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Green Patents or Growth? European and the USA Firms' Size Dynamics and Environmental Innovations Financial Gains

Anastasia Semenova [1,*], Konstantin Semenov [2] and Maxim Storchevoy [3]

[1] Department of Economics, St. Petersburg School of Economics and Management, HSE University (National Research University 'Higher School of Economics'), 3A Kantemirovskaya Street, St. Petersburg 194100, Russia
[2] School of Computer Technologies and Information Systems, Institute of Computer Science and Cybersecurity, Peter the Great St. Petersburg Polytechnic University, 29 Politekhnicheskaya Street, St. Petersburg 195251, Russia; semenov.k.k@iit.icc.spbstu.ru
[3] Department of Management, St. Petersburg School of Economics and Management, HSE University (National Research University 'Higher School of Economics'), 3A Kantemirovskaya Street, St. Petersburg 194100, Russia; mstorchevoy@hse.ru
* Correspondence: assemenova@hse.ru

Abstract: In the context of environmental challenges and sustainable development, modern firms strive for competitive advantage through environmental innovations (EIs), yet the impact of EIs on firms' performance remains a controversial topic in the scholarly discourse. While some authors highlight a positive influence, numerous studies reveal ambivalence or even negative effects on firms' financial performance. This inconsistency highlights the insufficient exploration of various aspects of the financial implications of EIs. Recognizing the moderating role of firms' size dynamics, often overlooked in existing studies, this research investigates how the changing size of firms influences the relationship between EIs and financial performance. Analyzing data from 1136 European and North American firms over the period 2012–2019, with and without green patents, the study reveals distinct correlation results between environmental innovations (EIs) and financial performance in a specific industry, differing in both the short and long run. Firms experiencing greater growth compared to industry growth tend to implement more EIs compared to their counterparts. Growing firms with EIs show superior long-term financial performance but experience poorer short-term financial results compared to their counterparts without EIs. Notably, as green firms age, the influence of firms' size dynamics on the EI–financial performance relationship diminishes.

Keywords: environmental innovations; financial performance; green patents; sustainability

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1. Introduction

Modern firms struggle to achieve competitive advantage under limitations of environmental issues and the growing demand for sustainability. In this context, the key role is played by environmental innovations (EIs). The impact of EIs on firms' financial performance (FP) is a controversial issue which attracted much attention of scholars from various perspectives. Some authors report a positive influence [1,2], but quite many studies demonstrate ambivalent or negative impacts [3–5]. This inconsistency in the findings suggests that some crucial financial aspects of EIs are still underexplored. Some studies suggest that the firms' size is a strong moderator of the relationship between EIs and FP [6,7]. Xie and colleagues [8] proved that the relationship between EIs and FP is U-shaped, with negative impact in the beginning and a more positive return at the higher levels of EIs.

Many studies of EIs and FP assume that the firms' size is a constant control variable. The regression models usually use variables like $size_t$, where t represents the specified year in panel data [8–10], but almost never use variables that characterize firms' size dynamics—variables like $Size_t$–$Size_{t-k}$, where $k \geq 1$. So, in this case the effects which

are in reality caused by the firms' growth or downsizing may be wrongly attributed to other effects.

Our goal is to study how the *changing size of the firms* impacts the relationship between EIs and FP. Using data for 1136 European and North American firms with at least one green patent (GP) and 2395 firms without GPs for the period 2012–2019, we examined the impact of the firms' size dynamics on how EIs affect FP and explored the differences of the effect in the short term and in the long run. Hence, this research makes a significant contribution to the existing literature by providing exemplary nuanced insights into the financial implications of EIs. The essential objective of the paper is to study the details of the mentioned influence: the impact of different industries, industry growth, firm age.

Our findings reveal a positive correlation between EIs for some industries and the FP of firms, both in the short and long run. Firms experiencing greater growth compared to industry or economic growth tend to implement more EIs compared to their counterparts. Moreover, the financial returns from GPs are higher for the firms exceeding industry or general economic growth. Interestingly, as green firms age, the impact of firms' size dynamics on the relationship between EIs and FP becomes less distinct. In the long term, growing firms with EIs demonstrate superior FP compared to their counterparts without EIs. However, in the short term, growing firms with EIs show poorer FP compared to those without EIs. This nuanced analysis sheds light on the varying dynamics of the relationship between EIs and FP. Unlike many studies that consider the impact of EIs in isolation, this research uniquely emphasizes the moderating role of firms' size dynamics. By acknowledging that the effects of EIs on FP are not uniform and can be influenced by the changing size of firms over time, the study introduces a novel perspective and allows for a more accurate and comprehensive assessment of the real-world implications of EIs both in the short and in the long run.

The rest of the paper is organized as follows. Section 2 reviews the theoretical background, and Section 3 develops hypotheses. Sections 4 and 5 discuss the sample and method; Section 6 presents the results, and Section 7 provides their interpretation. Section 8 concludes.

2. Theoretical Background

Growing environmental challenges, together with competitive pressure, technological advancements [11], and environmental policies are compelling firms worldwide to enhance their environmental performance, making the impact of EIs on FP a focal point for scholars and practitioners seeking a balance between economic growth and environmental commitment.

The impact of EIs on firms' financial performance is grounded in the following theoretical framework. Sometimes, EIs generate economic value by reducing costs or enhancing products, prompting firms to adopt these innovations voluntarily, without regulatory pressure [6,11]. Conversely, some firms only meet minimal environmental regulations and see additional environmental investments as unprofitable [3]. Nevertheless, EIs can offer economic benefits in both scenarios and, when protected by patents, can provide a sustainable competitive advantage, aligning with the resource-based view (RBV) approach to strategic management [12]. However, there is an optimal level of EIs for economic viability; surpassing this threshold can negatively impact financial results. As noted by some researchers [5], an excessive focus on EIs, compared to other forms of environmental activism, can harm the financial performance of pioneering firms.

We will understand EI as "assimilation or exploitation of a product, production process, service or management or business method that it is novel to the firm or user and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives" ([13], p. 3). The traditional microeconomics view is that EIs should have a negative impact for profit because it represents *private costs and public benefits*, because EIs are forced by government regulation to achieve some ecological purposes which benefit

the whole society and simply increase costs of individual firms without bringing extra profit [14–16]. However, it is not very accurate for two reasons.

First, the government only introduces some requirements on the impact on the environment, but it does not tell the firms how to achieve them. So, after a new regulation is introduced, it is up to the firms as to how to meet the targets, and here, a good EI can help a firm to achieve lower costs than its rivals, and, therefore, gain some additional profit. The scholars discussed several ways how EIs may help the firm to improve FP: reduce expenses for handling waste, reduce usage of resources, implement cycled processes, etc. [6,17–26]. A more fundamental EI may be undertaken when a firm moves from ex post "pollution control" focused on handling the results of pollution and waste to ex ante "pollution prevention" focused on changing the whole technological process to generate less pollution and waste at all [12]. That is why EIs can bring extra profit to the firm even in traditional microeconomics.

Second, the traditional microeconomic view is itself an oversimplified view of the organizations assuming absolute rationality, full knowledge and one decisionmaker. In reality, as the behavioral economic theory noticed [27], the firms are complex organizations with limited knowledge and many centers of decision making, which can behave far from rational. This angle was brought to the EI debate by Porter and van der Linde [28], who emphasized the six behavioral organizational factors which may prevent EI: lack of awareness about environmental problems, lack of data about environmental problems, uncertainty that investments will be valuable, organizational inertia, uneven transitional playing field during the transition period, and opportunistic behavior of competitors avoiding environmental investments. Again, the idea of Porter and van der Linde was that it is the task of the government to introduce regulation which will force the organizations to overcome their behavioral limitations and to make rational steps in improving environmental and financial conduct.

However, the benefits from EI are not guaranteed to all firms. First, there may be severe competition in an industry and all EIs will sooner or later be copied by competitors. Therefore, EI may bring financial benefits only in two forms—a *Schumpeterian rent* which will be earned for some time before the competitors will copy EI, or a *Ricardian rent* which may be enjoyed for a long time if the competitors cannot copy EI [12]. Without distinguishing between these two types of rent, it does not make sense to conduct empirical research because we will not know what pattern of financial return should be looked for in the short and long run. Also, the empirical research will be very inaccurate if we do not specify who is implementing EI—the pioneer (who can enjoy Schumpeterian rent) or the follower (who can hope at best to stay in the industry but will not gain any additional profit from this). Some researchers tried to account for this factor: Przychodzen and colleagues [5] studied the differences in financial results of the firm-pioneers and firm-followers; Wu [29] explored the financial implications of exploratory EIs (having a longer period of development) and exploitative EIs (quick result-oriented) and showed that the influence of the latter is positive, while the former's influence is ambivalent.

Additionally, there are two other factors which may significantly moderate the influence of EI on FP: *differentiation of firms* and *industry condition*. First, the firms are differentiated in their organizational capabilities (routines) to find and seize profit opportunities. It is logical to assume that the firms with better capabilities will be able to implement EI more effectively (being faster pioneers or faster followers, creating hard-to-copy EIs, etc.). Second, the opportunities to extract profit may depend on the age of the industry. In the early stage of development of every industry, there is an effect of "low hanging fruit"—easy and inexpensive improvements in pollution prevention [17,24,30]. It means that the growing industries should have this effect because the growth means that there are new opportunities discovered and there should be "low hanging fruits". The stable industry means that the firms already used many opportunities for improvement and all low-hanging fruits were already gathered, so EIs, as any other innovations, will have a lower return, all other things being equal, compared to the growing industry.

3. Building Hypotheses

It is very difficult to measure EIs as such because this phenomenon is not reported by the firms and cannot be observed by an outsider. There is only one good observable indicator of EI—the number of GPs received by the firm during a given period. Arundel and Kemp [31] stated that: "patents are the most commonly used data to construct intermediate indicators for inventions"; "patents have several advantages over R&D expenditures"; "patent counts can be used as an indicator of the level of innovative activity in the environmental domain"; "in the same way as for innovation in general, patents covering eco-inventions can be used to measure research and inventive activities and to study the direction of research in a given technological field." Green patents number based on the OECD/WIPO database is included as criteria 3–4 in the ASEM (Asia-Europe Meeting) Eco-Innovation Index (2015 ASEI) Indicators in Section 3 "Eco-Innovation Activities."

The fact of receiving a GP obviously means that the firm is the pioneer and not the follower. So, we may assume that this firm will earn at least a Schumpeterian rent as a pioneer, and probably a Ricardian rent if the other firms will not be able to use this patent. Second, the mere fact of receiving patents means that the firm has better organizational capabilities and, ceteris paribus, can implement EI with higher financial benefits than other firms in the industry [32–34]. Therefore, GP number should be obviously correlated with higher FP.

Hypothesis 1. *In one industry, the higher number of GPs is positively correlated with FP of the firm both in the short run and in the long run.*

We can also test our assumption that the capability to develop EIs reflects the general superior organizational capabilities of the firm. Although the latter is also difficult to observe, we can use such a simple observable indicator as a *firm's profitability growth*. To be sure that this growth is a result of the firm's superior capabilities and not the general economic growth or industry expansion, we should measure the firm's relative profitability growth to other firms or, in other words, to the overall industry growth. Therefore, the higher the relative profitability growth of the firm, the higher the number of GPs it will produce.

Hypothesis 2. *The higher the profitability of the firm compared to industry growth, the larger the number of GPs this firm will implement compared to other firms.*

We can also test if the profitability growth of the firm may be a moderator between the number of GPs and FP. It is logical to assume that if the firm is not only good in EI but also has good general organizational capabilities, its FP will be even better. Therefore, we can check if the higher relative profitability firm's growth increases the financial return to its GP.

Hypothesis 3. *The higher the profitability of the firm compared to industry growth, the higher will be the financial return for its GP compared to other firms.*

The next moderator should be the *industry condition*. In the newer industries, there are more opportunities for innovations ("low hanging fruit" effect) as well as the higher differentiation between firms. Therefore, we may expect that in the older industries there will be less noticeable difference between the firms with larger and smaller numbers of GPs.

Hypothesis 4. *The older the green firm is, the less distinct the firms' size dynamics effect becomes in the context of the relationship between GPs number and FP.*

Lastly, we should check one more factor which may influence our results. The problem is that there may be a time lag between obtaining the patent and receiving financial return

from its practical use. If this time lag is significant and inevitable, then we should expect that our Hypotheses 1–4 will be more valid in the long run than in the short run.

Hypothesis 5. *In the long term, growing firms with GPs show even better financial results compared to the growing firms without GPs.*

Another factor which may take place is that, during the period of active R&D, the firm will spend extra resources compared to its rivals. So, in the short run, the first firm actively working on GP may have even worse FP than the firms which are not involved in this activity. Przychodzen et al. [5] showed that FP implications caused by EI implementation might be one- and two-year lagged. Semenova et al. [35] showed that these time lags differ for small, medium, and large firms, shedding more light on how firms' size moderates the relationship between EIs and firms' FP [6,7].

Hypothesis 6. *In the short term, growing firms with GPs show worse financial results compared to the growing firms without EIs.*

4. Sample

Following [36–38], we assessed green activism by identifying firms holding GPs, focusing on North America and Europe, which typically have the highest number of GPs. We gauged firms' FP using return on assets (ROA), a widely accepted measure for its stability and reliability [3,29,39].

Using data from the Orbis, Google Patents, and WIPO databases, we gathered information on 3531 primarily European and North American enterprises for 2012–2019 (sample A). We included firms marked in the Orbis database as they have at least ever had a GP. We computed ROA values as the ratio between the firm's annual profits and its total assets values obtained from Orbis for all firms included in the sample.

We enhanced the accuracy of matching patents and firms following the previously developed procedure [35] described below. We used the WIPO database to collect the sample of green innovative firms with at least one green patent published in 2013–2018 and non-green innovative firms with no green patents published in 2010–2018 (sample B that contains 16,674 patents records). We specifically focused on the patents that were included in the WIPO category "24—environmental technology". In this paper, we use the patents' priority date as the date closest to the moment of environmental innovation introduction. In contrast, the publishing date cannot serve as a reliable indicator of the timing of ecological innovation; it can take more than a year from filing to the publication of a patent. For the patents in sample B in the article, the median time between publishing and priority date was equal to (1.79 ± 0.07) years. The information on patent dates was collected in the Google Patents database.

We formed the intersection of these two samples as follows. First, public authorities/states/governments and firms with no recent financial data were excluded from considering. After that, we matched the firms' names from sample A and sample B to find reliable intersections. To do that, based on [40–43], we performed the following.

1. We turned the firms' names in samples A and B into the uppercase text;
2. We removed "the" and non-text characters such as spaces, dots, commas, dots with commas, hyphens, single and double quotes, parentheses, etc. We replaced the symbol "&" with "AND";
3. We replaced all widely used abbreviations with the common reduced form: "INCORPORATED" to "INC", "OPENED JOINT STOCK COMPANY" to "OSJC", "PUBLIC LIMITED COMPANY" to "PLC", "LIMITED LIABILITY COMPANY" to "LLC", "LIMITED" to "LTD", "COMPANY" to "CO". The order of these replacements mattered;
4. We deleted all abbreviations from the endings of firms' names in samples A and B ("PUBL", "AB", "AG", "LTD", "INC", "CO", "LLC", "PLC", "OJSC") and, after that, from their beginnings ("OJSC", "LLC", "PLC");

5. For the non-trivial errors and variations in firms' names (such as typos), we calculated the Levenstein distance between all pairs of text strings representing firms' names included in sample A and sample B. For each pair, we normalized the obtained value following [44]. We interpreted the firms' names as coincidental if the normalized distance was lower than the pre-determined threshold based on the statistic of typos occurrence in economic databases.

The threshold value was determined as follows. After completing steps 1–5, the average length of a firm's name was calculated, and it equaled 16.1 symbols. Following [45,46], the typical errors in firms' names do not exceed 1–2 symbols (1-symbol typos were detected in 90–96% of cases in full-scale studies and at least 80% in small-scale studies). So, we set the threshold as 0.1 (Figure 1).

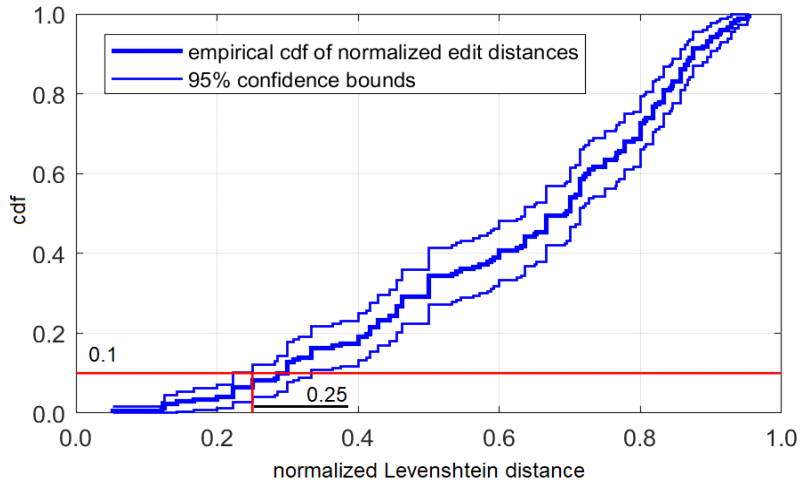

Figure 1. The empirical cumulative distribution function for edit distance normalized by the firms' name length.

The described procedure helped to increase the depth of the dataset's match and obtain the final accurate dataset. As a result, we obtained a sample of 1136 firms with green patents and 2395 firms without green patents.

Firms were categorized by size according to OECD standards: large (250+ employees), medium (50–249 employees), and small (fewer than 50 employees). Growing firms transitioned to larger size categories, while downsizing firms moved to smaller ones.

Further details on how the data sample was formed can be found in [35].

Table 1 presents the distribution of firms included in the collected sample by size and country. We used the widespread Alpha-2 codes (ISO 3166 [47]) for countries' designation.

Most of the studied firms in the sample are from Germany (521), Italy (483), Great Britain (421), the USA (387), Spain (212), Sweden (186), Netherlands (144), Belgium (129), and France (109). In Table 1, each cell contains two numbers divided by a slash; the first is the number of green firms, and the second is the number of firms without GPs. If a firm's size changed within the reviewed time period, then the median size was taken as its size during this time interval (Table 1).

Tables 2 and 3 display the descriptive statistics, including in-sample distributions, for firms holding green patents and those without GPs. The tables contain the values of the following sample statistical characteristics: mean value (mean), median value (med), standard deviation (s), and bounds of the confidence interval (CI) for confidence probability equal to 90% (formed by 5% and 95% quantiles). In the case of a firm experiencing a change in size during the examined time frame, the median size was taken to represent its size across this time interval in Tables 2 and 3.

Table 1. The firms' sample distribution by countries.

Firms' size	Country												
	AT	***BA***	***BE***	***BG***	***BM***	***CA***	***CH***	***CZ***	***DE***	***DK***	***EE***	***ES***	***FI***
Small	0/0	0/1	6/47	5/8	0/0	0/0	0/1	11/11	9/22	0/0	0/3	66/39	11/12
Medium	0/0	0/1	3/27	0/0	0/1	0/0	0/0	23/11	73/58	0/0	0/0	18/28	6/13
Large	6/11	0/0	8/38	0/0	3/29	1/5	2/33	8/7	126/233	3/6	1/0	14/47	19/24
Total	17	2	129	13	33	6	36	71	521	9	4	212	85
Firms' size	**Country**												
	FR	***GB***	***GR***	***HR***	***HU***	***IE***	***IT***	***LI***	***LT***	***LU***	***LV***	***NL***	***NO***
Small	7/17	19/65	2/1	2/1	0/17	2/1	141/100	0/0	1/0	0/0	2/4	28/26	0/0
Medium	8/10	54/82	0/0	3/0	0/14	1/2	60/42	0/0	2/3	0/0	0/0	9/17	0/0
Large	19/48	75/126	0/2	0/0	0/4	4/9	51/89	1/0	2/1	0/7	0/0	12/52	2/6
Total	109	421	5	6	35	19	483	1	9	7	6	144	8
Firms' size	**Country**												
	PL	***PT***	***RO***	***RS***	***RU***	***SE***	***SI***	***SK***	***TR***	***UA***	***US***		
Small	1/3	2/6	14/9	0/0	11/192	32/56	1/16	6/2	0/0	0/4	2/3		
Medium	0/4	2/4	2/2	0/2	3/104	8/21	1/4	3/3	0/0	0/5	2/6		
Large	0/10	1/2	2/2	0/0	2/128	14/55	0/2	1/0	2/4	0/5	95/279		
Total	18	17	31	2	440	186	24	15	6	14	387		

The period considered in the paper included the years 2012–2019—the interval between the European debt crisis (2011) and the economic tectonic shifts caused by COVID-19 appearance (2020). The authors suppose that this interval can be treated as sufficiently heterogeneous for the considered region—despite the Brexit stock market crash (2016) and stock market selloff in 2015–2016, since we did not see significant changes in our sample descriptive statistics in Table 2 for the corresponding years.

Additionally, we considered the industries to which the analyzed firms belong, as well as their ages, to ensure sufficient information for comparing growing and downsizing firms. To collect these additional data, we used Company Dataset from People Data Labs that includes 14.1+ million companies and their attributes (https://www.peopledatalabs.com/company-dataset, accessed on 11 September 2023). We aligned the data on industries and founding years by cross-referencing the firms' names in our sample of 3531 firms with the Company Dataset from People Data Labs, which comprises over 14.1 million firms. To achieve this, we employed the procedure presented before and outlined in [35], making minor extensions for faster computations.

Thus, we enriched our dataset with information on firms' industries and ages. Table 4 displays the distribution of firms by industries, including those with no fewer than 15 firms, while Figure 2 illustrates the distribution by ages.

Table 2. Descriptive statistics for green firms' total sample (1136 firms).

	Small Firms (381)				Medium Firms (281)				Large Firms (474)			
	Mean	**Med**	**s**	**90% CI**	**Mean**	**Med**	**s**	**90% CI**	**Mean**	**Med**	**s**	**90% CI**
Patents number	7.92	4	16.17	[1.00, 26.5]	9.63	4	17.47	[1.00, 35.9]	51.64	7	193.4	[1.00, 206.8]
ROA in 2012	0.061	0.036	0.253	[−0.39, 0.81]	0.048	0.048	0.087	[−0.17, 0.22]	0.045	0.043	0.061	[−0.09, 0.17]
ROA in 2013	0.044	0.028	0.297	[−0.56, 0.66]	0.048	0.053	0.083	[−0.17, 0.22]	0.052	0.046	0.058	[−0.06, 0.17]
ROA in 2014	0.021	0.023	0.271	[−0.61, 0.48]	0.046	0.041	0.081	[−0.13, 0.20]	0.052	0.048	0.054	[−0.06, 0.16]
ROA in 2015	0.049	0.024	0.339	[−0.46, 0.58]	0.048	0.039	0.084	[−0.13, 0.24]	0.046	0.044	0.057	[−0.08, 0.16]
ROA in 2016	0.022	0.027	0.300	[−0.57, 0.53]	0.050	0.040	0.085	[−0.12, 0.24]	0.047	0.045	0.060	[−0.08, 0.17]
ROA in 2017	0.024	0.018	0.206	[−0.47, 0.44]	0.047	0.038	0.081	[−0.12, 0.21]	0.047	0.042	0.054	[−0.07, 0.16]
ROA in 2018	0.020	0.013	0.235	[−0.42, 0.43]	0.048	0.039	0.088	[−0.12, 0.23]	0.046	0.044	0.060	[−0.08, 0.17]
ROA in 2019	0.059	0.013	0.327	[−0.41, 0.98]	0.071	0.037	0.136	[−0.14, 0.47]	0.067	0.048	0.120	[−0.10, 0.43]

Table 3. Descriptive statistics for the total sample of the firms without green patents (2395 firms).

	Small Firms (620)				Medium Firms (459)				Large Firms (1316)			
	Mean	**Med**	**s**	**90% CI**	**Mean**	**Med**	**s**	**90% CI**	**Mean**	**Med**	**s**	**90% CI**
Patents number	0	0	0	[0, 0]	0	0	0	[0, 0]	0	0	0	[0, 0]
ROA in 2012	0.045	0.027	0.174	[−0.34, 0.43]	0.035	0.030	0.095	[−0.21, 0.21]	0.035	0.030	0.052	[−0.08, 0.15]
ROA in 2013	0.036	0.025	0.177	[−0.41, 0.39]	0.037	0.030	0.102	[−0.18, 0.25]	0.039	0.035	0.051	[−0.07, 0.15]
ROA in 2014	0.053	0.030	0.154	[−0.27, 0.44]	0.038	0.032	0.094	[−0.19, 0.24]	0.041	0.036	0.047	[−0.04, 0.15]
ROA in 2015	0.043	0.026	0.143	[−0.27, 0.38]	0.038	0.034	0.098	[−0.20, 0.22]	0.038	0.033	0.049	[−0.06, 0.14]
ROA in 2016	0.043	0.024	0.157	[−0.32, 0.41]	0.038	0.034	0.095	[−0.20, 0.22]	0.037	0.032	0.051	[−0.07, 0.15]
ROA in 2017	0.033	0.023	0.176	[−0.38, 0.45]	0.044	0.037	0.098	[−0.21, 0.23]	0.040	0.033	0.046	[−0.04, 0.14]
ROA in 2018	0.040	0.023	0.146	[−0.31, 0.41]	0.033	0.035	0.107	[−0.23, 0.20]	0.040	0.033	0.048	[−0.05, 0.15]
ROA in 2019	0.080	0.025	0.223	[−0.22, 0.78]	0.053	0.035	0.120	[−0.19, 0.34]	0.045	0.038	0.059	[−0.07, 0.19]

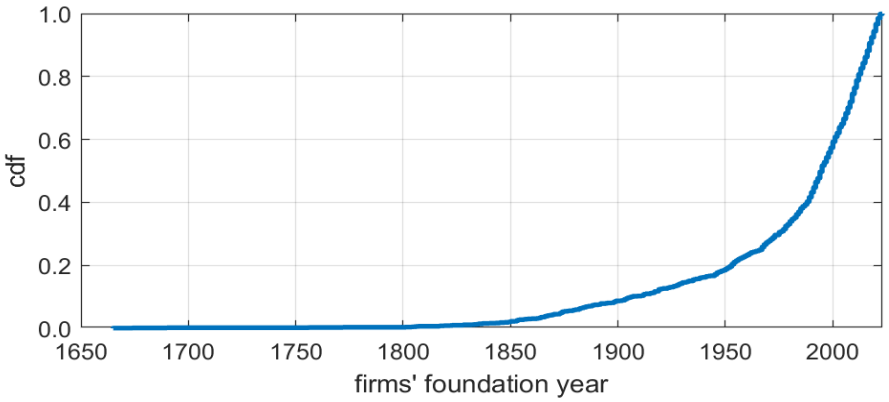

Figure 2. The cumulative distribution function for firms' foundation years.

Table 4. Firms' distribution by industries.

Industry	Firms Number	Industry	Firms Number	Industry	Firms Number	Industry	Firms Number	Industry	Firms Number
machinery	162	environmental services	69	utilities	45	wholesale	29	aviation and aerospace	22
mechanical or industrial engineering	154	management consulting	67	plastics	44	biotechnology	27	food production	22
construction	142	renewables and environment	67	real estate	44	retail	26	internet	20
chemicals	112	mining and metals	58	research	42	transportation/ trucking/ railroad	26	textiles	20
automotive	100	building materials	55	higher education	35	hospital and health care	25	international trade and development	18
information technology and services	94	banking	52	marketing and advertising	34	pharmaceuticals	25	architecture and planning	17
financial services	84	computer software	49	telecommunications	33	civil engineering	24	furniture	16
electrical/ electronic manufactur-ing	83	consumer goods	49	business supplies and equipment	30	food and beverages	23	investment management	16
oil and energy	74	medical devices	49	facilities services	30	industrial automation	23	packaging and containers	16

5. Methods

The study begins by examining key insights outlined in Hypotheses 5 and 6, then proceeds to explore the remaining hypotheses (Hypotheses 1–4), demonstrating consistent outcomes across diverse study designs. This underscores the resilience of observed effects on firms' size dynamics, despite differences in industry affiliation and firm age.

To test Hypotheses 5 and 6, we examined how changes in firm size impact the financial outcomes of EI across short (2-year period) and long (8-year period) time frames spanning from 2012 to 2019. To mitigate the impact of individual events in specific years, we examined all two-year periods within the specified time range (2012–2014, 2013–2015, 2014–2016, 2015–2017, 2016–2018, 2017–2019) and aggregated the results across these periods. We examined the disparities in the increase in return on assets between firms with at least one green patent and those without green patents. To estimate the firms' financial success over an extended time interval exceeding one year, we applied various metrics with different sensitivity to data outliers and black-swan-like events:

- the difference between firm's ROA of the first and the last year within the studied time interval: $\Delta\text{ROA} = \text{ROA}_{2019} - \text{ROA}_{2012}$;
- the median value of annual ROA growth averaged over the studied time interval: $\text{Med} = \text{median}\{(\text{ROA}_{t+1} - \text{ROA}_t) : t \in [2013,\ 2019]\}$;
- the difference between maximum and minimum ROA values from 2012 to 2019: $\text{Range} = \max\limits_{t\in[2012,2019]} \text{ROA}_t - \min\limits_{t\in[2012,2019]} \text{ROA}_t$;
- the slope of ROA values changing from 2012 to 2019 estimated using linear regression based on the ordinary least squares techniques: $\text{Slope} = \frac{1}{42} \cdot \sum_{t=2012}^{t=2019} (t - 2015) \cdot \left(\text{ROA}_t - \overline{\text{ROA}}\right)$, where $\overline{\text{ROA}} = \frac{1}{8} \cdot \sum_{t=2012}^{t=2019} \text{ROA}_t$ represents the average value of ROA.

The combination of these metrics helps to infer the differences samples' means and medians, enabling a nuanced distinction of details.

To assess the effect in the short-time perspective, we analyzed the FP of firms in relation to the timing of GP implementation. We selected the firms that changed size and considered differences between ROA's growth of firms with at least one GP and firms without GPs. For that, we investigated ROA values on the second year after the GP implementation following [35]. We used two metrics—absolute and relative—to compare firms-GP holders and firms without GPs:

- firm's ROA in the second year after GP implementation, ROA_{t_k+2}, where k = 1, 2, . . ., K is the index of green patent, and t_k shows the year of its implementation;
- – relative growth of a firm's ROA in the second year following GP implementation compared to the ROA in the year of patent implementation: $\gamma_{\text{ROA}} = \frac{\text{ROA}_{t_k+2}}{\text{ROA}_{t_k}} - 1$.

We compared the financial results of firms-GP holders in two ways:

- incorporating each GP implemented between 2010 and 2017 for each relevant firm into the respective samples as independent elements;
- considering only the most recent GP implemented in 2010–2017 (with the control that no additional GPs were implemented in 2018–2019) for each relevant firm in the corresponding samples as their independent elements.

The first approach is linked to smaller statistical errors attributed to sample sizes but entails greater errors arising from the potential influence of GPs implemented in the subsequent years. The second way reduces the compared samples but isolates the impact of GPs on the firm's FP.

For each firm with a GP, we identified the years in which we conducted the comparison of financial indicators. Subsequently, for all firms without GPs that met the specified conditions (size, presence of growth or decline, etc.), we curated a sample of their financial indicators in the identified year or years. We computed the required metrics, determined the median, and conducted a comparison with the specific firm with a GP. In this case, we used paired versions of one-sided t- and Mann–Whitney U-tests.

In this segment of the study, we compare the financial outcomes of green firms with the median results of a sufficiently large sample of firms without GPs. As an alternative strategy, to clarify our findings from potentially influencing factors, we apply the direct comparison between two samples of firms that differ only in one significant attribute: we additionally consider their countries, industries, and ages. We followed the principles of PSM methodology and the leading papers in this research area [39,48–51], this approach enhances the clarity of our computational results and reinforces the conclusions drawn.

We followed [52] to categorize countries by income into four groups: low-income, lower-middle-income, upper-middle-income, and high-income economies. We used data on each country's position in this classification for each year from 2012 to 2019, obtained from the World Bank countries analytical history.

We mapped the industries list used in the Company Dataset from People Data Labs (San Francisco, CA, USA) with [53] and used only sectors and industry groups for analyzed firms' sample.

The pairs of firms primarily differed in only one tested attribute (such as growing vs. stable-size or with eco-patents vs. without them, etc.) and closely matched in terms of industry sector and country income group. In cases where several possible pairs could be formed for one firm, we selected the pair with the closest proximity in foundation years. This approach ensured that we had pairs of samples with more or less sufficient sizes.

In this part of our study, we used paired one-sided t- and sign tests to detect paired differences.

To test Hypothesis 1, we analyzed the linear correlation coefficients ρ_2 and ρ_8 between the FP of firms from one industry over short-term (2 years) and long-term (8 years) time periods and the number EP of their GP issued in the year preceding these periods. Here, ρ_k is the correlation coefficient between EP_t and FP_{t+k}, where t denotes the observed year. The analysis incorporated data from 2012 to 2019. To mitigate the influence of potential outliers, we excluded the top and bottom 10% of the firm-year observations with the largest and smallest FP_{t+k} values. The correlation coefficient was computed along with its confidence interval for 95% confidence probability to account for the sample size effects. A positive correlation detection was inferred if both ends of this interval were positive. Additionally, the significance of the correlation coefficient value was tested. The study considered the size of firms and investigated correlation effects for large, medium, and small firms separately.

To assess the firms' FP, we used two measures: absolute value $FP_t = ROA_t$ of ROA and relative value $FP_{t+k} = (ROA_{t+k} - ROA_t)/ROA_t$ of ROA increase in the corresponding time period ($k = 2$ or $k = 8$). The first measure estimates the absolute rate of FP enabling an association between the issuance of GP and absolute-valued FP: the wealthier the firm, the more eco-active it is, regardless of the time period's length. The second metric links the growth in a firm's FP with the strength of its eco-activism. This enables the detection of a dependency such as the following: the more eco-active a firm is, the more or less it gains from this in different time periods.

To test Hypothesis 2, we calculated the slope coefficients α_6 of least-squares linear regression using the ordinary least squares between the growth measure FG for firms from one industry over a 6-year period and the total number EP of their GP issued during the same time period. All relevant data from 2012 to 2019 were included in the analysis. The time period's length was constrained by the limitations of our dataset and was the maximum possible within those constraints.

For regression, the independent variable represented the ratio of FG values included in the set that were smaller than the specified one, while the dependent variable reflected the same ratio for the corresponding EP value. Consequently, the larger the FG value, the closer to 1 it became, and the smaller it was, the closer to 0. The same pattern applied to EP. These variables are the same with empirical cdf for the population of FG and EP values correspondingly:

$$\mathrm{cdf}_j^{\mathrm{FG}} = \frac{1}{N} \cdot \#\left\{\mathrm{FG}_i : \mathrm{FG}_i < \mathrm{FG}_j; i = 1, 2, \ldots N\right\},$$

$$\mathrm{cdf}_j^{\mathrm{EP}} = \frac{1}{N} \cdot \#\{\mathrm{EP}_i : \mathrm{EP}_i < \mathrm{EP}_j;\ i = 1, 2, ..N\},$$

where N is the considered subsample size, # is the cardinality (elements number) for the set mentioned in the brackets { }; the set is described with the direct enumeration of elements of the larger set satisfying the conditions listed after the colon.

The slope coefficients were calculated between the sets $\mathrm{cdf}_j^{\mathrm{FG}}$ and $\mathrm{cdf}_j^{\mathrm{EP}}$, $j = 1, 2, \ldots N$. This regression design enabled us to compare each value in the set with others, effectively normalizing the influence of the absolute scale of FG and EP values.

We employed two measures to assess firms' profitability growth FG. First was equal to the difference between the firm's size in the last year of the studied time period and in the first year: $\mathrm{FG}_t = \mathrm{Size}_{t+6} - \mathrm{Size}_t$, where Size_t is the firm's size in the year t, since the firm's size dynamics comes as a proxy to firms' resources and capabilities [6]. Firms' sizes were quantitatively formalized as follows: for micro firms, their size was assigned to 0, for small firms—to 1, for middle-sized firms—to 2, and for large firms—to 3. The second measure of firms' profitability was equal to the growth of firm's FP expressed with ROA increase: absolute $\mathrm{FG}_t = \mathrm{ROA}_{t+6} - \mathrm{ROA}_t$ and relative $\mathrm{FG}_t = (\mathrm{ROA}_{t+6} - \mathrm{ROA}_t)/\mathrm{ROA}_t$. The total number of GPs for the corresponding time period was computed as $\mathrm{EP}_{t:t+6} = \sum_t^{t+6} \mathrm{Patents}_t$, where $\mathrm{Patents}_t$ is the number of GPs issued by the firm in year t.

The slope coefficient α_6 was computed with its confidence interval at a 95% confidence level to account for the influence of sample size. If both borders of this interval had the same sign, it allowed us to consider the sign of the established linear dependence (positive or negative). We also tested the significance of the coefficient value α_6 and presented the related p-values. As in other parts of the study, we considered the size of firms where it was possible, especially when FG was measured through ROA values.

To determine if the industry is growing or not, we used the ratio of related firms for which value FG_t was positive and the sign of the averaged FG_t. value. If the first one was larger than 0.5 and the second one was positive, then the industry was considered to be growing. If the first one was smaller than 0.5 and the second one was negative, then the industry was considered to be decreasing. Other variants indicate an ambiguous situation (neither growing nor decreasing). We employed the symbols "↑" and "↓" in the tables to indicate industry growth or decline. The symbol "~" represents a close-to-stagnant state of the industry, where the difference from stagnation cannot be recognized as significant.

To test Hypothesis 3, we applied the same approach used for Hypothesis 2. The slope coefficients were denoted as β_6 for the related computations.

We employed two variants of firms' profitability measures. The first was determined by the linear component of the dependency Size_t from year t. To calculate this, we applied the linear regression with the form $\mathrm{Size}_t = \overline{\mathrm{Size}} + \gamma \cdot t$, where Size_t represented the firm's size in the year t, $\overline{\mathrm{Size}}$ was equivalent to the mean size during the studied time period, and was the mentioned coefficient. For each firm, FG = γ. The second measure of a firm's profitability was equivalent to the increase in the firm's FP expressed by the growth in ROA. To determine it, we also applied the linear regressions with the following forms: ROA_{t+1}–$\mathrm{ROA}_t = \overline{\Delta\mathrm{ROA}} + \kappa_{abs} \cdot t$ and $(\mathrm{ROA}_{t+1}$–$\mathrm{ROA}_t)/\mathrm{ROA}_t = \overline{\delta\mathrm{ROA}} + \kappa_{rel} \cdot t$, for absolute and relative ROA increase as firms' growth measures. The quantities under the horizontal line represent the averaged values and do not play any role in the analysis. So, for this case of firms' growth studying, FG = κ_{abs} or FG = κ_{rel}.

The chosen time shift aligns with the existing literature, suggesting that the maximum impact of the introduction of GP on FP occurs in the second year after GP implementation [5,35]. The applied model was as follows: ROA_{t+1}–$\mathrm{ROA}_t = \overline{\Delta\mathrm{ROA}} + \lambda_{abs} \cdot \mathrm{EP}_t$ for ROA absolute increase, or $(\mathrm{ROA}_{t+1}$–$\mathrm{ROA}_t)/\mathrm{ROA}_t = \overline{\delta\mathrm{ROA}} + \lambda_{rel} \cdot \mathrm{EP}_t$ for ROA relative increase. EP_t presents the number of GPs issued in the year t, and the values below the horizontal line indicate the mean values in linear regressions. So, the financial return measure (FP) for GPs used in our studies was defined as FP = λ_{abs} or FP = λ_{rel}.

To assess Hypothesis 3, we compare FP with FG. To confirm Hypothesis 3, we need to observe that for growing industries, the slope (β_6) was statistically significant and positive.

If not, this would provide grounds to reject the tested hypothesis. For declining industries, we anticipated a negative value of β_6, aligning with the mechanism described in the section of the paper dedicated to the results of studying Hypothesis 2. All computations were conducted independently for each industry. Similar to previous procedures, we considered only the 90% central values in the samples, excluding outliers. In the case where we measured firms' growth with FG = κ_{abs} or FG = κ_{rel}, we grouped firms into subsamples based on their sizes (micro and small together, medium, large).

To test Hypothesis 4, we used the same design as in testing Hypothesis 3, but with an additional consideration for the firms' age. We categorized firms as young if their age was less than 10 years in the initial year of our FP analysis (2012) and as old if their age exceeded 20 years accordingly. First, we analyzed industries all together considering different variants of measured FG and FP. We used 80% confidence bounds for the coefficient value β_6 to compare them for young and old firms. Given the considerable random spread in the analyzed data, a confidence probability of 80% is more suitable to highlight significant differences. We also calculated the probability q that old firms benefit more from size growth than young firms in the given context of the relationship between GP and FP: $q = \text{Prob}\left(\beta_6^{old} > \beta_6^{young}\right)$, where Prob(A) is the probability of the random event A occurrence, β_6^{old} and β_6^{young} are the values of coefficient β_6 for old and young firms correspondingly. The values of q are equivalent to p-value when testing statistical hypothesis if $\beta_6^{young} > \beta_6^{old}$.

6. Results

Findings from testing Hypotheses 5 and 6 are outlined below. The main results, indicated by p-values, are presented in the tables. Groups compared are specified as "the first group" vs. "the second group" (the order is significant due to the use of one-sided tests). Group names include sample sizes.

When forming comparison groups, firms were labeled as "growing" if their size significantly increased from the first to the final year of the study period. Conversely, firms were termed "downsizing" if their size significantly decreased over the same period. Firms with at least one GP were categorized as "GP holders" if they implemented a GP during the study period. The "stable-sized" group included firms with relatively constant size throughout the study period.

Over the long-term research period (8 years), we compared two independent subsamples:

C1: 57 growing firms with at least one GP vs. 163 growing firms without a GP.

C2: 118 downsizing firms with at least one GP vs. 242 downsizing firms without a GP.

C3-1: 57 growing firms with at least one GP vs. 442 stable-sized large firms with at least one GP.

C3-2: 57 growing firms with at least one GP vs. 217 stable-sized medium firms with at least one GP.

C3-3: 57 growing firms with at least one GP vs. 217 stable-sized small firms with at least one GP.

C4: 17 originally small but growing firms with at least one GP vs. 442 stable-sized large firms with at least one GP.

Table 5 presents test results (p-values) color-coded as follows: green for values below 0.05, yellow for values between 0.05 and 0.15, and red for values above 0.90.

We controlled that, on average, the slopes' value was positive for growing firms and negative for downsizing firms.

In a short-term research period (2 years) considering only the latest GP, we compared two independent subsamples:

C1: isolated influence of the implementation of one GP for 20 growing firms vs. the median of 70 growing firms without a GP.

C2: one GP implementation's isolated influence for 118 downsizing firms vs. the median of 242 downsizing firms without a GP.

C3-1: one GP implementation's isolated influence for 18 growing firms vs. one GP implementation isolated influence for 244 stable-sized large firms.

C3-2: one GP implementation's isolated influence for 18 growing firms vs. one GP implementation's isolated influence for 158 stable-sized medium firms.

C3-3: one GP implementation's isolated influence for 18 growing firms vs. one GP implementation isolated influence for 143 stable-sized small firms.

C5: one GP implementation's isolated influence for 4 originally small, but growing firms vs. one GP implementation isolated influence for 143 stable-sized small firms.

Table 5. The *p*-values of the two-sample tests for the long-time period (8 years).

	C1		C2		C3-1		C3-2		C3-3		C4	
	***t*-Test**	**U-Test**	***t*-Test**	**U-Test**	***T*-Test**	**U-Test**	***t*-Test**	**U-Test**	***t*-Test**	**U-Test**	***t*-Test**	**U-Test**
ΔROA	0.108	0.553	0.757	0.915	0.003	0.376	0.025	0.203	0.071	0.052	0.595	0.660
Med	0.456	0.369	0.544	0.996	0.838	0.242	0.849	0.392	0.825	0.119	0.110	0.195
Range	0.013	0.058	0.751	0.878	0.000	0.000	0.001	0.000	0.222	0.000	0.000	0.000
Slope	0.095	0.633	0.762	0.911	0.002	0.459	0.034	0.234	0.107	0.088	0.715	0.904

Table 6a shows the obtained results of two-sample tests (*p*-values).

In a short-time period research (2 years) encompassing all implemented GPs, the following comparisons were made:

C1: 28 growing firms with GP vs. the medians of 70 growing firms without a GP.

C2: 49 downsizing firms with GP vs. the medians of 155 downsizing firms without a GP.

C3-1: 28 growing firms with GP vs. 835 stable-sized large firms with implemented GP.

C3-2: 28 growing firms with GP vs. 275 stable-sized medium firms with implemented GP.

C3-3: 28 growing firms with green patents vs. 205 stable-sized small firms with implemented green patents.

C5: 8 originally small but growing firms with GP vs. 205 stable-sized small firms with GP.

Table 6b presents the respective results of two-sample tests (*p*-values).

Table 6. (a) The *p*-values of the two-sample tests for the short time period (2 years) considering only the latest GP per firm. (b) The *p*-values of the two-sample tests for the short time period (2 years), considering all implemented GPs of the firms.

(a)

	C1		C2		C3-1		C3-2		C3-3		C5	
	***t*-Test**	**U-Test**	***t*-Test**	**U-Test**	***t*-Test**	**U-Test**	***t*-Test**	**U-Test**	***t*-Test**	**U-Test**	***t*-Test**	**U-Test**
ROA_{t_k+2}	0.970	0.979	0.675	0.750	0.977	1.000	0.995	1.000	0.610	0.999	0.603	0.948
γ_{ROA}	0.528	0.868	0.872	0.632	0.615	0.981	0.696	0.954	0.582	0.932	0.390	0.261

(b)

	C1		C2		C3-1		C3-2		C3-3		C5	
	***t*-Test**	**U-Test**	***t*-Test**	**U-Test**	***t*-Test**	**U-Test**	***t*-Test**	**U-Test**	***t*-Test**	**U-Test**	***t*-Test**	**U-Test**
ROA_{t_k+2}	0.724	0.956	0.520	0.388	0.999	1.000	0.990	1.000	0.536	0.998	0.623	0.996
γ_{ROA}	0.808	0.828	0.878	0.500	0.618	0.936	0.974	0.886	0.971	0.883	0.536	0.450

The second part of our study, employing PSM-based direct comparisons considering industries, countries, and ages, shows closely aligned results.

The long-term research period (8 years) involved comparing pairs of firms as follows.

C1: growing firms with at least one GP vs. growing firms without a GP (36 pairs).

C2: downsizing firms with at least one GP vs. downsizing firms without a GP (74 pairs).

C3-1: growing firms with at least one GP vs. stable-sized large firms with at least one GP (39 pairs).

C3-2: growing firms with at least one GP vs. stable-sized medium firms with at least one GP (39 pairs).

C3-3: growing firms with at least one GP vs. stable-sized small firms with at least one GP (38 pairs).

C4: originally small but growing firms with at least one GP vs. stable-sized large firms with at least one GP (13 pairs).

Table 7 presents the results of paired difference tests (p-values) with the same color-coding as described earlier.

Table 7. The p-values of the paired difference tests for the long-time period (8 years).

	C1		C2		C3-1		C3-2		C3-3		C4	
	***t*-Test**	**Sign-Test**	***t*-Test**	**Sign-Test**	***t*-Test**	**Sign-Test**	***t*-Test**	**Sign-Test**	***t*-Test**	**Sign-Test**	***t*-Test**	**Sign-Test**
ΔROA	0.449	0.203	0.840	0.900	0.555	0.832	0.255	0.100	0.204	0.100	0.169	0.867
Med	0.189	0.008	0.997	1.000	0.748	0.500	0.395	0.500	0.721	0.686	0.291	0.046
Range	0.106	0.005	0.840	0.591	0.071	0.002	0.116	0.148	0.118	0.002	0.005	0.046
Slope	0.576	0.632	0.839	0.719	0.512	0.899	0.023	0.005	0.139	0.314	0.400	0.867

The short-time period (2 years) research considering only the latest GP included the following comparisons in firms' pairs:

C1: one GP implementation's isolated influence for growing firms compared with growing firms without a GP (15 pairs).

C2: one GP implementation's isolated influence for downsizing firms compared with downsizing firms without a GP (21 pairs).

C3-1: one GP implementation's isolated influence for growing firms vs. for stable-sized large firms (13 pairs).

C3-2: one GP implementation's isolated influence for growing firms vs. for stable-sized medium firms (13 pairs).

C3-3: one GP implementation's isolated influence for growing firms vs. for stable-sized small firms (13 pairs).

C5: one GP implementation's isolated influence for originally small, but growing firms vs. for stable-sized small firms (3 pairs).

Table 8a includes the results of paired difference tests (p-values) with the same color-coding as described earlier.

The short-time period (2 years) research considering all the implemented GPs contained the following comparisons in firms' pairs:

C1: growing firms with GP vs. growing firms without a GP at all (22 pairs).

C2: downsizing firms with GP vs. downsizing firms without a GP at all (34 pairs).

C3-1: growing firms with GP vs. stable-sized large firms with GP (22 pairs).

C3-2: growing firms with GP vs. stable-sized medium firms with GP (22 pairs).

C3-3: growing firms with GP vs. stable-sized small firms with GP (22 pairs).

C5: originally small but growing firms with GP vs. stable-sized small firms with GP (7 pairs).

Table 8b includes the results of paired difference tests (p-values) with the same color-coding as described earlier.

When testing Hypothesis 1, first, the results were compiled in Table 9a,b. These tables include correlation coefficients values for firms' eco-activism (measured by the number of GP) and their FP (measured by ROA). Data were gathered for each industry separately. Table 9a shows results for the short-term (2 years) correlation between patent quantity (EP_t) and ROA_{t+2}, including sample size, p-values for correlation coefficient significance testing, and confidence interval boundaries for the correlation coefficient (CI). Table 9b follows the same structure but presents data for the long-term (8 years) period. The color scheme used for highlighting remains consistent with previous tables.

Table 8. (a) The *p*-values of the paired difference tests for the short time period (2 years) considering only the latest GP per firm. (b) The *p*-values of the paired difference tests for the short time period (2 years) considering all implemented GPs of the firms.

(a)

	C1		C2		C3-1		C3-2		C3-3		C5	
	***t*-Test**	**Sign-Test**	***t*-Test**	**Sign-Test**	***t*-Test**	**Sign-Test**	***t*-Test**	**Sign-Test**	***t*-Test**	**Sign-Test**	***t*-test**	**Sign-Test**
ROA_{t_k+2}	0.721	0.500	0.209	0.961	0.999	0.998	0.851	0.997	0.982	1.000	0.955	1.000
γ_{ROA}	0.852	0.849	0.903	0.668	0.962	0.991	0.005	0.090	0.956	0.993	0.471	0.800

(b)

	C1		C2		C3-1		C3-2		C3-3		C5	
	***t*-Test**	**Sign-Test**	***t*-Test**	**Sign-Test**	***t*-Test**	**Sign-Test**	***t*-Test**	**Sign-Test**	***t*-Test**	**Sign-Test**	***t*-Test**	**Sign-Test**
ROA_{t_k+2}	0.721	0.262	0.168	0.804	0.677	0.996	0.783	0.999	0.902	1.000	0.933	1.000
γ_{ROA}	0.706	0.738	0.951	0.804	0.900	0.997	0.115	0.088	0.827	0.878	0.178	0.438

Table 9. (a) The correlation coefficient ρ_2 (between EP_t and ROA_{t+2}) testing. (b) The correlation coefficient ρ_8 (between EP_t and ROA_{t+8}) testing.

(a)

Industry	**Firms' Size**								
	Large			**Middle**			**Small**		
	n	***p***	**CI**	***n***	***p***	**CI**	***n***	***p***	**CI**
Energy	224	0.519	[−0.173, 0.088]	77	0.717	[−0.184, 0.264]	64	0.495	[−0.326, 0.162]
Materials	864	0.004	[0.031, 0.163]	353	0.012	[0.030, 0.241]	312	0.150	[−0.024, 0.171]
Industrials	2135	0.555	[−0.055, 0.030]	1317	0.050	[0.000, 0.108]	1257	0.394	[−0.031, 0.079]
Consumer Discretionary	829	0.401	[−0.039, 0.097]	272	0.810	[−0.133, 0.105]	204	0.125	[−0.030, 0.242]
Consumer Staples	117	0.588	[−0.207, 0.119]	45	0.382	[−0.411, 0.167]	62	0.690	[−0.298, 0.201]
Health Care	370	0.199	[−0.168, 0.035]	112	0.936	[−0.178, 0.193]	181	0.560	[−0.169, 0.092]
Financials	553	0.082	[−0.009, 0.156]	64	–	–	88	0.593	[−0.264, 0.154]
Information Technology	576	0.840	[−0.090, 0.073]	168	0.234	[−0.060, 0.240]	294	0.677	[−0.138, 0.090]
Communication Services	301	0.673	[−0.089, 0.137]	105	0.096	[−0.029, 0.344]	161	0.974	[−0.157, 0.152]
Real Estate	90	0.198	[−0.072, 0.335]	55	0.784	[−0.300, 0.230]	42	–	–

(b)

Industry	**Firms' Size**								
	Large			**Middle**			**Small**		
	n	***p***	**CI**	***n***	***p***	**CI**	***n***	***p***	**CI**
Energy	82	0.006	[0.090, 0.487]	33	0.421	[−0.209, 0.465]	24	0.482	[−0.471, 0.238]
Materials	321	0.002	[0.064, 0.277]	135	0.459	[−0.106, 0.231]	120	0.007	[0.112, 0.590]
Industrials	794	0.187	[−0.116, 0.023]	499	0.903	[−0.093, 0.082]	470	0.221	[−0.034, 0.146]
Consumer Discretionary	312	0.842	[−0.100, 0.122]	97	0.768	[−0.228, 0.170]	81	0.869	[−0.236, 0.201]
Consumer Staples	44	0.536	[−0.382, 0.207]	17	0.461	[−0.318, 0.616]	25	0.789	[−0.442, 0.346]
Health Care	136	0.986	[−0.167, 0.170]	40	0.906	[−0.294, 0.263]	75	0.423	[−0.136, 0.314]
Financials	201	–	–	29	–	–	37	0.779	[−0.366, 0.281]
Information Technology	211	0.820	[−0.120, 0.151]	68	0.711	[−0.281, 0.195]	104	0.519	[−0.253, 0.130]
Communication Services	115	0.715	[−0.216, 0.150]	41	0.726	[−0.256, 0.358]	57	0.367	[−0.143, 0.371]
Real Estate	34	0.763	[−0.385, 0.290]	21	0.639	[−0.516, 0.339]	17	–	–

Continuing with the testing of Hypothesis 1, we obtained results compiled in Table 10a,b. These tables contain correlation coefficient values for firms' eco-activism (measured by the number of GPs) and their FP, this time assessed by the relative increase in ROA in the given time period. Otherwise, the format is similar to Table 9a,b.

Table 10. (a) The correlation coefficient ρ_2 (between EP_t and $FP_t = (ROA_{t+2} - ROA_t)/ROA_t$) testing. (b) The correlation coefficient ρ_8 (between EP_t and $FP_t = (ROA_{t+8} - ROA_t)/ROA_t$) testing.

(a)									
Industry	**Firms' Size**								
	Large			**Middle**			**Small**		
	n	***p***	**CI**	***n***	***p***	**CI**	***n***	***p***	**CI**
Energy	169	0.257	[−0.058, 0.212]	58	0.890	[−0.275, 0.241]	47	0.794	[−0.323, 0.251]
Materials	648	0.033	[0.007, 0.160]	267	0.012	[0.030, 0.241]	225	0.952	[−0.135, 0.127]
Industrials	1598	0.721	[−0.058, 0.040]	980	0.504	[−0.041, 0.084]	937	0.241	[−0.026, 0.102]
Consumer Discretionary	623	0.119	[−0.016, 0.140]	200	0.579	[−0.177, 0.100]	156	0.728	[−0.184, 0.130]
Consumer Staples	88	–	–	33	0.811	[−0.304, 0.381]	45	0.094	[−0.039, 0.465]
Health Care	273	0.701	[−0.142, 0.096]	85	0.382	[−0.303, 0.120]	137	0.084	[−0.020, 0.308]
Financials	409	0.831	[−0.107, 0.086]	51	–	–	69	–	–
Information Technology	426	0.987	[−0.096, 0.094]	128	0.592	[−0.220, 0.127]	212	0.846	[−0.133, 0.109]
Communication Services	227	0.775	[−0.111, 0.149]	80	0.974	[−0.216, 0.223]	113	0.176	[−0.306, 0.058]
Real Estate	68	0.677	[−0.189, 0.286]	41	0.315	[−0.446, 0.155]	32	–	–
(b)									
Industry	**Firms' Size**								
	Large			**Middle**			**Small**		
	n	***p***	**CI**	***n***	***p***	**CI**	***n***	***p***	**CI**
Energy	28	0.409	[−0.505, 0.224]	10	0.711	[−0.705, 0.541]	–	–	–
Materials	106	0.150	[−0.051, 0.323]	46	0.203	[−0.456, 0.105]	41	0.766	[−0.350, 0.264]
Industrials	265	0.255	[−0.189, 0.051]	165	0.111	[−0.029, 0.272]	160	0.235	[−0.062, 0.246]
Consumer Discretionary	104	0.022	[0.033, 0.400]	34	0.981	[−0.342, 0.334]	26	0.599	[−0.292, 0.475]
Consumer Staples	16	–	–	–	–	–	–	–	–
Health Care	46	0.226	[−0.449, 0.114]	15	–	–	25	0.199	[−0.145, 0.598]
Financials	66	–	–	11	–	–	13	–	–
Information Technology	72	0.391	[−0.132, 0.326]	24	0.390	[−0.237, 0.547]	33	0.635	[−0.417, 0.265]
Communication Services	39	0.239	[−0.480, 0.130]	15	0.745	[−0.576, 0.442]	18	0.722	[−0.393, 0.534]
Real Estate	12	0.702	[−0.485, 0.651]	–	–	–	–	–	–

The results of testing Hypothesis 2 are presented in Tables 11 and 12a,b. First, we examined the statistical evidence concerning the relationship between firms' profitability growth, measured by size increase compared to the industry, and the number of GPs, detailed in Table 11. Second, we replicated the study, this time measuring firms' profitability growth by their FP increase, with results presented in Table 12a,b.

Table 11. The slope coefficient α_6 (between $EP_{t:t+6}$ and $FG_t = Size_{t+6} - Size_t$) testing.

Industry	**Total**		
	n	***p***	**CI**
Energy ↑↓	52	0.239	[−0.137, 0.537]
Materials ↓↓	216	0.474	[−0.386, 0.180]
Industrials ~↓	666	0.739	[−0.116, 0.164]
Consumer Discretionary ↑↓	185	0.132	[−0.074, 0.532]
Consumer Staples ↑↓	33	0.742	[−0.452, 0.325]
Health Care ↑↓	94	0.511	[−0.474, 0.238]
Financials ↓↓	110	0.583	[−0.924, 1.636]

Table 11. *Cont.*

Industry	Total		
	n	***p***	**CI**
Information Technology ↓↑	150	0.312	[−0.391, 0.126]
Communication Services ↑↑	81	0.845	[−0.324, 0.266]
Real Estate ↓↓	27	0.558	[−4.85, 8.77]

Table 12. (a) The slope coefficient α_6 (between $EP_{t:t+6}$ and $FG_t = ROA_{t+6} - ROA_t$) testing. (b) The slope coefficient α_6 (between $EP_{t:t+6}$ and $FG_t = (ROA_{t+6} - ROA_t)/ROA_t$) testing.

(a)

Industry	Firms' Size									Total		
	Large			Middle			Small					
	n	***p***	**CI**	***n***	***p***	**CI**	***n***	***p***	**CI**	***n***	***p***	**CI**
Energy ↑↓	34	0.260	[−0.718, 0.201]	13	0.554	[−0.586, 1.037]	–	–	–	56	0.851	[−0.379, 0.314]
Materials ↓↓	134	0.999	[−0.227, 0.227]	55	0.870	[−0.376, 0.319]	51	0.971	[−0.385, 0.371]	240	0.796	[−0.192, 0.148]
Industrials ~↓	331	0.808	[−0.160, 0.125]	209	0.941	[−0.176, 0.190]	191	0.709	[−0.229, 0.156]	731	0.570	[−0.127, 0.070]
Consumer Discretionary ↑↓	129	0.516	[−0.161, 0.318]	39	0.417	[−0.260, 0.614]	35	0.575	[−0.316, 0.560]	203	0.215	[−0.069, 0.307]
Consumer Staples ↑↑	18	0.045	[0.012, 0.943]	–	–	–	–	–	–	35	0.000	[0.299, 0.940]
Health Care ↑↑	55	0.073	[−0.031, 0.687]	17	0.484	[−0.964, 0.479]	31	0.092	[−0.071, 0.886]	103	0.066	[−0.016, 0.507]
Financials ↓↓	82	0.021	[0.025, 0.298]	12	–	–	15	–	–	109	0.039	[0.006, 0.215]
Information Technology ↓↓	86	0.085	[−0.526, 0.035]	30	0.132	[−0.842, 0.116]	45	0.220	[−0.637, 0.150]	161	0.009	[−0.473, −0.069]
Communication Services ↑↑	48	0.840	[−0.352, 0.430]	17	0.731	[−0.746, 0.536]	22	0.381	[−0.339, 0.849]	87	0.777	[−0.243, 0.324]
Real Estate ↓↓	14	0.836	[−0.694, 0.844]	–	–	–	–	–	–	29	0.977	[−0.496, 0.482]

(b)

Industry	Firms' Size									Total		
	Large			Middle			Small					
	n	***p***	**CI**	***n***	***p***	**CI**	***n***	***p***	**CI**	***n***	***p***	**CI**
Energy ↑↑	34	0.780	[−0.404, 0.533]	13	0.931	[−0.792, 0.858]	–	–	–	56	0.733	[−0.287, 0.405]
Materials ↓↑	134	0.326	[−0.114, 0.339]	55	0.095	[−0.052, 0.626]	51	0.367	[−0.205, 0.544]	240	0.081	[−0.019, 0.319]
Industrials ↓↓	331	0.064	[−0.276, 0.008]	209	0.943	[−0.190, 0.176]	191	0.895	[−0.180, 0.205]	731	0.122	[−0.176, 0.021]
Consumer Discretionary ↑↓	129	0.538	[−0.165, 0.314]	39	0.099	[−0.070, 0.779]	35	0.935	[−0.423, 0.458]	203	0.123	[−0.040, 0.336]
Consumer Staples ↑↑	18	0.945	[−0.547, 0.512]	–	–	–	–	–	–	35	0.212	[−0.142, 0.616]
Health Care ↑↑	55	0.098	[−0.058, 0.664]	17	0.889	[−0.684, 0.782]	31	0.607	[−0.373, 0.628]	103	0.120	[−0.055, 0.471]
Financials ↓↑	82	0.017	[0.030, 0.302]	12	-	0, 0	15	–	0, 0	109	0.041	[0.004, 0.214]
Information Technology ↓↑	86	0.921	[−0.300, 0.271]	30	0.150	[−0.828, 0.134]	45	0.598	[−0.504, 0.294]	161	0.262	[−0.323, 0.089]
Communication Services ↓↑	48	0.688	[−0.469, 0.312]	17	0.625	[−0.489, 0.788]	22	0.278	[−0.274, 0.902]	87	0.551	[−0.198, 0.368]
Real Estate ↓↓	14	0.531	[−0.533, 0.982]	–	–	–	–	–	–	29	0.841	[−0.440, 0.537]

The results of testing Hypothesis 3 are presented in Tables 13a,b and 14a–d. First, we examined whether there is statistically significant evidence regarding the relationship between the firms' profitability growth, measured by its size increase compared to the industry, and the financial return for its FP compared to other firms. The results are collected in Table 13a,b for two distinct measures of firms' FP increase (absolute and relative ones). Second, we replicated the study for the case when the firms' profitability growth was measured by their ROA increase, as applied in Hypothesis 2 testing. The results are shown in Table 14a–d for all four possible combinations of absolute and relative measures for firms' growth and their FP.

Table 13. (a) The slope coefficient β_6 (between FP = λ_{abs} and FG = γ) testing. (b) The slope coefficient β_6 (between FP = λ_{rel} and FG = γ) testing.

(a)			
Industry	**Total**		
	n	***p***	**CI**
Energy ↑↑	52	0.841	[−0.216, 0.176]
Materials ↑↓	215	0.756	[−0.160, 0.116]
Industrials ↑↓	660	0.037	[−0.163, −0.005]
Consumer Discretionary ↑↓	185	0.661	[−0.134, 0.085]
Consumer Staples ↑↑	33	0.989	[−0.396, 0.401]
Health Care ~↓	94	0.228	[−0.369, 0.089]
Financials ↑↓	99	0.568	[−0.012, 0.007]
Information Technology ↑↓	148	0.475	[−0.164, 0.077]
Communication Services ↑↑	78	0.052	[−0.000, 0.101]
Real Estate ↑↓	27	0.942	[−0.387, 0.416]
(b)			
Industry	**Total**		
	n	***p***	**CI**
Energy ↑↓	52	0.462	[−0.112, 0.051]
Materials ↑↓	215	0.367	[−0.059, 0.158]
Industrials ↑↓	660	0.068	[−0.143, 0.005]
Consumer Discretionary ↑↓	185	0.688	[−0.121, 0.183]
Consumer Staples ↑↑	33	0.779	[−0.249, 0.329]
Health Care ~↓	94	0.301	[−0.065, 0.210]
Financials ↑↓	99	0.568	[−0.012, 0.007]
Information Technology ↑↓	148	0.893	[−0.094, 0.082]
Communication Services ↑↑	78	0.074	[−0.005, 0.109]
Real Estate ↑↓	27	0.643	[−0.351, 0.221]

Table 14. (a) The slope coefficient β_6 (between FP = λ_{abs} and FG_t =κ_{abs}) testing. (b) The slope coefficient β_6 (between FP = λ_{abs} and FG_t =κ_{rel}) testing. (c) The slope coefficient β_6 (between FP = λ_{rel} and FG_t =κ_{abs}) testing. (d) The slope coefficient β_6 (between FP = λ_{rel} and FG_t =κ_{rel}) testing.

(a)												
Industry	**Firms' Size**									**Total**		
	Large			**Middle**			**Small**					
	n	***p***	**CI**	***n***	***p***	**CI**	***n***	***p***	**CI**	***n***	***p***	**CI**
Energy ↑↑	31	0.310	[−0.173, 0.527]	0	–	–	0	–	–	55	0.576	[−0.326, 0.183]
Materials ~↓	125	0.004	[−0.429, −0.082]	39	0.301	[−0.535, 0.170]	36	0.723	[−0.390, 0.273]	232	0.007	[−0.301, −0.047]
Industrials ↑↑	306	0.785	[−0.115, 0.087]	159	0.907	[−0.178, 0.158]	152	0.050	[0.000, 0.328]	717	0.239	[−0.030, 0.120]
Consumer Discretionary ↓↑	122	0.842	[−0.139, 0.170]	29	0.683	[−0.283, 0.426]	23	0.569	[−0.243, 0.431]	201	0.981	[−0.120, 0.123]
Consumer Staples ↓↓	18	0.958	[−0.543, 0.517]	0	–	–	0	–	–	33	0.056	[−0.770, 0.011]
Health Care ↑↓	54	0.281	[−0.378, 0.112]	0	–	–	18	0.633	[−0.408, 0.652]	101	0.670	[−0.157, 0.243]
Financials ↑↓	81	0.083	[−0.152, 0.010]	0	–	–	11	–	–	109	0.090	[−0.113, 0.008]
Information Technology ↓↑	83	0.720	[−0.160, 0.231]	12	0.806	[−0.756, 0.602]	31	0.799	[−0.441, 0.343]	152	0.823	[−0.139, 0.175]
Communication Services ~↓	44	0.696	[−0.320, 0.216]	0	–	–	18	0.653	[−0.269, 0.418]	84	0.553	[−0.117, 0.217]
Real Estate ↑↑	13	0.848	[−0.619, 0.739]	0	–	–	0	–	–	28	0.697	[−0.491, 0.333]

Table 14. *Cont.*

(b)

Industry	Firms' Size									Total		
	Large			Middle			Small					
	n	*p*	CI	*n*	*p*	CI	*n*	*p*	CI	*n*	*p*	CI
Energy ↑↑	31	0.674	[−0.429, 0.282]	31	–	–	0	–	–	55	0.807	[−0.224, 0.286]
Materials ~↑	125	0.209	[−0.291, 0.064]	125	0.490	[−0.477, 0.233]	36	0.720	[−0.272, 0.391]	232	0.262	[−0.202, 0.055]
Industrials ~↑	306	0.424	[−0.060, 0.142]	306	0.485	[−0.227, 0.108]	152	0.800	[−0.187, 0.145]	717	0.840	[−0.083, 0.067]
Consumer Discretionary ↓↑	122	0.649	[−0.119, 0.190]	122	0.630	[−0.270, 0.430]	22	0.500	[−0.234, 0.465]	200	0.559	[−0.086, 0.158]
Consumer Staples ↓↑	18	0.067	[−0.916, 0.035]	18	–	–	0	–	–	33	0.141	[−0.696, 0.104]
Health Care ~↑	54	0.855	[−0.225, 0.270]	54	–	–	18	0.527	[−0.366, 0.688]	101	0.550	[−0.140, 0.260]
Financials ↑↓	81	0.169	[−0.138, 0.025]	81	–	–	11	–	–	109	0.171	[−0.104, 0.019]
Information Technology ↓↑	83	0.204	[−0.069, 0.318]	83	0.049	[0.004, 1.115]	31	0.202	[−0.138, 0.624]	152	0.052	[−0.001, 0.309]
Communication Services ~↓	44	0.344	[−0.140, 0.392]	44	–	–	18	0.573	[−0.250, 0.435]	84	0.183	[−0.054, 0.277]
Real Estate ↑↑	12	0.158	[−0.868, 0.162]	13	–	–	0	–	–	28	0.881	[−0.444, 0.383]

(c)

Industry	Firms' Size									Total		
	Large			Middle			Small					
	n	*p*	CI	*n*	*p*	CI	*n*	*p*	CI	*n*	*p*	CI
Energy ↑↑	31	0.757	[−0.221, 0.301]	0	–	–	0	–	–	55	0.869	[−0.162, 0.137]
Materials ~↓	125	0.027	[−0.346, −0.021]	39	0.383	[−0.508, 0.199]	36	0.406	[−0.392, 0.162]	232	0.008	[−0.277, −0.043]
Industrials ~↑	306	0.023	[0.018, 0.238]	159	0.093	[−0.023, 0.291]	152	0.466	[−0.111, 0.241]	717	0.029	[0.008, 0.155]
Consumer Discretionary ↓↑	122	0.300	[−0.082, 0.264]	29	0.595	[−0.287, 0.491]	23	0.619	[−0.256, 0.420]	201	0.580	[−0.096, 0.170]
Consumer Staples ↓↓	18	0.194	[−0.585, 0.128]	0	–	–	0	–	–	33	0.008	[−0.790, −0.128]
Health Care ↑↓	54	0.906	[−0.218, 0.246]	0	–	–	18	0.915	[−0.458, 0.507]	101	0.045	[0.004, 0.335]
Financials ↑↓	81	0.083	[−0.152, 0.010]	0	–	–	11	–	–	109	0.090	[−0.113, 0.008]
Information Technology ↓↑	83	0.408	[−0.108, 0.264]	12	0.605	[−0.511, 0.833]	31	0.187	[−0.129, 0.632]	152	0.114	[−0.028, 0.263]
Communication Services ~↓	44	0.197	[−0.394, 0.084]	0	–	–	18	0.387	[−0.243, 0.594]	84	0.895	[−0.167, 0.146]
Real Estate ↑↑	13	0.486	[−0.157, 0.080]	0	–	–	0	–	–	28	0.941	[−0.252, 0.234]

(d)

Industry	Firms' Size									Total		
	Large			Middle			Small					
	n	*p*	CI	*n*	*p*	CI	*n*	*p*	CI	*n*	*p*	CI
Energy ↓↑	31	0.015	[−0.535, −0.064]	0	–	–	0	–	–	55	0.010	[−0.327, −0.046]
Materials ~↑	125	0.352	[−0.243, 0.087]	39	0.615	[−0.445, 0.267]	36	0.670	[−0.220, 0.338]	232	0.484	[−0.161, 0.077]
Industrials ~↑	246	0.412	[−0.130, 0.053]	129	0.024	[−0.367, −0.027]	122	0.193	[−0.067, 0.328]	575	0.159	[−0.126, 0.021]
Consumer Discretionary ~↑	122	0.626	[−0.131, 0.216]	29	0.312	[−0.191, 0.576]	22	0.487	[−0.231, 0.468]	200	0.437	[−0.081, 0.186]
Consumer Staples ↓↑	18	0.350	[−0.532, 0.200]	0	–	–	0	–	–	33	0.361	[−0.533, 0.200]
Health Care ~↓	54	0.916	[−0.220, 0.244]	0	–	–	18	0.103	[−0.804, 0.082]	101	0.782	[−0.145, 0.193]
Financials ↑↓	81	0.169	[−0.138, 0.025]	0	–	–	11	–	–	109	0.171	[−0.104, 0.019]
Information Technology ↓↑	83	0.577	[−0.134, 0.239]	12	0.929	[−0.653, 0.709]	31	0.202	[−0.138, 0.625]	152	0.369	[−0.080, 0.213]
Communication Services ~↑	44	0.782	[−0.210, 0.277]	0	–	–	18	0.111	[−0.081, 0.708]	84	0.117	[−0.031, 0.277]
Real Estate ↑↑	13	0.701	[−0.579, 0.404]	0	–	–	0	–	–	28	0.314	[−0.177, 0.530]

The results of testing Hypothesis 4 are shown in Table 15 and visually depicted in Figure 3.

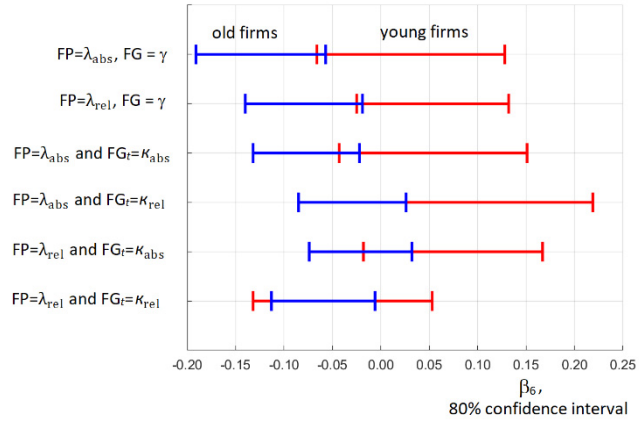

Figure 3. Confidence bounds for coefficient β_6 values for young and old firms.

Table 15. The difference in the impact of size dynamics between old and young firms on the relationship between GP and FP.

Measures FP, FG	Young Firms			Old Firms			q
	n	β_6	CI	n	β_6	CI	
FP = λ_{abs}, FG = γ	117	0.0310	[−0.066, 0.128]	486	−0.1243	[−0.191, −0.057]	0.045
FP = λ_{rel}, FG = γ	117	0.0534	[−0.025, 0.132]	486	−0.0798	[−0.140, −0.019]	0.042
FP = λ_{abs} and FG$_t$ = κ_{abs}	179	0.0539	[−0.043, 0.151]	533	−0.0771	[−0.132, −0.022]	0.065
FP = λ_{abs} and FG$_t$ = κ_{rel}	179	0.1222	[0.026, 0.219]	532	−0.0298	[−0.085, 0.026]	0.039
FP = λ_{rel} and FG$_t$ = κ_{abs}	179	0.0743	[−0.018, 0.167]	533	−0.0210	[−0.074, 0.032]	0.126
FP = λ_{rel} and FG$_t$ = κ_{rel}	179	−0.0395	[−0.132, 0.053]	532	−0.0596	[−0.113, −0.006]	0.405

7. Discussion

This section is organized as follows. We present the consideration and discussion of results obtained for each Hypothesis stated in the paper—from Hypothesis 1 up to Hypothesis 6,—and finalize the section with brief constating of hypotheses confirmation for reader convenience.

Hypothesis 1. As it follows from Table 9a,b, we observe the strong positive correlation between *absolute assessment of firms' FP* in the short and long time run for large- and medium-sized firms in the field of materials, particularly medium-sized industrial firms over a 2-year period. We also observe some positive correlations for large financial firms, medium-sized firms in communication services, small firms in materials, and consumer discretionary. For other industries and firms' sizes, we did not obtain reliable grounds for accepting or rejecting Hypothesis 1. The most likely possible reason is that the variance of FP results caused by other factors is too large to detect the influence of GPs. Therefore, we observe some evidence in favor of Hypothesis 1 in the field of materials (all sizes) and less pronounced for other industries.

Such results may be caused by the fact that the materials industry has a more pronounced effect of eco-innovation impact on financial results since this effect is direct and immediate—reducing resource intensity, costs, and emissions in the materials' production leads to economic benefits.

Table 10a,b displays similar results for *relative assessments of firms' FP* across various industries in the short and long time frames. A strong positive correlation is observed for large- and medium-sized firms in materials, and some evidence for large firms in the consumer discretionary sector and small firms in the consumer staples and health care sectors over a 2-year period. For other industries and firm sizes, we did not obtain reliable grounds to consider the correlation coefficient as non-zero.

Summarizing the findings, there is evidence supporting Hypothesis 1, particularly significant for material firms of all sizes and less pronounced for other industries. The

absence of statistically significant evidence in some studies does not necessarily imply a lack of correlation but rather indicates limitations in detecting it due to insufficient data or sample sizes. Positive correlations were observed for large- and medium-sized material firms, with some evidence for certain firms in the consumer discretionary sector over shorter time frames.

However, for other industries and firm sizes, reliable grounds to consider the correlation coefficient as non-zero were not obtained. In the long term, smaller set sizes resulted in fewer statistically significant results, with positive correlations observed for certain large firms in the consumer discretionary sector and indications for others, particularly in materials and medium-sized industrial firms. However, conclusive findings for small firms remain elusive. These results are consistent with those presented in related tables.

Positive relationships are demonstrated by the materials sector, which may be very reasonably interpreted as a positive cost impact of EI, because the industries that are focused on the extraction and processing of raw materials may produce a lot of waste or harm to the environment, which may be costly to prevent, i.e., the technological innovations with reduce waste or prevent harm will obviously lead to lower costs.

Hypotheses 2 and 3. There is no evidence suggesting that firms with higher profitability compared to industry growth implement more GPs or achieve higher financial returns for their GPs compared to other firms (Tables 11, 12a,b and 13a,b). The statistically significant results are controversial and might require additional research together with the industry growth analysis.

Hypothesis 4. All approaches to measure firms' growth and FP increase resulting from the implementation of GPs consistently indicate that older firms benefit less from this effect compared to younger firms, supporting Hypothesis 4. Among the various modeling approaches, the variant using two relative measures stands out. Considering the results of testing Hypothesis 3, we believe that this circumstance largely indicates the inconsistency of the combination of measures used for FP and FG and should be excluded from consideration.

Hypotheses 5 and 6. Table 5 shows the following situation for the time period of 8 years. Comparison C1 demonstrates that the growing firms with at least one implemented GP experience greater financial gains than growing firms without a GP. Comparison C2 provides evidence that downsizing firms with GPs more frequently exhibit financial decline than downsizing firms without a GP (confirmed by the U-test results and the outcomes of applying Med metrics). Comparisons C3-1, C3-2 and C3-3 show that growing firms with at least one GP over the 8-year period exhibit better FP than stable-sized firms with at least one GP. Finally, comparison C4 demonstrates that successful innovators among originally small firms, on average, show better FP in compared to the stable-sized large firms with at least one GP.

Table 6a,b shows that, in the short period (2 years), the growth requires substantial resources that are withdrawn from the firms' total income. Apparently, the financial benefits that come as a result of GP implementation do not outweigh this withdrawal. The results of comparisons C1 in Table 6a,b demonstrate that averaged costs of fast growth are significantly larger than the averaged increase in firms' FP caused by GP implementation. Tests under comparison C2 illustrate that, for downsizing firms, the financial decrease associated with the process of downsizing is much larger than the change in ROA caused by GP implementation. This additionally emphasizes the significance of the financial implications caused by GPs. Comparisons C3-1, C3-2 and C3-3 indicate that fast-growing firms benefit less and less frequently compared to stable-sized large, medium, or even small firms. The comparison of originally small firms grown in 2 years (C5) shows a similar pattern.

Tables 7 and 8a,b show a similar picture for a case when we implemented full PSM considering firms' industry, country type and age. The occurred differences compared to Tables 5 and 6a,b do not significantly change the conclusions made and even strengthen

them. This shows that the discovered effect is comparable to the effects related to firms' industry and age. Thus, Hypotheses 5 and 6 are supported.

Briefly, we can state the following on the tested hypotheses:

- **Hypotheses 4–6 were fully confirmed;**
- we found evidence **supporting Hypothesis 1, particularly significant for firms of all sizes from the materials industry and less pronounced for other industries**;
- on the whole, we found **no empirical evidence to support Hypotheses 2 and 3**, separate registered cases require additional research.

8. Conclusions

This section presents the essential findings that can be derived from the discussed results of the paper. It shows the theoretical, managerial and regulatory implications, and recommendations for policymakers.

We found new empirical evidence about the relationship between EI and FP, considering the firms' size dynamics, firms' age, short-term, long-term and industry effects. First, we found a general positive correlation between the implementation of GP and firms' FP, particularly in the field of materials for both large- and medium-sized firms. Second, we did not find a universal relationship between firms' growth and the number of implemented GPs. The results vary across industries, suggesting that the impact of GPs on growth is context-dependent. Notably, the financial sector showed a significant positive correlation, contrary to expectations. Third, contrary to the theoretical analysis, our study did not find obvious evidence that firms experiencing higher growth than their industries tend to have greater financial returns from GPs. Fourth, our study found that older firms generally benefit less from the positive effects associated with GPs compared to younger companies. This supports the notion that the age of the firm plays a role in determining the EI's financial outcomes. Finally, our research proved that, in the long term, growing firms with GPs show better financial results compared to the growing firms without a GP, whereas in the short term, growing firms with GPs show worse financial results compared to the growing firms without EI.

There are several *theoretical implications* of these findings.

We suggest studying this connection in dynamics by distinguishing short-term and long-term effects in various aspects: (1) the age of the firm determines its ability to innovate, and (2) the age of the industry determines the possibility of attaining the return from EI. Additionally, our study introduces novel metrics, such as the Range metric, to provide a more precise reflection of the impact of GP on FP over a longer time period. The findings emphasize the importance of success in implementing GPs and highlight the complexity of the relationships between eco-innovation, firm growth and financial outcomes.

We use the assumptions of both microeconomic theory and behavioral economics, as well as resource-based view theory, to develop testable predictions about the role of EI in various industries. First, the generally positive correlation between the implementation of GPs and firms' FP supports the assumption based on microeconomics that GPs may directly influence FP by reducing costs of compliance with ecological regulation or the assumption of behavioral economics [28] that governmental ecological regulation pushes the firms to review their operational routines and to find underexplored sources of efficiency. These explanations are not mutually exclusive and complement each other.

An alternative theoretical explanation suggests that the firms are different and have various organizational capabilities. So, the firms with superior organizational capabilities demonstrate both higher GP productivity and higher FP. There are two explanations for why superior organizational capabilities may influence the number of GPs. First, the mere receiving of a patent requires systematic organizational work because the process of meeting all formal demands of the patent authority in the country assumes some degree of organizational power. Second, what is more important, the development of environmental innovation which has a patentable technological and scientific significance requires superior organizational capabilities in knowledge management and R&D. Both

alternative explanations (casual and correlational) are theoretically sound, and we cannot make a choice in favor of one of them without additional empirical data on the nature of green innovations in these companies. However, the empirical test of the hypothesis about growth and financial return of GPs shed additional light on this dilemma. As this hypothesis also assumes superior organizational capabilities, which lead to a superior growth rate compared to the industry average, it may be reasonable to assume that superior organizational capabilities will also lead to higher returns from GP. However, empirical findings do not support this, which means that GP has some financial impact that is not influenced by organizational capabilities, i.e., the first microeconomic and behavioral explanations look more sound.

The empirical fact that older firms generally benefit less from the positive effects associated with GPs compared to younger companies may be better explained with microeconomic theory because older firms have more legacy factors, which may require higher switching costs, which is why they achieve lower financial returns from EI than younger firms. Behavioral analysis of this relationship predicts the opposite result—the older the firm is, the more inefficiency it accumulates, so after the external pressure leads to the organizational change, the financial impact of this will be higher than for the younger firm. However, the empirical findings do not support this, which is why the microeconomic explanation looks more relevant. The industrial context of GPs and FP relationships also supports the microeconomics predictions.

The study implies several *managerial and regulatory implications*. Firms, especially in the materials sector, can strategically invest in GP, as they positively influence FP, particularly for large- and medium-sized firms. Managers can develop long-term plans that incorporate sustainability goals to harness these benefits.

The impact of GPs on firm growth is context-dependent, varying across industries. Managers can tailor their EI strategies to align with industry-specific dynamics. For instance, the financial sector has shown a significant positive correlation with GPs, suggesting that financial firms should prioritize EI. Contrary to theoretical expectations, higher-growth firms do not necessarily achieve greater financial returns from GPs compared to their industry peers. It is suggested to manage expectations and not solely rely on growth as a determinant of financial success from GPs.

Older firms generally benefit less from GPs than younger firms. Managers in established firms should be aware of this trend and possibly focus on rejuvenating their innovation processes to better leverage the benefits of GPs. In the long term, growing firms with GPs outperform those without in terms of financial results. However, in the short term, these firms may experience worse financial outcomes. Managers can adopt a long-term perspective, committing to sustained investments in green technologies despite short-term financial challenges.

Efficient resource allocation is crucial to support EI projects, ensuring that they are adequately funded and shielded from short-term financial pressures. This may involve setting up dedicated budgets for R&D in sustainable technologies. Effective communication of the long-term benefits of GPs to investors and customers is also important, emphasizing the company's commitment to sustainability. Transparency in reporting sustainability efforts can build investor confidence and attract environmentally conscious consumers.

Policymakers can encourage a long-term perspective on EI by providing stable and sustained support for firms engaged in environmental initiatives. This may involve designing policies that consider the extended timeframe required for substantial financial returns from GP. Policymakers can facilitate an environment that encourages sustainable growth, particularly in industries where EI is pivotal.

9. Limitations and Future Work

It is essential to acknowledge the *limitations* of the study, including potential data constraints and the need for further exploration of certain industry-specific dynamics. We need to design a more nuanced study of FG's role to further test once more our

theoretical predictions. This should begin with combined measures that simultaneously describe the various aspects of firm growth and continue by using both absolute and relative forms of these measures to examine their influence on the results. Moreover, we may consider adding other characteristics, such as organizational culture, leadership styles, and innovation management practices, which contribute to a more comprehensive understanding of the factors influencing the financial outcomes of GPs. Conducting cross-validation with different sets of metrics for assessing FP and growth could validate the robustness of observed correlations and enhance the reliability of the study's conclusions.

Another limitation is that the authors assumed that economic fluctuations and market conditions did not significantly affect financial outcomes associated with environmental innovations. The time period considered in the paper included the years 2012–2019 and mostly European and North American firms—the interval between the European debt crisis and the economical tectonic shifts caused by COVID-19 appearance. The authors suppose that this interval can be treated as sufficiently heterogeneous for the considered region—despite the Brexit stock market crash (2016) and stock market selloff in 2015–2016, since we did not see the significant changes in our sample descriptive statistics in Table 2 for the corresponding years for the sample analyzed.

The paper presents research findings that reveal the effects that were not previously described in the literature. We demonstrate the impact of firm growth dynamics on the relationship between EI and FP. Our research indicates that the effect size is large and statistically significant, even with coarse measures. A significant limitation of our study is that we assessed environmental innovations solely through the introduction of green patents and categorized firm size as small, medium, or large.

Thus, an essential direction for further work is an in-depth study of the identified effects through a more accurate and comprehensive formalization of firm size and eco-activities. It will make it possible to refine the found dependencies quantitatively. At the same time, our research already clearly indicates that growth dynamics should be part of econometric models that study the relationship between environmental innovation and the financial performance of firms.

The sample used in this paper primarily consists of firms from Europe and the USA, which may limit the generalizability of the findings to other geographic contexts.

A potential direction for future research could be to examine the correlations between changes in firm size and industry conditions and, if present, assess how these correlations influence the relationship between firm EI and FP.

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