Do Human Resources and the Research System Affect Firms’ Innovation Activities? Results from Poland and the Czech Republic

Aleksandra Zygmunt
Faculty of Economics and Management, Opole University of Technology, ul. Luboszycka 7, 45-036 Opole, Poland; a.zygmunt@po.edu.pl; Tel.: +48-77-449-8800

Received: 31 January 2020; Accepted: 5 March 2020; Published: 23 March 2020

Abstract: Strong relationships between innovation of firms and sustainable development of regions and countries have priority in issues related to firms’ innovation performance. In this paper, particular emphasis is given to Poland and the Czech Republic as countries with similar innovation performance. Specifically, it seems interesting to identify the extent to which human resources and the research system in these countries matter in firms’ innovation activities. Thus, the aim of the paper is to test whether human resources and the research system affect Polish and Czech firms’ innovation activities. The data were sourced from the European Innovation Scoreboard (2018, 2019) for the period of 2010–2016. A set of variables concerning human resources and the research system were employed. The hypotheses were tested with the Cobb–Douglas function. This paper contributes to the existing literature by adding to studies that seek to identify determinants of firms’ innovation activities. The findings indicate the statistical significance of such a variable related with human resources, as lifelong learning for innovation activities of firms from Poland and such a variable connected with the research system, as the top 10% most cited publications on Czech firms’ innovation activities. The paper has practical and policy implications. There is a need, among others, to strengthen knowledge diffusion processes between firms and universities, research organisations, and institutional environments in order to improve innovation activities of firms.

Keywords: firms’ innovation activities; human resources; the research system; Poland; the Czech Republic; sustainable development of regions and countries

1. Introduction

It has been widely argued that innovation stimulates competitive advantage of firms, regions, and countries [1,2] and contributes to sustainable development [3]. This implies the importance of actions enhancing innovation. The value of innovation has been recognised by the European Union, which, in the Europe 2020 Strategy, emphasises substantial concern about the creation of conditions for sustainable and inclusive growth [4,5]. Particularly, major focus is given to interaction between firms’ innovation and the economic growth of regions and countries [6]. In this context, the rank of innovation activities of firms seems crucial because of their significant contribution to the enhancing competitiveness of regions and countries [7]. The determinants of firm innovation are the subject of extensive theoretical and empirical studies [8]. A growing body of literature deals with the role of knowledge diffusion in firms’ innovation performance [9,10]. Such processes foster innovations and increase competitive advantage. These issues are particularly considered in endogenous growth and knowledge spillover theories. In this regard, the current state of the literature largely supports the view of human resources as being important in knowledge diffusion and in fostering firms’ innovation performance [11,12], with high-skilled workers believed to constitute a crucial factor for building
competitive advantage of firms [10]. It is also believed that the research system plays a significant role in knowledge diffusion processes [6]. Specifically, it has been observed that the research system reflects the competitiveness of the science and capacity for involvement in firms’ innovation performance by providing knowledge [13,14]. Human resources and the research system, being essential for innovation performance of firms, are of special interest to European Union firms [4]. However, for all that, the debate on the determinants of firms’ innovation performance is still incomplete, particularly with regards to human resources and the research system.

This paper seeks to add to the existing knowledge by investigating the importance of human resources and the research system for firms’ innovation activities. These relationships were tested for Poland and the Czech Republic. Focusing on these countries may provide an interesting setting since innovation performance in Poland and the Czech Republic is similar and below the European Union’s average [4]. Hence, it seems important to investigate what enhances firms’ innovation performance in these countries and consequently, increases their competitive advantage. However, despite growing literature on firms’ innovation performance [15–17], little attention has been devoted so far to the significance of human resources and the research system for innovation activities of Polish and Czech firms.

To address this important gap, this study aims to test whether human resources and the research system affect Polish and Czech firms’ innovation activities. The data used in the study were sourced from the European Innovation Scoreboard (2018, 2019). The Cobb–Douglas function was used to test the hypotheses. The research period was 2010–2016.

This study adds evidence to the literature on the relevance of human resources and the research system in pursuing innovation activities in Polish and Czech firms. It also contributes to the existing studies by employing the Cobb–Douglas function to investigate the extent to which human resources and the research system matter in firms’ innovation activities.

The remainder of the paper is structured as follows: The first section provides theoretical background and hypothesis development. The second section presents the methodology employed to identify the importance of human resources and the research system for Polish and Czech firms’ innovation activities. The third section introduces the results, comprising a comparative analysis of the variables employed for the study. This section also sheds light on the effect of human resources and the research system on innovation activities of firms from Poland and the Czech Republic. The fourth section discusses the results. In the final section, conclusions are provided together with policy and practical implications of the study, limitations and suggestions for further research.

2. Literature Review

Over the past years, a vast body of literature has argued that the interaction between firms, regions, and countries is a key to sustainable development [12]. The existing evidence suggests that innovation activities of firms are crucial for the sustainable development of regions and countries [10]. A number of theoretical and empirical studies deal with determinants of innovation performance [6,18,19]. Most of them point to the importance of both endogenous and exogenous determinants in enhancing competitiveness of firms, regions, and countries [20–26]. Particularly, a considerable amount of research has been devoted to investigating how Research and Development (R&D) expenditures might have an impact on firms’ innovation activities [16,17]. It has been suggested that public and private expenditure on R&D can shift firms’ competitive advantage [15].

In the most recent studies, a great attention has been devoted to recognising the role of knowledge diffusion in improving innovation performance [1,27]. These studies point out that the network among firms, universities, research organisations and institutional environments is essential to build competitive advantages of firms, regions and countries [18]. As noted by Broekel and Boschma, “firms’ embeddedness in knowledge networks is crucial for their economic success” [28] (p. 3) and firms tend to acquire knowledge from various sources [14]. A number of studies highlight human resources [13,29,30] and the research system [31,32] as playing a pivotal role for firms’ innovation
performance. This set of studies argues that human resources (regarded, among others, as the knowledge or skills of workers) have a high potential for enhancing competitive advantage not only of firms, but also of regions and countries [10,29]. These studies also emphasise the research system as knowledge infrastructures that may affect knowledge creation and knowledge diffusion [27].

The existing evidence suggests that high-skilled workers are more likely to increase firms’ innovation performance [11,33]. This indicates that tertiary education, second-stage tertiary education, and lifelong learning might matter for firms and their innovation activities [4]. Particularly, second-stage tertiary education is regarded as a substantial determinant of innovation, with its considerable leverage on knowledge creation and competitive advantage enhancement [5,34]. For example, it has been observed that doctoral graduates are “an important source of skilled and innovative knowledge workers” [35] (p. 60) because of their contribution to knowledge diffusion.

Another part of the literature is focused on identifying the relevance of tertiary education for firms’ innovation performance [4]. A wide body of empirical literature assesses the role of a population with a bachelor’s degree and above as a source of workers with advanced skills [36,37]. In this sense, the European Union emphasises the population, especially aged 25–34, having completed tertiary education as the group reflecting relatively quick changes in educational policy and in labour market needs [5].

A growing body of work also investigates lifelong learning as relevant for firms’ innovation performance [4]. As noted by Mitchell and MacFarlane, lifelong learning means “learning that continues throughout one’s life” [38] (p. 67) and contributes to improving worker knowledge and skills [12,39]. Following this idea, lifelong learning contributes to innovation performance of firms as a significant stock of knowledge.

There are strong arguments for regarding the research system as fundamental for knowledge diffusion among firms, universities and research organisations, which is likely to affect firms’ innovation activities [6,27,40,41]. It has been observed that the research system plays a crucial role in external knowledge creation [13,14]. Following this, the existing literature shows the relevance of international scientific co-publications, the top 10% most cited publications, and foreign doctorate students for innovation performance of firms [5].

The existing evidence suggests that international scientific co-publications are indicative of science productivity [42]. As noted by Hoekman, Frenken, and Tijsen, such science collaboration “generates intellectual benefits through the cross-fertilisation of ideas” [43] and contributes to knowledge diffusion [44]. This may affect the enhancement of competitive advantage of firms, regions, and countries.

Another line of literature indicates foreign doctorate students as an important part of knowledge diffusion processes [4,47]. In line with this argument, firms, through a network with the research system, may acquire high-quality external knowledge. This may contribute to enhancing firms’ innovation activities and, consequently, to improving the economic growth of regions, countries, and to sustainable development.

Hence, while a considerable amount of research has been devoted to investigating the role of human resources and the research system in firms’ innovation activities, very few studies have analysed this topic in regard to Polish and Czech firms. Therefore, it is significant to carry out research in respect to Poland and the Czech Republic and investigate how human resources and the research system affect
innovation activities of firms in countries with similar innovation performance and remaining below the European Union’s average. Thus, the hypotheses to be tested are the following:

**Hypothesis 1 (H1).** Human resources positively affect firms’ innovation activities.

**Hypothesis 2 (H2).** The research system has a positive effect on innovation activities of firms.

### 3. Materials and Methods

This study is based on data sourced from the European Innovation Scoreboard (2018, 2019) for Poland (PL) and the Czech Republic (CZ). The European Innovation Scoreboard covers data related to innovation performance of the European Union Member States from such sources as (among others) Eurostat and Scopus, and puts special emphasis on the significance of small and medium-sized enterprises (SMEs) in achieving competitive advantage of regions and countries. Using data from the European Innovation Scoreboard allows a comparative analysis between Poland and the Czech Republic in terms of the effect of human resources and the research system on firms’ innovation activities. The research period was 2010–2016. The research is divided into two parts. The first part contains a comparative analysis of human resources and the research system (explanatory variables), and innovation performance of firms (dependent variables) between Poland and the Czech Republic. The second part focuses on how human resources and the research system affect innovation activities of Polish and Czech firms, with the usage of the Cobb–Douglas function.

Due to various measurements of human resources, the research system, and innovation activities of firms, the study follows the European Innovation Scoreboard approach, where variables used in the study have been embodied by a set of indicators.

The description of these variables is found in Table 1.

**Table 1.** Description of variables.

| Variables                                | Description |
|------------------------------------------|-------------|
| **Human resources**                      |             |
| New doctorate graduates                  | X₁          |
| Population aged 25–34 having completed tertiary education | X₂          |
| Lifelong learning                        | X₃          |
| **The research system**                  |             |
| International scientific co-publications  | X₄          |
| The top 10% most cited publications      | X₅          |
| Foreign doctorate students               | X₆          |
| **Innovation activities of firms**       |             |
| SMEs introducing product or process innovations | Y₁          |
| SMEs introducing marketing or organisational innovations | Y₂          |
| SMEs innovating in-house                 | Y₃          |

Source: own study based on [4,5].

Table 2 shows the summary statistics of variables.
To detect the presence of a high level of collinearity between explanatory variables, the graph analysis method [48] was used.

To investigate whether human resources and the research system affect Polish and Czech firms’ innovation activities, the Cobb–Douglas function was used. This function is distinguished by simplicity and good matching to empirical data [49]. First, six models were estimated (three for Poland and three for the Czech Republic) on the basis of the Cobb–Douglas function [50]:

\[
Y = b_0 x_1^{b_1} x_2^{b_2} \ldots x_k^{b_k}
\]

(1)

where \(b_0, b_1, \ldots, b_k\) are constants.

Such a number of models corresponds to various measurements of firms’ innovation activities and results from the diversity of innovation performance [51]. Next, the generated models were log-transformed according to the formula:

\[
\ln(Y) = b_0 + b_1 \ln(X_1) + b_2 \ln(X_2) + \ldots + b_k \ln(X_k)
\]

(2)

where \(b_0, b_1, \ldots, b_k\) are constants.

Least-squares regression was applied to verify the statistical significance of the models. The Breusch–Godfrey test was employed to control for the autocorrelation.

4. Results

4.1. Comparative Analysis

Figures 1–6 present the results of the comparative analysis of explanatory variables between Poland and the Czech Republic in 2010–2016. In line with the obtained results, an important feature can be observed when comparing Poland and the Czech Republic in terms of human resources. With regard to the variables employed for the study, the Czech Republic in 2010–2016 is performing much better than Poland (Figures 1–3).
Sustainability has a higher potential to increase innovation performance of firms and, consequently, to enhance competitiveness of regions and the country.

This may result in deterioration of the ability of science to get involved in innovation activities in Poland and the Czech Republic, much lower innovation performance of firms. This may contribute to limitations in knowledge diffusion among universities, research organisations, and firms. This may result in deterioration of the ability of science to get involved in innovation activities in Poland and the Czech Republic, much lower innovation performance of firms. This may contribute to limitations in knowledge diffusion among universities, research organisations, and firms.

**Figure 1.** New doctorate graduates per 1000 population aged 25–34. Source: own study based on [4,5].

**Figure 2.** Percentage of the population aged 25–34 having completed tertiary education. Source: own study based on [4,5].

**Figure 3.** Percentage of the population aged 25–64 participating in lifelong learning. Source: own study based on [4,5].

**Figure 4.** Number of scientific publications with at least one co-author based abroad per million population. Source: own study based on [4,5].
In terms of the knowledge and skills of workers, these results suggest that the Czech Republic has a higher potential to increase innovation performance of firms and, consequently, to enhance competitiveness of regions and the country.

A significant gap between Poland and the Czech Republic can also be seen in the context of the research system (Figures 4–6). The results show a noticeably lower level of variables employed for the study in Poland in 2010–2016.

As compared to the Czech Republic, lesser knowledge creation by the research system in Poland may contribute to limitations in knowledge diffusion among universities, research organisations, and firms. This may result in deterioration of the ability of science to get involved in innovation performance of Polish firms and may affect competitive advantage.

Figures 7–9 show the results of the comparative analysis of dependent variables between Poland and the Czech Republic in 2010–2016. When considering the percentage of SMEs involved in innovation activities in Poland and the Czech Republic, much lower innovation performance of firms is found in Poland. This is noticeable for the percentage of SMEs introducing product or process innovations, the percentage of SMEs introducing marketing or organisational innovations, and the percentage of SMEs innovating in-house.
4.2. The Cobb–Douglas Function Estimation Results

The results of the verification of collinearity among explanatory variables highlight a high level of collinearity among them. This implies the elimination of selected variables. Hence, the Cobb-Douglas function estimation was based on the following explanatory variables: for Poland—lifelong learning ($X_3$) (in respect of human resources) and foreign doctorate students ($X_6$) (concerning the research system), for the Czech Republic—the top 10% most cited publications ($X_5$) (with regard to the research...
According to the results, in respect of the Czech Republic, all explanatory variables concerning human resources were excluded from the research.

Six estimation models (the first three for Poland, another three for the Czech Republic) are presented in Tables 3–8. In the models related to Poland, the statistical significance is seen to vary. In particular, the results indicate no evidence of statistical significance of Model 1 and Model 3 (Tables 3 and 4).

### Table 3. Estimation results: Model 1.

| Variable | Coefficients | Standard Error | t-Stat | p-Value | Significance F | $R^2$ |
|----------|--------------|----------------|--------|---------|----------------|------|
| const    | 2.9000       | 0.3050         | 9.5074 | 0.0007  | 0.5876         | 0.2334 |
| $\ln(X_3)$ | $-0.2468$   | 0.2285         | $-1.0801$ | 0.3409  | 0.6165         |      |
| $\ln(X_6)$ | 0.0672      | 0.1239         | 0.5422 | 0.6165  |                |      |

$\ln(Y_1) = 2.900 + (-0.2468)\ln(X_3) + 0.0672\ln(X_6)$

$Y_1 = 18.18X_3^{-0.25}X_6^{0.07}$

Source: own study based on [4,5].

### Table 4. Estimation results: Model 3.

| Variable | Coefficients | Standard Error | t-Stat | p-Value | Significance F | $R^2$ |
|----------|--------------|----------------|--------|---------|----------------|------|
| const    | 1.7716       | 1.0046         | 1.7635 | 0.1526  | 0.7532         | 0.1321 |
| $\ln(X_3)$ | 0.2563      | 0.7524         | 0.3406 | 0.7505  |                |      |
| $\ln(X_6)$ | 0.2311      | 0.4078         | 0.5664 | 0.6014  |                |      |

$\ln(Y_3) = 1.7716 + 0.2563\ln(X_3) + 0.2311\ln(X_6)$

$Y_3 = 5.88X_3^{0.26}X_6^{0.23}$

Source: own study based on [4,5].

### Table 5. Estimation results: Model 2.

| Variable | Coefficients | Standard Error | t-Stat | p-Value | Significance F | $R^2$ |
|----------|--------------|----------------|--------|---------|----------------|------|
| const    | $-0.3930$    | 1.0444         | $-0.3762$ | 0.7258  | 0.0635         | 0.7479 |
| $\ln(X_3)$ | 1.8129      | 0.7823         | 2.3175 | 0.0814 * |                |      |
| $\ln(X_6)$ | 0.7341      | 0.4242         | 1.7307 | 0.1586  |                |      |

$\ln(Y_2) = -0.3930 + 1.8129\ln(X_3) + 0.7341\ln(X_6)$

$Y_2 = 0.68X_3^{1.81}X_6^{0.73}$

Autocorrelation consistent. Level of statistical significance: * $p \leq 0.10$. Source: own study based on [4,5].

### Table 6. Estimation results: Model 4.

| Variable | Coefficients | Standard Error | t-Stat | p-Value | Significance F | $R^2$ |
|----------|--------------|----------------|--------|---------|----------------|------|
| const    | 3.3084       | 0.0612         | 54.0939 | 0.0000004 *** | 0.0888 | 0.4705 |
| $\ln(X_5)$ | 0.0875      | 0.0415         | 2.1079 | 0.0888 * |                |      |

$\ln(Y_1) = 3.308 + 0.0875\ln(X_5)$

$Y_1 = 27.34X_5^{0.09}$

Autocorrelation consistent. Level of statistical significance: *** $p \leq 0.01$; * $p \leq 0.10$. Source: own calculations based on data from [4,5].
Table 7. Estimation results: Model 6.

| Variable | Coefficients | Standard Error | t-Stat | p-Value     | Significance F | R²    |
|----------|--------------|----------------|--------|-------------|----------------|-------|
| const    | 3.1007       | 0.0822         | 37.719 | 0.00000027  | ***            | 0.0377| 0.6116|
| ln(X₅)   | 0.1565       | 0.0578         | 2.8061 | 0.0377 **   |                |       |

\[\ln(Y_3) = 3.1001 + 0.1565\ln(X_3)\]
\[Y_3 = 22.21X_5^{0.16}\]

Autocorrelation consistent. Level of statistical significance: *** \( p \leq 0.01 \); ** \( p \leq 0.05 \). Source: own study based on [4,5].

Table 8. Estimation results: Model 5.

| Variable | Coefficients | Standard Error | t-Stat | p-Value     | Significance F | R²    |
|----------|--------------|----------------|--------|-------------|----------------|-------|
| const    | 4.5253       | 0.3862         | 11.7182| 0.00008 *** | 0.0382         | 0.6096|
| ln(X₅)   | −0.7322      | 0.2620         | −2.7943| 0.0382 **   |                |       |

\[\ln(Y_2) = 4.5253 + (−0.7322)\ln(X_5)\]
\[Y_2 = 92.32X_5^{−0.73}\]

Autocorrelation consistent. Level of statistical significance: *** \( p \leq 0.01 \); ** \( p \leq 0.05 \). Source: own study based on [4,5].

Statistical significance is observed for Model 2, where innovation activities of Polish firms were described as the percentage of SMEs innovating in-house \( (Y_2) \) (Table 5). This model showed a good model fit in explaining innovation activities of Polish firms \( (R^2 = 0.7479) \).

The results suggest a strong positive effect of lifelong learning \( (X_3) \) on innovation activities of Polish firms in 2010–2016. The lack of significant effect of foreign doctorate students \( (X_6) \) on Polish firms’ innovation activities also appeared. In this context, innovation activities of firms from Poland were not associated with the research system.

With respect to the Czech Republic, a significant effect of the research system on innovation activities of Czech firms could be found in all models (Tables 6–8).

The findings confirm that the top 10% most cited publications \( (X_5) \) affected innovation activities of firms from the Czech Republic in 2010–2016. However, the research surprisingly suggests diverse results. Regarding Model 4 (Table 6) and Model 6 (Table 7), the results show that the top 10% most cited publications positively affect Czech firms’ innovation activities. On the other hand, Model 5 suggests a negative effect of the top 10% most cited publications on Czech firms’ innovation activities (Table 8). The results indicate that the coefficient of determination for Model 4 \( (R^2 = 0.4705) \), Model 5 \( (R^2 = 0.6096) \), and Model 6 \( (R^2 = 0.6116) \) is sufficient in explaining innovation activities of firms from the Czech Republic.

5. Discussion

The study provides insights into the effect of human resources and the research system on innovation activities of firms from Poland and the Czech Republic. Both in terms of human resources and the research system, the results of comparative analysis show a higher potential for the Czech Republic than Poland in 2010–2016. This suggests that firms from the Czech Republic are in much better shape than those from Poland when it comes to the ability to acquire high-skilled workers and external knowledge from universities and research organisations. This might result in a better basis to enhance innovation activities and, consequently, a greater increase in competitive advantage of regions and for the country than Poland.

The results of the Cobb–Douglas function estimation partially confirm the research hypotheses. Regarding Poland, the results find that innovation activities of Polish firms (measured as the percentage of SMEs introducing marketing or organisational innovations) were positively affected by only one variable related to human resources—lifelong learning. These findings are consistent with Hypothesis 1 and are similar to studies by [4,12,38], among others. To enhance innovation performance, the results suggest a need for intensifying the networks between Polish firms and the population aged 25–64 that is participating in lifelong learning. Contrary to expectations, the research system does not seem to
have been related with Polish firms’ innovation activities in 2010–2016. These findings do not uphold Hypothesis 2 and are contrary to, among others, [5,46]. These results imply a need for strengthening networks between the research system and firms in Poland for the diffusion of high-quality knowledge as the basis for increasing Polish firms’ innovation activities.

As regards the Czech Republic, the results suggest a significant effect of such a variable of the research system as the top 10% most cited publications on firms’ innovation activities in 2010–2016. However, it is remarkable that the research suggests diverse results. A positive effect of the top 10% most cited publications is related to innovation activities of firms described as the percentage of SMEs introducing product or process innovations and the percentage of SMEs innovating in-house. These results, confirmed with Hypothesis 2, are in line with [27]. On the other hand, the results show a negative effect of the top 10% most cited publications in association with firms’ innovation activities, measured as the percentage of SMEs introducing marketing or organisational innovations. These results do not confirm Hypothesis 2 and are contrary to, among others, [47]. Such results may imply limited abilities of firms from the Czech Republic to acquire high-quality knowledge from the research system. The above findings may arise from the diversity of firms’ innovation performance. It should be noted that a high level of collinearity between explanatory variables and the need to eliminate selected variables resulted in an inability to test the effect of variables related with human resources on Czech firms’ innovation activities. These also precluded the possibility to compare the results of the Cobb–Douglas function estimation between Poland and the Czech Republic. Further, in-depth studies are required to resolve this issue.

6. Conclusions

This paper contributes to the discussion of variables of firms’ innovation activities. The research was focused on Poland and the Czech Republic as the countries with similar innovation performance and remaining below the European Union’s average. This research complements previous studies by shedding light on the effect of variables related to human resources and the research system on Polish and Czech firms’ innovation activities.

The implication of the Cobb–Douglas function allows the identification of a positive effect of lifelong learning on Polish firms’ innovation activities in 2010–2016, supporting the idea that constant learning is the key to improving the knowledge and skills of workers and to enhancing firms’ innovation activities. The study also shows a significant and diverse effect of the top 10% most cited publications on Czech firms’ innovation activities. Such differentiation may stem from the diversity of firms’ innovation performance. The results highlight the need to strengthen the diffusion of high-quality knowledge among universities, research organisations, and firms.

This paper has practical and policy implications. As the study points the role of human resources and the research system in firms’ innovation activities, it is relevant to provide conditions for the development of human resources and the research system to enhance firms’ competitive advantage and sustainable growth of regions and countries. There is also a need to strengthen knowledge diffusion processes among firms, universities, and research organisations in order to improve innovation activities of firms.

This study faces limitations that may be examined in future research. First, this paper draws on data and measurement of variables from the European Innovation Scoreboard. It is important to observe whether the obtained results also hold for other descriptions of innovation activities of firms and other measurements of human resources and the research system. Second, future research should investigate the causes of the differential effect of variables employed for the study on Polish and Czech firms’ innovation activities. It would be also beneficial to carry out research using other econometrical methods.

Funding: This research was funded by Opole University of Technology.

Conflicts of Interest: The author declares no conflict of interest.
References

1. Audretsch, D.B.; Link, A.N. Entrepreneurship and knowledge spillovers from the public sector. *Int. Entrep. Manag. J.* 2018, 15, 1–14. [CrossRef]

2. Galindo, M.A.; Méndez, M.T. Entrepreneurship, economic growth, and innovation: Are feedback effects at work? *J. Bus. Res.* 2014, 67, 825–829. [CrossRef]

3. Klewitz, J.; Hansen, E.G. Sustainability-oriented innovation of SMEs: A systematic review. *J. Clean. Prod.* 2013, 65, 57–75. [CrossRef]

4. The European Commission. *European Innovation Scoreboard 2019*; Publications Office of the European Union: Luxembourg, 2019; pp. 1–95.

5. The European Commission. *European Innovation Scoreboard 2018*; Publications Office of the European Union: Luxembourg, 2018; pp. 1–104.

6. Isaksen, A.; Tödtling, F.; Trippl, M. Innovation Policies for regional structural change: Combining actor-based and system-based strategies. In *New Avenues for Regional Innovation Systems—Theoretical Advances, Empirical Cases and Policy Lessons*; Isaksen, A., Martin, R., Trippl, M., Eds.; Springer: Cham, Switzerland, 2018; pp. 221–238.

7. Edler, J.; Fagerberg, J. Innovation policy: What, why, and how. *Oxf. Rev. Econ. Policy* 2017, 33, 2–23. [CrossRef]

8. Schmiele, A. *Drivers for International Innovation Activities in Developed and Emerging Countries*; ZEW—Centre for European Economic Research Discussion Paper No. 09-064; ZEW: Mannheim, Germany, 2009; pp. 1–39.

9. Lopes, J.; Franco, M. Review about Regional Development Networks: An Ecosystem Model Proposal. *J. Knowl. Econ.* 2019, 10, 275–297. [CrossRef]

10. De Noronha Vaz, T.; Nijkamp, P. Knowledge and innovation: The strings between global and local dimensions of sustainable growth. *Entrep. Reg. Dev.* 2009, 21, 441–455.

11. D’Este, P.; Rentocchini, F.; Vega Jurado, J. The role of human capital in lowering the barriers to engaging in innovation: Evidence from the Spanish innovation survey. *Ind. Innov.* 2014, 21, 1–19. [CrossRef]

12. Tvaronavičienė, M.; Tarkhanova, E.; Durglishvili, N. Sustainable economic growth and innovative development of educational systems. *J. Int. Stud.* 2018, 11, 248–256. [CrossRef]

13. Fritsch, M.; Titze, M.; Piontek, M. Identifying cooperation for innovation—A comparison of data sources. *Ind. Innov.* 2019, 27, 1–30. [CrossRef]

14. Ferreira, J.J.M.; Carayannis, E.G. University-industry knowledge transfer—Unpacking the “black box”: An introduction. *Knowl. Manag. Res. Pract.* 2019, 17, 353–357. [CrossRef]

15. Prokop, V.; Stejskal, J.; Kuviková, H. The different drivers of innovation activities in European countries: A comparative study of Czech, Slovak, and Hungarian manufacturing firms. *Ekon. Časopis* 2017, 65, 31–45.

16. Szczepańska-Woszczyńska, K. Determinants of innovation activities in SMEs in Poland. *J. Adv. Res. Manag.* 2014, 10, 65–73.

17. Moreno, R.; Paci, R.; Usai, S. Spatial Spillovers and Innovation Activity in European Regions. *Environ. Plan. A Econ. Space* 2005, 37, 1793–1812. [CrossRef]

18. Jovovic, R.; Draskovic, M.; Delibasic, M.; Jovovic, M. The concept of sustainable regional development—Institutional aspects, policies and prospects. *J. Int. Stud.* 2017, 10, 55–266. [CrossRef]

19. Zygmun, A. Does investment impact on firms’ innovation activities? Evidence from Poland and the Czech Republic. In Proceedings of the 32nd International Business Information Management Association Conference (IBIMA), Seville, Spain, 15–16 November 2018; pp. 6942–6948.

20. Jovovic, R.; Draskovic, M.; Delibasic, M.; Jovovic, M. The concept of sustainable regional development—Institutional aspects, policies and prospects. *J. Int. Stud.* 2017, 10, 55–266. [CrossRef]

21. Zygmun, A. The financial sources of investment activity—A case of polish enterprise. *Ad Alta J. Interdiscip. Res.* 2015, 5, 89–92.

22. Pietrzak, M.B.; Balcerzak, A.P.; Gajdos, A.; Arendt, L. Entrepreneurial environment at regional level: The case of Polish path towards sustainable socio-economic development. *Entrep. Sustain. Issues Entrep. Sustain. Cent.* 2017, 5, 190–203. [CrossRef]

23. Zygmun, J. Does Level of Economic Growth Matter in Spatial Diversity in Entrepreneurial Activity in a Transition Economy? A Case of Poland. In Proceedings of the 32nd International Business Information Management Association Conference (IBIMA), Seville, Spain, 15–16 November 2018; pp. 6999–7006.
24. Zygmunt, J. Start-ups survival in a transition economy. In Proceedings of the 6th International Conference on Innovation Management, Entrepreneurship and Sustainability (IMES 2018), Prague, the Czech Republic, 31 May–1 June 2018; pp. 1175–1184.

25. Rokita-Poskart, D.; Mach, L. Selected Meso-Economic Consequences of the Changing Number of Students in Academic Towns and Cities (A Case Study of Poland). Sustainability 2019, 11, 1901. [CrossRef]

26. Heffner, K.; Klemens, B.; Solga, B. Challenges of Regional Development in the Context of Population Ageing. Analysis Based on the Example of Opolskie Voivodeship. Sustainability 2019, 11, 5207. [CrossRef]

27. Huggins, R.; Prokop, D.; Steffenson, R.; Johnston, A.; Clifton, N. The engagement of entrepreneurial firms with universities: Network formation, innovation, and resilience. J. Gen. Manag. 2014, 40, 23–51. [CrossRef]

28. Broekel, T.; Boschma, R. The cognitive and geographical structure of knowledge links and how they influence firms’ innovation performance. Reg. Stat. 2016, 6, 3–26. [CrossRef]

29. Mellander, C.; Florida, R. The rise of skills: Human capital, the creative class and regional development. In Handbook of Regional Science; Poot, J., Fischer, M., Nijkamp, P., Eds.; Springer: Paris, French, 2014; pp. 317–329.

30. Garrigos-Simon, F.J.; Botella-Carrubi, M.D.; Gonzalez-Cruz, T.F. Social Capital, Human Capital, and Sustainability: A Bibliometric and Visualization Analysis. Sustainability 2018, 10, 4571. [CrossRef]

31. Tödtling, F.; Grillitsch, M. Does Combinatorial Knowledge Lead to a Better Innovation Performance of Firms? Eur. Plan. Stud. 2015, 23, 1741–1758. [CrossRef]

32. Autant-Bernard, C.; Fadairo, M.; Massard, N. Knowledge diffusion and innovation policies within the European regions: Challenges based on recent empirical evidence. Res. Policy 2013, 42, 196–210. [CrossRef]

33. Anand, N.; Gardner, H.K.; Morris, T. Knowledge-based innovation: Emergence and embedding of new practice areas in management consulting firms. Acad. Manag. J. 2007, 50, 406–428. [CrossRef]

34. Baptista, A.; Frick, L.; Holley, K.; Remmik, M.; Tesch, J.; Åkerlind, G. The doctorate as an original contribution to knowledge: Considering relationships between originality, creativity, and innovation. Frontline Learn. Res. 2015, 3, 55–67.

35. Hancock, S. A future in the knowledge economy? Analysing the career strategies of doctoral scientists through the principles of game theory. High. Educ. 2019, 78, 33–49. [CrossRef]

36. Lee, S.V.; Florida, R.; Acs, Z.J. Creativity and Entrepreneurship: A Regional Analysis of New Firm Formation. Reg. Stud. 2004, 38, 879–891. [CrossRef]

37. Triventi, M.; Kulic, N.; Skopek, J.; Blossfeld, H.P. Secondary school systems and inequality of educational opportunity in contemporary societies. In Models of Secondary Education and Social Inequality an International Comparison; Blossfeld, H.P., Buchholz, S., Skopek, J., Triventi, M., Eds.; Edward Elgar Publishing: Cheltenham-Northampton, UK, 2016; pp. 3–24.

38. Mitchell, K.; MacFarlane, K. Geographies of Lifelong Learning and the Knowledge Economy. In Making Workers; Mitchell, K., Ed.; Pluto Press: London, UK, 2018; pp. 67–82.

39. Kryk, B. Accomplishment of the European Union Lifelong Learning Objectives in Poland. Oeconomia Copernic. 2016, 7, 389–404. [CrossRef]

40. Guerrero, M.; Urbano, D.; Herrera, F. Innovation practices in emerging economies: Do university partnerships matter? J. Technol. Transf. 2019, 44, 615–646. [CrossRef]

41. Polyakov, M. Modern trends in development of international scientific and technological cooperation. Econ. Educ. 2017, 2, 41–52.

42. Wagner, C.S.; Whetsell, T.A.; Leydesdorff, L. Growth of international collaboration in science: Revisiting six specialities. Scientometric 2017, 110, 1633–1652. [CrossRef]

43. Hoekman, J.; Frenken, K.; Tijssen, R.J.W. Research collaboration at a distance: Changing spatial patterns of scientific collaboration in Europe. Res. Policy 2010, 39, 662–673. [CrossRef]

44. Leydesdorff, L.; Wagner, C. International Collaboration in Science and the Formation of a Core Group. J. Informetr. 2009, 2, 317–325. [CrossRef]

45. Bornmann, L.; Mutz, R. Growth rates of modern science: A bibliometric analysis based on the number of publications and cited references. J. Assoc. Inf. Sci. Technol. 2015, 66, 2215–2222. [CrossRef]

46. Bienkowska, D.; Klofsten, M. Creating entrepreneurial networks: Academic entrepreneurship, mobility and collaboration during PhD education. High. Educ. 2012, 64, 207–222. [CrossRef]

47. Leydesdorff, L.; Wagner, C.S.; Bornmann, L. The European Union, China, and the United States in the top-1% and top-10% layers of most-frequently cited publications: Competition and collaborations. J. Informetr. 2014, 8, 606–617. [CrossRef]
48. Bartosiewicz, S. (Ed.) Metody Ekonometryczne. Przykłady i Zadania; PWE: Warszawa, Poland, 1980.
49. Piketty, T. Capital in the 21st Century; Belknap Press of Harvard University Press: Cambridge, MA, USA, 2014; pp. 1–452.
50. Borkowski, B.; Dudek, H.; Szczęsný, W. Ekonometria, Wybrane Zagadnienia; Wydawnictwo Naukowe PWN: Warszawa, Poland, 2003; pp. 1–290.
51. Żelazny, R.; Pietrucha, J. Measuring innovation and institution: The creative economy index. Equilib. Q. J. Econ. Econ. Policy 2017, 12, 43–62. [CrossRef]