

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/356387918>

How Can Brexit Affect the EU Research and Development?

Chapter · November 2021

CITATIONS
0

READS
3

2 authors:



[Anna Odrobina](#)
Cracow University of Economics

11 PUBLICATIONS 8 CITATIONS

SEE PROFILE



[Katarzyna Stabryła-Chudzio](#)
Cracow University of Economics

28 PUBLICATIONS 7 CITATIONS

SEE PROFILE

How Can Brexit Affect the EU Research and Development?

Anna ODROBINA

Cracow University of Economics, Cracow, Poland
e-mail: odrobina@uek.krakow.pl

Katarzyna STABRYLA-CHUDZIO

Cracow University of Economics, Cracow, Poland
e-mail: stabrylk@uek.krakow.pl

Abstract

The objective of this paper is to determine the influence of Brexit on the European Union with regards to research and development. The core research problem is an analysis of the decline of the EU's R&D potential, with special consideration given to the position of multinationals (MNEs) and to the EU budget on EU innovation policy. The analyses performed show that Brexit has significantly weakened the EU in the R&D area, especially for the resources of researchers and R&D personnel and the potential of EU companies in the pharmaceutical and biotechnology industry. However, taking into account the fact that in nominal terms Great Britain was one of the leading recipients of the Horizon 2020 programme and in the earlier scientific-research programmes, in the current multiannual financial framework other members could benefit more from common research funds. The UK will continue to participate in EU research programs, albeit on a third country basis, and therefore selectively. The established general rules in this matter provide an opportunity to continue the extensive EU-UK research cooperation, but they do not include the Erasmus program, which is important from the EU point of view.

Keywords: R&D, Brexit, EU multinationals, EU budget expenditure, Horizon 2020.

Introduction

Brexit has become a reality, after the transition period, the UK left the EU on December 31, 2020. In the literature on the subject, mainly from 2016, there have been presented differentiated scenario studies regarding the UK withdrawal, treating the situation of the British economy (Lawless and Morgenroth, 2016; Busch and Matthes, 2016; Singham et al., 2017; Steinberg, 2019; Vasilopoulou and Keith, 2019) or the functioning of the European Union (Belke and Gros, 2017; Sapir et al., 2017; Laffan, 2019; Leruth et al., 2019). Researchers and politicians analysed the effects of Brexit on various levels (McGrattan and Waddle, 2017; Oehler et al., 2017; Caporaso, 2018; Vandenbussche et al., 2019). Relatively little attention has so far been devoted to the issue of EU R&D in the context of Brexit. Research on this topic appeared in more general studies (Veugelers, 2016; Koepffel, 2016; Weresa, 2018) and it is this deficit that the authors intend to meet.

The aim of the study is to determine the impact of the UK on the EU in the area of R&D and the importance of the EU competitiveness in the global economy. As a result, an attempt was made to assess the extent of Brexit's weakening of various areas in EU R&D and financial consequences of Brexit for EU R&D. The study emphasizes the importance of innovation policy in the whole European Union as an answer to globalization and competitiveness with the third countries. The following research hypothesis was adopted: weakening in EU-27 R&D after Brexit requires rethinking ways to redevelopment EU R&D potential.

This analysis consists of two basic parts. The first concerns a specification of the changes in the EU position after Brexit, with regards to the chief measures of R&D expenditure and the EU's multinational enterprises in R&D, broken down into specific industries. In the second part, attention is focused on an analysis of the EU budget from the perspective of the changes to the financing of joint R&D programmes and the problems and challenges in EU-27 research and innovation policy.

Changes to the EU R&D potential as a Result of Brexit

Brexit weakened the potential of the EU as one of the main centres of world R&D activity. The withdrawal of UK resulted in a decrease of the EU share in global R&D expenditures to the level of 18.3% (from about 21%). Undoubtedly, this fact

Cite this Article as: Anna ODROBINA and Katarzyna STABRYLA-CHUDZIO "How Can Brexit Affect the EU Research and Development?" Proceedings of the 37th International Business Information Management Association (IBIMA), 30-31 May 2021, Cordoba, Spain, ISBN: 978-0-9998551-6-4, ISSN: 2767-9640

does not indicate a decline of the EU position in this respect, but given the dynamic development of the Asian centre (China, Japan, Republic of Korea, Taiwan) and the stabilized USA potential, such a weakening of the EU, which is currently struggling with the problem of catching up with the two leading global centres, may result in a loss of its attractiveness as a partner for collaboration for Asian and American economies (Odrobina and Stabryla-Chudzio, 2020).

The impact of Brexit on the main indicators of R&D has been summarized in table 1. Brexit weakened almost all the indicators by several per cent (from 11.6 to 14.6%) with the exception of a slight change in the BERD (Business Expenditure on R&D) share in GERD (Gross Domestic Expenditure on R&D) and slight improvement in the share of GERD in GDP. In the case of total expenditure R&D they have decreased by 11.6% because UK was ranked third among EU economies with regards to R&D expenditure.

The largest decrease (by 14.6%) has been observed after Brexit among the number of researchers in the EU, which must be regarded as an alarming depletion of R&D potential. A similar situation has been observed in the case of the entire R&D personnel, where the decrease has reached almost 14%. Human capital resources determine how dynamic and fast R&D can be, as creative work can be carried out solely by the human mind. The fact that the number of researchers in the EU has fallen by 317.5 thousand FTE, and the number of the entire R&D staff by about 463.5 thousand FTE, will lessen the capability to build new knowledge, especially as a result of the fact that a very low efficiency of use of the researchers' potential is currently observed in the EU: the number of researchers is higher than in the USA (1.4 million FTE); yet in spite of this, the EU keeps gaining poorer results with regards to the scale and intensity of R&D activity.

Table 1: The Changes of the Selected R&D Indicators in the EU in 2018

Indicators	EU-28	EU-27	Change
GERD (billion USD)	464.9	410.9	-11.6%
GERD as % of GDP	2.14	2.2	+2.8%
BERD (billion USD)	308.1	271.6	-11.8%
BERD as % of GERD	58.5	59.0	+0.9%
Researchers (in thousand FTE*)	2172.5	1855.0	-14.6%
R&D personnel (in thousand FTE*)	3302.9	2839.4	-14.0%
The number of triadic patents (in thousands)	13.5	11.8	-12.6%
The number of PCT patents (thousands)	51.6	45.5	-11.8%

*FTE – full time equivalent

Source: The author's own calculations on the basis of OECD 2020; WIPO 2020, Eurostat 2020.

To some degree, the problem of a low efficiency of R&D in the EU can be explained with an analysis of the involvement of business in R&D. EU business with an expenditure of 271.6 billion USD and a share of BERD in GERD at the level of 60.1%, seems quite limited. However, from an economic point of view, enterprises make up valuable entities, which carry out research and development with regards to a strong orientation on the commercial aspect of knowledge. In this respect, EU business is likely to weaken slightly as a result of Brexit.

A measure of the positive results of this R&D activity is patents granted which provide intellectual property with legal protection. The EU is an important entity creating new knowledge and technology in the world, which is evidenced by the number of patents. Therefore, in the case of both types of patents, Brexit, which decreased the number of patents in the EU by about 12%, also increased the gap between the EU and the USA, and therefore keeping up with the USA in patent activity will be even more difficult.

In the area of expenditure on R&D, a vital role is played by multinational enterprises (MNEs) that execute about a half of all world expenditure in this area. Because of their characteristics in the global market, such enterprises have a very large amount of activity in R&D investments, aimed at building competitive advantage in the demanding international environment (Lu and Chen, 2012; UNCTAD, 2005a, b). It is generally believed that MNEs are the driving force for the decentralization and internationalization of R&D (Karlsson, 2006; Hiratuka, 2011; European Commission, 2017a). It would be difficult to overestimate the significance of domestic MNEs for R&D activity, as the matter concerns not only the amount of the R&D expenditure, but also the creation of a network for collaboration and the transfer of knowledge on an international scale, which are at the core of corporate activity (Moncada-Paterno-Castello et al., 2011; De Prato and Nepelski, 2013; Zimmermann, 2015).

The current situation of the EU is disadvantageous, although EU-based enterprises belong to the MNE group with the highest R&D expenditure (Uppenberg, 2009; European Commission, 2020a). Given the fact that in the EU-28, the position of domestic MNEs was significantly lower than American and Asian MNEs, Brexit has worsen this situation and the scale of this impact seems to be enormous. It seems to be enough to mention that UK was the home country for 51 as 265 EU-based MNEs on the Top 1000 -one thousand MNEs with the highest R&D expenditure (European Commission 2020b). Therefore,

Brexit will result in the fact that a group of leading EU MNEs would decrease radically by 19.2%, reaching a total of only 214 enterprises. The impact of Brexit will be significant here as the number of MNEs in UK is similar as the number of such enterprises in Germany (70), followed by MNEs in France (39).

The involvement of enterprises in R&D expenditure is strongly determined by the type of activity which they carry out, as the five leading sectors account for about ¾ of the total R&D expenditure carried out by MNEs, and these branches comprise: pharmaceuticals and biotechnology, the automotive industry, IT hardware, IT software as well as electronics and electrical industry. MNEs in these five sectors affect global expenditure in R&D in a most significant way.

It must be observed that the EU's MNEs are the R&D leader in the automotive industry with expenditure at the level of 60 billion EUR in 2019, which made up 48.6% of MNE expenditure in this industry (table 2). A strong specialization of the EU automotive industry MNEs in the world industry can be pointed out here, so Brexit will not cause significant losses as the dominating MNEs in this area come from Germany, France and Italy.

Table 2: R&D Expenditure in the Top 1000 in the Five Leading Industries in 2019

Industry	Top 1000 (billion EUR)	EU-28		EU-27	
		billion EUR	Share in Top 1000 (%)	billion EUR	Share in Top 1000 (%)
Pharmaceuticals and biotechnology	137.3	36.6	26.7	27.3	19.9
Automotive industry	123.8	60.2	48.6	58.8	47.5
IT hardware	120.1	15.1	12.6	14.3	11.9
IT software	108.1	9.3	8.6	7.5	6.9
Electronics and electrical industry	56.5	9.7	17.2	9.3	16.5

Source: Authors own calculations on the basis of European Commission, 2020b.

Pharmaceuticals and biotechnology is the industry that be most weakened as a result of the Brexit as British MNEs rank third in the world (after American and Swiss ones). EU-28 corporations accounted for 26.7% of MNE expenses in this field, but Brexit resulted in the decrease of this share to a level below 20%. It must be added that in pharmaceuticals and biotechnology, US-based MNEs play a dominant role (accounting for about a half of world expenditure). The EU's MNEs have been increasing their R&D potential in this field, thanks to an increase in the activity of German, French, Irish and Danish MNEs. The time of the covid-19 pandemic has caused a strong mobilization of the EU to strengthen R&D in the health industry, in 2020 the EU decided to allocate funds of around EUR 1 billion to research related to the coronavirus pandemic, which will certainly strengthen the R&D potential of EU pharmaceutical and biotechnology companies (European Commission, 2020c).

It must be observed that the three other sectors will not be affected by the results of Brexit to a large degree, although here the EU's MNEs were never been very active. In the electronic and electrical industry, the leading position is occupied by Asian MNEs, whose share in R&D expenditure of this entire branch accounts for about 65%, with the most active enterprises being Japanese and Korean MNEs. An important position in this industry is occupied by German and French companies, but even so the EU share makes up 17.2% with Brexit likely to cause this number to decrease by about 0.7%. In IT hardware, a dominant role is played by MNEs from the USA, accounting for 58% of R&D expenditure for the entire branch. The significance of the EU in this industry in the world is relatively low, being on the level of 12.6% and the insignificant involvement of British MNEs results in the fact that Brexit decreased it by merely 0.7%. A similar situation is observed in the software industry, where the position of the unquestionable leader belongs to MNEs from the USA (about 73% expenditure on R&D of the whole branch). Japanese MNEs, which before 2013 ranked second, have recently been outrun by Chinese and Taiwanese MNEs, whose activity in this respect is gradually growing. EU-based MNEs, in turn, are responsible for about 8.6% of expenditure in this field, with German companies carrying out the largest expenditure. They are followed by MNEs from France and Great Britain, with the latter's share of R&D in this industry estimated to be 1.7%.

In the Top 1000, there are also companies belonging to other branches, and although their relative significance in the size of the R&D expenditure is lower, Brexit will significantly affect the R&D potential of the EU in a few industries. It must be observed that in the banking field, the EU's MNEs definitely occupied a leading position – R&D expenditure amounts to 9.2 billion EUR, whilst the world's expenditure amongst corporations total 10.5 billion EUR. Yet in this case, the largest expenditure on R&D is carried out by MNEs from UK (3.4 billion EUR). The EU's MNEs in media carried out R&D expenditure amounting to 1.2 billion EUR (about half of the world R&D), but British MNEs were here the most active (0.8 billion EUR). Moreover, the EU will suffer complete elimination in tobacco industry as British enterprises are the only corporations in the EU to carry out R&D activity. Brexit will also greatly affect the EU's MNEs in the food producer industry, where the R&D expenditure of the EU-28 in 2019 amounted to 2.1 billion EUR (with 5.1 billion EUR of world expenditure for MNEs) with British MNEs accounting for 0.9 billion EUR of this.

It seems justified for European Union to rely on the automotive industry, the source of the EU-27's R&D power, in building the potential of EU MNEs after Brexit. It is also desirable to strengthen the EU pharmaceutical and biotechnology industry to maintain the global attractiveness of EU. In turn, the problem of a significant weakening of human potential as a result of Brexit may be partially neutralized by supporting and promoting research cooperation within the EU, but also with the British side and the global environment.

British impact on EU R&D policy from financial perspective

As Browne, Johnson and Philips (2016, 33) point out, public funding of research and innovation (including infrastructure) by both national governments and the European Union is justified by the fact that the resulting knowledge and scientific progress are a supranational public good that it benefits the whole society and goes beyond national borders. As a result, spending from the EU budget can be granted in this case to the best research projects in the EU as a whole, and not the best in every country.

UK was one of the most important financial net contributor to the EU budget (EUR 6.8 billion in 2019), however research funding was the area with the largest net financial benefit for Great Britain. Under the 7th Framework Programme for research and innovation, which was implemented in 2007-13, the United Kingdom brought less than received. It means that UK research organizations and enterprises have received a surplus of almost EUR 500 million each year. This number has even increased during the *Horizon 2020* programme, the EU research and innovation funding programme worth EUR 80 billion, implemented in 2014-20 (figure 1). With all funding sources, including structural funds, UK enterprises and universities received around EUR 1 billion a year for R&D (Koeppel, 2016; Frenk et al., 2015, 12).

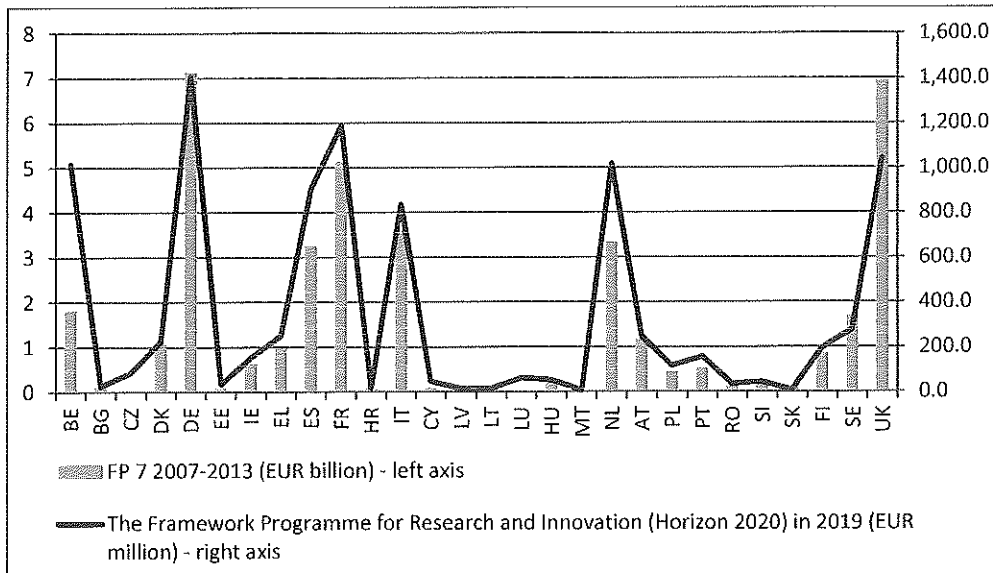


Figure 1: Distribution of EU Expenditure on Research, Development and Innovation (Framework Programme 7 and Horizon 2020) in EU-28 Countries. 2007 –13 and 2019

Source: Authors own preparation based on European Commission (2020d).

Following WTO rules the EU is trying to finance more projects that are closer to the market, but one of the weakest point of EU research is to give them practical meaning, although British potential here was one of the strongest EU R&D points (table 3). That is why it is worth to mention that many enterprises in the UK received funding under EU programme called Fast Track to Innovation Pilot, which provided approximately EUR 100 million a year to change innovations in market solutions. In consequence, by losing support from EU funds, British recipients need to be financially secured by national resources or private support (Koeppel, 2016).

From 2021, the R&D activities of the *Horizon Europe* are strengthened through the deployment and use (rapid dissemination) of R&D projects in other categories of expenditure from the EU budget such as cohesion policy, synergies with the *Erasmus Programme*, common agricultural, maritime and fisheries policy, *European Defense Fund*, *Digital Europe* programme or the *Connecting Europe Facility* (Council of the European Union 2020). It is worth emphasizing that about 80% of funds from the EU budget is shared between individual countries. In this context, the UK lost the possibility of direct co-financing from EU funds of such areas as agriculture, small and medium-sized enterprises, or industry, transport, also in the context of

cohesion policy. All these areas also comprise R&D activities. However, in particular, research funding is allocated on the basis of European Commission application procedure, with the division between the member states which is unknown when the MFF is agreed.

Table 3: Strengths of EU Research Policy and UK Potential

EU strengths	UK potential
<ul style="list-style-type: none"> - EU research policy provides transnational collaboration between research organizations across Europe, - lower costs for researchers and students in their scientific activity and mobility within the EU, - EU budget provides funds for scientific projects, - synergy effect and mutual benefits for leading researchers, students, EU universities and research centres in common projects and knowledge sharing 	<ul style="list-style-type: none"> - UK scientists prepare and coordinate more EU research projects than any other member country, - results obtained in research are more likely to benefit British entities than organizations from other member states, - important British involvement in shaping common (EU) research agenda, - UK universities strongly visited by leading researchers from all over the world thanks to their infrastructure, reputation and high quality level of research

Source: Koeppel (2016).

It is evident that *Horizon 2020* created an added value of integration process and simultaneously there is no evidence of significant substitution effects between EU and national R&D investment. According to its interim report of the European Commission, 83% of *Horizon 2020*-financed projects would not have realized without EU-level support (European Commission 2017a, 9, 17, 21, 29-31).

The UK withdrawal from the EU does not mean a complete lack of participation in EU finances. According to the EU-UK Trade and Cooperation Agreement, the Great Britain will take part in selected EU programmes and activities (Trade and Cooperation Agreement..., 2020). It is included in the agreement that the UK will participate in international programmes such as *Horizon Europe*, *ITER* (International Thermonuclear Experimental Reactor), the Euratom Research and Training programme or *Copernicus* (European Earth Observation Programme) and will have access to the services provided by EU Satellite Surveillance & Tracking (SST). In this situation, the UK will continue to pay a contribution to the EU budget (referring to the Swiss example it could be about 60% lower than at present). The UK contribution will be additional financial resource for the EU budget and will consist of an operational contribution and a participation fee of 4% of the annual operational contribution to finance the implementation of the programme. It will be calculated as the ratio of UK GDP to EU GDP, both presented in market prices.

The Great Britain, however, resigned from participation in the *Erasmus* exchange programme. Due to the aforementioned research and scientific potential, the UK will have no problem providing its students with a high academic level and attracting foreign students. However, for EU students wishing to study in the UK, there will be significant procedural and, above all, financial barriers.

It seems that, on the one hand, Brexit will allow the EU-27 to benefit more from R&D support programmes, as Great Britain was one of the main recipients of these funds. On the other hand, it should be noted that the EU budget will now be deprived of most of the contributions from the UK. However, UK participation in EU research programmes will create opportunities for the continuation of EU-UK research cooperation, valuable for both sides. Although taking into account the success of the British side in the use of EU funds in R&D so far, one should expect significant UK activity in EU programmes. At the same time, the selective participation of the UK in the EU innovation policy suggests that certain issues important for the EU, such as access to education in British universities, have not been positively resolved, especially in the context of a significant weakening of the human potential in R&D after Brexit.

Conclusion

Brexit poses a significant challenge for the EU, whose R&D potential has been greatly weakened, and analyses have shown that the impact of this weakening will be observable. In general terms, this means a downturn in EU research and development and jeopardises efforts made with the intention of dynamizing and speeding up technological progress.

The consequences of Brexit has also been seen with regards to the potential of the EU's MNEs, as Great Britain is the home country for 51 MNEs with the largest R&D expenditure. This will significantly weaken the EU's MNEs in competition with strong global companies. Therefore, the destabilization of EU potential after Brexit has been all the more problematic. The EU's MNEs in the automotive industry occupy the strongest position in the world and here Brexit is not likely to affect the position of the EU. After Brexit, a completely different situation has been observed in pharmaceuticals and biotechnology,

where the share of the EU's MNEs in global expenditure will fall by almost 10%. In the IT hardware, software, electronics and electrical industries, in turn, the engagement of EU enterprises in R&D is already relatively poor, which proves their weakness in comparison with MNEs from the USA and from Eastern Asia. Thus, a relative weakening of these industries as a result of Brexit, will enlarge the gap between MNEs in Europe and the other two centres.

As a result, elimination of EU expenditures for Great Britain (about EUR 7.6 billion in 2019) and, at the same time, no UK contribution (EUR 17.1 billion in 2019 after deduction of the rebate) forced other countries to take on an additional financial burden in some areas or it required a decision to reduce EU spending in the others. There is no doubt that the British R&D had a huge share in European funding. Taking into account the fact that in nominal terms the UK was in the top three (next to Germany and France) beneficiaries from the *Horizon 2020* programme and in earlier scientific-research programmes (receiving from 2014 on average about EUR 1 billion a year), it could be assumed that in the current multiannual financial framework these funds will be distributed among the 27 members with some participation of the third countries, especially that the research programme from 2021 will be additionally increased from 80 to 100 billion EUR.

This analysis, by no means does not exhaust the subject, but it does show a synthesis of Brexit's consequences for the potential of the EU in R&D activity. One must take into consideration that the effects of this weakening of R&D potential may lead to the weakening of the EU as a partner for R&D collaboration. To avoid this, in the light of Brexit, the EU should concentrate more on the intensification of its involvement in the creation of R&D potential, although, given the numerous problems resulting from Brexit, this might pose a difficult challenge.

Acknowledgment

The research has been carried out as part of a research initiative financed by the Ministry of Science and Higher Education (Poland) within "Regional Initiative of Excellence" Programme for 2019-2022. Project no.: 021/RID/2018/19. Total financing: 11 897 131,40 PLN.

References

- Belke, A. and Gros, D. (2017), 'The economic impact of Brexit: Evidence from modelling free trade agreements,' *Ruhr Economic Papers*, 700.
- Browne, J., Johnson, P. and Phillips, D. (2016), 'The budget of the European Union: a guide,' The Institute for Fiscal Studies, London, [Online], [Retrieved April 26, 2019] <https://www.ifs.org.uk/uploads/publications/bns/BN181.pdf>.
- Busch, B. and Matthes, J. (2016), 'Brexit - the economic impact: A meta-analysis,' *IW-Report* No. 10/2016, Institut der Deutschen Wirtschaft, Köln.
- Caporaso, J.A. (2018), 'Europe's Triple Crisis and the Uneven Role of Institutions: the Euro, Refugees and Brexit,' *Journal of Common Market Studies* 56 (6), 1345-1361.
- Council of the European Union (2020), Council regulation (EU, Euratom) 2020/2093 of 17 December 2020 laying down the multiannual financial framework for the years 2021 to 2027 (OJ L 433, 22.12.2020).
- De Prato, G. and Nepelski, D. (2013), *The Global R&D Network: A Network Analysis of International R&D Centres*, Joint Research Centre of the European Commission, Luxembourg.
- European Commission (2017a), *The 2017 EU Industrial R&D Scoreboard*, European Union, Luxembourg.
- European Commission (2017b), *Investing in the European future we want. Report of the independent High Level Group on maximising the impact of EU Research & Innovation Programmes*. European Commission Directorate-General for Research and Innovation Publications Office of the European Union, Luxembourg, [Online], [Retrieved June 10, 2019] http://ec.europa.eu/research/evaluations/pdf/archive/other_reports_studies_and_documents/hlg_2017_report.pdf.
- European Commission (2020a), *The 2019 EU Industrial R&D Scoreboard*, European Union, Luxembourg.
- European Commission (2020b), *R&D ranking of the world top 2500 companies 2019*, [Online], [Retrieved November 15, 2020] <http://iri.jrc.ec.europa.eu/scoreboard19.html>.
- European Commission (2020c), *EU Funding*, [Online], [Retrieved December 10, 2020] https://ec.europa.eu/info/research-and-innovation/research-area/health-research-and-innovation/coronavirus-research-and-innovation/financing-innovation_en.
- European Commission (2020d), *EU expenditure and revenue 2014-2020*, [Online], [Retrieved September 25, 2020] https://ec.europa.eu/budget/graphs/revenue_expenditure.html.
- Eurostat (2020), *Database*, [Online], [Retrieved December 2, 2020], <https://ec.europa.eu/eurostat/databrowser/view/tsc00001/default/table?lang=en>.
- Frenk, C., Hunt, T., Partridge, L., Thomson, J. and Wyatt, T. (2015), *UK research and the European Union: The role of the EU in funding UK research*, The Royal Society, London, [Online], [Retrieved June 10, 2019] <https://royalsociety.org/~media/policy/projects/eu-uk-funding/phase-2/EU-role-in-international-research-collaboration-and-researcher-mobility.pdf>.

- Hiratuka, C. (2011), Transnational Corporations and Internationalization of the Research and Development Activities in Developing Countries: The Relative Importance of Affiliates in Asia and Latin America. In: Capital without Borders: Challenges to Development, A. Deshpande (eds.), 147-164, Anthem Press, India.
- Karlsson, M., eds. (2006), The Internationalization of Corporate R&D Leveraging the Changing Geography of Innovation, Elanders, Stockholm.
- Koeppl, A. (2016), Brexit's Impact on R&D Funding, FTI Consulting Inc., Brussels.
- Laffan, B. (2019), 'How the EU27 Came to Be,' *Journal of Common Market Studies*, 57, Annual Review, 13–27.
- Lawless, M. and Morgenroth, E.L.W. (2016), 'The product and sectorlevel impact of a hard Brexit across the EU'. *ESRI Working Paper*, 550, Dublin.
- Leruth, B., Gänzle, S. and Trondal, J. (2019), 'Exploring Differentiated Disintegration in a Post-Brexit European Union,' *Journal of Common Market Studies*, 57 (5).
- Lu, L.Y.Y. and Chen, T.M. (2012), Technology Strategy of R&D Internationalization: An Empirical Study from a Developing Country, In: Creating and Managing a Technology Economy, F. Betz (eds.), 81-108, World Scientific Publishing, Singapore.
- McGrattan, E.R. and Waddle, A. (2017), 'The Impact of Brexit on Foreign Investment And Production,' *NBER Working Paper*, 23217, Cambridge.
- Moncada-Paterno-Castello, P., Vivarelli, M. and Voigt, P. (2011), 'Drivers and impacts in the globalization of corporate R&D: an introduction based on the European experience,' *Industrial and Corporate Change*, 20(2), 585–603.
- Odrobina, A and Stabryla-Chudzio, K. (2020), 'The European Union's R&D potential after Brexit – Opportunities and Treats,' Proceedings of the 36th International Business Information Management Association (IBIMA), 4-5 November 2020, Granada, Spain.
- OECD (2020), Main Science and Technology Indicators, [Online], [Retrieved November 15, 2020]. http://oecd/stats.oecd.org/BrandedView.aspx?oecd_by_id=strd-data-en&doi=data-00182-en.
- Oehler, A., Horn, M. and Wendt, S. (2017), 'Brexit: Short-term stock price effects and the impact of firm-level internationalization,' *Finance Research Letters*, 22, 175-181.
- Sapir, A., Schoemaker, D. and Véron, N. (2017), 'Making the Best of Brexit for the EU27 Financial System,' *Policy Brief* 1. Bruegel, Brussels, [Online], [Retrieved November 15, 2019] https://bruegel.org/wp-content/uploads/2017/02/Bruegel_Policy_Brief-2017_01-090217.pdf.
- Singham, S., Tylecote, R. and Hewson, V. (2017), The Brexit Inflection Point: The Pathway to Prosperity, Legatum Institute, London.
- Steinberg, J. (2019), 'Brexit and the macroeconomic impact of trade policy uncertainty,' *Journal of International Economics*, 117/2019, 175-195.
- Trade and Cooperation Agreement between the European Union and European Atomic Energy Community, of the one part, and the United Kingdom of Great Britain and Northern Ireland, of the other part (2020), European Union, Brussels, OJ L 444, 31.12.2020.
- UNCTAD (2005a), Survey on the internationalization of R&D, United Nations, New York and Geneva.
- UNCTAD (2005b), The impact of FDI on development: globalization of R&D by transnational corporations and implications for developing countries, UNCTAD, Geneva.
- Uppenberg, K. (2009). R&D in Europe. Expenditures across Sectors, Regions and Firm Sizes, Centre For European Policy Studies, Brussels.
- Vandebussche, H., Connell, W. and Simons, W. (2019), 'Global Value Chains. Trade Shocks and Jobs: An Application to Brexit,' *cesifo Working Papers*, 7473, January.
- Vasilopoulou, S. and Keith, D. (2019), 'Renegotiation Versus Brexit: The Question of the UK's Constitutional Relationship with the EU,' *Journal of Common Market Studies*, 57(3), 486–501.
- Veugelers, R. (2016), 'The European Union's growing innovation divide,' *Bruegel Policy Contribution*, 08/2016, Bruegel.
- Weresa, M.A. (2018), Brexit and Innovation: Focus on Research and Development in the UK, In: Brexit and the Consequences for International Competitiveness. A.M. Kowalski (eds.), 19-42, Palgrave Macmillan, Cham.
- WIPO (2020), WIPO statistics database, [Online], [Retrieved November 15, 2020], <https://www3.wipo.int/ipstats/index.htm?tab=patent>.
- Zimmermann, V. (2015), 'An international comparison of R&D: Germany benefits from industrial research strength,' *KFW Research* 105, 25 August, 1-5.