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ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

THE MODERATING ROLE OF UNCERTAINTY IN THE IMPACT OF R&D EXPENDITURES ON ENVIRONMENTAL INNOVATION*

AR-GE HARCAMALARININ ÇEVRESEL İNOVASYON ÜZERİNDEKİ ETKİSİNDE BELİRSİZLİĞİN DÜZENLEYİCİ ROLÜ

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Abstract

This study examines the moderating effect of uncertainty on the relationship between firms' research and development (R&D) expenditures and environmental innovation. Firms in Germany, France, Italy, and Spain, which are the first four largest economies in the European Union, are analyzed. A panel Tobit regression model is used to evaluate data from 102 that are involved in the consumer cyclicals, industry, energy, and raw materials sectors between 2006 and 2019. The findings indicate that while uncertainty plays a negative moderating role in the relationship between R&D spending and environmental innovation, R&D expenditures itself has a positive impact on environmental innovation. The research results on the relationship between uncertainty, R&D, and environmental innovation offer valuable insights for academics and policymakers. Additionally, these findings contribute to the expanding ESG literature by highlighting how uncertainty can diminish the positive effects of firms' R&D investments on environmental innovation in the specified countries.

Keywords: R&D, Environmental Innovation, Uncertainty, Panel Tobit Regression, Moderating Role
JEL Classification: D89, M19, O39

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Öz

Bu çalışma, firmaların araştırma ve geliştirme (Ar-Ge) harcamaları ile çevresel inovasyon arasındaki ilişkide belirsizliğin düzenleyici etkisini incelemektedir. Avrupa Birliği'nin ilk dört büyük ekonomisi olan Almanya, Fransa, İtalya ve İspanya'daki firmalar analiz edilmiştir. Panel Tobit regresyon modeli, 2006-2019 yılları arasında tüketici döngüselleri, sanayi, enerji ve hammadde sektörlerinde yer alan 102 firmanın verilerini değerlendirmek için kullanılmıştır. Bulgular, belirsizliğin Ar-Ge harcamaları ile çevresel inovasyon arasındaki ilişkide negatif bir düzenleyici rol oynarken, Ar-Ge harcamalarının tek başına çevresel inovasyon üzerinde pozitif bir etkiye sahip olduğunu göstermektedir. Belirsizlik, Ar-Ge ve çevresel inovasyon arasındaki ilişkiye dair araştırma sonuçları, akademisyenler ve politika yapıcılar için değerli çıkarımlar sunmaktadır. Ayrıca bu bulgular, belirsizliğin belirtilen ülkelerde firmaların Ar-Ge yatırımlarının çevresel inovasyon üzerindeki olumlu etkilerini nasıl azaltabileceğini vurgulayarak genişleyen ÇSY literatürüne katkıda bulunmaktadır.
Anahtar Kelimeler: AR-GE, Çevresel İnovasyon, Belirslizlik, Panel Tobit Regresyon, Düzenleyici Rol
Jel Sınıflandırması: D89, M19, O39

1. Introduction

Innovation activities have become crucial at both a macro framework and a micro level in the world. It is possible to state that innovation has an effect on firms' competitiveness and growth just as it has an essential power on ensuring economic growth and welfare (Akcigit, 2022; Rennings & Rammer, 2011). Therefore, reasons such as the need for firms to survive, develop, take an active place on the market, make their customers loyal and acquire new customers have made innovation a key factor (Raymond & St-Pierre, 2010). Here, it is crucially important for companies to monitor the changing perception of all stakeholders in the realization of innovation. In parallel with this, with the increasing interest in sustainability approach, it has become inevitable for firms to take environmental issues into account in innovation. Especially in recent times, the negative effects of climate change on a global scale are very effective in environmental innovation gaining such importance (Chasiotis et al., 2023). Environmental innovation can be defined as organizational practices and changes focusing on the environment with different degrees of novelty that have an impact on firms' products, production processes and marketing (Dias Angelo et al., 2012). From this point of view, it is possible to say that environmental innovation actually overlaps with innovation activities in general.

R&D and innovation are seen by many firms as central to their survival strategies (Lawson et al., 2006). This is because these activities play a critical role in productivity growth, competitiveness of the firm, and ultimately continuity and sustainability. Firms that engage in R&D activities bring new products to the market and increase productivity with new processes, while firms that do not engage in R&D activities are more exposed to demand fluctuations (Añón-Higón et al., 2015). Considering the strong link between environmental innovation and innovation, it is possible to say that R&D investments are a driving force for environmental innovation (Liao & Liu, 2021; Zahra & George, 2002).

It is not always possible for firms to make R&D investments at the same level. Especially crises and uncertainties can directly affect firms' investment decisions. Crises and uncertainties affect innovation activities through channels such as lower R&D expenditures, loss of human capital,

lower risk taking, etc. (Chandra et al., 2009). For example, policy uncertainty increases the option value of waiting for corporate R&D investment, so that uncertainty delays R&D investment and hinders innovation (Huang et al., 2023; Julio & Yook, 2012). Many economists have also shown that increased uncertainty causes firms to reduce investment, bond issuance and spending, thus stifling innovation in the form of R&D spending and new product development (Al-Thaqeb et al., 2022; Li et al., 2021; Shankar, 2020). Similarly, uncertainty in economic policies and regulations encourages firms to postpone investments in environmental R&D or delay environmental projects that are costly to recover. One consequence of these decisions is that firms innovate less for the environment (Kyaw, 2022).

A significant number of theoretical studies have shown that investment in R&D is the main driver of productivity and economic growth in industrial and developing countries by leading to innovations and has positive effects on employment (Bayoumi et al., 1999; Becker, 2015; Di Cintio et al., 2017; Edquist & Henrekson, 2017; Esteve-Pérez & Rodríguez, 2013; Falk & de Lemos, 2019; Pessoa, 2010; Shefer & Frenkel, 2005; Tingvall & Videnord, 2020).

However, there is no specific study examining the impact of R&D investments on environmental innovation in particular. Similarly, there are not many studies that jointly test the impact of uncertainty on R&D expenditures and innovation outputs (Tajaddini & Gholipour, 2020). Considering this information, in order to contribute to the relevant gap in the literature, this study aims to investigate the moderating role of uncertainty in the impact of R&D investments on environmental innovation. Therefore, both the effect of R&D investments on environmental innovation and how this effect changes during periods of uncertainty are analyzed.

2. Literature and Hypothesis Development

Fatemi et al. (2018) investigates the effect of environmental, social, and governance (ESG) activities and their disclosure on firm value. They find that ESG strengths increase firm value and that weaknesses decrease it. They find that disclosure plays a crucial moderating role by mitigating the negative effect of weaknesses and attenuating the positive effect of strengths. They analyze 403 U.S. firms between 2006 and 2011. Xu et al. (2021) examine the impacts of R&D investment and ESG performance on green innovation performance. This paper also investigates the moderating effect of ESG performance between R&D investment and green innovation performance. The study uses the data of 223 Chinese listed companies over the period 2015–2018. The ESG indices issued by SynTao Green Finance are used to measure ESG performance. The results show that R&D investment has a positive impact on green innovation performance and ESG performance can increase the number of green invention patents. In addition, ESG performance moderates the relationship between R&D investment and green innovation performance. Vural-Yavaş (2021) investigates the effect of the economic policy uncertainty (EPU) on ESG performances, using 6,562 firm-year observations from 15 developed European countries covering the period from 2004 to 2017. The result of this paper contributes to ESG and corporate governance literature by demonstrating that EPU influences the ESG score. Their results indicate that, during periods of high uncertainty, firms are more dedicated

to the sustainability issues and attain higher level of ESG performance. This paper also contributes to literature by showing that the market competition positively moderates the relationship between uncertainty and ESG. Nirino et al. (2021) aims to explore the impact of corporate controversies on financial performance and proposes the positive moderating role of ESG practices over the aforementioned relationship. Using a database of 356 European listed companies, linear regression models confirm a negative and significant relationship between corporate controversies and financial performance. However, it was not possible to confirm the positive moderating effect of ESG practices on the relationship between controversies and financial performance. Forliano et al. (2022) analysis of 688 companies from the Refinitiv database that have won grants and had their ESG score assessed over the past eight years. This study found that R&D expenditures positively mediate between grants and ESG performance. Indeed, firms receiving grants, regardless of their nature, necessitate time to align with the requirements demanded by public bodies and develop sustainable, innovative outcomes. Moreover, despite there is still some debate if R&D intensity leads to higher ESG performance or not, we found a significant association between these two dimensions. Ilyas et al. (2022) examine 2,017 US. firms from 2002 to 2018. This study aims to examine the impact of EPU on firm investment in corporate social responsibility (CSR)'s ESG dimensions. Additionally, the study examines whether firm size moderates the EPU–CSR relationship. The findings reveal that firms increase their CSR investment in response to high EPU. The results are consistent in all the three ESG/CSR dimensions: ESG. Moreover, the positive association between EPU and CSR is driven by firm size, indicating that large-sized firms have the resources and incentives to invest more in CSR. Tang (2022) considers China's A-share listed companies as an example, the research applied linear regressions with panel data, using the ESG rating of SynTao Green Finance Agency as a proxy variable of ESG performance. The results show that ESG performance significantly promotes the quantity and quality of corporate innovation and is mediated by alleviating the financial constraints and agency cost. Internal and external governance plays different roles the higher institutional investors' attention as an external governance form does not help enterprises improve the quantity and quality of corporate innovation; however, CEO duality as an internal governance form strengthens the effect of ESG performance on corporate innovation. Based on the above rationales, the following hypothesis are proposed.

H1: *R&D expenditures have a positive effect on environmental innovation.*
H2: *Ambiguity has a moderating role in the effect of R&D expenditures on environmental innovation.*

Methodology

According to the hypotheses formulated, the model considered in the study is as follows.

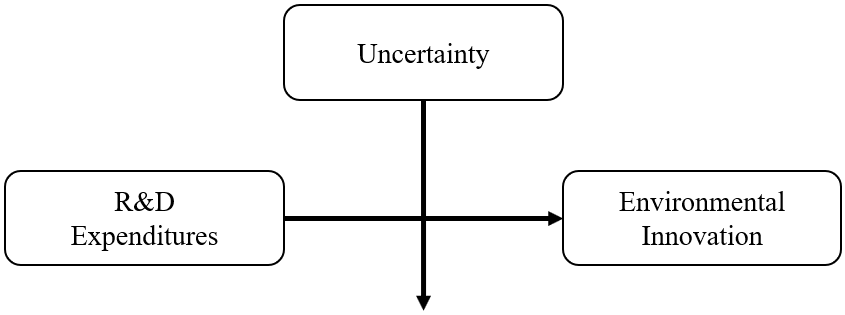

Figure 1: Research Model

The constructed mathematical models for testing the hypotheses can be shown as follows.

$$EI_t = \beta_0 + \beta_1 R\&D_{t-1} + \beta_2 lev_{t-1} + \beta_3 cash_{t-1} + \beta_4 capex_{t-1} + \beta_5 ebitda_{t-1} + \beta_6 roa_{t-1} \quad (1)$$

$$EI_t = \beta_0 + \beta_1 R\&D_{t-1} + \beta_2 R\&D \times Uncertainty_{t-1} + \beta_3 lev_{t-1} + \beta_4 cash_{t-1} + \beta_5 capex_{t-1} + \beta_6 ebitda_{t-1} + \beta_7 roa_{t-1} \quad (2)$$

In Equations (1) and (2) EI_{t-1} variable is the environmental innovation score of the firm in period t and $R\&D_t$ variable refers to the R&D expenditures of firms in period t. Leverage, cash, capex, ebitda and roa variables, which are frequently used in similar studies in the literature, are included in the models as control variables. In Equation (2) $R\&D \times Uncertainty_{t-1}$ is the moderating variable that shows the interaction between R&D expenditures and uncertainty index in period t-1. All variables except R&D expenditures and ebitda are observed to be ratio or index values. Therefore, since R&D expenditures and ebitda variables are quantified in firm balance sheets, the natural logarithm of these variables is taken for the reliability of the results. Accordingly, the mathematical models considered in the study have been updated as follows.

$$EI_t = \beta_0 + \beta_1 lnR\&D_{t-1} + \beta_2 lev_{t-1} + \beta_3 cash_{t-1} + \beta_4 capex_{t-1} + \beta_5 ebitda_{t-1} + \beta_6 roa_{t-1} \quad (1)$$

$$EI_t = \beta_0 + \beta_1 lnR\&D_{t-1} + \beta_2 R\&D \times Uncertainty_{t-1} + \beta_3 lev_{t-1} + \beta_4 cash_{t-1} + \beta_5 capex_{t-1} + \beta_6 lnebitda_{t-1} + \beta_7 roa_{t-1} \quad (2)$$

Since the lower bound of the dependent variable is zero and the upper bound is unlimited, the collected data were analyzed by panel tobit regression method.

For this study, a total of 102 enterprises from Germany (34), France (40), Spain (17) and Italy (11), which are the first four largest economies among the member countries of the European Union, were included in the study. These firms operating in raw materials, industry, energy and consumer cyclicals sectors. The Economic Uncertainty Index (EPU) (Baker et al., 2016) is used as the uncertainty variable. The firm, macro and ESG data used in the study are taken from the Thomson Reuters database, while the uncertainty index is taken from its own website where the index is calculated. Financial institutions and real estate investment trusts were not included in the study due to their

different balance sheet structures. Since the firms in the study were publicly offered at various times, unbalanced panel data was used. Firms with at least 4 years of data were included in the study. After all these criteria, the study consists of 102 firms and 1319 firm-year observations.

4. Findings

Before testing the hypotheses in line with the models, the stationarity of the variables is examined due to the panel data structure. For this purpose, firstly, for each variable, Peseran CD test is used to examine whether there is correlation between units. The purpose of this test is to determine which of the first – or second-generation tests to be used in the unit root test. If there is no inter-unit correlation in the variable of interest, first generation unit root tests are used, and if there is inter-unit correlation, second generation unit root tests are used. The results of Peseran CD test for the variables considered in the study are summarized in the table below.

Table 1: Peseran CD Test Results of Variables

Variable	CD Test	p-value	Variable	CD Test	p-value
EI	22.7	0.0000	Cash	14.438	0.0000
lnR&D	21.086	0.0000	Capex	30,04	0.0000
Uncertainty	217.903	0.0000	lnEbitda	29.785	0.0000
Lev	4.83	0.0000	ROA	27.035	0.0000

According to the results of the Peseran CD test, the p-values of all variables are less than the significance level of 0.05. Accordingly, all variables are correlated between units ($0.0000 < 0.05$). Therefore, it is appropriate to use one of the second-generation unit root tests for unit root testing. In this study, Fisher Phillips Perron panel unit root test is applied due to the unbalanced panel data. The results obtained are as follows.

Table 2: Fisher Phillips Perron Panel Unit Root Test Results

Variable		Statistics	p-value
EI	Inverse chi-squared (204)	1328.7716	0.0000
	Inverse normal	-20.8760	0.0000
	Inverse logit t (514)	-34.1492	0.0000
	Modified inv. chi-squared	55.6845	0.0000
lnR&D	Inverse chi-squared (204)	234.9319	0.0000
	Inverse normal	-3.1542	0.0000
	Inverse logit t (514)	-4.3705	0.0000
	Modified inv. chi-squared	6.6832	0.0000
Uncertainty	Inverse chi-squared (204)	211.1816	0.3504
	Inverse normal	-2.4421	0.0073
	Inverse logit t (514)	-2.4068	0.0082
	Modified inv. chi-squared	0.3555	0.3611

Lev	Inverse chi-squared (204)	328.1463	0.0000
	Inverse normal	-4.6359	0.0000
	Inverse logit t (514)	-5.0767	0.0000
	Modified inv. chi-squared	6.1462	0.0000
Cash	Inverse chi-squared (204)	585.6248	0.0000
	Inverse normal	-11.3169	0.0000
	Inverse logit t (514)	-13.6361	0.0000
	Modified inv. chi-squared	18.8932	0.0000
Capex	Inverse chi-squared (204)	505.1999	0.0000
	Inverse normal	-6.7545	0.0000
	Inverse logit t (514)	-10.2321	0.0000
	Modified inv. chi-squared	14.9116	0.0000
lnEbitda	Inverse chi-squared (204)	452.9680	0.0000
	Inverse normal	-6.1836	0.0000
	Inverse logit t (514)	-8.2656	0.0000
	Modified inv. chi-squared	12.3258	0.0000
ROA	Inverse chi-squared (204)	652.4523	0.0000
	Inverse normal	-12.9925	0.0000
	Inverse logit t (514)	-15.8304	0.0000
	Modified inv. chi-squared	22.2017	0.0000

According to the results of the Fisher Phillips Perron panel unit root test, the p-value values calculated as a result of the test statistics for all variables except the Uncertainty variable were obtained as 0.0000. Accordingly, since the p-value is less than 0.05, it is concluded that these variables do not contain unit root. However, in the Uncertainty variable, the p-value value of the two tests was greater than 0.05. For this reason, Uncertainty variable is found to contain a unit root. In order to get rid of the unit root, logarithmic transformation was applied (ln Uncertainty). According to the Peseran CD test applied to the obtained lnUncertainty variable, the result of correlation between units was obtained. In the subsequent Fisher Phillips Perron panel unit root test, since the p-value value of all tests was less than 0.05, stationarity was also achieved in the lnUncertainty variable. After the unit root tests, the multicollinearity problem was analyzed. Since the Variance Inflation Factor (VIF) values obtained are calculated below 5, it is seen that there is no multicollinearity problem.

After determining that the variables do not contain unit roots and that there is no multicollinearity problem, the hypotheses were tested. At this stage, panel tobit regression was applied to test the hypotheses since the dependent variable EI has a continuous structure and contains zero values as well as positive values. The panel tobit regression results are summarized in Table 3.

Table 3: Panel Tobit Regression Results

	A	B	C	D
Variable	**Coef.**	**Coef.**	**Coef.**	**Coef.**

lnR&D	7.241824*	7.062134*	31.29336*	26.8935*
lnUncertainty	12.87251*	13.53873*	66.16082*	58.8178*
lnR&D × lnUncertainty			-4.38265*	-3.925862*
Lev	30.82988*	24.31755*	21.14734*	28.70173*
Cash	30.56167***	27.91085**	44.15759*	47.58451*
Capex	10.8354	-29.98201	-38.61017	-116.9924*
lnEbitda	1.187642	0.4730437	0.9773927	2.604199*
ROA	-88.8028*	-93.87989*	-73.54754*	-88.95779*
Wald chi2(11)	448.92	481.13	482.91	628.60
Prob > chi2	0.0000	0.0000	0.0000	0.0000
Sector Effect	No	Yes	No	Yes
*0.01; **0.05; ***0.1				

While sector effects are not taken into account in modules A and C of Table 3, sector effects are included in the analysis in modules B and D. The hypotheses formulated within the scope of the study are included in modules B and D. Modules A and C were carried out in order to see the changes by taking the sector effect into account. Accordingly, for the purpose of the study, it is concluded that both R&D expenditures (lnR&D) and uncertainty (lnUncertainty) positively affect environmental innovation (EI). In addition, the variable lnR&D × lnUncertainty, which shows the interaction of lnR&D and lnUncertainty variables, has a negative effect. Therefore, it is possible to say that R&D expenditures made by firms positively affect environmental innovation, while uncertainty reduces this positive effect. In other words, it can be stated that uncertainty has a moderating role in the effect of R&D expenditures on environmental innovation. The graphical representation of this moderating role is as follows.

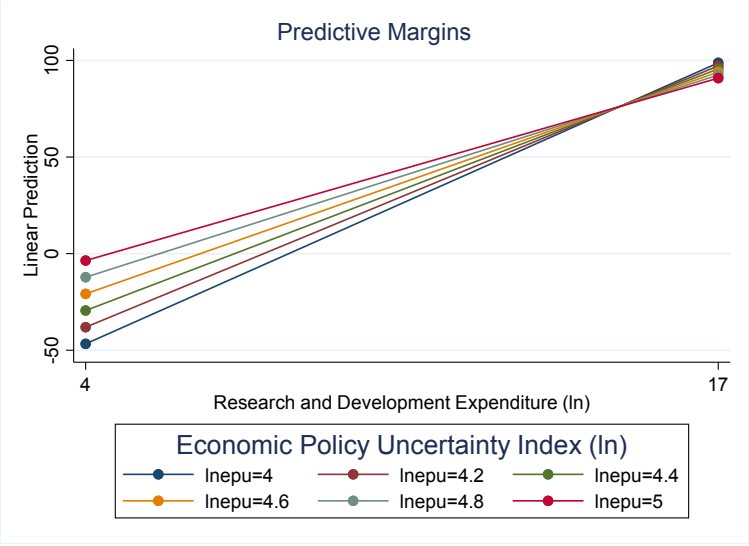

Figure 2: Graph for Regulatory Role

When the graph is analyzed, it is observed that as the uncertainty index increases, the slope showing the effect of R&D expenditures on environmental innovation decreases. For example, when the uncertainty index is 4, the slope of the effect of R&D expenditures on environmental innovation is steeper, whereas when the uncertainty index is 5, this slope becomes more horizontal. Mathematically, the calculations of the slope coefficients (average marginal effects) are as follows.

Tablo 4: Average Marginal Effects

lnUncertainty	**1:** 4		
	2: 4.2		
	3: 4.4		
	4: 4.6		
	5: 4.8		
	6: 5		
lnR&D	**dy/dx**	**Std. Err.**	**P>|z|**
1	11.19005	1.115616	0.000
2	10.40488	0.9609112	0.000
3	9.61971	0.8175386	0.000
4	8.834538	0.6925725	0.000
5	8.049365	0.5976719	0.000
6	7.264193	0.5486665	0.000

The slopes obtained as a result of the tobit regression of the effect of R&D expenditures on environmental innovation are calculated as 11.19005 when uncertainty is 4 and 7.264193 when uncertainty is 5. Therefore, the average effect values obtained confirm the decrease in the slopes seen in the graph.

3. Conclusion

In this study, which examines the regulatory role of uncertainty in the impact of R&D investments on environmental innovation, it is concluded that the impact of R&D investments on environmental innovation decreases during periods of uncertainty. This is because, in times of uncertainty, firms mainly stop, postpone or cancel their future activities. Therefore, R&D investments and innovation efforts tend to decrease in these periods when the level of risk-taking decreases. In line with this result in the literature, Kyaw (2022) explained that uncertainty in economic policies and regulations encourages firms to postpone environmental R&D investments and environmental projects that are costly to recover. For this reason, he stated that firms tend to reduce their environmental innovation activities during periods of uncertainty. The main reason for this result is that the return on R&D investments made during this period is much more difficult and firms tend to be much more meticulous in their investment decisions (Al-Thaqeb et al., 2022; Li et al., 2021; Shankar, 2020).

Based on the findings of the study, the fact that R&D investments and innovation activities slow down or stop the development of national economies during periods of uncertainty requires policymakers to take action. Certainly, policymakers and governments can emphasize the importance of reducing uncertainty to encourage both R&D investments and environmental innovation. Moreover, in cases where uncertainty cannot be reduced, the negative impact of uncertainty can be mitigated through grants, incentives and subsidies. On the other hand, a better transition to the post-uncertainty period can be achieved by providing support to firms in innovative sectors. In addition, relevant ministries and sub-organizations, as well as policymakers in times of uncertainty, can create a fund to support firms' activities in times of uncertainty. Like policymakers, firms can also reduce their R&D investments financially during periods of uncertainty, but they can also cooperate with start-ups. In this way, both start-ups' initiatives can find a response in the market and large firms can save money on R&D investments for innovation.

The study focuses on firms belonging to the four major economies of Europe. Therefore, this situation can be shown as the most important limitation of the study. In addition, R&D investments were evaluated as the driving force of environmental innovation. Concepts such as environmental responsibility, recycling practices, emissions, etc. among the drivers of environmental innovation are not addressed in the study. In addition, uncertainty scores are included in the scope of the analysis in the study, and crisis periods or other uncertainties are not included in the analysis. Therefore, future studies may examine the regulatory mechanism of uncertainty in the impact of R&D investments on innovation activities, especially in developing countries. In addition, the results obtained can be extended by considering other drivers of environmental innovation. Similarly, more comprehensive studies can be conducted by differentiating other periods of crisis and uncertainty.

References

Akcigit, U. (2022). Innovation, public policy and growth: what the data say. In U. Akcigit, C. B. Fasil, G. Impullitti, O. Licandro, & M. Sanchez-Martinez (Eds.), *Macroeconomic Modelling of R&D and Innovation Policies* (pp. 9–22). Palgrave Macmillan. https://doi.org/10.1007/978-3-030-71457-4_2

Al-Thaqeb, S. A., Algharabali, B. G., & Alabdulghafour, K. T. (2022). The pandemic and economic policy uncertainty. *International Journal of Finance & Economics*, 27(3), 2784–2794. https://doi.org/10.1002/ijfe.2298

Añón-Higón, D., Manjón-Antolin, M., Mañez, J. A., & Sanchis-Llopis, J. A. (2015). Does R&D protect SMEs from the hardness of the cycle? Evidence from Spanish SMEs (1990-2009). *International Entrepreneurship and Management Journal*, 11(2), 361–376. https://doi.org/10.1007/s11365.014.0329-0

Baker, S. R., Bloom, N., & Davis, S. J. (2016). Measuring Economic Policy Uncertainty. *The Quarterly Journal of Economics*, 131(4), 1593–1636. https://doi.org/10.1093/qje/qjw024

Bayoumi, T., Coe, D. T., & Helpman, E. (1999). R&D spillovers and global growth. *Journal of International Economics*, 47(2), 399–428. https://doi.org/10.1016/S0022-1996(98)00018-X

Becker, B. (2015). Public R&D policies and private R&D investment: a survey of the empirical evidence. *Journal of Economic Surveys*, 29(5), 917–942. https://doi.org/10.1111/joes.12074

Chandra, V., Eröcal, D., Padoan, P. C., & Primo Braga, C. A. (2009). Introduction: why innovation matters. In V. Chandra, D. Eröcal, P. C. Padoan, & C. A. Primo Braga (Eds.), *Innovation and Growth* (pp. 11–14). OECD. https://doi.org/10.1787/978.926.4073975-3-en

Chasiotis, I., Georgakopoulos, G., & Toudas, K. (2023). Does market competition affect environmental innovation? Some international evidence. *Theoretical Economics Letters*, 13(05), 1121–1130. https://doi.org/10.4236/tel.2023.135061

Di Cintio, M., Ghosh, S., & Grassi, E. (2017). Firm growth, R&D expenditures and exports: an empirical analysis of italian SMEs. *Research Policy*, 46(4), 836–852. https://doi.org/10.1016/j.respol.2017.02.006

Dias Angelo, F., Jose Chiappetta Jabbour, C., & Vasconcellos Galina, S. (2012). Environmental innovation: in search of a meaning. *World Journal of Entrepreneurship, Management and Sustainable Development*, 8(2/3), 113–121. https://doi.org/10.1108/204.259.61211247734

Edquist, H., & Henrekson, M. (2017). Swedish lessons: how important are ICT and R&D to economic growth? *Structural Change and Economic Dynamics*, 42, 1–12. https://doi.org/10.1016/j.strueco.2017.05.004

Esteve-Pérez, S., & Rodríguez, D. (2013). The dynamics of exports and R&D in SMEs. *Small Business Economics*, 41(1), 219–240. https://doi.org/10.1007/s11187.012.9421-4

Falk, M., & de Lemos, F. F. (2019). Complementarity of R&D and productivity in SME export behavior. *Journal of Business Research*, 96, 157–168. https://doi.org/10.1016/j.jbusres.2018.11.018

Fatemi, A., Glaum, M., & Kaiser, S. (2018). ESG performance and firm value: The moderating role of disclosure. *Global Finance Journal*, *38*, 45–64. https://doi.org/10.1016/j.gfj.2017.03.001

Forliano, C., Ballerini, J., De Bernardi, P., & Quaglia, R. (2022). The mediating role of R&D investments in the relationship between awarded grants and ESG performance. *2022 IEEE International Conference on Technology Management, Operations and Decisions, ICTMOD 2022*, *December*, 1–5. https://doi.org/10.1109/ICTMOD55867.2022.100.41825

Huang, J., Wang, Z., Jiang, Z., & Zhong, Q. (2023). Environmental policy uncertainty and corporate green innovation: evidence from China. *European Journal of Innovation Management*, 26(6), 1675–1696. https://doi.org/10.1108/EJIM-12-2021-0591

Ilyas, M., Mian, R. U., & Suleman, M. T. (2022). Economic policy uncertainty and firm propensity to invest in corporate social responsibility. *Management Decision*, *60*(12), 3232–3254. https://doi.org/10.1108/MD-06-2021-0746

Julio, B., & Yook, Y. (2012). Political uncertainty and corporate investment cycles. *The Journal of Finance*, 67(1), 45–83. https://doi.org/10.1111/j.1540-6261.2011.01707.x

Kyaw, K. (2022). Effect of policy uncertainty on environmental innovation. *Journal of Cleaner Production*, 363, 132645. https://doi.org/10.1016/j.jclepro.2022.132645

Lawson, C. P., Longhurst, P. J., & Ivey, P. C. (2006). The application of a new research and development project selection model in SMEs. *Technovation*, 26(2), 242–250. https://doi.org/10.1016/j.technovation.2004.07.017

Li, X., Hu, Z., & Zhang, Q. (2021). Environmental regulation, economic policy uncertainty, and green technology innovation. *Clean Technologies and Environmental Policy*, 23(10), 2975–2988. https://doi.org/10.1007/s10098.021.02219-4

Liao, Z., & Liu, Y. (2021). What drives environmental innovation? A meta-analysis. *Business Strategy and the Environment*, 30(4), 1852–1864. https://doi.org/10.1002/bse.2720

Nirino, N., Santoro, G., Miglietta, N., & Quaglia, R. (2021). Corporate controversies and company's financial performance: Exploring the moderating role of ESG practices. *Technological Forecasting and Social Change*, *162*. https://doi.org/10.1016/j.techfore.2020.120341

Pessoa, A. (2010). R&D and economic growth: how strong is the link? *Economics Letters*, 107(2), 152–154. https://doi.org/10.1016/j.econlet.2010.01.010

Raymond, L., & St-Pierre, J. (2010). R&D as a determinant of innovation in manufacturing SMEs: an attempt at empirical clarification. *Technovation*, 30(1), 48–56. https://doi.org/10.1016/j.technovation.2009.05.005

Rennings, K., & Rammer, C. (2011). The impact of regulation-driven environmental innovation on innovation success and firm performance. *Industry & Innovation*, 18(3), 255–283. https://doi.org/10.1080/13662.716.2011.561027

Shankar, N. (2020). Role of global economic policy uncertainty on firms' participation in innovation and new product introductions: an empirical study in African SMEs. *Transnational Corporations Review*, 12(4), 360–378. https://doi.org/10.1080/19186.444.2020.1832425

Shefer, D., & Frenkel, A. (2005). R&D, firm size and innovation: an empirical analysis. *Technovation*, 25(1), 25–32. https://doi.org/10.1016/S0166-4972(03)00152-4

Tajaddini, R., & Gholipour, H. F. (2020). Economic policy uncertainty, R&D expenditures and innovation outputs. *Journal of Economic Studies*, 48(2), 413–427. https://doi.org/10.1108/JES-12-2019-0573

Tang, H. (2022). The effect of politician turnover on firm innovation: The mediating role of financial constraints. *Sustainability*, *14*. https://doi.org/10.1080/09537.325.2022.2139236

Tingvall, P. G., & Videnord, J. (2020). Regional differences in effects of publicly sponsored R&D grants on SME performance. *Small Business Economics*, 54(4), 951–969. https://doi.org/10.1007/s11187.018.0085-6

Vural-Yavaş, Ç. (2021). Economic policy uncertainty, stakeholder engagement, and environmental, social, and governance practices: The moderating effect of competition. *Corporate Social Responsibility and Environmental Management*, *28*(1), 82–102. https://doi.org/10.1002/csr.2034

Xu, J., Liu, F., & Shang, Y. (2021). R&D investment, ESG performance and green innovation performance: Evidence from China. *Kybernetes*, *50*(3), 737–756. https://doi.org/10.1108/K-12-2019-0793

Zahra, S. A., & George, G. (2002). Absorptive capacity: a review, reconceptualization, and extension. *Academy of Management Review*, 27(2), 185–203. https://doi.org/10.5465/amr.2002.6587