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# Suburbanization in the Context of R&D Projects Fund Allocation

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***Abstract:***

***Purpose:*** *The innovativeness of the economy originates in companies that conduct research and development activities (R&D) commonly supported by various public funding schemes.*
***Design/Methodology/Approach:*** *Factors that decide in favor of subvention attribution are discussed by analyzing private companies that applied for R&D co-financing within the Smart Growth Operational Program (SG OP) during 2015, with particular attention to the geographic location of applicants. A logistic regression (LOGIT) model with a maximum likelihood estimation is used to study the relationship between the outcome (receiving funding or not) and various potential predictors.*
***Findings:*** *Analysis implies that a decisive factor for obtaining the subvention is the localization of Poland's business. Furthermore, the results also imply that while funding R&D activities, there is a negative bias towards companies located in wealthy Polish regions subject to intensive suburbanization processes.*

***Keywords:*** *Poland, European Union, suburbanization, R&D, innovation, grants, logistic regression, location.*

***JEL classification:*** *H29, O38, R10, R12.*

***Paper type:*** *Research article.*

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## 1. Introduction

Since becoming a member of the European Union (EU) on May 1, 2004, Poland has been steadily catching up with the EU regarding economic development and prosperity levels. However, productivity increases have been primarily based on importing know-how and foreign technology (Bogomil and Wielądek, 2014; *Kapil et al.*, 2013). Unfortunately, Poland ranks among the lowest in the EU on all innovation measures, from private-sector research and development (R&D) expenditure to patenting (Krajewski, 2014). Further economic growth can be in jeopardy if the country's innovation is not improved (Romer P.M., Endogenous Technological Change, 1990).

Poland, as the whole country, is positioned low in the rankings of innovativeness. However, innovativeness varies significantly between different regions and metropolises of Poland. Several studies were conducted to describe this phenomenon (Golejewska, 2012; Górecka and Muszyńska, 2011; Nowakowska, 2009; Siłka, 2012). Indeed, according to the findings presented in the Regional Innovation Scoreboard (European Commission, 2017), 7 out of 16 Polish regions have been classified as moderate innovators and none as innovation leader or decisive innovator. Moreover, research results show that high innovation inputs do not often correspond to high innovation outputs (Golejewska, 2013). Nowak (2018) assessed regional variations in enterprise output innovation, studying enterprises from 16 voivodeships. The "best performers" are the Lublin, Pomeranian, and Masovian regions, which display the highest percentage of innovation-active enterprises both in industry and in services. The lowest performance in overall innovativeness demonstrated Warmian-Masurian and Świętokrzyskie Voivodeships. Golejewska (2013) shows that different Poland regions investigated in terms of their innovativeness differ significantly in their performance. Interestingly, the group of leaders consists of regions with the highest (Masovian, Lower Silesian, Silesian Voivodeships) and one of the lowest living standards (Subcarpathian Voivodeship).

The conclusion arising from such studies is that the voivodeships in Poland differ significantly in their innovativeness. However, voivodeships' performance does not correlate with the traditional division of Poland into the West-East part. Moreover, a recent study shows that Polish regions are also internally diversified regarding innovativeness (Brodzicki and Golejewska, 2017). However, it is still challenging to find out a clear identification of the main features of the regions that influence innovativeness level. This paper will attempt to link a phenomenon of suburbanization to innovativeness by investigating the efficiency of application for R&D grants within the EU-sponsored schemes. It is doing so by investigating the likelihood of grant receipt versus vector of company characteristics, including location. Previously, Konopielko, Kochański, and Woźniak (2019) attempted to determine whether submission time matters for the application quality, thus identifying procrastination symptoms in innovators' behavior. In this paper, geographical dimension is taken into account, particularly concerning the suburbanization progress of selected regions.

## 2. Development of Large Cities and Suburbanization

Although not a new phenomenon, suburbanization is one of the main trends in the spatial and socio-economic development of urbanized areas globally. Broadly speaking, as a model of urban and metropolitan development, it denotes the process of de-concentration in the urban region, consisting of the movement of population and economic entities from the core city towards the suburban zone, which results in the dynamic development of the suburbs, remaining in a healthy functional relationship with the center (Clapson, 2010; Fischler, 2005; Hall, 2006; Harris, 2015; McCann, 2009; Saff, 2006). Initially, suburbanization was primarily of a population and settlement nature. The development of the suburbs was determined mainly by housing needs and families' life aspirations - in response to the negative aspects and costs of urban living (Champion, 2001). Suburbanization as a demographic process was reflected in phase models of the urban life cycle. According to them, it constitutes one of the stages of the development of the urbanized area (urban region), following the urbanization phase and preceding the deurbanization phase, which is manifested in the domination of population development in the suburban area over the core city (Klaassen and Paelinck, 1979; van den Berg *et al.*, 1982). In the complex suburbanization process, the phase of de-concentration of the population usually precedes the de-concentration of jobs and the economic development of the suburbs (Chiang, 2012).

From an economic perspective, suburbanization is a spatial expression of economic entities' decisions looking for new investment opportunities. Given the disadvantages of economic activities emerging over time in core cities, the suburbs (due to cheaper land and better environmental conditions) are a convenient alternative for further development (Mace, 2009). Increasingly, industrial plants move to the suburban zone, and high-tech enterprises and service providers prefer to be located in areas adjacent to cities but not directly within their borders (Gottdiener and Budd, 2005). The successive process of relocating companies from central cities to their surroundings is also observed in Poland's metropolitan areas (Dej *et al.*, 2019; Dej and Jarczewski, 2018). Economic suburbanization refers to the concept of growth poles and the related processes of diffusion of development impulses. As one of the creators of this concept, F. Perroux (1970) notes, the development process does not appear everywhere at the same time. Initially, it concentrates with varying intensity, primarily at points or poles of growth. Only with time does it spread through various channels and with different consequences for the entire economy (Perroux 1970).

Contemporary suburbanization is a complex and multidimensional phenomenon, leading to the emergence of several different spatial and functional forms of urbanized areas. In the context of economic development and generating innovations in suburban zones, such a form is, for example, the edge city. This notion was popularized in 1992 by J. Garreau about the complex functional structures taking shape on the outskirts of American cities. In his approach, edge cities: (1) have at least 5 million square feet of office space for lease (as workplaces characteristic of the modern information age), (2) have a minimum of 600,000 square feet of

commercial space for rent, (3) have more workplaces than bedrooms, (4) are perceived by the population as one place, (5) 30 years earlier, they did not resemble cities at all (Garreau, 1992).

From the findings of previous researchers, the main reason for the scale of regional disparities in Poland was the process of monopolization, particularly intensive until 2010. It manifested itself in the dynamic development of the largest cities and their immediate surroundings subject to city sprawl. Only in these areas, specialized services allowing for R&D activities with the high added value could be located. The deciding factor in developing the service industry in significant cities' surrounding areas was foreign capital (Gorzelak and Smętkowski, 2019), while access to qualified staff and infrastructure cannot be underestimated. Smart specialization is a concept that can help answer questions about the factors determining regional development and innovation activity in the Polish regions (Dziemianowicz and Peszat, 2014).

The concept of smart specialization is based on endogenous growth theory assumptions, which distinguishes itself from neoclassical growth by emphasizing that economic growth is an endogenous outcome of an economic system, not the result of forces that act from outside (Romer, 1994). Fundamentally, the internal resources such as entrepreneurs, employees, the local elite, and the relations between them determine the development of a given territorial unit and thus the area's innovativeness. In particular, the interactions between the different factors and network cooperation play an increasingly significant role in creating competitive advantages (Dziemianowicz *et al.,* 2010). Matters associated with social capital also act as factors that play an essential role in regional development (Swianiewicz *et al.*, 2008).

The concept of smart specialization combines various elements of the development above theories and concepts, but its essence is its foundation on the strong points of the regions and development of competitive advantage on a large scale. According to its principles, resources should be focused on a small number of priorities that already have economic and innovative potential or a potential high enough for the region to create advantages (Foray, 2009). Therefore, the regions should be specialized in the fields they are already well-developed, but they should also seek relations with other fields, expanding their potential to innovate, so-called specialization through diversification (Foray *et al.,* 2012).

## 3. Studies on Determinants of Public Funding Allocation

There are two noteworthy aspects to study when keeping in mind public funding of the R&D project in private companies. The most studied until now concentrates on the effectiveness of R&D activities after the public support has been gained. Those studies focus mostly on additionality and crowding-out effects. Most of the studies suggest a positive effect of the public support for R&D. However, this positive effect is mild and is mostly based on the lack of crowding-out effect (Hall and Maiffiolli,

2008; Dimos and Pugh, 2016). The additionality effect is rarely reported (Dimos and Pugh, 2016; Marino, L'huillery, Parotta and Sala, 2016; Radicic and Pugh, 2017).

On the other hand, receiving a public subsidy is not a random phenomenon, and therefore, particular attention should be paid to the selection process of R&D projects awarded funding. There are not many studies on this topic. Feldman and Kelley (2001) studied the winners of awards from the Advanced Technology Programme (ATP) in the United States. They were lucky to have access to information from a survey of ATP applicants. They found that the number of business and university linkages significantly affected the probability of winning financial support. Lichtenberg (1999) studied the biomedical field and, more precisely, how the topic of R&D influenced whether the institution got financing. He showed that disease burden, prevalence, and incidence had a significant impact on whether a research institution got funding from the National Institutes of Health (NIH).

In Poland, Konopielko and Rusak (2017) have analyzed 235 companies from Masovian Voivodeship that received co-funding for innovation activities. They have shown that less money was donated for enterprises' innovation activity, and more money was spent on increasing the production (European Commission, 2015). This phenomenon is especially alarming when one considers that the analyzed program's subvention was explicitly dedicated to increasing innovativeness and entrepreneurship in Masovian Voivodeship.

## 4. Data and Coverage

Smart Growth Operational Program (SG OP) is the second biggest program in Poland and the biggest in the European Union in terms of the volume of funds available for supporting R&D and innovation activities in Polish enterprises (European Commission, 2015). There is 8.6 billion EUR and 36.8 billion PLN dedicated for this purpose. The funds have been available from 2014 to 2020. This program's primary goal is the financial support of R&D programs in Polish enterprises and the commercialization of their results. Altogether, 23 billion PLN is dedicated to supporting entrepreneurs who have presented R&D programs and are chosen during competitive selections. Measure 1.1 proposes funding for R&D or only for development projects conducted by entrepreneurs. This program is directed to:

- businesses (especially small and medium),
- research institutions and universities,
- corporations that bring together business and research institutions.

Altogether, for the years 2014 - 2020, EUR 1.94 billion, i.e., around PLN 7.9 - 8.4 billion, has been available to support R&D programs in the Polish companies. Until the end of 2019, 19 competitions were conducted. Altogether, 5123 proposals were submitted to the evaluation commission, and 1228 proposals were chosen to support SG OP funds. It means, on average, 23,97% of submitted proposals were selected for receiving support.

This work aims to reveal factors that decide whether a given company obtains co-funding or not. Many factors could influence a successful outcome when applying for the funding, but not many are measurable. The set of data available contains six of them:

- amount of funding,
- field of activity,
- size of the company,
- type of the company (joint-stock company, a limited partnership company, private limited company etc.),
- location of the company within Poland (voivodeship),
- objective of R&D activities (industrial research and development work versus only development work).

The data for the analysis was gathered from the National Center for Research and Development (NCBR) official site with six above mentioned independent variables and the dependent variable - Y (financing received - 1 or not received - 0). Note that our model is not linear since the dependent variable took only two values, either 1 or 0). As mentioned above, the dependent variable takes binary values. Therefore, we must exclude other common types of econometric models like linear regression, cointegration, etc. Consequently, the logistic regression was used to design the model. Because our Y (dependent variable) is categorical, financing is either received (1) or not (0) that is a binary response variable, we use the logit function of Y (See Equation 1) instead of just Y:

$$\ln\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \ldots + \beta_k X_k = \beta_0 + \sum_{i=1}^{m} \beta_i X_i \qquad (1)$$

where: $Y = \ln\left(\frac{P}{1-P}\right)$ and P is defined as the probability that Y=1.

LOGIT model output coefficients are denoted as $\eta_i$, where i = 31 and represents 31 parameters which have been analyzed. Moreover, the output coefficients (Equation 2) can be also defined mathematically as follows:

$$\eta_i = \text{Logit}(P_i) = \log\frac{P_i}{1-P_{i_1}} \qquad (2)$$

Likewise, output coefficients are received as odds ratios (Equation 3).
Mathematically one can describe them as follows:

$$\text{odds ratio}_{\,i} = \frac{P_i}{1-P_{i_1}} \qquad (3)$$

Formula (3) merely describes the ratio of getting funding vs not getting one. As an example, if the probability of getting funding is 0.5, the odds are even or 50%. And with a probability of 1/3, the odds are 33.3%. Such is the reasoning behind the output coefficients in LOGIT model. In order to retrieve the odds from the LOGIT

coefficient shown in the regression output window of GRETL software, one needs to apply an anti-LOGIT transformation expressed by Equation 4:

$$P_i = \text{Logit}^{-1}(\eta_i) = \frac{e^{\eta_i}}{1+e^{\eta_1^i}} \quad (4)$$

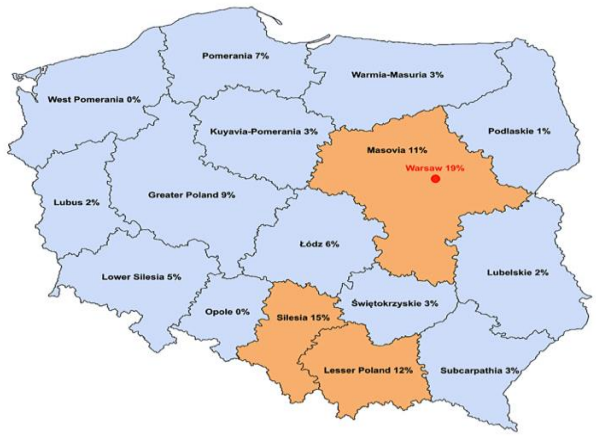
And to receive the odds, one uses the formula above:

$$\text{odds}_i = e^{\text{Logit}(\eta_i)} \quad (5)$$

One can construe the logit function as the natural log of the odds that Y equals one category. For mathematical simplicity, we will assume Y has only two categories and code them as binary values or 0 and 1. All that means is the successful obtainment of EU funding and is viewed as the response to the independent variables [amount of funding], [points obtained], [R&D/type], [region], [legal form], [size of the enterprise], [type of activity: computing, etc.]. In 2015 there were four selection rounds in which Polish companies could get financial support for R&D in their companies. From 244 companies that received financing, we have selected 114 that obtained the number of points above the margin necessary for qualifying for financing. Altogether, PLN 955,6 billion was distributed among these 114 companies.

The companies applying for R&D co-funding within Measure 1.1 originated from diverse regions of Poland. The map below shows the distribution of applicants in 2015 by voivodeships. Out of 16 voivodeships, only Opolskie and West Pomeranian Voivodeships were not represented in 2015. The majority of the firms that applied, i.e., 57%, were from three Poland regions: Masovian, Silesian, and Lesser Poland. Out of these three, Masovian Voivodeship and Warsaw constituted 30% of firms seeking the subvention. Worth mentioning that Masovian and Silesian Voivodeships have the highest GDP per capita in Poland according to Eurostat (Eurostat, 2017) EUR 33 500 and EUR 23 100, respectively.

***Figure 1.*** *Applicants by Voivodeship (SG OP. Measure 1.1), 2015*




***Source:*** *Own elaboration based on PARP data.*

To get subvention from SG OP, Measure 1.1 in the year 2015, a company applying for the co-funding had to receive a minimum of 13 points. To analyze the factors that decide which company gets co-funding, we had to compile the information about the companies that got the subvention and the information about companies that did not get such financial assistance in the same selection run. We picked to analyze the equivalent number (114) of companies that contracted the subvention with the lowest number of points (from 13 to 23) against the companies that were not successful in contracting to finance but received nearly the required number of points. We reasoned that comparing the companies with a similar number of points will give us a better representation of the factors that decide whether a given company contracts the subvention. We expected that the companies that got a similar number of points would not differ significantly in their size, amount of employed people, budget, etc. In theory, we could have taken the companies with the highest number of points for the analysis and compared them to those with the lowest number of points. However, we reasoned that in such cases, those companies would differ in almost all aspects of their structure, size, and activity, and it could be then challenging to isolate the main factors that decide for securing the subvention.

A LOGIT model was generated to assess which factors are essential in determining whether a company receives subvention for R&D activities in 2015; in this model, the dependent variable is a qualitative one indicating the receipt or non-receipt of co-financing. Thus, dependent variable is:

- $Y_i$ - co-financing attribution {1 - funding received; 0 - no funding received}
- Independent variables are:
- $x_{1i}$ - co-financing amount [PLN]
- $x_{2i}$ - number of points awarded
- $x_{3i}$ - sub-measure {1 - industrial research and development; 0 - development work}
- $x_{4i}$ - field of activity {1 - information and computer; 0 - otherwise}
- $z_{1i}$ - small enterprise {1 - small enterprise; 0 - otherwise}
- $z_{2i}$ - medium enterprise {1 - medium enterprise; 0 - otherwise}
- $z_{3i}$ - large enterprise {1 - large enterprise; 0 - otherwise}
- $s_{1i}$ - joint-stock company {1 - joint-stock company; 0 - otherwise}
- $s_{2i}$ - limited partnership {1 - limited partnership; 0 - otherwise}
- $s_{3i}$ - a company with limited liability {1 - company with limited liability; 0 - otherwise}
- $s_{4i}$ - general partnership {1 - general partnership; 0 - otherwise}
- $s_{1i}$ - civil law partnership {1 - partnership; 0 - otherwise}
- $s_{1i}$ - limited joint-stock partnership {1 - limited joint-stock partnership; 0 - otherwise}
- $s_{1i}$ - a private enterprise {1 - an individual enterprise; 0 - otherwise}
- $w_{1i}$ - Lower Silesian Voivodeship {1 - Lower Silesian Voivodeship; 0 - otherwise}
- $w_{2i}$ -Kuyavian-Pomeranian Voivodeship {1-Kuyavian-Pomeranian Voivodeship; 0 - otherwise}

- $w_{3i}$ - Lublin Voivodeship {1 - Lublin Voivodeship; 0 - otherwise}
- $w_{4i}$ - Lubusz Voivodeship {1 - Lubusz Voivodeship; 0 - otherwise}
- $w_{5i}$ - Łódź Voivodeship {1 - Łódź Voivodeship; 0 - otherwise}
- $w_{6i}$ - Lesser Poland Voivodeship {1 - Lesser Poland Voivodeship; 0 - otherwise}
- $w_{7i}$ - Masovian Voivodeship {1 - Masovian Voivodeship; 0 - otherwise}
- $w_{8i}$ - Masovian (Warsaw) {1 - Masovian (Warsaw); 0 - otherwise}
- $w_{9i}$ - Opole Voivodeship {1 - Opole Voivodeship; 0 - otherwise}
- $w_{10i}$ - Subcarpathian Voivodeship {1 - Subcarpathian Voivodeship; 0 - otherwise}
- $w_{11i}$ - Podlaskie Voivodeship {1 - Podlaskie Voivodeship; 0 - otherwise}
- $w_{12i}$ - Pomeranian Voivodeship {1 - Pomeranian Voivodeship; 0 - otherwise}
- $w_{13i}$ - Świętokrzyskie Voivodeship {1 - Świętokrzyskie Voivodeship; 0 - otherwise}
- $w_{14i}$ - Silesian Voivodeship {1 - Silesian Voivodeship; 0 - otherwise}
- $w_{15i}$ -Warmian-MasurianVoivodeship {1 - Warmian-MasurianVoivodeship; 0 - otherwise}
- $w_{16i}$ - Greater Poland Voivodeship {1 - Greater Poland Voivodeship; 0 - otherwise}
- $w_{17i}$-West Pomeranian Voivodeship {1 - West Pomeranian Voivodeship; 0 - otherwise}

## 5. Results of the Analysis and Interpretation

The model was estimated using GRETL a cross-platform software package for econometric analysis, written in the C programming language. It is a free, open-source software.

In GRETL software the Maximum Credibility Method was applied to analyze the data, so that after number of estimations rounds the most credible model has been obtained, while insignificant variables eliminated. The presented model correctly describes 207 out of 228 cases (90.8% prediction rate), and thus it is reliable. In the case of companies not getting funded, it accurately predicts 98 out of 114 cases, representing an 86% success rate. Moreover, it accurately predicted 109 out of 114 cases with a 96% success rate in companies that received funding. The number of points awarded by 1 increased the chance of receiving a co-financing average by 2.24 times. This is an excellent internal control suggesting that the prediction done by the model is credible. One expects that with the increase of the company's points, there are higher chances for subvention attribution.

***Table 1.*** *GRETL final regression output.*

| Variable | Coefficient est. | Standard error | Z | p-value | |
|---|---|---|---|---|---|
| Financing amount | -7,50197e-08 | 3,08809e-08 | -2,429 | 0,0151 | ** |
| Points awarded | 0,807350 | 0,124138 | 6,504 | 7,84e-11 | *** |
| Lower Silesia | -10,3301 | 1,78969 | -5,772 | 7,83e-09 | *** |
| Kuyavia-Pomerania | -8,58225 | 1,88961 | -4,542 | 5,58e-06 | *** |
| Lublin Voivodeship | -7,51260 | 2,50968 | -2,993 | 0,0028 | ** |

| | | | | | |
|---|---|---|---|---|---|
| Lubusz Voivodeship | -9,36766 | 2,32652 | -4,026 | 5,66e-05 | *** |
| Łódź Voivodeship | -8,70535 | 1,69964 | -5,122 | 3,03e-07 | *** |
| Lesser Poland | -8,41293 | 1,57274 | -5,349 | 8,83e-08 | *** |
| Masovia | -8,99416 | 1,57828 | -5,699 | 1,21e-08 | *** |
| Warszawa | -10,7869 | 1,74720 | -6,174 | 6,67e-10 | *** |
| Subcarpathia | -9,51909 | 1,87436 | -5,079 | 3,80e-07 | *** |
| Podlaskie | -7,67144 | 2,20479 | -3,479 | 0,0005 | *** |
| Pomerania | -8,39135 | 1,74170 | -4,818 | 1,45e-06 | *** |
| Świętokrzyskie | -9,61770 | 1,86793 | -5,149 | 2,62e-07 | *** |
| Silesia | -9,29261 | 1,58925 | -5,847 | 5,00e-09 | *** |
| Greater Poland | -9,14882 | 1,62529 | -5,629 | 1,81e-08 | *** |

*Note: *p<0.1; **p<0.05; ***p<0.01*

| | | | |
|---|---|---|---|
| Arithmetic average | 0,500000 | Standard deviation | 0,501100 |
| McFadden R2 | 0,521357 | Corrected R2 | 0,420115 |
| Likelihood logarithm | -75,64356 | Akaike information criterion | 183,2871 |
| Schwarz Bayes' criterion | 238,1566 | Hannan-Quinn criterion | 205,4253 |

| | |
|---|---|
| Standard errors based on Hessian | Logit estimation. Observations 1 -228 |

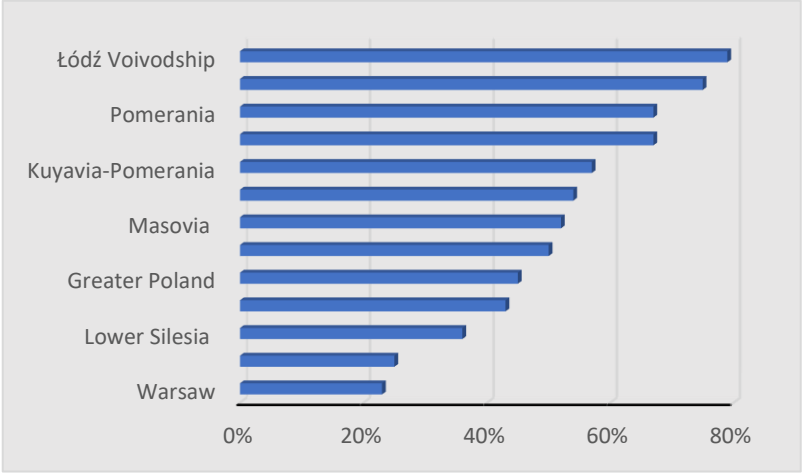
| Number of cases of "correct prediction" = 207 (90,8%) | | |
|---|---|---|
| f (beta'x) to the means of the independent variables = 0,250 | | |
| Likelihood-ratio test: Chi-square (16)= 164,788 [0,0000] | | |
| | Predicted | |
| | 0 | 1 |
| Observed 0 | 98 | 16 |
| 1 | 5 | 109 |

***Source:*** *Own elaboration.*

Based on the presented model, we can state that only two factors have a real impact on the subvention attribution. Those factors are the amount of money for which the company applied and the company localization within Poland. The second factor that has an impact, according to my analysis, is the location of the company within Poland. The percentage of companies that got funding varied from almost 80% (Łódź Voivodeship) to less than 25 % (Lubusz Voivodeship 25% and the City of Warsaw 23%) see Figure 2.

It is relevant to comment on the fact that three voivodeships in which the percentage of funding allocation is the highest are from southeast Poland, while the three regions in which the percentage of funds allocation was the lowest are those which are considered rich regions, i.e., City of Warsaw and western voivodeships (Lubusz, Lower Silesian). Notably, the least awarded voivodships can also be primarily concentrated around large cities (i.e., Warsaw as a capital city, Wrocław, and Rzeszów) where the process of suburbanization is relatively more advanced than is other voivodships.

***Figure 2.*** *Enterprises by location within Poland that obtained funding (%), 2015*




***Source:*** *Own elaboration based on NCRD data.*

## 6. The Bias Towards Company Location for Funds Attribution

The analysis suggests that the only statistically significant factor that correlates with the subvention attribution is its localization within Poland. Indeed, the overall trend is that the highest percentage of funding allocation is for companies from south-east Poland, while the lowest percentage of funds allocation is for those considered rich regions, i.e., Warsaw and western voivodeships. More precisely, the voivodeships, in which it was the hardest to get subvention, were precisely those for which the GDP per capita was the highest in 2015. According to data, the companies from the City of Warsaw, Lower Silesian, and Greater Poland Voivodeships had the least chance of receiving subvention. Those are the same regions in which the GDP per capita was the highest in the country (159.4 %, 111.5%, and 108.8%, average for the country = 100%).

On the other hand, the value of GDP per capita in 2015 was the lowest in Lublin Voivodeship (68.6% of the country's average). Interestingly, the companies' voivodeship got the subvention for R&D most easily (just after Łódź Voivodeship). In these rich regions, the suburbanization processes were also relatively well accelerated.

However, our analysis suggests the bias when subvention for R&D activity is attributed to the private sector. The agency that distributes the public funds does not easily attribute money if it is located in Poland's wealthy region, such as the City of Warsaw, Lower Silesian, or Greater Poland Voivodeships. We did not record such a strong bias in other directions, i.e., the companies from the most impoverished regions did not contract to fund the easiest (except for Lublin Voivodeship).

Two arguments could explain the companies' lack of bias from low regions (Lublin, Podlaskie, and Subcarpathian Voivodeships). The first one is the limitation of our

analysis. Indeed, we did not have many firms in our analysis from those three Voivodeships (4, 2, and 7, accordingly). Thus, it might be that there is a positive bias when awarding funds for low regions, but we did not see it in the investigation due to an insignificant number of instances.

The other argument is that the projects of firms from low regions were less adequate (i.e., received fewer points) than projects from companies from other regions. A small number of submitted projects from the "poor voivodeships" might reflect the low desire or ability (or both) of companies in those regions to invest capital and time into R&D activities.

On the other hand, due to a sound sample representation, we are quite confident that it is more challenging to get funding if the company is located in Poland's wealthy region, such as the City of Warsaw, Lower Silesian Greater Poland Voivodeships. It is especially evident for the City of Warsaw and its suburban regions, which are particularly disfavored. The gap between the percentage of companies that obtained funding in the City of Warsaw and other regions is large, regardless of even lower allocation of funds. This gap is inversely correlated with the region's wealth and can be partially linked with suburbanization processes.

Thus, regions more suburbanized generated lower quality projects due to geographical and intellectual distance between enterprises and R&D centers traditionally located centrally in town. Reversely, more "compact" urban settings, with less advanced urban sprawl, contribute to closer following of enterprise needs by the R&D sector, thus resulting in more promising and more feasible projects. Another explanation can be that, in a more suburbanized environment, numerous companies pretend to run R&D activities and apply for subsidies for their routine business activities. However, such a hypothesis cannot be verified without more detailed data on rejected applications, not publicly available.

One can argue whether such bias is favorable or not. It might seem reasonable to allocate capital into lesser developed regions, encouraging innovative activities and promoting growth in those regions. However, there are few drawbacks to such reasoning. The overall GDP per capita might not be appropriate to reflect private business R&D activities in the region. Indeed, the City of Warsaw hosting offices of numerous domestic and international companies.

Consequently, their profits, wages, and salary incomes (high compared to other regions) are taken into GDP per capita results for the region. This subsequently obscures the real picture of what wealth is produced by small and medium businesses in this region. Indeed, the analysis performed by Nowak (2018) shows that Masovian Voivodeship does not have the maximum number of innovative businesses in industry or services. Moreover, such negative bias towards the City of Warsaw and other wealthy regions (mostly metropolitan zones) might go against the theory of diffusion and spread of development from the metropolitan zones into the surrounding territories proposed and promoted by Gorzelak Smętkowski (2019).

## 7. Potential Consequences of the Bias in Funds Attribution for R&D Activities

Our analysis suggests a negative bias towards companies belonging to Poland's wealthy and more suburbanized regions in subvention allocation for R&D activities in these companies. However, this negative bias might have a negative consequence on overall R&D activities. Indeed, the subventions' goal is to increase the R&D activities, significantly to increase the personal financial inputs into R&D (additionality effect). It is reasonable to think that private companies from wealthy regions of Poland have more excellent resources and could increase the R&D expenditures on their own to a greater extent than those from low regions.

Limiting access to subventions can lead to a decrease in additionality, which in theory should be one of the main objectives in R&D co-funding. On the other hand, shifting the money flow from wealthy regions to poor ones might easily lead to a crowding-out effect. Undeniably, it is reasonable to assume that the companies from low regions that got subventions will not be keen to increase their spending on research and development activities. Instead, they might attempt to decrease their financing for R&D being supported by funds offered by public subventions (over-full crowding effect). Thus, a negative bias towards companies from wealthy regions and a positive one towards the companies from low regions might lead to diminished additionality effect and surge in crowding out effect, finally acting against the primary goal of R&D co-funding.

## 8. Conclusions and Future Work

This paper aims to study whether there are factors that affect the funding of R&D activities in Poland by EU, Smart Growth Operational Programme, and Measure 1.1. The results show a negative bias towards private companies from Poland's wealthy regions (the City of Warsaw, Lower Silesian, and Greater Poland Voivodeships), where urban sprawl around large cities is also most advanced. Altogether, the long-term consequences of such bias, however, are difficult to foresee. They might be detrimental to private companies from those regions, but they might diminish in additionality and increase the crowding-out effect in lower regions.

Further research is indispensable to verify reported here negative bias. A similar analysis needs to be performed, considering many companies within the more extended period. If the negative bias is substantiated, the consequences of such a situation can be studied as it will be noteworthy to comprehend whether funding R&D undertakings in lower regions of Poland leads to the intensification in the innovativeness and economic performance of the companies from those regions and the overall improved economic performance of those regions. Likewise, it will be meaningful to consider companies' innovativeness from disfavored regions or registered in the quickly suburbanizing areas. Will they continue to develop despite the low financing of R&D activities, or will they face a decline?

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