, with a 0.12 R² value, which shows that government support through state aid sustains to a certain extent the development of patent applications. However, the lower relevance of this relationship comparing to the relationship between GERD and patent applications may argue that state aid to R&D targets a more diverse set of economic objectives which do not always reflect in the development of innovations.

**Table 3:** The relationship between patent applications and state aid to R&D

Equation: \( \text{Patents (t)} = C(1) + C(2) \times \text{State aid (t)} \)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C(1)</td>
<td>52.198</td>
<td>7.3579</td>
<td>7.0942</td>
<td>0.0000</td>
</tr>
<tr>
<td>C(2)</td>
<td>681.51</td>
<td>103.32</td>
<td>6.5961</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

**Weighted Statistics**

<table>
<thead>
<tr>
<th>R²</th>
<th>Adjusted R²</th>
<th>F-statistic</th>
<th>Prob (F-statistic)</th>
<th>Mean dependent var</th>
<th>Sum squared resid</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1227</td>
<td>0.1199</td>
<td>43.509</td>
<td>0.0000</td>
<td>87.485</td>
<td>2484376</td>
</tr>
</tbody>
</table>

Source: author’s own calculations based on data from Eurostat

Considering the specific nature of R&D activities, we have introduced a time lag between the period when state aid has been granted and the period when the patent application was measured by statistics. From an econometric perspective, the time lag reflects that R&D support through state aid continues to exert an effect on the innovation capabilities of the companies after the support has been made. Therefore, when using state aid values from the previous year, we have found a relationship which maintains its statistical significance and has a 0.13 R² value, which shows that state aid investment has influenced the capacity to generate innovations through patent applications after the government support, was made.

**Table 4:** The relationship between patent applications and state aid to R&D (lagged)

Equation: \( \text{Patents (t)} = C(1) + C(2) \times \text{State aid (t-1)} \)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C(1)</td>
<td>51.124</td>
<td>7.6637</td>
<td>6.6709</td>
<td>0.0000</td>
</tr>
<tr>
<td>C(2)</td>
<td>736.48</td>
<td>110.30</td>
<td>6.6769</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Source: author’s own calculations based on data from Eurostat
When extending the time lag to a period of two years, the positive relationship between variables maintains with a 0.16 $R^2$ value. While public support through state aid contributes to the development of patent applications after the grant has been provided, we appreciate that it is reasonable to expect even longer lags for spill overs because of the additional diffusion lag and also for the basic R&D because of the longer invention to innovation lag.

Table 5: The relationship between patent applications and state aid to R&D (lagged)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C(1)$</td>
<td>46.978</td>
<td>8.7159</td>
<td>5.3899</td>
<td>0.0000</td>
</tr>
<tr>
<td>$C(2)$</td>
<td>953.33</td>
<td>141.56</td>
<td>6.7344</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Weighted Statistics

<table>
<thead>
<tr>
<th>R2</th>
<th>Adjusted R2</th>
<th>F-statistic</th>
<th>Prob (F-statistic)</th>
<th>Mean dependent var</th>
<th>Sum squared resid</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1647</td>
<td>0.1610</td>
<td>45.352</td>
<td>0.0000</td>
<td>90.630</td>
<td>1811703</td>
</tr>
</tbody>
</table>

Source: author’s own calculations based on data from Eurostat

Conclusions

The present paper provided an analysis of the relationship between state aid to R&D and patent applications in the context of general public policies targeting R&D in the EU. In this respect, we have assumed that state aid contributes to the development of innovative activities, measured by patent applications, which were estimated as a function of state aid, in order to evaluate the nature of the interconnection between these variables.

The relationship between state aid to R&D and patent applications was found to be positive. However, we consider that the moderate level of the statistical significance of state aid when comparing to GERD may suggest that the main objective of state aid is to address potential market imperfections that are happening in the economy. However, in the context of the economic crisis leading to a general reduction of private funds allocated to R&D activities, state aid to R&D may represent a complementary tool aimed at stimulating economic development through innovative activities.

Furthermore, we believe that public policies for R&D should be better targeted in order to support the private sector involved in R&D activities. In this respect, it is important to mention that state aid should not be designed to help the companies that would have been involved in financing R&D even without benefiting from the government support, because in these conditions private investment would be reduced. Thus, we believe that state aid to R&D should not replace private funds for supporting research and innovation but to represent an incentive meant to address problems that might occur in the market and to sustain private sector in a transparent and non-discriminatory manner.

In order to further consolidate the role and importance of state aid in fostering innovations, we appreciate that further research should include a qualitative perspective designed to analyse effective channels of improving the relationship between public and private sector in financing R&D. Since there is a variety of financial instruments designed to act as incentives
for R&D activities, we consider that there is a strong need for a better coordination between public and private institutions involved in financing R&D, on the one hand, and direct and indirect instruments of intervention, on the other hand, in order to create favourable conditions for undertaking R&D activities.

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