The Role of Public Support for Innovativeness in SMEs Across European Countries and Sectors of Economic Activity

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Abstract: The paper investigates the impact of public support for innovation activities on adoption of different innovation strategies and propensities to introduce product, process, organizational and marketing innovations in European small and medium enterprises. In estimating these effects, country and sectoral heterogeneities are taken into account. Effectiveness of alternative policy mixes is also evaluated. The analysis is based on a multivariate, multi-stage econometric model and data from the Community Innovation Survey 2014. It is found that innovation support is utilized differently by newer and older members of the European Union, with the former investing mainly in acquisition of machinery, equipment, software, buildings, knowledge and trainings and the latter directing aid, to a larger extent, to research and development and introduction of innovations. The results also indicate various effectiveness of support from alternative institutional sources. Aid from the EU is more beneficial for manufacturing, while national and local support is more effective in older EU countries than newer members of the European Union and services sector. Using various but not all types of policy mixes is estimated to increase the chances of innovating. It is concluded that innovation support might not be optimally used in newer members of the EU and that better coordination of aid from the EU and national institutions could lead to improved economic results.

Keywords: innovation support; innovation inputs; innovations; SMEs; policy mix; multivariate probit

1. Introduction

Research and development (R&D) has public good characteristics (non-rivalry, non-excludability), so appropriability of private R&D outputs is not perfect. Due to lower private than social returns, the level of R&D activities is socially suboptimal. Moreover, information asymmetry between creditors and R&D performing firms implies that research and development cannot be used as a collateral in loan contracts and that external capital may be too costly or not available to firms aimed at introducing innovations [1]. Additionally, according to the neoclassical paradigm, short-term efficiency does not encourage to invest in new products and processes.

Both the public good characteristics of R&D and capital market imperfections provide theoretical rationale for public intervention. Subsidies can mitigate market failures by decreasing unit costs of R&D investments and increasing the expected profitability of funded research and development projects. This incentivizes greater private R&D spending, which is popularly defined as input additionality (see [2]).

However, other theoretical perspectives suggest that intervention may lead to the crowding out phenomenon (see [3]). Such an outcome may be explained by means of public choice theory stating that public agencies tend to adopt opportunistic behavior. They may be interested in supporting firms...
with research and development projects that are likely to succeed irrespectively of public support. This “cherry-picking” strategy is aimed at justifying the role of the agency and perpetuating its existence. Funding projects which are most likely to be privately financed in the absence of public support may also result in crowding out (see [4]).

Due to the lack of conclusiveness, both of theory and of evaluation literature (e.g., crowding out is found by Lach [5] and rejected by Hussinger [6]), there is a need for further studies devoted to the support-effects nexus. Assessing effects of innovation aid is a challenging task, since there are difficulties in controlling for selection bias, discriminating different effects induced by heterogeneous treatment levels provided to firms and isolating the effects of subsidies from other confounding factors such as the contextual implementation of alternative innovation policies. Moreover, the number of studies providing results on the impact of innovation support on enterprises’ development is limited. This study fills the gap by evaluating effectiveness of support not only in the context of innovation inputs but in the context of innovation outputs, as well. In order to achieve that, a multivariate and multi-stage econometric model is constructed. Since the knowledge concerning a joint impact of support from different sources in stimulating innovativeness seems to be scarce, we fill the existing gap and evaluate the role of policy mixes.

What is more, most of the studies devoted to the impact of support measures provide results for data aggregated across all industries and countries or for individual countries or sectors. Conclusions from the latter type of studies are often mixed. For example, positive effects of institutional support on product/process innovativeness are found for Chinese enterprises by Zhang et al. [7]. Czarnitzki and Fier [8] conducted an empirical investigation for services companies and showed that participants of innovation policy schemes had a significantly higher innovation intensity than other firms. On the other hand, public support for Irish manufacturing companies did not significantly increase propensity of non-exporters to start exporting activities [9]. Based on such findings, it seems that the analysis of efficiency of support policy in the European Union as well as provision of recommendations for policy makers should be conducted separately for services and manufacturing as well as homogenous groups of countries, representing similar stages of economic development. Apart from the results based on data for all available economies and industries, we thus compare the parameter estimates across older and newer members of the European Union as well as between manufacturing and services companies. Therefore, this paper contributes to understanding heterogeneity of the impact of support measures.

It should be stressed that most of existing studies are focused on innovation activities of large and very large enterprises (see e.g., [10–12]). In turn, we focus on small and medium enterprises (SMEs) which constitute an overwhelming majority of all firms in the European Union, generate a considerable share of jobs and the total value added. For example, in 2017, SMEs accounted for 99.8% of all firms in the non-financial business sector of the EU-28 and provided 66.4% of employment and 56.8% of value added of this sector (see [13]). At the same time, SMEs face many barriers to innovation and so public support aimed at this sector is considered as particularly relevant. Therefore, our study contributes to the economic literature with regard to the impact of public support and policy mix on innovativeness in small and medium enterprises.

In this research study, we identify factors affecting probability of obtaining support for innovation activities from different institutional sources and evaluate its impact on innovation inputs and outputs. In the calculations, we use the Community Innovation Survey (CIS) 2014 data and address the sample selection bias problem present in the CIS dataset. The main research objective is to evaluate the role of innovation support in stimulating investments in research and development, acquisition of knowledge and emergence of various types of innovations. Moreover, differences in the support-innovativeness nexus between enterprises representing manufacturing and services as well as new and old members of the European Union are evaluated. Additionally, the impact of a policy mix strategy on innovativeness is analyzed by estimating, whether enterprises utilizing more than one source of support have larger propensities to introduce innovations than firms using support from one source only.
The paper has the following structure. In Section 2, literature review on the role of public support is presented. In the Section 3 the conceptual model, data, hypotheses and econometric methods are described. Section 4 presents the estimation results and discussion. Section 5 concludes the paper.

2. Literature Review

The extent to which public support for innovations is associated with additionality or crowding-out effects has been widely investigated. Alternative forms of additionality have been studied, including consequences for input (growth of R&D investments), output (e.g., increased social or private returns) or signal/certification effects consisting in indicating that supported firms are worth investing in by private agents. Some studies distinguish further types of behavioral additionalities which concern changes in the internal processes of the firm (see [14]).

Investigations of input additionality of public R&D support i.e., inducing private firms to undertake investments in R&D which would not have arisen in the absence of public aid, led to mixed evidence. According to Dimos and Pugh [15], this is due to alternative treatment by different authors of unobservable firm heterogeneity. Another reason for the mixed conclusions is pointed out by Castellacci and Lie [16] who emphasize the need for sectoral analyses which may bring out the role of public support. A survey by Zúñiga-Vicente et al. [17] attribute the overall inconclusiveness of input additionality studies to, among others, differences in methodology, population under investigation (involving alternative countries, periods, sectors and types of enterprises) and characteristics of public support programs.

Papers reporting input additionality include studies by e.g., Aerts and Schmidt [18] or Hussinger [19]. Freitas et al. [20] conclude that input additionality is greater for enterprises from R&D oriented sectors, while Czarnitzki and Hussinger [21] find that public R&D subsidies in Germany stimulate R&D spending in the business sector. Mixed results or evidence of crowding out effects can be found in articles by Lach [5] or Görg and Strobl [22]. In a recent study, Marino et al. [4], studying French enterprises, report crowding-out of private R&D expenditure for medium-high levels of public subsidies which becomes stronger under the R&D tax credit scheme. Crowding-out is also found by Yu et al. [23] for China’s renewable energy sector, however the emergence of this effect depends on the subsidized amount.

A growing number of studies investigates output additionalities describing the effects of public R&D support for the results of firms’ innovation activities. The papers differ, among others, by the selection of the innovation output variable. Czarnitzki and Hussinger [21] find a positive impact of public support on firms’ patenting activity. Szczygielski et al. [24] demonstrate that public support leads to an increase in the introduction of process and product innovations as well as innovations new to the market. Doh and Kim [25] report that technological development assistance funds were helpful in acquiring patents and registering new design. The impact of direct subsidies on the R&D employment in Flanders is investigated by Czarnitzki and Lopes-Bento [26]. It is found that these subsidies increase the R&D workforce. Using Norwegian data, Cappelen et al. [27] conclude that tax credits significantly influence the development of new production processes and products new to the firm, however they do not lead to creation of products new to the market or more patents.

Signaling character of public support consists in changing information asymmetries between firms and investors concerning the quality of a project or company applying for a subsidy. It has been pointed out by some authors that the selection of a project by public bodies can be relatively unprejudiced and accurate (see e.g., [28,29]). In a theoretical paper, Kleer [30] shows that if subsidies are granted based on a quality requirement and can thus be associated with a quality signal, they can lead to an increase in external investments in R&D. Similar conclusions are formed based on theoretical models of Takalo and Tanayana [31] who additionally indicate that the quality signal may be strengthened if the knowledge of projects’ screening may deter entrepreneurs with low quality from applying for public support. Certification effects are also found in applied articles by Meuleman and De Maeseneire [32] and Colombo et al. [33] who conclude that they are particularly relevant in
areas where it might be more difficult to evaluate expected risks and benefits from a project and those associated with larger financial constraints, i.e., in high tech industries, for start-ups and for small new-technology-based firms, respectively.

It should be emphasized that countries of the European Union differ with respect to investments in innovation inputs and outputs (see [34]). Therefore, enterprises from these countries may react alternatively to innovation support and apply different innovation strategies. For example, higher propensity to buy machinery and equipment and lower propensity to invest in research and development and innovation outputs in post-transition economies were found by [35]. In turn, developed economies were shown to use innovation-based growth strategies by e.g., Acemoglu [36].

The analysis of the impact of different support measures is incomplete without investigating the policy mix phenomenon. Results of some analyses indicate that interplay of different forms of support enhance innovativeness (see [37]). In particular, consistency of instrument mix with policy aims seems to be crucial for investing in research and development (see [38]). As argued by Borrás and Edquist [37], instruments of innovation policy have to be combined into mixes addressing the multi-dimensional and complex nature of innovation.

In this paper, we concentrate on heterogeneity of effects of innovation support between new and old EU member states. Moreover, we compare the effects of support between manufacturing and services. We also analyze whether utilization of policy mix increases propensity to introduce innovations.

3. Model and Variables

The data used in the analysis come from Community Innovation Survey 2014 and describe enterprises from 15 European countries. Firms’ responses describe their innovation output and activities in the three years between 2012 and 2014. In the harmonized survey, an innovation is defined as “the introduction of a new or significantly improved product, process, organizational method or marketing method” by an enterprise.

The relationships studied in the paper are presented in Figure 1. These include dependencies between features of enterprises, support for innovations, innovation inputs and innovation outputs represented by various types of innovations.

According to this conceptual model, in the first step, the propensity to obtain public support for innovations is explained by features of SMEs. Since the CIS dataset contains information on three sources of innovation aid (the European Union, national government and local government), the parameters of a multivariate probit model explaining probabilities of obtaining support from different institutions are estimated. In estimating the parameters of this and remaining equations, a sample selection problem featuring our dataset is taken into account. The details are relegated to Appendix A. Table 1 presents the dependent variables associated with public support.

In the next step, predicted values for support variables are calculated (see Appendix A) and these theoretical variables are used as explanatory in the equations explaining innovation inputs. The variables used as dependent in the second step of the estimation procedure are presented in Table 2.

Since there are two dependent binary variables associated with innovation inputs, the parameters of a bivariate probit model are estimated in this step. Predicted values of the innovation inputs
indicators are used in the third step as explanatory. At this stage, propensity of enterprises to introduce four types of innovations is modeled using a multivariate probit model. Table 3 presents the dependent variables.

Table 1. Binary dependent variables associated with public support.

| Name of Variable | Definition of Variable                                      |
|------------------|------------------------------------------------------------|
| SUP_EU           | 1 in the case of enterprises, which obtained support from the European Union |
| SUP_NAT          | 1 in the case of enterprises, which obtained support from the national government |
| SUP_LOC          | 1 in the case of enterprises, which obtained support from the local government |

Table 2. Binary dependent variables describing innovation inputs.

| Name of Variable | Definition of Variable                                      |
|------------------|------------------------------------------------------------|
| RD               | 1 if the firm engaged in in-house or external R&D           |
| ACQ              | 1 if the firm acquired machinery, equipment, software, buildings or knowledge as well as those which engaged in training for innovative activities |

Table 3. Binary dependent variables describing innovation outputs.

| Name of Variable | Definition of Variable                                      |
|------------------|------------------------------------------------------------|
| IN_PROD          | 1 in the case of enterprises, which introduced a product innovation |
| IN_PROC          | 1 in the case of enterprises, which introduced a process innovation |
| IN_ORG           | 1 in the case of enterprises, which introduced an organizational innovation |
| IN_MARK          | 1 in the case of enterprises, which introduced a marketing innovation |

Table 4 provides the variables, which are considered as explanatory in all three multivariate probit models. Furthermore, Table 5 introduces dummy variables used to control for country and industry heterogeneities.

Table 4. Explanatory variables.

| Variable         | Definition                                                                 | Justification                                                                 |
|------------------|---------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| GROUP_DOM        | 1 if the firm was a part of a group of enterprises with headquarters located in the same country | Subsidiaries can face problems associated with decision making processes which can be particularly severe for branches of small and medium enterprises (see e.g., [39]). On the other hand, business group affiliation promotes some types of innovativeness (see [16]). |
| GROUP_EU         | 1 if the firm was a part of a group of enterprises with headquarters located in another EU country |
| GROUP_OTHER      | 1 if the firm was a part of a group of enterprises with headquarters located outside the EU |
| CO_GP            | 1 if the firm co-operated on any innovation activities with other enterprises within its group | Enkel et al. [40] define “open innovation” as the paradigm stating that companies should use internal and external ideas, as well as external and internal paths to enter new markets. It is stressed that innovation cooperation has become an important element of corporate strategy [41,42] and companies that cooperate introduce innovations more often [43]. |
| CO_SUP           | 1 if the firm co-operated on any innovation activities with suppliers of equipment, materials, component, or software |
| CO_CUST          | 1 if the firm co-operated on any innovation activities with clients or customers from the private or public sector |
| CO_COMP          | 1 if the firm co-operated on any innovation activities with competitors or other enterprises in its sector |
| COCONS           | 1 if the firm co-operated on any innovation activities with consultants or commercial labs |
| CO_UNI           | 1 if the firm co-operated on any innovation activities with universities or other higher education institutes |
| CO_GOV           | 1 if the firm co-operated on any innovation activities with government, public or private research institutes |
Table 4. Cont.

| Variable | Definition | Justification |
|----------|------------|---------------|
| MARLOC   | 1 if the firm sold goods and/or services in local/regional markets within its country | As Fillipetti et al. [44] suggest, innovative firms are more successful in competing internationally and the exposure to alternative business and innovation contexts leads to innovation. |
| MARNAT   | 1 if the firm sold goods and/or services in the national market |
| MAREUR   | 1 if the firm sold goods and/or services in other EU or associated countries |
| MAROTH   | 1 if the firm sold goods and/or services in any country outside of the EU and the associated countries |
| MARKET_LOC | 1 if the firm had the largest turnover from activities in local/regional markets |
| MARKET_NAT | 1 if the firm had the largest turnover from activities in the national market |
| MARKET_EUR | 1 if the firm had the largest turnover from activities in markets in the EU or associated countries |
| MARKET_OTH | 1 if the firm had the largest turnover from activities in markets outside of the EU or associated countries |
| PUBDOM   | 1 if the firm had any contracts to provide goods or services for domestic public sector |
| PUBFOR   | 1 if the firm had any contracts to provide goods or services for foreign public sector |
| ENMRG    | 1 if the firm merged with or took over another enterprise or a part of another enterprise |
| ENOUT    | 1 if the firm sold, closed or contracted out some of the tasks or functions |

Multinomial variable

| EMPUD    | Represents percent of employees with a tertiary degree x. It takes values from the set \{0,1,2,3,4,5,6\}: 0 if x<0%, 1 if 1%≤x<5%, 2 if 5%≤x<10%, 3 if 10%≤x<25%, 4 if 25%≤x<50%, 5 if 50%≤x<75% and 6 if x≥75%. |

Many studies find that companies whose employees are highly educated have higher levels of absorptive capacity (see e.g., [47]) and higher probability of engaging in innovations [48]. However, it has been also discussed that, since higher education becomes more and more wide-spread, having more employees with tertiary degree may no longer be sufficient to achieve competitive advantage in terms of firm-level innovation [49].

Table 5. Binary variables associated with country groups and classification of economic activities (NACE) groups.

| Variables associated with countries | Countries |
|-----------------------------------|-----------|
| OLD_EU                            | Spain, Greece, Portugal, Germany, Norway |
| NEW_EU                            | Cyprus, Estonia, Latvia, Lithuania, Bulgaria, Romania, Croatia, Czech Republic, Slovakia |

| Variables associated with NACE groups | NACE groups |
|--------------------------------------|-------------|
| MHT                                  | 21, 26      |
| MMHT                                 | 19–20, 27–30 |
| MMLT                                 | 22–25, 33   |
| MLT                                  | 10–18, 31–32 |
| SKIS                                 | 50–51, 58–63, 64–66, 69–75, 78, 80, 84–93 |
| SLKIS                                | 45–47, 49, 52–53, 55–56 |
The impact of support and innovation inputs on innovativeness may differ across countries and industries. Arguments for heterogeneous effects of public support are provided among others by [50]. Therefore, it seems reasonable to compare the impact of support for enterprises from different countries and representing various sectors. As a result, separate estimations are conducted for:

- enterprises from Norway and old EU member states (OLD_EU),
- enterprises from new EU member states (NEW_EU),
- enterprises representing manufacturing (MHT, MMHT, MMLT, MLT),
- enterprises representing services (SKIS, SLKIS).

Companies may be supported from different sources at the same time. Results of numerous studies indicate that enterprises, which use more than one source of support have higher propensity to introduce innovations (see e.g., [37,51]). It was analyzed whether this tendency was observed in the group of European firms in the years 2012-2014. In order to evaluate the impact of policy mix on innovativeness, the following variables describing the receipt of financial aid were defined:

\[ \begin{align*}
G_{111} &= \text{SUP}_{EU}\ i \times \text{SUP}_{NAT}\ i \times \text{SUP}_{LOC}\ i, \\
G_{110} &= \text{SUP}_{EU}\ i \times \text{SUP}_{NAT}\ i \times (1 - \text{SUP}_{LOC}\ i), \\
G_{101} &= \text{SUP}_{EU}\ i \times (1 - \text{SUP}_{NAT}\ i) \times \text{SUP}_{LOC}\ i, \\
G_{011} &= (1 - \text{SUP}_{EU}\ i) \times \text{SUP}_{NAT}\ i \times \text{SUP}_{LOC}\ i, \\
G_{100} &= \text{SUP}_{EU}\ i \times (1 - \text{SUP}_{NAT}\ i) \times (1 - \text{SUP}_{LOC}\ i), \\
G_{010} &= (1 - \text{SUP}_{EU}\ i) \times \text{SUP}_{NAT}\ i \times (1 - \text{SUP}_{LOC}\ i), \\
G_{001} &= (1 - \text{SUP}_{EU}\ i) \times (1 - \text{SUP}_{NAT}\ i) \times \text{SUP}_{LOC}\ i.
\end{align*} \]

Then, the role of local support in stimulating the propensity to introduce product innovations as additional to the EU and government support was evaluated according to the following formula:

\[ \begin{align*}
\text{EF}_{1\text{PROD}} &= \frac{\sum_{i} G_{111} \times (P(\text{IN}_{\text{PROD}} = 1 | G_{111} = 1, x_{i}) - P(\text{IN}_{\text{PROD}} = 1 | G_{110} = 1, x_{i}))}{\sum_{i} G_{111}}.
\end{align*} \]

where \(x_{i}\) denotes a vector of explanatory variables without the indicators associated with public support. Analogous formulas were used for studying the effects of remaining policy mixes and other types of innovations. These formulas are provided in Appendix B.

On the basis of the proposed conceptual model and previous research studies, the following hypotheses were formulated:

**Hypothesis 1:** The effects of innovation support are different for the new and old EU member states: while the former focus on investing in innovation inputs the latter also use support directly for introducing innovations.

**Hypothesis 2:** New countries of the European Union tend to direct innovation support for acquisition of machinery, equipment, software, buildings, knowledge and trainings for innovative activities, while older members of the EU invest more in intra- and extramural research and development. As a result, product innovations emerge less often in the new member states.

**Hypothesis 3:** Support from the EU is more effective in the new member states while aid at the national and local level is more effective in old EU member states.

**Hypothesis 4:** Support from the EU is more efficient in the case of manufacturing, while services rely to a larger extent on support from local and national sources.
Hypothesis 5: Enterprises utilizing a policy mix have larger propensities to introduce different kinds of innovations than firms using support from one source only.

4. Results and Discussion

Before presenting the main estimation results, we first report some descriptive statistics for the dependent variables. Table 6 shows the distribution of support variables across groups of countries and NACE groups.

Table 6. Distribution of support variables across country groups and NACE groups.

|        | SUP_LOC | SUP_NAT | SUP_EU |
|--------|---------|---------|--------|
| ALL    | 0.07    | 0.15    | 0.07   |
| OLD_EU | 0.08    | 0.14    | 0.05   |
| NEW_EU | 0.04    | 0.18    | 0.20   |
| MHT    | 0.15    | 0.42    | 0.17   |
| MMHT   | 0.11    | 0.22    | 0.09   |
| MMLT   | 0.06    | 0.11    | 0.06   |
| MLT    | 0.09    | 0.16    | 0.08   |
| SKIS   | 0.11    | 0.24    | 0.12   |
| SLKIS  | 0.03    | 0.05    | 0.03   |

Results from Table 6 indicate that support from the national government was the most commonly used type of innovation aid in all subgroups. Moreover, distribution of institutions providing funds was different for old and new EU countries. New countries of the European Union received more public support from the European Union and from the national government. Directing more EU funds to newer members is aimed at supporting the catching up processes in these countries and, in effect, strengthening the European Union integration. For the group encompassing old members of the European Union and Norway, the share of firms obtaining support from regional sources was higher than in the case of new EU member states. Moreover, percentage of firms obtaining support strongly varied across industry groups. In general, manufacturing companies obtained more support than services. In the group of manufacturing enterprises, probability of obtaining support was the highest for high technology and medium-high technology firms. Low technology and medium-low technology manufacturers were not able to receive so much support for innovation activities. In the group of service companies, the level of advancement had a similar impact on the chance of obtaining support for innovation activities.

Table 7 presents the shares of small and medium enterprises investing in research and development as well as buying machinery, equipment, software, buildings or knowledge and engaging in training for innovative activities. The percentage of firms which introduced various types of innovations is also reported.

The results indicate that enterprises from Norway and the old European Union are more innovative than firms located in new EU member states. In turn, innovative firms from new countries of the European Union invest more often in research and development and acquisition of machinery, equipment, software, buildings, knowledge and trainings. The tendency to invest in research, development, knowledge and equipment is correlated with the level of technological advancement. High technology manufacturers and medium-high technology manufacturers invest more often in research and development and ACQ than medium-low and low technology manufacturers. The same correlation is observed in services. The share of knowledge intensive services investing in research and development as well as buying knowledge, machinery and equipment is higher than
the share of less knowledge intensive services. The same rule concerns propensities to introduce innovations. High and medium-high manufacturing companies tend to introduce product, process, organizational and marketing innovations more frequently than low and medium-low manufacturers. Knowledge intensive services are also more innovative than less knowledge intensive services.

Table 7. Distribution of variables associated with innovation activities across country and NACE groups.

|        | RD   | ACQ   | IN_PROD | IN_PROC | IN_ORG | IN_MARK |
|--------|------|-------|---------|---------|--------|---------|
| ALL    | 0.34 | 0.35  | 0.20    | 0.20    | 0.21   | 0.20    |
| OLD_EU | 0.32 | 0.25  | 0.26    | 0.26    | 0.28   | 0.24    |
| NEW_EU | 0.43 | 0.82  | 0.13    | 0.13    | 0.13   | 0.14    |
| MHT    | 0.73 | 0.45  | 0.49    | 0.34    | 0.35   | 0.33    |
| MMHT   | 0.57 | 0.40  | 0.40    | 0.31    | 0.28   | 0.27    |
| MMLT   | 0.24 | 0.31  | 0.16    | 0.18    | 0.18   | 0.18    |
| MLT    | 0.36 | 0.40  | 0.21    | 0.24    | 0.22   | 0.17    |
| SKIS   | 0.51 | 0.44  | 0.31    | 0.26    | 0.30   | 0.26    |
| SLKIS  | 0.15 | 0.28  | 0.09    | 0.13    | 0.16   | 0.16    |

Table 8; Table 9 present estimation results for the models explaining innovation inputs and innovation outputs obtained on the basis of the whole sample (Estimation results for the equation explaining propensity to obtain support are available from the authors on request). The tables show respectively, the role of innovation support as well as R&D and ACQ expenditures and the impact of the remaining explanatory variables.

Results from Table 8 indicate that innovation aid is an important source of financing intra- and extramural R&D and acquisition of external knowledge and equipment. The only exception is given by support from the European Union which does not significantly influence spending on research and development. The largest impact for both R&D and ACQ corresponds to innovation aid provided by central governments. Results from the second part of Table 8 show that innovation expenditures serve the desired goal of leading to more innovations of all types with product innovations being especially driven by R&D intensity. Innovation support does not have a direct effect in all the cases. A direct impact of innovation support on creation of new solutions was, however, found for the EU and local aid.

Table 8. Relations between support, innovation inputs and innovativeness for the whole sample.

|        | RD   | ACQ   | IN_PROD | IN_PROC | IN_ORG | IN_MARK |
|--------|------|-------|---------|---------|--------|---------|
| SUP_EU | -    | 0.058 ** | 0.048 ** | 0.086 *** | -      | -       |
| SUP_NAT| 0.252 *** | 0.150 *** | -       | -       | -      | -       |
| SUP_LOC| 0.201 *** | 0.117 *** | 0.075 *** | -       | 0.054 ** | 0.074 *** |
| RD    | -    | -     | 0.203 *** | 0.037 ** | 0.110 *** | 0.151 *** |
| ACQ   | -    | -     | -       | 0.417 *** | 0.301 *** | 0.209 *** |

** and *** indicate significance at the 5% and 1% levels.

As follows from the results provided in Table 9, domestic or EU group affiliation promoted R&D investments. Being a part of a national group was also a direct stimulant for the emergence of process, marketing and organizational innovations. In addition, the latter novelties were more likely to occur within a group of companies reaching beyond the EU. The impact of group allocation was, however, not unidirectional as belonging to some types of groups was associated with lower ACQ spending or fewer innovations. The bi-directional impact of group membership confirms findings from many research studies (see Table 4). In light of our results, difficulties with decision making processes,
negatively affected propensity to acquire knowledge and machinery as well as introduce product innovations. On the other hand, process and organizational innovations as well as investing in research and development seemed to be promoted by business affiliation (see [16]).

Table 9. Impact of other explanatory variables on innovation inputs and innovation outputs for the whole sample.

| Group       | RD    | ACQ   | IN_PROD | IN_PROC | IN_ORG | IN_MARK |
|-------------|-------|-------|---------|---------|--------|---------|
| GROUP_DOM   | 0.276 *** | -     | -0.0212 *** | 0.084 ** | 0.132 *** | 0.062 # |
| GROUP_EU    | 0.080 *   | -0.069 #   | -       | -       | -       | -0.156 ***  |
| GROUP_OTH   | -      | -     | -       | -       | 0.212 ** | -       |
| MARLOC      | -     | 0.144 *** | 0.141 *** | 0.137 *** | 0.121 *** | 0.207 *** |
| MARNAT      | 0.186 *** | -     | -       | 0.242 *** | 0.275 *** | 0.447 *** |
| MAREUR      | 0.175 *** | -     | -0.168 *** | 0.269 *** | 0.220 *** | 0.234 *** |
| MAROTH      | 0.150 *** | -     | -       | 0.231 *** | 0.198 *** | 0.350 *** |
| MARKET_NAT  | -     | -     | -       | 0.173 *** | 0.134 *** | 0.175 *** |
| MARKET_EU   | 0.117 *** | 0.101 *** | -       | 0.202 *** | 0.185 *** | -       |
| MARKET_OTH  | 0.113 *   | -     | -       | 0.189 *** | 0.220 *** | -       |
| EMPUD       | 0.111 *** | -0.023 ** | -0.023 ** | 0.016 #   | 0.084 *** | 0.067 *** |
| ENMrg       | 0.140 *** | -     | -0.180 *** | 0.382 *** | 0.506 *** | 0.300 *** |
| ENOUT       | 0.169 *** | -     | -0.327 *** | 0.619 *** | 0.782 *** | 0.607 *** |
| PUBDOM      | 0.103 *** | 0.086 ** | -0.250 *** | 0.456 *** | 0.516 *** | 0.499 *** |
| PUBFOR      | 0.293 *** | -     | -0.142 *   | 0.422 *** | 0.402 *** | 0.434 *** |
| CO_GP       | 0.114 **   | 0.086 #   | 0.158 *** | -       | 0.134 *** | 0.128 *** |
| CO_SUP      | 0.239 *** | 0.500 *** | 0.129 *** | 0.411 *** | 0.185 *** | 0.243 *** |
| CO_CUST     | 0.190 *** | 0.080 #   | 0.395 *** | -       | 0.143 *** | -       |
| CO_COMP     | -      | 0.142 **   | -       | 0.142 *   | 0.204 ** | 0.070 #   |
| CO_CONS     | 0.327 *** | 0.203 *** | -       | -       | 0.224 *** | 0.209 *** |
| CO_UNI      | 0.634 *** | -0.078 #   | 0.104 *   | -       | -       | -       |
| CO_GOV      | 0.387 *** | -     | -0.149 **   | -       | -0.94 *** | -0.195 *** |

#, *, ** and *** indicate significance at the 20%, 10%, 5% and 1% levels.

Further results suggested a positive linkage between internationalization and investing in R&D as well as the probability of introducing process, organizational and marketing innovations. This confirms the results obtained by Fillipetti et al. [44], who suggested that international exposure should improve innovativeness. Market reach was, however, not directly significant for the emergence of product innovations.

Enterprises with contracts to provide goods or services for domestic or foreign public sector were more likely to invest in innovation inputs, especially in R&D. A direct and positive impact was also found with respect to the introduction of process, organizational and marketing innovations. These types of contracts were, however, directly associated with launching fewer new products. This result is in line with findings obtained, among others, by Uyarra et al. [45], who noticed that the user-supplier interaction and management of risk could influence suppliers' ability to innovate. Similar effects as for public procurement, stemmed from merging or taking over another enterprise or a part of another enterprise or selling, closing or contracting out some of the tasks or functions and having a larger share of employees with higher education. While the latter encouraged spending on R&D, it discouraged ACQ investments.

In general, there was a positive relation between cooperation and chances of spending on innovation inputs and introducing innovations. In particular, all types of joint activities, apart from collaboration with competitors, increased the probability of investing in R&D. Links with universities...
and higher education institutes were especially relevant in this respect. While this type of cooperation encouraged internal and external research and development efforts, they discouraged spending on ACQ. In addition, many direct, positive relations between cooperation indicators and innovation outputs were found. This concerned mainly joint efforts within a group or with suppliers of equipment, materials, components or software. As could be expected, cooperation with clients or customers, consultants and commercial laboratories and competitors were relevant for organizational and/or marketing novelties. The obtained results are in line with the “open innovation” paradigm of Enkel et al. [40] (see Table 4) and the results obtained in [42] suggesting that innovation cooperation has become an important element of corporate strategy. One type of cooperation, i.e., cooperation with government or private or public research institutes was directly disadvantageous with respect to most of innovation indicators. This result is a bit surprising, since alternative studies have found positive impact of cooperation with public research institutions on innovativeness (see e.g., [44]). The discrepancy in results may be due to differences in sample of countries used in analysis. Findings from the cited paper concern France and Germany, while in this study they were obtained for the database on a larger number of countries.

Apart from estimating simultaneous equations models using data for all enterprises, the models were also estimated for firms representing new and old member states of the European Union as well as for manufacturing and services, separately. Table 10 includes the estimates for support and input variables for all four groups of enterprises.

**Table 10.** The impact of support and innovation inputs on innovation outputs in sub-groups.

| Support | NEW_EU | OLD_EU | Manufacturing | Services |
|---------|--------|--------|---------------|----------|
| SU Bình IN_PROD | - | 0.070 ** | 0.084 ** | - |
| SU Bình IN_PROC | 0.059 ** | 0.142 *** | 0.159 *** | - |
| SU Bình IN_ORG | -0.45 * | 0.072 ** | - | - |
| SU Bình IN_MARK | - | 0.062 ** | - | - |
| SU Bình IN_PROC | - | 0.111 *** | - | 0.111 *** |
| SU Bình IN_ORG | - | 0.022 ** | - | - |
| SU Bình IN_MARK | - | - | - | - |
| SU Bình IN_PROC | - | 0.079 ** | - | 0.129 *** |
| SU Bình IN_PROC | 0.181 *** | - | - | - |
| SU Bình IN_ORG | 0.135 *** | - | - | - |
| SU Bình IN_MARK | - | 0.029 ** | 0.062 # | 0.040 # |
| SU Bình EU-RD | - | - | - | - |
| SU Bình EU-ACQ | 0.071 ** | - | 0.170 *** | - |
| SU Bình NAT-RD | 0.045 # | 0.408 *** | 0.187 *** | 0.334 *** |
| SU Bình NAT-ACQ | 0.162 *** | 0.146 *** | 0.115 *** | 0.186 *** |
| SU Bình LOC-RD | 0.113 ** | 0.241 *** | 0.158 ** | 0.124 ** |
| SU Bình LOC-ACQ | - | 0.152 *** | 0.187 *** | - |
| RD Bình IN_PROD | 0.099 *** | 0.277 *** | 0.277 *** | 0.211 *** |
| RD Bình IN_PROC | 0.131 *** | - | - | 0.037# |
| RD Bình IN_ORG | 0.144 *** | 0.086 *** | 0.065 ** | 0.075 *** |
| RD Bình IN_MARK | 0.152 *** | 0.155 *** | 0.138 *** | 0.113 *** |
| ACQ Bình IN_PROD | - | 0.096 *** | 0.059 * | 0.046 * |
| ACQ Bình IN_PROC | 0.495 *** | 0.359 *** | 0.330 *** | 0.415 *** |
| ACQ Bình IN_ORG | 0.330 *** | 0.282 *** | 0.300 *** | 0.302 *** |
| ACQ Bình IN_MARK | 0.219 *** | 0.202 *** | 0.227 *** | 0.205 *** |

#, *, ** and *** indicate significance at the 20%, 10%, 5% and 1% levels.
Results from Table 10 demonstrate that innovation support is utilized differently by the new and old EU member states. They also suggest various effectiveness of aid from alternative institutional sources in these two country groups.

While both groups direct aid to engage in research and development and acquisition, which later have a positive impact on the emergence of innovations, the older European Union members are able to use it directly to launch new products, processes as well as organizational and marketing solutions to a much greater extent than the newer EU members. The results also suggest that the two groups of countries tend to use alternative innovation strategies, with older members of the EU focusing on spending innovation support on R&D and newer members of the European Union investing in ACQ. Higher propensity to buy machinery and equipment as well as lower propensity to invest in research and development and innovation outputs is in line with several studies devoted to innovativeness in post-transition economies (see e.g., [35]). One of the reasons is high risk of failure associated with R&D investments. In the light of the estimates, this makes supporting product innovations more difficult in countries which joined the EU more recently. These observations are similar to those of Acemoglu et al. [36] who show that developing countries prefer investment-based growth strategies while countries from the technological frontier gain more from pursuing innovation-based growth strategies.

Given that support from the EU is mainly directed to the new member states, it is also important to investigate the effectiveness of this and other kinds of support. The following conclusions can be formulated in this respect. Aid at the local and national levels increases the chances of investing in innovation inputs to a greater extent in the old member states, while support from the EU plays an important role for investments in ACQ in new member states only. These differences between old and new EU member states are in line with findings obtained, among others, by Cie´ slik et al. [51]. The conclusions change, however, when direct effects of financial aid on the emergence of innovations is considered. In this area, the older members of the EU are able to use support from the European Union and central authorities much more effectively than the newer EU members (see also [52]). This shows that innovation aid is not being used optimally to achieve economic results in the latter group of countries.

Results from the second part of Table 10 shed some light on the usefulness of various kinds of innovation support for promoting novelties in manufacturing and services. It can be seen that aid from the EU is more effective in the former sector as it stimulates both innovation inputs and outputs. Support at the local and national levels was an important driver of R&D and ACQ investments in both areas of economic activity, however a direct, positive effect on innovations was greater for services. This concerned, in particular, the emergence of product innovations. Higher efficiency of support from the European Union in the case of manufacturing companies and greater efficiency of support from the local and national government in the case of services is in line with Hypothesis 4.

In the next step, the role of policy mix in stimulating innovativeness was evaluated for the whole sample. This was done by computing the marginal impact of various kinds of support as additional to other types of innovation aid. These effects were calculated according to Equation (8) (for studying the role of adding local aid for product innovations) and based on formulas from Appendix B (for other matches of innovation and support types). Table 11 presents the results.

It can be seen, that in majority of cases, positive effects from policy mixes were obtained. It means that enterprises utilizing a policy mix have larger propensities to introduce innovations than firms using support from one source only. In short, obtaining support from a third source (local government, central government or the European Union) on top of the other two kinds of innovation aid increased the propensity to introduce different types of innovations. In turn, with a few exceptions, enterprises obtaining support from two sources had a larger chance to introduce product, process, marketing and organizational innovations as compared to firms, which received support from one source only. This result is in line with findings of other studies (see e.g., [37]). It turns out that interplay between different support measures positively affects innovativeness (see [51]). Some negative effects from
policy mixes were observed when national support was combined with the EU support and when local support was added to the EU aid. These negative estimates indicate some flaws in the corresponding types of policy mixes which might be more difficult to design between institutions from a specific country and the EU. No negative effects of this kind (substitutability of support from two alternative sources) were observed at the national level when local and central support were combined.

| Table 11. The role of policy mix. |
|-----------------------------------|
|                                   |
| **EU support as additional to national and local support** | **Product Innovation** | **Process Innovation** | **Organizational Innovation** | **Marketing Innovation** |
| 0.014                             | 0.036                  | 0.083                  | 0.035                          |
| **National support as additional to EU and local support** | **EU support as additional to national and support** | **Product Innovation** | **Process Innovation** | **Organizational Innovation** | **Marketing Innovation** |
| 0.103                             | 0.045                  | 0.122                  | 0.067                          |
| **Local support as additional to national and EU support** | **EU support as additional to national support** | **Product Innovation** | **Process Innovation** | **Organizational Innovation** | **Marketing Innovation** |
| 0.023                             | 0.060                  | 0.171                  | 0.058                          |
| **EU support as additional to national support** | **EU support as additional to local support** | **Product Innovation** | **Process Innovation** | **Organizational Innovation** | **Marketing Innovation** |
| 0.046                             | 0.013                  | −0.026                 | 0.007                          |
| **EU support as additional to local support** | **National support as additional to local support** | **Product Innovation** | **Process Innovation** | **Organizational Innovation** | **Marketing Innovation** |
| 0.081                             | 0.078                  | 0.044                  | 0.044                          |
| **National support as additional to local support** | **National support as additional to support** | **Product Innovation** | **Process Innovation** | **Organizational Innovation** | **Marketing Innovation** |
| 0.170                             | 0.087                  | 0.083                  | 0.078                          |
| **National support as additional to EU support** | **Local support as additional to EU support** | **Product Innovation** | **Process Innovation** | **Organizational Innovation** | **Marketing Innovation** |
| 0.052                             | −0.101                 | 0.002                  | 0.017                          |
| **Local support as additional to EU support** | **Local support as additional to national support** | **Product Innovation** | **Process Innovation** | **Organizational Innovation** | **Marketing Innovation** |
| −0.027                            | −0.086                 | 0.046                  | 0.008                          |

**5. Conclusions**

Lower private returns as compared to social returns from research and development activities call for public support of innovation projects. Such aid can lead to input as well as output additionalities. However, as documented by some research articles, subsidies may also cause the crowding-out effect. This study, based on the Community Innovations Survey 2014, contributes to the understanding of heterogeneity of effects that support measures from alternative institutions have across European countries and two sectors of economic activity.

The conducted complex quantitative analysis of the role and efficiency of public support measures used by SMEs led to a large number of conclusions. In particular, it made it possible to evaluate the research hypotheses presented in Section 3.

The results indicated significant differences in innovation strategies and usage of innovation aid between firms from the richest European countries and enterprises located in new member states of the European Union, addressed in Hypotheses 1 and 2. These hypotheses were supported by the data. It was shown that companies from Norway and old member states of the EU successfully applied support at both intermediate and final stages of the innovation process i.e., to finance innovation inputs and the subsequent emergence of innovations. As far as innovation strategies are concerned, they invested more in internal and external research and development. In contrast, firms located in new EU member states tended to direct innovation aid mainly to finance innovation inputs. In this area, they spent more willingly on acquiring machines, equipment, software, buildings, knowledge and trainings. These results mean that innovation support may be used suboptimally in the newer member states of the EU. They also explain why fewer innovations are introduced in these countries. This concerns, in particular, product innovations which rely more heavily on R&D investments.

Heterogeneity of outcomes was also found when analyzing efficiency of different sources of support for firms representing old and new EU member states as well as services and manufacturing sectors. Support from the European Union stimulated introduction of different kinds of innovations in the old countries of the European Union but was not used by them to finance innovation inputs. On the
other hand, new EU members successfully applied it to support acquisition of knowledge, machinery and equipment but were not able to use it efficiently for introducing innovations. Support from the local and central government significantly increased propensities to introduce product and marketing innovations in the case of enterprises located in Norway and old countries of the European Union and process and organizational innovations in the remaining companies. National support provided positive effects only in the case of firms from old EU countries. These findings showed that Hypothesis 3, motivated by directing a predominant share of EU innovation funds to new member states, was too general and was only partially supported by the analysis. Further results showed that support from the European Union was efficient in the case of manufacturing companies and inefficient in services sector, which could rely to a larger extent on local and national aid. This conclusion was in line with Hypothesis 4.

Finally, it was shown that companies using more than one source of support, innovated more intensively. This provided evidence in favor of Hypothesis 5. In particular, using two or three sources of public support increased the propensity to introduce organizational innovations. Therefore, enterprises aimed at being more innovative should consider applying for support from different institutional sources. A few exceptions to the general result concerning positive economic outcomes of policy mixes involved combinations of EU with national or local aid. This might call for better coordination of policies between EU and national governments which could lead to improved economic results.

Some limitations of the above conclusions should be emphasized. Since statistical data become outdated quickly, conclusions concerning significant differences between old and new countries of the European Union are valid for the period 2012-2014. Strengthening of the integration process should reduce these differences in the future.

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Appendix A

Appendix A provides a detailed description of econometric models used to obtain the results presented in the main part of the article. First, the way of dealing with the sample selection problem is described and then the particular equations are given.

Some information concerning innovation strategies, innovation support and cooperation on innovation activities is available in the CIS database only in the case of innovative enterprises. In order to avoid the selection bias problem, a dummy variable \( IN_i \) was defined, which took value 1 for enterprises, that introduced a product or process innovation or had ongoing or abandoned innovation activities for these types of novelties. Then, the following probit selection model explaining propensity to be innovative was estimated:

\[
IN_i^* = x_i^{IN} \beta^{IN} + \epsilon_i^{IN}, \quad (A1)
\]

\[
IN_i = \mathbb{I}\{IN_i^* > 0\}, \quad (A2)
\]

\[
\epsilon_i^{IN} \sim N(0,1), \quad (A3)
\]
and the inverse Mills ratio was calculated as:

$$\text{IMR}_{\text{IN}} = \frac{\phi(\hat{x}^\text{IN}_{\text{IN}} \hat{\beta}^\text{IN})}{1 - \Phi(\hat{x}^\text{IN}_{\text{IN}} \hat{\beta}^\text{IN})}$$  \hspace{1cm} (A4)$$

where $\phi$ and $\Phi$ denote respectively, the density and the cumulative density function of the standard normal distribution. The variable IMR$_{\text{IN}}$ was subsequently used as a regressor in further models in order to take into account sample selection.

The model used to identify the factors affecting probability of obtaining support from various institutions was a trivariate probit of the form:

$$\text{SUP}_{\text{EU}}^* = x^\text{SUP}_{\text{EU}} \beta^\text{SUP}_{\text{EU}} + \epsilon^\text{SUP}_{\text{EU}}$$ \hspace{1cm} (A5)$$

$$\text{SUP}_{\text{NAT}}^* = x^\text{SUP}_{\text{NAT}} \beta^\text{SUP}_{\text{NAT}} + \epsilon^\text{SUP}_{\text{NAT}}$$ \hspace{1cm} (A6)$$

$$\text{SUP}_{\text{LOC}}^* = x^\text{SUP}_{\text{LOC}} \beta^\text{SUP}_{\text{LOC}} + \epsilon^\text{SUP}_{\text{LOC}}$$ \hspace{1cm} (A7)$$

$$\text{SUP}_{\text{EU}} = I\{\text{SUP}_{\text{EU}}^* > 0\}$$ \hspace{1cm} (A8)$$

$$\text{SUP}_{\text{NAT}} = I\{\text{SUP}_{\text{NAT}}^* > 0\}$$ \hspace{1cm} (A9)$$

$$\text{SUP}_{\text{LOC}} = I\{\text{SUP}_{\text{LOC}}^* > 0\}$$ \hspace{1cm} (A10)$$

$$[\epsilon^\text{SUP}_{\text{EU}} \epsilon^\text{SUP}_{\text{NAT}} \epsilon^\text{SUP}_{\text{LOC}}]’ \sim N(0, I)$$ \hspace{1cm} (A11)$$

where, for the estimation based on the whole sample, $x^\text{SUP}_{\text{EU}}$, $x^\text{SUP}_{\text{NAT}}$, and $x^\text{SUP}_{\text{LOC}}$ included explanatory variables described in Table 4; Table 5 as well as IMR$_{\text{IN}}$.

The estimated Equations (A5)–(A11) were used to compute predicted values for the latent variables SUP$_{\text{EU}}^*$, SUP$_{\text{NAT}}^*$ and SUP$_{\text{LOC}}^*$.

In the next step, the following bivariate probit model, explaining innovation inputs, was considered:

$$\text{RD}^*_i = x^\text{RD} \beta^\text{RD} + \epsilon^\text{RD}_i$$ \hspace{1cm} (A12)$$

$$\text{ACQ}^*_i = x^\text{ACQ} \beta^\text{ACQ} + \epsilon^\text{ACQ}_i$$ \hspace{1cm} (A13)$$

$$\text{RD}_i = I\{\text{RD}^*_i > 0\}$$ \hspace{1cm} (A14)$$

$$\text{ACQ}_i = I\{\text{ACQ}^*_i > 0\}$$ \hspace{1cm} (A15)$$

$$[\epsilon^\text{RD}_i \epsilon^\text{ACQ}_i]’ \sim N(0, I)$$ \hspace{1cm} (A16)$$

where the vectors of regressors additionally contained SUP$_{\text{EU}}^*$, SUP$_{\text{NAT}}^*$ and SUP$_{\text{LOC}}^*$. The model was used to calculate RD$^*$ and ACQ$^*$.

Eventually, simultaneous equations for innovation outputs were specified analogously to (A5)–(A11) and (A12)–(A16) for the four latent variables: IN$_{\text{PROD}}^*$, IN$_{\text{PROC}}^*$, IN$_{\text{ORG}}^*$ and IN$_{\text{MARK}}^*$. The list of explanatory variables was extended to include RD$^*$ and ACQ$^*$.

Appendix B

Below the formulas used to evaluate the effects of using alternative policy mixes are further presented. First the remaining equations used to study the role of local support as additional
to the EU and government support, analogous to Equation (8), are provided. They concern the introduction of process, organizational and marketing innovations:

\[
\text{EF1}_{\text{PROC}} = \frac{\sum_{G111_i=1} (P(\text{IN\_PROC}_i = 1 | G111_i = 1, x_i) - P(\text{IN\_PROC}_i = 1 | G110_i = 1, x_i))}{\sum_i G111_i} \tag{A17}
\]

\[
\text{EF1}_{\text{ORG}} = \frac{\sum_{G111_i=1} (P(\text{IN\_ORG}_i = 1 | G111_i = 1, x_i) - P(\text{IN\_ORG}_i = 1 | G110_i = 1, x_i))}{\sum_i G111_i} \tag{A18}
\]

\[
\text{EF1}_{\text{MARK}} = \frac{\sum_{G111_i=1} (P(\text{IN\_MARK}_i = 1 | G111_i = 1, x_i) - P(\text{IN\_MARK}_i = 1 | G110_i = 1, x_i))}{\sum_i G111_i} \tag{A19}
\]

Since the remaining formulas are constructed analogously to (8) and (A17)–(A19), in what follows, the equations associated with propensities to introduce product innovations are only described. These associated with probabilities of introducing other types of innovations can be obtained with obvious modifications.

The impact of government support as additional to the EU and local aid as well as the role of EU support as additional to the local and government support were computed as:

\[
\text{EF2}_{\text{PROD}} = \frac{\sum_{G111_i=1} (P(\text{IN\_PROD}_i = 1 | G111_i = 1, x_i) - P(\text{IN\_PROD}_i = 1 | G101_i = 1, x_i))}{\sum_i G111_i} \tag{A20}
\]

and

\[
\text{EF3}_{\text{PROD}} = \frac{\sum_{G111_i=1} (P(\text{IN\_PROD}_i = 1 | G111_i = 1, x_i) - P(\text{IN\_PROD}_i = 1 | G011_i = 1, x_i))}{\sum_i G111_i} \tag{A21}
\]

The importance of EU support in stimulating innovativeness as additional to the national support was reflected by:

\[
\text{EF4}_{\text{PROD}} = \frac{\sum_{G110_i=1} (P(\text{IN\_PROD}_i = 1 | G110_i = 1, x_i) - P(\text{IN\_PROD}_i = 1 | G010_i = 1, x_i))}{\sum_i G110_i} \tag{A22}
\]

while the role of EU support added to the local support was evaluated on the basis of the following formula:

\[
\text{EF5}_{\text{PROD}} = \frac{\sum_{G101_i=1} (P(\text{IN\_PROD}_i = 1 | G101_i = 1, x_i) - P(\text{IN\_PROD}_i = 1 | G100_i = 1, x_i))}{\sum_i G101_i} \tag{A23}
\]

Analogously, the significance of national support in enhancing innovativeness as additional to the EU support was calculated as:

\[
\text{EF6}_{\text{PROD}} = \frac{\sum_{G110_i=1} (P(\text{IN\_PROD}_i = 1 | G110_i = 1, x_i) - P(\text{IN\_PROD}_i = 1 | G100_i = 1, x_i))}{\sum_i G110_i} \tag{A24}
\]

while the role of national support provided together with local support was given by:

\[
\text{EF7}_{\text{PROD}} = \frac{\sum_{G011_i=1} (P(\text{IN\_PROD}_i = 1 | G011_i = 1, x_i) - P(\text{IN\_PROD}_i = 1 | G001_i = 1, x_i))}{\sum_i G011_i} \tag{A25}
\]

Finally, the role of local support was evaluated using:

\[
\text{EF8}_{\text{PROD}} = \frac{\sum_{G011_i=1} (P(\text{IN\_PROD}_i = 1 | G011_i = 1, x_i) - P(\text{IN\_PROD}_i = 1 | G100_i = 1, x_i))}{\sum_i G011_i} \tag{A26}
\]
and

$$EF9_{\text{PROD}} = \frac{\sum_{G011_i = 1} (P(\text{IN\_PROD}_i = 1 | G011_i = 1, x_i) - P(\text{IN\_PROD}_i = 1 | G010_i = 1, x_i))}{\sum_{i} G011_i}. \quad (A27)$$

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