



Munich Personal RePEc Archive

Revisiting the sustainability-innovation nexus: Lessons learned from the US

Fafaliou, Irene and Giaka, Maria and Konstantios, Dimitrios
and Polemis, Michael

Department of Economics, University of Piraeus, 185 34 Piraeus,
Greece, Entrepreneurship, Technology, and Economic Strategy Lab,
University of Piraeus, Piraeus, Greece, Hellenic Competition
Commission, Athens, Greece

April 2020

Online at <https://mpra.ub.uni-muenchen.de/99834/>
MPRA Paper No. 99834, posted 26 Apr 2020 08:25 UTC

Revisiting the sustainability-innovation nexus: Lessons learned from the US

Irene Fafaliou^{a,b}, Maria Giaka^{a,b}, Dimitrios Konstantios^a and Michael Polemis,^{*ac}

^a Department of Economics, University of Piraeus, 185 34 Piraeus, Greece

^b Entrepreneurship, Technology, and Economic Strategy Lab, University of Piraeus, Piraeus, Greece

^c Hellenic Competition Commission, Athens, Greece

Abstract

The relationship between innovation and corporate sustainability constitutes a long-lasting debate among policymakers and researchers. Despite the significant contributions to this field, extant literature does not provide clear answers. This can be attributed to the fact that prior studies do not incorporate the various aspects of innovation to measure their impact on sustainability performance. This study aims to cover this gap in the emerging literature by using a unique micro-level panel dataset consisting of a large number of firms scattered across the US states over the period 2007-2016. Our findings reveal that the basic mechanism for achieving corporate sustainability is through the innovation channel. We also argue that the quantity and value of innovation enhance the sustainability level, whereas these effects are strengthened in times of recession (global financial crisis). The empirical results survive robustness checks under alternative innovation measures and different econometric techniques dealing with endogeneity and reverse causality. Lastly, policy implications relating to the nature of corporate sustainability performance are also provided.

JEL classification: 031; 034; L2

Keywords: Innovation; Sustainability; Patents; Trademarks; Corporate Sustainability Performance

1. Introduction

The study of corporate sustainability is rather new in the field of economics and management science. Existing literature deals with the environmental, social and governance (ESG) dimensions of companies, as these are important factors for the economic value, competitiveness, and resilience of the company in the modern globalized environment. The researchers argue that companies, by incorporating sustainable policies into their strategy, enhance transparency by reducing asymmetric information, thus increasing trust between different stakeholders (Eccles et al., 2014). Companies with a strong environmental and social reputation, contribute more to social well-being than others (McWilliams and Siegel, 2001; Godfrey, 2005; Jacobs et al., 2010; and Hsu, 2012).

Wang and Lin (2007) address the topic of corporate sustainability in terms of the collective effort needed to incorporate economic, environmental, and social considerations into a business strategy. Other articles consider further aspects of corporate sustainability like the rise of business cost resulting from companies' non-compliance with governmental rules and regulations that meet sustainability goals. Since the non-compliance cost is usually burdensome for both small and large companies, it is argued that companies which implement sustainable policies not only outweigh the cost of regulations but also build positive customer relationships (Sen and Bhattacharya, 2001), enhance their brand name, and establish reputation (Fombrun and Shanley, 1990).

The increasing importance of sustainable practices is further reflected in a series of studies covering a wider range of concerns. To give some typical examples, Ziegler and Schröder (2010) explore the impact of sustainability on the firm's size. Other studies (Margolis and Walsh, 2003; Wagner, 2010) examine possible interactions between sustainability and corporate performance whereas a number of researchers investigate the impact of sustainability on financial performance (Eccles et al., 2014; Dimson et al., 2015; Fatemi et al., 2015, Edmans, 2011; and Krüger, 2015).

Nowadays, it is evident that the corporate dimension of sustainability is a complex issue, as it involves various aspects of management, including cost savings, reputation maintenance, hiring talented people, risk management performance and achieving resource efficiency. All types of companies and businesses of all sizes have now recognized that achieving sustainability through innovation plays a catalytic role in their development. Yet, despite the growing concern about the impact of innovation on corporate sustainability, we fairly think that the subject remains an open challenge for researchers and policy makers who demand to better understand it. Part of the reason of these unmet expectations is that different

businesses have different dynamics depending on their unique characteristics, such as the degree of innovation implemented, the level of market recognition and the way they compete. The argument that different aspects of innovation create a unique and superior business combination, goes back to Schumpeter (1942). Recent research has shown that innovation can be expressed through various knowledge assets such as R&D investments and patents (Cockburn and Griliches, 1988; Hall et al., 2005). Further, Allegrizza and Guarda-Rauchs (1999) see trademarks as a soft intensive form of product innovation that adds value to a company. This idea that companies use trademarks to strengthen their strategic position has also been extensively explored by scholars such as Sandner and Block (2011), Block et al. (2014) and Bernstein (2015).

This paper follows closely the steps of various seminal studies in the field (Corrado and Hulten, 2010; Eisefeldt and Papanikolaou, 2013, 2014; and Peters and Taylor, 2016). Our purpose is to investigate whether firms that are engaged in innovation investments become more sustainable. In doing so, we develop four testable hypotheses regarding the impact of various aspects of innovation on sustainability (ESG).

This study contributes to the literature on many fronts. First, we use a newly developed dataset to measure the Socially Responsible Investment (SRI).¹ In contrast to CSR perspective which has a self-regulation form and provides information about company's efforts to have a positive impact on employees, consumers, environment, community, and Triple Bottom Line approach, which focuses on future strategies, ESG quantifies company's sustainability performance to arrive at a more precise assessment of a company's actions. By using ESG, our study takes advantage of this new sophisticated metric that can quantify in detail a firm's sustainable performance and examines the sustainability -innovation nexus in a more comprehensive way. Second, previous literature has focused only on the research and development (R&D) measure of innovation input (Brown et al., 2009; Wagner, 2010) and relates this measure to sub-quantitative corporate sustainability measures. Instead, we examine the impact of research and development expenses (innovation inputs), patents, trademarks, organizational and knowledge capital (innovation outputs) on the viability of a firm. To our knowledge, this is the first study to perform such a comprehensive analysis.

¹ SRI includes any strategy which seeks to achieve both financial return and social/environmental goals. Under SRI, firms are encouraged to reduce environmental degradation by promoting consumer protection, human rights, and racial or gender diversity. Corporate social responsibility (CSR) integrates the economic, legal, ethical, and philanthropic responsibilities of a company towards its stakeholders (Carrol, 1991; Hill et al., 2007), the Triple Bottom Line (TBL) approach (Elkington, 1998) that considers the economic, environmental, and social dimensions into a firm's strategy and (ESG) index quantifies company's exposure to environmental, social and governance matters.

The rest of this paper proceeds as follows. Section 2 refers to the existing theory and presents a testable hypothesis for our empirical part. Section 3 describes the data, discusses the sample selection, and reports the descriptive statistics evidence. Section 4 introduces our estimation strategy whereas Section 5 presents the analytical framework and discusses the main results. Section 6 discusses the robustness analysis. Section 7 concludes the paper.

2. Related literature and Hypotheses Development

2.1 Environmental, social, and governance framework

The model of the ESG aspects on corporate sustainability was first introduced back in the 1950s (Carrol, 2009) and since then has gained significant attention within the business strategy analytical framework.² Within the last years, many researchers cast light on various issues related with this framework of reference. In particular, Ghoul *et al.* (2011) report that a strategy based on the ESG model, creates firms' value. Ng and Rezaee (2015) propose that firms which achieve a simultaneous social, environmental, and financial performance increase their corporate sustainability and, in this way, create value for all stakeholders (Schuler *et al.*, 2017). In other words, when a firm embraces a strategy in the context of the ESG model and conducts business with ethical consideration (Hoepner *et al.*, 2016), it incorporates the organizational capital that matters for the stakeholders and succeeds in becoming economically effective (Sharfman and Fernando, 2008; Schuler *et al.*, 2017).

Firms that implement strategies concerning social responsibility to protect the surrounding community have also many advantages. According to many scholars, firms invest more and more in green practices, therefore managing to reduce their carbon emissions (Hart and Ahuja, 1996). As a side effect, environmentally-friendly firms accomplishing higher returns than others which disregard society's welfare (King and Lenox, 2002). Eccles and Serafeim (2013) argue that the firms, through these types of strategies, can contribute to social prosperity and create a more sustainable society. Others, such as Stern (2008) claim that firms

² The ESG describes the environmental, social and corporate governance issues. The environmental vector, includes climate change, GHG emissions, global pollution, waste issues, and animal mistreatment. The social vector is divided into two parts; the community relations that include human rights abuses, corporate complicity, impacts on communities and social discrimination and the employee relations that include forced labor, discrimination in employment, poor employment conditions. The governance vector that includes corruption, bribery, extortion, money laundering, executive compensation issues, misleading communication, fraud, tax evasion, tax optimization and anti-competitive practices to ensure transparency and accountability.

adopt green strategies only to overcome regulations and avoid legal penalties imposed by disobedience to the law such as carbon tax. Whatever their intentions, companies benefit from the introduction of these socially responsible behavioral motivations and, thus, often succeed in producing profitable results. Furthermore, firms with strong environmental awareness, have lower loan spreads and lower average capital cost (Sharfman and Fernando, 2008; Ambec and Lanoie, 2008).

McGuire et al. (1988) demonstrate that a firm can be exposed to risks from lawsuits and fines, as an aftermath of an absence of a strategy related to social responsibility. Furthermore, if a firm fails to commit to the community, consumers may boycott its brand (Sen et al., 2001). Margolis and Walsh (2003) showed that as firms become more socially responsible and concentrate on environmental, social and ethical cases, they establish a strong brand name and outperform their competitors. Employees' relations (Edmans, 2011) and social giving (Brammer and Millington, 2008) can be further identified as corporate social dimensions, that a firm should address to improve its reputation and social image (Fombrun and Shanley, 1990; Hsu, 2012). Consumers prefer to buy a product or a service from firms with ethical awareness (Godfrey, 2005). Consequently, firms incorporate strategies sensitized in socially sustainable practices to reinforce customer loyalty (McWilliams and Siegel, 2001; Sen and Bhattacharya, 2001). Corporate governance can be quantified and its consequences may have positive effects on the profits of a firm (Godfrey, 2009). A firm's ultimate social responsibility goal is to increase profits. Shareholders observe that the financial performance is better as the corporate governance increases and invest in firms with higher ESG performance (Cremers and Ferrell, 2014; Jo and Harjoto, 2011), which in turn leads to lower cost of equity financing (Cremers and Nair, 2005).

It is worth to note that according to several surveys, institutional ownership (shareholder governance mechanism) and the percentage of external directors on corporate boards have a negative effect on bond yields and a positive effect on bond valuations. Creditors consider that the firms with ESG concerns may damage their reputation and financial position while lenders consider the firms with ESG strategy as a profitable investment that can lead to better lending conditions, through transparency and accountability.

2.2 The multi-dimensional nature of innovation

Innovation is the way to companies' s growth and evolution. Porter and van der Linde (1995) report that firms in the modern competitive economies innovate with the purpose to raise productivity, to lower the total cost and improve their value. Nidumolu et al. (2009) consider

innovation as the key to progress whereas other scholars (Brown and Eisenhardt, 1995; Maskus and Penubarti, 1995; Wadhwa and Kotha, 2006; Miller *et al*, 2007) claim that firms anticipate competitors more on a technology and quality basis rather than price competition. Hall (1992) argues that firms with innovation and intangible assets create a competitive advantage and value for a longer period of time.

To understand the conceptual differences of innovation as well as their relationship to corporate sustainability, we need to study further the different aspects of innovation such as R&D, patents, trademarks, organization capital and knowledge capital. R&D activities, patents and trademarks were often used as individual variables for measuring companies' innovation activities (Kleinknecht *et al.*, 2002). Using a set of key variables that construct the concept of corporate innovation, this research is the first of its kind which studies the overall impact of innovation across all dimensions of firms' sustainability.

In particular, we distinguish between the input and output factors of the innovation process. Due to their differences in many ways, especially considering the high uncertainty surrounding investments in R&D, their effects on firms' sustainability may differ. Firstly, we use as an input factor to the innovation process, the knowledge capital, which is valued as the replacement cost of unsuccessful expenditures on R&D (Sandner and Block, 2011; Peters and Taylor, 2016). Knowledge-based capital consists of all the knowledge that a company possess, such as information, experience, learning skills of its employees and it's a key factor for efficiency and innovation. Chen, (2008) and Boiral (2002) report that the knowledge capital of a firm is part of the intangible capital that is created by R&D and gives a significant competitive advantage to a firm.

Secondly, we take a step forward and separate the output factors of the innovation process to record the difference between an innovation with a patent and a non-patented one. We use a number of innovation-outputs, such as patents, trademarks, organizational and knowledge capital, to explore their impact on corporate sustainability.

Organizational capital is another important corporate asset that contains diversified risk characteristics for a firm's internal and external environment. There are many scholars in the field that studied organizational capital and have analyzed its important contribution in the production processes and systems (Prescott and Visscher, 1980; Atkeson and Kehoe, 2005; Eisefeldt and Papanikolaou, 2013; Lustig *et al*, 2011). Organizational capital can include knowledge that has been registered, captured, exchanged or even codified, through several tools, such as databases, manuals, routines, and patents. It constitutes of human and social capital interactions. It is a value contributing asset that differentiates the firm from its

competitors and, thus, it creates a competitive advantage. Moreover, it enables tangible and intangible assets, such as machinery, buildings, land, patents, brands and human capital, to be productive. To capture the aggregate effect of innovation on corporate sustainability, we use the intangible capital construct which is the sum of the knowledge capital and the organizational capital (Peters and Taylor, 2016). As far as we know there is no previous research that studies in such detail the impact of innovation aspects on sustainability so we expect to make a significant contribution.

2.3. Sustainability: A risk mitigation tool

Being innovative and sustainable requires more than just having good ideas. By investing in R&D, companies generate new knowledge and increase their knowledge capital. But companies need to keep in mind that innovation activity is a long and continuous process, idiosyncratic and without guaranteed results (Holmstrom, 1989). To gain competitive advantage through innovation (Brown and Eisenhardt, 1995; Wadhwa and Kotha, 2006; Miller et al, 2007), firms have to take risks and invest significantly in intangible capital (Helfat, 1994). They should use trademarks (Cardozo et al., 1995; Cockburn and Griliches, 1988) and patents (Hall et al., 2005; Sandner and Block, 2011) to promote and secure new products. The implementation of such strategies increases investment in intangible assets and the uncertainty of the company. Eisfeldt and Papanikolaou (2013) report that firms with higher organization capital are considered riskier by shareholders than those with physical capital. This leads shareholders who invest in those companies to seek higher risk premiums. Huberman and Regev (2001) report that intangible assets due to the increased asymmetric information they enclose are difficult to be assessed, especially by investors with limited attention. From all of the above, we end up that firms with increased intangible assets such as R&D, patents, trademarks, knowledge, and organizational capital involve significant non-systemic risk and are hard to be evaluated. However, during the years firms tend to hold more and more intangible assets (Syverson 2011; Kogan et al., 2017) to become more competitive and increase their performance (Grant, 1996). Hence, there is a strong need to implement risk control and limitation policies through monitoring and the development of appropriate innovation strategies.

The development of a framework with appropriate sustainability strategies and the disclosure of information about this implementation can help investors to evaluate long-term risk factors and identify investment opportunities based on these risks. Innovation is a long-

term investment so investors and shareholders want to minimize the risk to invest in firms that are likely to be out of business shortly. Sustainability scoring framework is a tool that enables investors to formulate strategies in this direction by making quantitative driven investing. One of the many advantages of this quantitative analysis is that mirrors the value of the firm's intangible capital (Peters and Taylor, 2016). Investors, through the implementation of the ESG analytical framework, are motivated to invest responsibly in order to create value (McGuire et al., 1998). The ESG is a risk mitigation tool that can reduce asymmetric information around innovation and create transparency. It consists an important tool especially for the risk averted investors who shape strategies with the belief that the benefits may lie more in reducing risk versus adding value. Following the discussion above, we came to the conclusion that is very useful for the highly intensive innovation companies to be sustainable.

2.4. Innovation and sustainability nexus

Given that the concept of the sustainability covers a large range of aspects, someone would expect to see these differences depicted in much of the earlier research related to the subject. The literature shows, however, that most of the studies undertaken up to now focus just on the effects of individual innovation aspects rather than on a more holistic approach. A large number of studies found a positive relationship between innovative environmental strategies and firms' performance (Hart, 1995; Nehrt, 1998, Dean and Brown, 1995; Porter and van der Linde, 1995; Klassen and McLaughlin, 1996; Judge and Douglas, 1998; Sharma and Vredenburg, 1998; Klassen and Whybark, 1999). Firms use proactive environmental strategies to overcome regulatory issues, entry barriers and increase their capabilities as well as social acceptance (Dean and Brown, 1995; Hart, 1995; Russo and Fouts, 1997; Sharma and Vredenburg, 1998; Aragón-Correa and Sharma, 2003). Other studies report that highly innovative firms respond more to rapid and abrupt environmental changes (Schumpeter, 1942; Grossman and Helpman, 1994). Sustainable innovation is not only limited to overcoming regulation cost associated with environmental outcomes (Carrion-Flores and Innes 2010) but also has the potential to radically change the structures of corporate innovation (Aghion et al., 2015). This is mainly because innovation generates positive externalities and accelerates the diffusion and adoption of new, more sensitive, sustainable standards.

Another strand of literature reports a positive association between corporate governance and various aspects of innovation (R&D, patents, and trademarks). Sandner and Block (2011) argue that R&D, patent and trademark activity increases market value by protecting firms'

knowledge and marketing assets. Firms through innovation transmit information and signal their value, increase transparency, and untimely increase their financial performance (Landes and Posner, 1987; Cockburn and Griliches, 1988; Besen and Raskind, 1991). This paper follows the work of Heeley et al. (2007), Krasnikov et al. (2009), Sandner and Block (2011), Useche (2014), Bernstein (2015), and Block *et al.* (2014) who empirically examined the relationship between innovation and corporate sustainability. All the above yields substantial first-mover advantages that help firms to adapt and face regulators as allies by leading the way towards innovative corporate sustainability

2.5 Hypothesis Development

Based on the above discussion, we end up making testable predictions. Innovation is a significant factor that creates value and helps firms to turn the compliance arising from the regulations to opportunity but it is also idiosyncratic in nature and has an economic cost and risk. Investment in innovation, however, improves the monitoring, raises awareness, develops risk prevention strategies and formulates tools for responding to different levels of market and technological challenges. In addition, innovation is an essential factor that enhances competitiveness, technological improvements, and helps firms to comply with the rules before they are legally enforced.

2.2.1. R&D activity has a positive impact on sustainability (H1)

The literature justifies that R&D is linked positive with innovation. We hypothesize that R&D empowers companies to generate innovation, increase their competitiveness and formulate the tools to be more sustainable.

2.2.2. Patents activity has a positive impact on sustainability (H2)

The literature provides evidence that patents promote and secure new products and the firm's market position. Also, they enable companies to increase their standards and turn regulators into allies by leading the way. Firms' patents activity enhances and protects ESG possible outcomes. We hypothesize that patents have a positive impact on sustainability.

2.2.3 Trademarks activity has a positive impact on sustainability (H3).

The literature documents that trademarks express the firm's soft intensive innovation about the product and enable companies to establish and secure a strong market position and customers' loyalty. Firms create trademarks at the early stage of sustainable development as a tool to capitalize and protect its possible outcomes. Therefore, we assume that trademarks of a protective and informative role have a positive impact on sustainability.

2.2.3 Firms' knowledge and organizational capital have a positive impact on sustainability (H4).

We proxy the quality of innovation by using the firm's replacement cost of organization and knowledge capital. The former, that is the organizational capital, is an important corporate asset that contains diversified risk characteristics and comprises the value of a firm's capabilities such as organizational learning, infrastructure, organization processes, and knowledge to create products and services as well as the organization's philosophy. It provides information on internal knowledge (Atkeson and Kehoe,2005), strategies, technology and human capital (Eisfeldt and Papanikolaou,2013). The latter, that is the knowledge capital, comprises the value of the firm's knowledge and internal procedures. It represents the full body of knowledge and innovation that the firm possesses. It also contains human, relational, and structural capital such as experience, learning, and skills of employees. Chen (2008) and Boiral (2002) with their empirical results propose that it enhances a firm's efficiency and improves its competitive advantage. Additional, knowledge capital is a catalyst that through knowledge transfer plays a significant role in the formation of better strategies which help the integration of tangible and intangible assets. From all the above, we expect that firms who invest in organizational and knowledge capital will face a higher probability to comply with regulations, reduce risk, increase the revenue streams, and create sustainability. So, we expect a positive relationship between knowledge capital, organizational capital, and sustainability.

3. Data and sample variables

Our empirical analysis is based on a micro-level dataset of 1,048 US firms covering the period 2007- 2016. We solely focus on firms that report R&D spending for the whole period of our analysis. Our variables come from different databases. Specifically, the dependent variable is firm sustainable performance (*ESG*) and is constructed based on a firm's risk index (Rep Risk Index, *RRI*). We define $ESG=100-RRI$, where *RRI* is a proprietary risk metric that quantifies

a company's exposure to environmental, social and governance matters. The RRI score is calculated based on several factors. It includes possible information source influences, frequency of criticisms, and the novelty and severity of the criticism. The RRI score ranges from zero (lowest) to 100 (highest) and the higher the value of the score, the higher the risk exposure. Accordingly, our dependent variable (*ESG*) ranges from zero (lowest level of sustainability) to 100 (highest level of sustainability). Information on RRI is derived from the: RepRisk, *Global Business Intelligence* database. We also consider three major components of (*ESG*), namely the environmental (*Environmental*), social (*Social*) and corporate (*Corporate*).³ We obtain information for the firm's sales (*Sales*) in millions of dollars from the Compustat database. To increase the sensitivity of our analysis we capture the firm's innovation using the following variables: (i) R&D spending (millions of dollars) share to total sales (*R&D/ Total Assets*) which is the major asset of the innovation activity and represents the input of innovation; (ii) The number of patents of a firm share to total sales (*Pat/Total Assets*) as an output of innovation activity; (iii) In addition to the innovation of the product, we use (*Trademarks/Sales*) to capture the firm's soft intensive innovation around the product. Therefore, we study the impact of innovation on firms' sustainable performance through the market establishment channel. Data on the former's measures come from the Compustat database, while for the latter from the Orbis Intellectual Property, a global company database, produced by the Bureau Van Dijk. Finally, following Peters and Taylor (2016) to study in a more holistic way a firm's innovation activity we use the replacement cost of a firm's organizational capital, knowledge capital and intangible capital as a proxy of a firm's innovation. These measures come from the WRDS database Peters and Taylor (2016). To capture firms' market establishment, we use trademarks as a share of sales (*TM/Sales*) and data come from the Orbis database. Finally, we add a dummy for the 2008 financial crisis (*Crisis*) which takes the value of 1 for the years 2007, 2008 and zero otherwise. Table 1 provides the summary statistics of our sample variables over the examined period.

³ Environmental sustainability relates to environmental policy and environmental management performance; Social sustainability concerns citizenship and socially responsible stakeholders' engagement, labor practice indicators, human capital development, knowledge management, and organizational learning, social reporting, talent attainment, and retention. Corporate governance sustainability as defined by Letza et al. (2004), is about the understanding and institutional arrangements for relationships among various economic actors and corporate participants who may have direct or indirect interest in a corporation, such as shareholders, directors/ managers, employees, creditors, suppliers, customers, local communities, government, and the general public.

Table 1: Descriptive statistics

<i>Variable</i>	Obs	Mean	Std. Dev.	Min	Max
<i>ESG</i>	6,802	91.33	11.65	28.5	100
<i>Sales/Total assets</i>	6,802	1.12	.81	0	8.60
<i>(Sales/Total assets)²</i>	6,802	1.93	3.83	0	74.07
<i>Sales growth (%)</i>	6,802	.24	6.10	0	474.81
<i>Advertising</i>	6,802	111.86	503.56	0	9729
<i>Firm Age</i>	6,802	36.47	29.85	2	159
<i>R&D/Total assets (%)</i>	6,802	.08	1.43	0	93.08
<i>Patents/Total assets (%)</i>	6,802	.03	1.00	0	61.32
<i>Knowledge Capital/Total assets (%)</i>	6,802	.42	7.20	0	469.65
<i>Organization Capital/Total assets (%)</i>	6,802	.34	1.26	0	81.13
<i>TM/Sales (%)</i>	6,802	.03	1.04	0	53.57
<i>Crisis</i>	6,802	.11	.31	0	1

This table reports descriptive statistics for a sample of 1,048 US firms. It provides the mean, standard deviation, minimum and maximum statistics for the sample as well as the total number of observations.

Table 1 documents descriptive statistics for our sample. Firms' sustainable performance (*ESG*) is on average quite high and about 91.33 (out of 100), and on average, firms grow by 0.24%. When it comes to their innovation performance, firms spend, on average, 8% of their economic value on R&D investment. Respectively, the share of patents to total assets and trademarks to sales is 3%. Last but not least, a firm's organization and knowledge capital replacement cost weighted by total assets is 34% and 42% respectively.

Figure 1 provides a visualization of the spatial distribution of sustainability across the US states over the sample period, 2007 - 2016. As we have the location of the firms and their sustainability performance, we were able to provide a spatial presentation of the firms in our sample.

Figure 1: Spatial distribution of average sustainability performance for US firms, 2007-2016

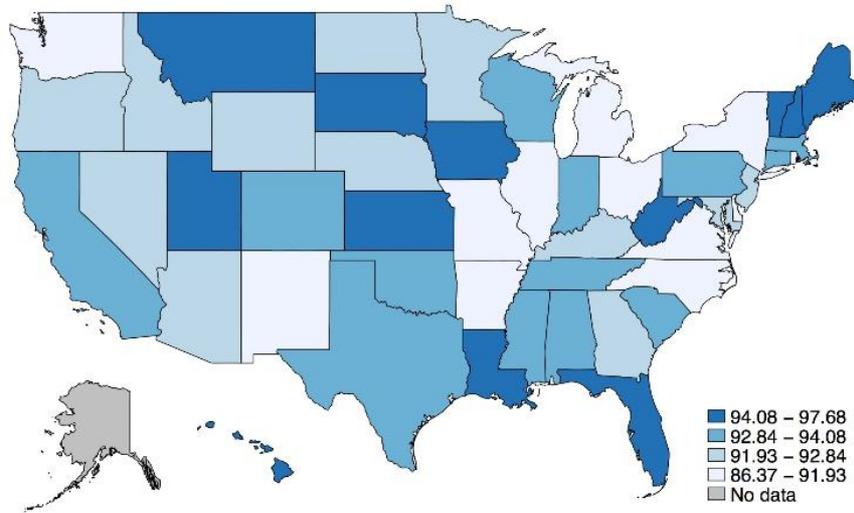


Figure 1, documents high concentration in sustainable firms with deep blue in the Northeast, Southeast, and central states, whereas in a very light blue (almost white) are states with the least sustainable performance. Comparing Figure 1 with Figure A.1, A.2 and A.3 in Appendix one can derive a positive relationship between sustainability, innovation, and firms' market establishment.

4. Estimation strategy and methodology

To support the basic research hypotheses (i.e., H1, H2, and H3) as expressed in a previous section of this paper, our model follows closely Wagner (2010) description of which is given in brief as follows:

$$SUS_{it} = \beta_i + \beta_1 (Sales/Total\ assets)_{t-1} + \beta_2 (Sales/Total\ assets)^2_{t-1} + \beta_3 (Sales\ growth)_{t-1} + \beta_4 (FirmAge)_{t-1} + \beta_5 (Patents/Total\ assets)_{t-1} + \beta_6 (Trademarks/Total\ assets)_{t-1} + \beta_7 (Sales\ growth)_{t-1} + \beta_8 (R\&D/Total\ assets)_{t-1} + \beta_9 (Advertising)_{t-1} + \beta_{10} (Crisis_dummy)_{t-1} + \varepsilon_{it} \quad (1)$$

The following equation tries to explore the validity of hypothesis (H4):

$$SUS_{it} = \beta_i + \beta_1 (Sales/Total\ assets)_{t-1} + \beta_2 (Sales/Total\ assets)^2_{t-1} + \beta_3 (Sales\ growth)_{t-1} + \beta_4 (FirmAge)_{t-1} + \beta_5 (Knowledge\ Capital/Total\ assets)_{t-1} + \beta_6 (Organization\ Capital/Total\ Assets)_{t-1} + \beta_7 (Advertising)_{t-1} + \beta_8 (Crisis_dummy)_{t-1} + \varepsilon_{it} \quad (2)$$

We use the following variation to study the effect of innovation efficiency on sustainability

$$\begin{aligned}
SUS_{it} = & \beta_0 + \beta_1 (Sales/Total\ assets)_{t-1} + \beta_2 (Sales/Total\ assets)_{t-1}^2 + \beta_3 (Sales\ growth)_{t-1} + \beta_4 (FirmAge)_{t-1} \\
& + \beta_5 (Crisis)_{t-1} + \beta_6 (Advertising)_{t-1} + \beta_7 (Patents/Total\ assets)_{t-1} + \beta_8 (Trademarks/Sales)_{t-1} \\
& + \beta_9 (Patents/R\&D)_{t-1} + \beta_{10} (TM/R\&D)_{t-1} + \varepsilon_{it}
\end{aligned} \tag{3}$$

where t and i are year and firm, respectively and ε_{it} is i.i.d. error term.

The dependent variable is the firm's sustainability performance (ESG) index. To increase the sensitivity of our analysis we capture the firm's innovation using the following variables: (i) R&D spending (millions of dollars) share to total sales ($R\&D/Total\ Assets$) which is the major asset of the innovation activity and represents the input of innovation; (ii) The number of patents of a firm to total assets ($Pat/Total\ Assets$) as an output of innovation activity; (iii) In addition to the innovation of the product, we use the share of trademarks over sales ($Trademarks/Sales$) to capture the firm's soft intensive innovation on the product. Therefore, we study for the first time in the literature the impact of innovation on sustainability through the channel of firm's market establishment (iv) Finally, following Peters and Taylor (2016) our study is also the first that uses the replacement cost of intangible capital, knowledge capital and organizational capital, to capture the aggregate effect of the quality of innovation on sustainability.

In line with Johnstone and Labonne (2009), we control for firms' sales over total assets ($Sales/Total\ Assets$); we use the quadratic term of the former variable ($Sales/Total\ assets$)² to control for diminishing returns and the sales growth ($Sales\ Growth$) to control for profitability trend. Finally, we control for firm extroversion using advertising expenses ($Advertising$), firm age ($FirmAge$), and cold periods (Crisis Dummy) as in Gompers (1995) and Li (2008). In our analysis, we use both industry and year fixed effects.

Although we use a rich set of control variables there may be still unobserved variables that are missing from our model as well as problems that may arise from the heterogeneity between the firms in the sample. For this reason, we re-estimate our model applying propensity matching score techniques (Rosenbaum and Rubin, 1983) to alleviate possible endogeneity issues⁴. Specifically, we use a propensity to match firms that have innovation below the average

⁴ Based on the propensity score matching method, we match firms that have sustainability above the sector average (i.e. treated firms) with those they do not (i.e. control firms) based on the control variables of our model specification. To further account that our results are not driven by different matching methods we use the three most common methods (Zhao 2004) which are based on the nearest neighbor, kernel, and stratification matching.

of our sample with those above. In this way, we compare firms in matching samples that differ only in the level of innovation.

To secure our findings and check for robustness, we re-estimate our model with the two-stage least square method (2SLS). For this reason, we employ exogenous instruments to firm-specific characteristics (e.g. state R&D weighted by firm size, yearly total Utility patents issued to state residents⁵, and Higher Education R&D performance⁶). In all the regressions, we keep the number of observations constant for a better comparison of the estimates and include industry and year fixed effects. Overall, our estimation strategy by using 2SLS with a rich set of instruments and propensity matching score techniques, secures that our results are not driven by endogeneity and reverse causality.

5. Results and discussion

Our first hypothesis argues that there is a positive relationship between sustainability and innovation. Table 2 presents the estimates of equation (1). Columns (1) and (2) refer to innovation investment, *R&D*, columns (3) to (7) on the output of innovation in various specifications expressed by patents and trademarks. Finally, column (8) tests for the extroversion of innovation through advertising. Robust standards are included in the parentheses.

Table 2: Effect of Innovation on Sustainability (Dep. Var.: ESG)

VARIABLES	(1) ESG	(2) ESG	(3) ESG	(4)	(5) ESG	(6) ESG	(7) ESG	(8) ESG	(9) ESG
$(Sales/Total\ assets)_{t-1}$	0.871*** (0.330)	0.885*** (0.330)	0.869*** (0.329)	0.870*** (0.330)	0.883*** (0.330)	0.807** (0.328)	0.820** (0.329)	0.755** (0.326)	0.882*** (0.330)
$(Sales/Total\ assets)^2_{t-1}$	-0.052 (0.059)	-0.054 (0.059)	-0.052 (0.059)	-0.052 (0.059)	-0.054 (0.059)	-0.041 (0.059)	-0.043 (0.059)	-0.037 (0.059)	-0.052 (0.059)
$(Sales\ growth)_{t-1}$	0.026* (0.015)	0.026* (0.015)	0.026* (0.015)	0.026* (0.015)	0.026* (0.015)	0.026* (0.015)	0.026* (0.015)	0.025* (0.015)	0.027* (0.015)
$(FirmAge)_{t-1}$	-0.067***	-0.067***	-0.067***	-0.067***	-0.067***	-0.063***	-0.063***	-0.065***	-0.067***

⁵ Yearly totals for patents granted is determined by the residence of the first-named inventor

⁶ The Higher Education Research and Development performance is a source of information for R&D expenditures at U.S. colleges and universities

	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
<i>Crisis</i>	6.919***	6.915***	6.920***	6.916***	6.916***	7.199***	7.196***	7.334***	6.909***
	(0.504)	(0.504)	(0.504)	(0.504)	(0.504)	(0.501)	(0.501)	(0.498)	(0.505)
<i>(Advertising)_{t-1}</i>	-0.008***	-0.008***	-0.008***	-0.008***	-0.008***	-0.008***	-0.008***	-0.010***	-0.008***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
<i>(Patents/Total assets)_{t-1}</i>			0.128***		0.128***	0.134***	0.133***	0.127***	0.127***
			(0.033)		(0.033)	(0.036)	(0.036)	(0.034)	(0.032)
<i>(R&D/Total assets)_{t-1}</i>	0.088**	0.087**							
	(0.038)	(0.038)							
<i>(TM/Sales)_{t-1}</i>		0.077***		0.078***	0.078***		0.072***	0.067***	0.076***
		(0.019)		(0.019)	(0.019)		(0.019)	(0.019)	(0.019)
<i>(Patents/Total assets)_{t-1}</i> <i>x(Advertising)_{t-1}</i>								0.302***	
								(0.061)	
<i>(TM/ R&D)_{t-1}</i>									0.271***
									(0.097)
<i>(Patents/ R&D)_{t-1}</i>									0.045
									(0.080)
<i>Observations</i>	6,802	6,802	6,802	6,802	6,802	6,802	6,802	6,802	6,802
<i>R-squared</i>	0.288	0.288	0.288	0.288	0.288	0.300	0.300	0.314	0.289
<i>Year FE</i>	YES								
<i>Sector FE</i>	YES								
<i>ROBUST</i>	YES								

The table reports coefficient estimates and standard errors of regressions based on equations (1) and (3). The dependent variable is the firm's sustainability (ESG). All variables are defined in Table A1. The estimation method is OLS with robust standard errors. All models include year and industry fixed effects. An asterisk indicates significance at the 10% level; two indicate significance at the 5% level; three indicate significance at the 1% level.

The key explanatory variables are *(R&D/ Total Assets)*, *(Patents/Total assets)* and *(TM/Sales)*. In line with Johnstone and Labonne (2009), we control for firms' sales over total assets (*Sales/Total Assets*); we use the quadratic term of the former variable *(Sales/Total assets)²* to control for diminishing returns and the sales growth (*Salesgrowth*) to control for profitability trend. Finally, we control for firm extroversion using advertising expenses (*Advertising*), firm age (*FirmAge*), and cold periods (*Crisis_dummy*) as in Gompers (1995) and Li (2008). The response variable is the firm's sustainability performance, (*ESG*). In our analysis, we use both industry and year fixed effects.

As Table 2 shows, estimates are quite stable and statistically robust across all the specifications. Sales (*Sales/Total assets*) have a positive impact on sustainability as a one percent increase in sales results in 0.75 (column 8) to 0.88 (column 2) units of increase of the firm's sustainability performance⁷. This finding is in alignment with prior literature (see for

⁷ In level-log specifications, as it is ours, estimates of log regressors are interpreted as follows: If regressor x increases by one percent, one expects regressant y to increase by $(\beta_1/100)$ units of y [$\Delta y = (\beta_1/100) \% \Delta x$].

example Hirsch, 1990; Wagner, 2010). Further, we examine the presence of no linear effects of sales on sustainability by using the quadratic term of sales ($Sales/Total\ assets$)². We expect to find a negative association with sustainability, as the marginal effect is negative at the data means but we take no statistically significant effect. In other words, we argue that non-linear effects are not present and monotonicity prevails. Growth in sales ($Sales\ growth$) is generally found to be positively correlated with a firm's value (Hirsch, 1990). Specifically, we argue that when a firm's sales growth is relatively high, corporate sustainability is positively related to firm value. In contrast, when a firm's sales growth is relatively low, the magnitude of the positive relationship is reduced. The higher the sales growth, the stronger the relationship will be between corporate sustainability and firm value. The possible managerial implication for this result is that some investors may be hesitant about a firm's sustainable strategies which, in their beliefs, will increase a firm's production and operation costs and thus reduce sales. Therefore, good news on sales growth for a sustainable firm will stimulate investors to give a higher valuation. Investing in R&D activity is associated with an increase of 0.08 of the firm's sustainability, as the coefficient ($R\&D/Total\ assets$) in columns (1) and (2) indicate. Investing in patents also increases the sustainability performance of a firm. An increase of patent activity ($PAT/Total\ assets$) relates to an increase of a firm's performance from 0.127 to 0.134 percent as it is shown in columns (3) and (5) to (8) respectively. A firm's reconcilability and penetration in the market -both proxied by trademarks ($TM/Sales$) in columns (2) to (4) and (7) to (8) are important factors for a firm's sustainability. Even when we include hard intensive innovation measures such as R&D and patents together results do not alter and trademarks effect plays a significant role in firms' sustainability that ranges from 0.67 to 0.77. The financial crisis of 2008, as expected, had a positive impact on firms' sustainability.⁸ Last but not least, as column (8) presents the effect of advertising on innovation increases sustainability. Consumers are making adjustments in their preferences and strongly support companies that are more sustainable conscious.

In column (9) we use an alternative model specification to study the impact of innovation efficiency on sustainability.⁹ Therefore, we construct the variables ($Patents/R\&D$ and $TM/R\&D$) as the shares of patents and trademarks to R&D to capture hard and soft intensive innovation efficiency respectively (see Hirshleifer, 2013). These measures are not in general

⁸ Firms use sustainability as a risk mitigation tool.

⁹ Is the maximization of the output produced from the invested R&D improving innovation performance and enhancing competitiveness?

highly correlated with the innovation predictors (Chan, 2001; Gu, 2005) that we have already used therefore their usage may reveal useful incremental information.

Based on the above considerations, we estimate equation (3). The results document that soft intensive innovation efficiency matters (see Table A2). The intuition behind this finding is that the ultimate competitive advantage in terms of sustainability is capitalized from policies and methods that companies develop. This finding is in line with the existing literature (McWilliams and Siegel, 2001; Sen and Bhattacharya, 2001; Godfrey, 2005).

Next, we split the response variable (ESG) into its three major components namely environmental (EP), social (SP) and governance (GP). As Table 3 shows, columns (1) to (4) and columns (5) to (7) present the effect of innovation expressed by R&D patents and trademarks respectively on the major components of sustainability.

Table 3: Effect of Innovation on the three major sustainability (ESG) components namely environmental (EP), social (SP) and governance (GP)

VARIABLES	(1) ESG	(2) EP	(3) SP	(4) GP	(5) EP	(6) SP	(7) GP
$(Sales/Total\ assets)_{t-1}$	0.871*** (0.330)	0.035*** (0.009)	-0.004 (0.008)	0.048*** (0.009)	0.035*** (0.009)	-0.004 (0.008)	0.048*** (0.009)
$(Sales/Total\ assets)^2_{t-1}$	-0.052 (0.059)	-0.006*** (0.002)	0.004*** (0.001)	-0.005*** (0.002)	-0.006*** (0.002)	0.004*** (0.001)	-0.005*** (0.002)
$(Sales\ growth)_{t-1}$	0.026* (0.015)	0.000 (0.000)	0.000 (0.000)	0.001** (0.000)	0.000 (0.000)	0.000 (0.000)	0.001** (0.001)
$(Advertising)_{t-1}$	-0.008*** (0.001)	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)
$(FirmAge)_{t-1}$	-0.067*** (0.005)	-0.001*** (0.000)	-0.001*** (0.000)	-0.000*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.000*** (0.000)
<i>Crisis</i>	6.919*** (0.504)	0.007 (0.009)	0.130*** (0.014)	0.208*** (0.013)	0.007 (0.009)	0.130*** (0.014)	0.208*** (0.013)
$(Patents/Total\ assets)_{t-1}$					0.001*** (0.000)	0.001** (0.001)	0.005*** (0.001)
$(TM/Sales)_{t-1}$					0.001*** (0.000)	0.001 (0.001)	0.003*** (0.001)
$(R\&D/Total\ assets)_{t-1}$	0.088** (0.038)	0.001** (0.000)	0.001 (0.001)	0.003*** (0.001)			
<i>Observations</i>	6,802	6,802	6,802	6,802	6,802	6,802	6,802
<i>R-squared</i>	0.288	0.134	0.108	0.129	0.134	0.108	0.129
<i>Year FE</i>	YES						
<i>Sector FE</i>	YES						
<i>ROBUST</i>	YES						

The table reports coefficient estimates and standard errors of regressions based on equations (1). The dependent variable is the firm's sustainability (ESG) and its components namely environmental (EP), social (SP) and governance (GP). All variables are defined in Table A1. The estimation method is OLS with robust standard errors. All models include year and industry fixed effects. An asterisk indicates significance at the 10% level; two indicate significance at the 5% level; three indicate significance at the 1% level.

As sales become larger, a firm's sustainability increases at a decreasing rate until it reaches a maximum level; this finding also aligns with existing literature (Wagner, 2010). In the next stage, we check for non-linear effects of sales on sustainability by using the quadratic term of sales ($Sales/Total\ assets$)², we find a negative and statistically significant correlation with all components of sustainability. The dynamics of the market, proxied by the growth of sales ($Sales\ growth$), do not play an important role in environmental (EP) and social (SP) component but for governance (GP) is statistically significant. We find a positive relation between innovation proxy by R&D, patents and trademarks and firms' sustainable performance (ESG). One can note that although the coefficients are different in size compared to those reported in Table 2, their relative significance remained unaltered. One reason for this might be attributed to the fact that firms are less motivated to work on social aspects of sustainability as regulation or taxation are more relevant to the other two aspects of the ESG.

In the next stage, we study the impact of innovation quality on a firm's corporate sustainability which is a direct test that corresponds in our hypothesis (H4). The structure of Table 4 resembles that of Table 2, but we shed light on the quality aspect of innovation proxy by its value. We use knowledge capital, organization capital and their aggregate sum intangible capital to measure the value of innovation.

Table 4: Effect of the value of Innovation on Sustainability (Dep. Var.: ESG)

VARIABLES	(1) ESG	(2) ESG	(3) ESG	(4) ESG	(5) ESG	(6) ESG
$(Sales/Total\ assets)_{t-1}$	0.870*** (0.329)	0.871*** (0.330)	0.799** (0.331)	0.891*** (0.329)	0.902*** (0.331)	0.741** (0.334)
$(Sales/Total\ assets)^2_{t-1}$	-0.052 (0.059)	-0.052 (0.059)	-0.045 (0.059)	-0.055 (0.059)	-0.056 (0.059)	-0.038 (0.059)
$(Sales\ growth)_{t-1}$	0.026* (0.015)	0.026* (0.015)	0.026* (0.015)	0.024* (0.014)	0.025* (0.014)	0.027* (0.015)
$(FirmAge)_{t-1}$	-0.067*** (0.005)	-0.067*** (0.005)	-0.067*** (0.005)	-0.067*** (0.005)	-0.067*** (0.005)	-0.067*** (0.005)
<i>Crisis</i>	6.920*** (0.504)	6.919*** (0.504)	6.929*** (0.504)	5.777*** (0.652)	6.710*** (0.529)	6.339*** (0.614)
$(Advertising)_{t-1}$	-0.008*** (0.001)	-0.008*** (0.001)	-0.008*** (0.001)	-0.008*** (0.001)	-0.008*** (0.001)	-0.008*** (0.001)
$(Intangible\ Capital/Total\ assets)_{t-1}$	0.019** (0.009)			0.019** (0.009)		
$(Organization\ Capital/Total\ assets)_{t-1}$			0.272* (0.154)			0.264* (0.150)
$(Knowledge\ Capital/Total\ assets)_{t-1}$		0.018** (0.008)			0.017** (0.008)	

<i>(Intangible Capital/Total assets)</i> _{t-1}					1.588***	
<i>x Crisis</i>					(0.435)	
<i>(Knowledge Capital/Total assets)</i> _{t-1}					0.912***	
<i>x Crisis</i>					(0.297)	
<i>(Organization Capital/Total assets)</i> _{t-1}						2.075**
<i>x Crisis</i>						(1.009)
Observations	6,802	6,802	6,802	6,802	6,802	6,802
<i>R-squared</i>	0.288	0.288	0.289	0.289	0.288	0.289
<i>Year FE</i>	YES	YES	YES	YES	YES	YES
<i>Sector FE</i>	YES	YES	YES	YES	YES	YES
<i>ROBUST</i>	YES	YES	YES	YES	YES	YES

The table reports coefficient estimates and standard errors of regressions based on equations (2). The dependent variable is the firm's sustainability (ESG). All variables are defined in Table A1. The estimation method is OLS with robust standard errors. All models include year and industry fixed effects. An asterisk indicates significance at the 10% level; two indicate significance at the 5% level; three indicate significance at the 1% level.

In line with Johnstone and Labonne (2009), we control for firms' sales over total assets (*Sales/Total Assets*); we use the quadratic term of the former variable (*Sales/Total assets*)² to control for diminishing returns and the sales growth (*Salesgrowth*) to control for profitability trend. Finally, we control for firm extroversion using advertising expenses (*Advertising*), firm age (*FirmAge*), and cold periods (*Crisis_dummy*) as in Gompers (1995) and Li (2008). The response variable is the firm's sustainability performance, (*ESG*). In our analysis, we use both industry and year fixed effects. The results indicate that the value of innovation measured by organization, knowledge, and intangible capital has a positive impact on the firm's sustainability. We find that coefficients of (*Organization Capital/Total assets*) and (*Knowledge Capital/Total assets*) are positive and statistically significant as well as their aggregate effect expressed by the coefficient of (intangible capital/total assets). Besides, in crisis periods this impact becomes significantly stronger which probably happens because companies through target innovation activity invest in their resources and competencies resulting in higher sustainable performance and ultimately better resilience. The results are in line with the theoretical arguments of (section 5.1) and support the argument that asset accumulation is not only vital for the firm's growth and market establishment but and for its sustainable performance. The value generated by innovation, in particular, is highly beneficial for a firm's sustainability, as via ESG strategy differentiation a firm can penetrate in the market. In sum, we document in this section that firms with higher innovation quality are associated with better (ESG) performance and this effect in cold periods becomes even stronger.

6. Robustness checks

This section presents the necessary robustness of our findings. One could argue that the results may be driven by endogeneity issues. To alleviate such concerns and address possible feedback effects between innovation and sustainability, we deploy two techniques: a) instrumental analysis and b) propensity matching score. These techniques are described below.

6.1. Instrumental Analysis

We first perform two-stage least square (2SLS) estimation. We include the same control variables and industry year fixed effect as in our corresponding baseline regressions. We use as instruments the state R&D weighted by firm size; the yearly total utility patents issued to state residents and the Higher education R&D performance. The intuition in using these variables comes from the fact that our sample includes firms from states with different innovation activities, institutional characteristics, and regulations. These characteristics play a crucial role in shaping firm's innovation activity. The former instruments, are exogenous to firm's specific characteristics so we expect the results to be causal. Our equations will be exactly identified. We use the under-identification test by Kleibergen and Paap to check if the number of instruments is adequate compared with the number of the endogenous variables. The null hypothesis is that there is under-identification and is required a value lower than 0.05 to reject the null hypothesis at the 5% level. We use the Hansen over-identification test to test for possible correlation between the instruments and the error term. If there is any correlation then the instruments are not treated as acceptable. Under the null hypothesis over identifying restrictions are valid, and is required a higher value than 0.05 to reject the null hypothesis at the 5% level. We check for the instrument's explanatory powers by using a weak identification test. In this test, we compare the critical values with Cragg-Donald Wald F statistic and if any of them is greater than that, then the instruments are weak and do not have explanatory power. Finally, we use Durbin and Wu-Hausman tests to check if the variables are exogenous or endogenous. These statistics have very low p -value we correctly performed 2sls. In Table 5, we report our instrumental variable results.

Table 5: Instrumental Variable Analysis on the Relationship Between Innovation and Sustainability

VARIABLES	(1) ESG	(2) ESG	(3) ESG	(4) ESG	(5) ESG
$(Sales/Total\ assets)_{t-1}$	0.352 (0.365)	0.293 (0.363)	0.031 (0.361)	0.345 (0.365)	0.308 (0.363)
$(Sales/Total\ assets)^2_{t-1}$	0.017 (0.069)	0.025 (0.069)	0.053 (0.068)	0.018 (0.069)	0.022 (0.069)
$(Sales\ growth)_{t-1}$	0.031 (0.019)	0.031 (0.019)	0.031 (0.019)	0.031 (0.019)	0.031 (0.019)
$(FirmAge)_{t-1}$	-0.064*** (0.004)	-0.064*** (0.004)	-0.064*** (0.004)	-0.064*** (0.004)	-0.064*** (0.004)
<i>Crisis</i>	7.122*** (0.494)	7.124*** (0.494)	7.119*** (0.494)	7.119*** (0.494)	7.151*** (0.520)
$(Advertising)_{t-1}$	-0.009*** (0.000)	-0.009*** (0.000)	-0.009*** (0.000)	-0.009*** (0.000)	-0.009*** (0.000)
$(Patents/Total\ assets)_{t-1}$		0.903*** (0.248)	(0.519)	(0.520)	
$(R\&D/Total\ assets)_{t-1}$	0.739*** (0.204)				
$(Intangible\ Capital/Total\ assets)_{t-1}$					0.122*** (0.033)
$(Knowledge\ Capital/Total\ assets)_{t-1}$				0.144*** (0.040)	
$(Organization\ Capital/Total\ assets)_{t-1}$			0.781*** (0.217)		
<i>Observations</i>	6,802	6,802	6,802	6,802	6,802
<i>R-squared</i>	0.275	0.276	0.279	0.275	0.276
<i>Year FE</i>	YES	YES	YES	YES	YES
<i>Industry FE</i>	YES	YES	YES	YES	YES
Under-Identification Test	0.000	0.000	0.000	0.000	0.000
Weak-Identification Test	46.879 (13.91)	68.095 (13.91)	53.388 (13.91)	49.545 (13.91)	50.733 (13.91)
Over-Identification Test	0.229	0.237	0.194	0.238	0.242
Durbin (score)	0.000	0.000	0.00	0.000	0.000
<i>Wu-Hausman</i>	0.000	0.000	0.00	0.000	0.000

Notes: This table documents 2sls estimates and stander errors (in parentheses) based on equations (1) and (2). Columns 1 focus only on firms in R&D activity; Column 2 considers the firm's patent activity. Column 3 and column 4 document evidence for the value of innovation expressed by *Knowledge Capital* and *Organization Capital*. In all regressions, we keep the number of observations constant for a better comparison of the estimates and include industry and year fixed effects. All models include year and industry fixed effects. In all models, the instrumental variables are stated higher education R&D performance, utility patents issue to state and state total industry R&D performance. Under-Identification Test reports the p -value of the LM test by Kleibergen and Paap, which requires a value lower than 0.05 to reject the null hypothesis at the 5% level. Weak-Identification Test reports the Wald F -statistic test by Kleibergen and Paap, which must be higher than its critical value included in parentheses to reject the null. Over-Identification Test reports the p -value of the over-identification test by Hansen, which requires a value higher than 0.05 to reject the null hypothesis at the 5% level. Durbin and Wu-Housman statistics have very low p -value so correct performed 2sls. An asterisk indicates significance at the 10% level; two indicate significance at the 5% level; three indicate significance at the 1% level.

Focusing on the estimates of our interest, both quantity and quality measures of innovation continue to play an important role in firms' sustainable performance. We find that the coefficients of our instrumental analysis are positive and significant at 1% level across all proxies of innovation and associated with an increase of 0,14 to 0,9 of the firm's sustainability depending on the innovation proxy we use. In sum, the output of IV analysis indicates that the results of our baseline are causal which supports our hypothesis H1 to H4.

6.2. Propensity Matching

A second approach to alleviating possible endogeneity concerns involves propensity score matching analysis. The idea behind this, is to compare ESG performance of similar firm's along other dimensions with only differences in their innovation profile. We compare with propensity score matching method firms that have innovation over the average with those who do not. In order to do it, we construct dummy files (*DummyR&D*, *DummyPatents*, *DummyTrademarks*, *DummyKnowledgeCapital*, *DummyOrganization Capital*) that take value 1 if innovation aspect is over the average and zero otherwise. We match firms with similar characteristics across the control variables, so any observed difference across the firm is then attributed to their innovation behavior. Our results provide evidence that in matching samples, controlling for all the other factors and with only different the level of innovation, firms with innovation activity over the average have around 0.996 to 3.907 times more sustainable performance depending on innovation aspect and the matching method.

Table (6) : Robustness results with Propensity Score Matching

Panel A: This table presents propensity for
Dependent Variable: Sustainability

Treatment Variable:	R&D			Patents			Trademarks		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Nearest neighbor	3.907*** (0.299)			2.650*** (0.922)			0.651 (1.041)		
Kernel		3.907*** (0.269)			2.829*** (0.229)			2.995*** (0.645)	
Stratification			3.907*** (0.102)			2.200*** (0.309)			1.691*** (0.796)
Observations	6,802	6,802	6,802	2.650*** 6,802	6,802	6,802	6,802	6,802	6,802

Panel B: This table presents propensity for

Dependent Variable: Sustainability

Treatment Variable:	Knowledge Capital			Organization Capital		
	(1)	(2)	(3)	(4)	(5)	(6)
Nearest neighbor	1.522*** (0.518)			1.317** (0.605)		
Kernel		1.908*** (0.478)			1.089*** (0.269)	
Stratification			1.479*** (0.302)			0.996*** (0.187)
Observations	6,802	6,802	6,802	6,802	6,802	6,802

Notes: In this table, we present robustness for all the aspects of innovation by using Propensity Matching score techniques based on the control variables of Table 3. In Columns (1), (4), (7) we employ the nearest neighbor method, additionally in columns (2), (5), (8), and (3), (6), (9) the kernel and at the stratification method (Zhao 2004) respectively. An asterisk indicates significance at the 10% level; two indicate significance at the 5% level; three indicate significance at the 1% level. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

7. Conclusions

In this paper, we analyze the impact of several aspects of innovation on a firm's sustainability. The results of the innovation effect on sustainability suggest that the theoretical arguments behind the positive forces of innovation are dominant in our sample. The effect of innovation quality and efficiency on sustainability is also inline and generalize these findings in our sample. This study is the first that relates all types of innovation with firms' sustainability performance and, in this sense, we provide a policy implication for the possible formulation of sustainable strategies. Our study focuses on US firms, so takes place in an economically developed economy.

Firm's sustainability is promoted not only by its innovative activity but additionally by the exposure in relative higher of lower innovation environments. Our sample includes firms from states with different innovation activities, institutional characteristics, and regulations. This characteristic differs and cannot be sufficiently captured by state-year fixed effects but have an important effect on the firm's innovation. Thus, we don't argue that these specific characteristics are less important in shaping ESG than the firm's innovation activity. Precisely the opposite; due to these characteristics business innovation activity is shaping up.

Our results indicate that the quantity and value of innovation do enhance corporate sustainable performance. We also argue that these effects become even stronger during times of recession (e.g. global financial crisis). We supplement our analysis with the use of various

techniques such as the propensity matching score and instrumental variable analysis to check for robustness of our findings. The empirical results reveal that our analysis survives robustness checks.

The current framework will offer new insights and help firms to evolve and design business strategies according to the “new sustainable rules” of the modern economic environment. Indeed, the case of sustainability is already starting to transform the competitive business environment and forces companies to adapt their standards and turn regulators into allies by leading the way in sustainable products and services. Developing new strategies and addressing the needs of the current sustainable way requires to learn question existing knowledge mechanism. While firms struggle to adapt, those who have already pursued sustainable innovation advance as leaders beyond the competition.

References

- Aghion, P. *et al.* (2015) 'Industrial policy and competition', *American Economic Journal: Macroeconomics*, 7(4), pp. 1–32. doi: 10.1257/mac.20120103.
- Allegrezza, S., Guarda-Rauchs, A., 1999. The determinants of trademarks deposits: an econometric investigation. *Econ. Appliquée* 52 (2), 51–68.
- Ambec and Lanoie (2008) 'Does It Pay to Be Green? A Systematic Overview', *Academy of Management Perspectives*, 22(4), pp. 45–62. doi: 10.5465/amp.2008.35590353.
- Aragón-Correa, J. A. and Sharma, S. (2003) 'A Contingent Resource-Based View of Proactive Corporate Environmental Strategy', *The Academy of Management Review*, 28(1), p. 71. doi: 10.2307/30040690.
- Atkeson, A. and Kehoe, P. J. (2005) 'Modeling and measuring organization capital', *Journal of Political Economy*, 113(5), pp. 1026–1053. doi: 10.1086/431289.
- Bernstein, S. (2015) 'Does Going Public Affect Innovation?', *Journal of Finance*, 70(4), pp. 1365–1403. doi: 10.1111/jofi.12275.
- Besen S M. and Raskind L J. (1991) 'An introduction to the law and economics of Intellectual', *Journal of Economic Perspectiv*, 5(1), pp. 3–27. doi: 10.4337/9781782540465.00005.
- Block, J. H. *et al.* (2014) 'Trademarks and venture capital valuation', *Journal of Business Venturing*. Elsevier Inc., 29(4), pp. 525–542. doi: 10.1016/j.jbusvent.2013.07.006.
- Boiral, O. (2002) 'Tacit knowledge and environmental management', *Long Range Planning*, 35(3), pp. 291–317. doi: 10.1016/S0024-6301(02)00047-X.
- Brammer, S., & Millington, A. (2008). Does it pay to be different? An analysis of the relationship between corporate social and financial performance. *Strategic Management Journal*, 29(12), 1325–1343. doi:10.1002/smj.714
- Brown, J. R., Fazzari, S. M. and Petersen, B. C. (2009) 'Financing innovation and growth: Cash flow, external equity, and the 1990s r&d boom', *Journal of Finance*, 64(1), pp. 151–185. doi: 10.1111/j.1540-6261.2008.01431.x.
- Brown, S. L. and Eisenhardt, K. M. (1995) 'Resources, Firms, and Strategies: A Reader in the Resource-based Perspective', *Academy of Management Review*, 20(2), pp. 343–378.
- Cardozo, R. *et al.* (1995) 'Product-market choices and growth of new businesses', *IEEE Engineering Management Review*, 23(2), pp. 10–16. doi: 10.1111/1540-5885.1040331.
- Carrión-Flores, C. E. and Innes, R. (2010) 'Environmental innovation and environmental performance', *Journal of Environmental Economics and Management*, 59(1), pp. 27–42. doi: 10.1016/j.jeem.2009.05.003.

- Carroll, A. B. (1991) 'The pyramid of corporate social responsibility: Toward the moral management of organizational stakeholders', *Business Horizons*, 34(4), pp. 39–48. doi: 10.1016/0007-6813(91)90005-G.
- Carroll, A. B. (2009) 'A History of Corporate Social Responsibility: Concepts and Practices', *The Oxford Handbook of Corporate Social Responsibility*, (January). doi: 10.1093/oxfordhb/9780199211593.003.0002.
- Chan, L. K. C., Lakonishok, J. and Sougiannis, T. (2001) 'The stock market valuation of research and development expenditures', *Journal of Finance*, 56(6), pp. 2431–2456. doi: 10.1111/0022-1082.00411.
- Chen, Y. S. (2008) 'The positive effect of green intellectual capital on competitive advantages of firms', *Journal of Business Ethics*, 77(3), pp. 271–286. doi: 10.1007/s10551-006-9349-1.
- Cockburn, I. and Griliches, Z. (1988) 'Industry Effects and Appropriability Measures in the Stock Market's Valuation of R&D and Patents', *The American Economic Review*, Vol. 78, No. 2, pp. 419-423, <http://www.jstor.org/stable/1818161> .
- Corrado, C. A. and Hulten, C.R., (2010) Measuring Intangible Capital: How Do You Measure a "Technological Revolution", *American Economic Review* 100 (2), 99-104
<http://www.jstor.org/stable/27804971>
- Cremers, K. J. M. and Nair, V. B. (2005) 'Governance mechanisms and equity prices', *Journal of Finance*, 60(6), pp. 2859–2894. doi: 10.1111/j.1540-6261.2005.00819.x.
- Cremers, M. and Ferrell, A. (2014) 'Thirty years of shareholder rights and firm value', *Journal of Finance*, 69(3), pp. 1167–1196. doi: 10.1111/jofi.12138.
- Dean, T. J. and Brown, R. L. (1995) 'Pollution Regulation as a Barrier to New Firm Entry: Initial Evidence and Implications for Future Research', *Academy of Management Journal*, 38(1), pp. 288–303. doi: 10.5465/256737.
- Dimson, E., Karakaş, O. and Li, X. (2015) 'Active Ownership', *Review of Financial Studies*, 28(12), pp. 3225–3268. doi: 10.1093/rfs/hhv044.
- Eccles, R. G. and Serafeim, G. (2013) 'The performance frontier: Innovating for a sustainable strategy', *Harvard business review* 91(5), 50-56, 58, 60, 150
- Eccles, R. G., Ioannou, I. and Serafeim, G. (2014) 'The impact of corporate sustainability on organizational processes and performance', *Management Science*, 60(11), pp. 2835–2857. doi: 10.1287/mnsc.2014.1984.
- Edmans, A. (2011) 'Does the stock market fully value intangibles? Employee satisfaction and equity prices', *Journal of Financial Economics*. Elsevier, 101(3), pp. 621–640. doi: 10.1016/j.jfineco.2011.03.021.

Eisfeldt, A. L. and Papanikolaou, D. (2013) 'Organization capital and the cross-section of expected returns', *Journal of Finance*, 68(4), pp. 1365–1406. doi: 10.1111/jofi.12034.EI

Eisfeldt, Andrea L., and Dimitris Papanikolaou. 2014. "The Value and Ownership of Intangible Capital." *American Economic Review*, 104 (5): 189-94.

Elkington, J. 1998, Partnerships from cannibals with forks: The triple bottom line of 21st-century business. *Environ. Qual. Manag.*, 8, 37–51.

Fatemi, A., Fooladi, I. and Tehranian, H. (2015) 'Valuation effects of corporate social responsibility', *Journal of Banking and Finance*. Elsevier B.V., 59, pp. 182–192. doi: 10.1016/j.jbankfin.2015.04.028.

Fombrun, C. and Shanley, M. (1990) 'What'S in a Name? Reputation Building and Corporate Strategy.', *Academy of Management Journal*, 33(2), pp. 233–258. doi: 10.2307/256324.

Ghoul, S. *et al.* (2011) 'Does corporate social responsibility affect the cost of capital?', *Journal of Banking and Finance*, 35(9), pp. 2388–2406. doi: 10.1016/j.jbankfin.2011.02.007

Godfrey, P. C. (2005) 'The relationship between corporate philanthropy and shareholder wealth: A risk management perspective', *Academy of Management Review*, 30(4), pp. 777–798. doi: 10.5465/AMR.2005.18378878.

Godfrey, P. C. And Merrill, Craig B. And Hansen, J. M. (2009) 'The Relationship Between Corporate Social Responsibility And Shareholder Value: An Empirical Test Of The Risk Management Hypothesis', *Strategic Management Journal*, 30, pp. 425–445. doi: 10.1002/smj.

GOMPERS, P. A. (1995) 'Optimal Investment, Monitoring, and the Staging of Venture Capital', *The Journal of Finance*, 50(5), pp. 1461–1489. doi: 10.1111/j.1540-6261.1995.tb05185.x.

Grant, R. M. (1996), *Strategic Management Journal*, 17(Winter Special Issue), pp. 109–122. doi: 10.2307/2486994.

Grossman, G. M. and Helpman, E. (1994) 'Endogenous Innovation in the Theory of Growth', *Journal of Economic Perspectives*, 8(1), pp. 23–44. doi: 10.1257/jep.8.1.23.

Gu, F (2005) 'Innovation, future earnings, and market efficiency', *Journal of Accounting, Auditing and Finance*, 20(4), pp. 385–418. doi: 10.1177/0148558x0502000405.

Hall, B. H., Jaffe, A. and Trajtenberg, M. (2005) 'Market value and patent citations', *RAND Journal of Economics*, 36(1), pp. 16–38.

Hall, R. (1992) 'The Strategic Analysis of Intangible Issues', *Strategic Management Journal*, 13(March 1991), pp. 135–144.

Hart, S. L. and Ahuja, G. (1996) 'Does it Pay to be Green.', *Business Strategy and the Environment*, pp. 30–37.

- Hart, S. (1995) 'a Natural-Resource-Based the Firm', *Academy of Management Review*, 20(4), pp. 986–1014.
- Heeley, M. B., Matusik, S. F. and Jain, N. (2007) 'Innovation, appropriability, and the underpricing of initial public offerings', *Academy of Management Journal*, 50(1), pp. 209–225. doi: 10.5465/AMJ.2007.24162388.
- Helfat, C. E. (1994) 'Firm-Specificity in Corporate Applied R&D', *Organization Science*, 5(2), pp. 173–184. doi: 10.1287/orsc.5.2.173.
- Hill, R. P. *et al.* (2007) 'Corporate social responsibility and socially responsible investing: A global perspective', *Journal of Business Ethics*, 70(2), pp. 165–174. doi: 10.1007/s10551-006-9103-8.
- Hirsch, B. T. (1990) 'Market structure, union rent seeking, and firm profitability', *Economics Letters*, 32(1), pp. 75–79. doi: 10.1016/0165-1765(90)90052-3.
- Hirshleifer, D., Hsu, P.-H., Li, D., 2013. Innovative efficiency and stock returns. *Journal of Financial Economics* 107, 632–654. <https://doi.org/10.1016/j.jfineco.2012.09.011>
- Hoepner, A. *et al.* (2016) 'The Effects of Corporate and Country Sustainability Characteristics on The Cost of Debt: An International Investigation', *Journal of Business Finance and Accounting*, 43(1–2), pp. 158–190. doi: 10.1111/jbfa.12183.
- Holmstrom, B. (1989) 'AGENCY COSTS AND INNOVATION', *Journal of Economic Behavior and Organization*, 2, pp. 305–327.
- Hsu, K. T. (2012) 'The Advertising Effects of Corporate Social Responsibility on Corporate Reputation and Brand Equity: Evidence from the Life Insurance Industry in Taiwan', *Journal of Business Ethics*, 109(2), pp. 189–201. doi: 10.1007/s10551-011-1118 0.
- Huberman, G. and Regev, T. (2001) 'Contagious speculation and a cure for cancer: A nonevent that made stock prices soar', *Journal of Finance*, 56(1), pp. 387–396. doi: 10.1111/0022-1082.00330.
- Jacobs, B. W., Singhal, V. R. and Subramanian, R. (2010) 'An empirical investigation of environmental performance and the market value of the firm', *Journal of Operations Management*, 28(5), pp. 430–441. doi: 10.1016/j.jom.2010.01.001.
- Jo, H. and Harjoto, M. A. (2011) 'Corporate Governance and Firm Value: The Impact of Corporate Social Responsibility', *Journal of Business Ethics*, 103(3), pp. 351–383. doi: 10.1007/s10551-011-0869-y.
- Johnstone, N. and Labonne, J. (2009) 'Why do manufacturing facilities introduce environmental management systems? Improving and/or signaling performance', *Ecological Economics*. Elsevier B.V., 68(3), pp. 719–730. doi: 10.1016/j.ecolecon.2008.06.003.

- Judge, W and Thomas J. Douglas (1998) 'Performance implications of incorporating natural environmental issues into the strategic planning process: an empirical assessment', *Journal of Management Studies*, 35(March), pp. 241–262.
- King, A. and Lenox, M. (2002) 'Exploring the locus of profitable pollution reduction', *Management Science*, 48(2), pp. 289–299. doi: 10.1287/mnsc.48.2.289.258.
- Klassen, R. D. and McLaughlin, C. P. (1996) 'The impact of environmental management on firm performance', *Management Science*, 42(8), pp. 1199–1214. doi: 10.1287/mnsc.42.8.1199.
- Klassen, R. D. and Whybark, D. C. (1999) 'The impact of environmental technologies on manufacturing performance', *Academy of Management Journal*, 42(6), pp. 599–615. doi: 10.2307/256982.
- Kleinknecht, A., Van Montfort, K. and Brouwer, E. (2002) 'The Non-Trivial Choice between Innovation Indicators', *Economics of Innovation and New Technology*, 11(2), pp. 109–121. doi: 10.1080/10438590210899.
- Kogan, L. *et al.* (2017) 'Technological innovation, resource allocation, and growth', *Quarterly Journal of Economics*, 132(2), pp. 665–712. doi: 10.1093/qje/qjw040.
- Krasnikov, A., Mishra, S. and Orozco, D. (2009) 'Evaluating the Financial Impact of Branding Using Trademarks: A Framework and Empirical Evidence', *Journal of Marketing*, 73(6), pp. 154–166.
- Krüger, P. (2015) 'Corporate goodness and shareholder wealth', *Journal of Financial Economics*. Elsevier, 115(2), pp. 304–329. doi: 10.1016/j.jfineco.2014.09.008.
- Landes, W. M. and Posner, R. A. (1987) 'Trademark Law: An Economic Perspective', *Journal of Law and Economics*, 30(2), pp. 265–309. <http://www.jstor.org/stable/725498>
- Letza, S., Sun, X. and Kirkbride, J. (2004) 'Shareholding versus stakeholding: A critical review of corporate governance', *Corporate Governance: An International Review*, 12(3), pp. 242–262. doi: 10.1111/j.1467-8683.2004.00367.x.
- Li, F. (2008) 'Annual report readability, current earnings, and earnings persistence', *Journal of Accounting and Economics*, 45(2–3), pp. 221–247. doi: 10.1016/j.jacceco.2008.02.003.
- Lustig, H., Syverson, C. and Van Nieuwerburgh, S. (2011) 'Technological change and the growing inequality in managerial compensation', *Journal of Financial Economics*. Elsevier, 99(3), pp. 601–627. doi: 10.1016/j.jfineco.2010.09.007.
- Margolis, J. D. and Walsh, J. P. (2003) 'Misery Loves Companies: Rethinking Social Initiatives by Business', *Administrative Science Quarterly*, 48(2). doi: 10.2307/3556659.

- Maskus, K. E. and Penubarti, M. (1995) 'How trade-related are intellectual property rights?', *Journal of International Economics*, 39(3–4), pp. 227–248. doi: 10.1016/0022-1996(95)01377-8.
- McGuire, Jean B., Sundgren, Alison and Schneeweis, T. (1988) 'Corporate Social Responsibility and Firm Financial Performance', *Academy of Management*, 31(4), pp. 854–872. <http://www.jstor.org/stable/256342>
- McWilliams, Abigail and Siegel, D. (2001) 'Corporate Social Responsibility: A Theory of the Firm Perspective', *The Academy of Management Review*, 26(1), pp. 117–127.
- Miller, D. J., Fern, M. J. and Cardinal, L. B. (2007) 'The use of knowledge for technological innovation within diversified firms', *Academy of Management Journal*, 50(2), pp. 308–326. doi: 10.5465/amj.2007.24634437.
- Nehrt, C. (1998) 'Maintainability of first mover advantages when environmental regulations differ between countries', *Academy of Management Review*, 23(1), pp. 77–97. doi: 10.5465/AMR.1998.192962.
- Ng, A. C. and Rezaee, Z. (2015) 'Business sustainability performance and cost of equity capital', *Journal of Corporate Finance*. Elsevier B.V., 34, pp. 128–149. doi: 10.1016/j.jcorpfin.2015.08.003.
- Nidumolu, Ram Prahalad, C.K. and Rangaswami, M. R. (2009) 'Why Sustainability Is Now the Key Driver of Innovation', *Harvard Business Review*, (9), pp. 57–64. doi: 10.1109/emr.2015.7123233.
- Peters, R. H. and Taylor, L. A. (2016) 'Intangible capital and the investment-q relation', *Journal of Financial Economics*. Elsevier B.V., 123(2), pp. 251–272. doi: 10.1016/j.jfineco.2016.03.011.
- Porter, M. E. and Van Der Linde, C. (1995) 'Green and competitive: Ending the stalemate', *Harvard Business Review*, pp. 120–134. doi: 10.1016/0024-6301(95)99997-e.
- Prescott, E. C. and Visscher, M. (1980) 'Organization Capital Michael Visscher', *The Journal of Political Economy*, 88(3), pp. 446–461
- Rosenbaum, P. R. and Rubin, D. B. (1983) 'The central role of the propensity score in observational studies for causal effects', *Biometrika*, 70(1), pp. 41–55. doi: 10.1017/CBO9780511810725.016.
- Russo, M. V. and Fouts, P. A. (1997) 'A resource-based perspective on corporate environmental performance and profitability', *Academy of Management Journal*, 40(3), pp. 534–559. doi: 10.2307/257052.

- Sandner, P. G. and Block, J. (2011) 'The market value of R & D, patents, and trademarks', *Research Policy*. Elsevier B.V., 40(7), pp. 969–985. doi: 10.1016/j.respol.2011.04.004.
- Sankar Sen and C. B. Bhattacharya (2001) 'Doing Better? Social Lead Consumer Reactions Doing Corporate Responsibility', *Journal of Marketing Research*, 38(2), pp. 225–243. doi: 10.1509/jmkr.38.2.225.18838.
- Schuler, D. *et al.* (2017) Corporate Sustainability Management and Environmental Ethics', *Business Ethics Quarterly*, 27(2), pp. 213–237. doi: 10.1017/beq.2016.80.
- Schumpeter, J.A. (1942) *Capitalism, Socialism and Democracy*. Vol. 36, Harper & Row, New York, 132-145.
- Sen, S., Gürhan-Canli, Z. and Morwitz, V. (2001) 'Withholding Consumption: A Social Dilemma Perspective on Consumer Boycotts', *Journal of Consumer Research*, 28(3), pp. 399–417. doi: 10.1086/323729.
- Sharfman, M. P., & Fernando, C. S. (2008). *Environmental risk management and the cost of capital*. *Strategic Management Journal*, 29(6), 569–592. doi:10.1002/smj.678
- Sharma, S. and Vredenburg, H. (1998) 'Proactive corporate environmental strategy and the development of competitively valuable organizational capabilities', *Strategic Management Journal*, 19(8), pp. 729–753.
- Stern, N. (2008) 'The economics of climate change', *The American Economic Review*, 98(2), pp. 1–37. doi: 10.4324/9780203495780.
- Syverson, C. (2011) 'What determines productivity', *Journal of Economic Literature*, 49(2), pp. 326–365. doi: 10.1257/jel.49.2.326.
- Useche, D. (2014) 'Are patents signals for the IPO market? An EU-US comparison for the software industry', *Research Policy*. Elsevier B.V., 43(8), pp. 1299–1311. doi: 10.1016/j.respol.2014.04.004.
- Wadhwa, A. and Kotha, S. (2006) 'Knowledge creation through external venturing: Evidence from the telecommunications equipment manufacturing industry', *Academy of Management Journal*, 49(4), pp. 819–835. doi: 10.5465/AMJ.2006.22083132.
- Wagner, M. (2010) 'The role of corporate sustainability performance for economic performance: A firm-level analysis of moderation effects', *Ecological Economics*. Elsevier B.V., 69(7), pp. 1553–1560. doi: 10.1016/j.ecolecon.2010.02.017.
- Wang, L. and Lin, L. (2007) 'A methodological framework for the triple bottom line accounting and management of industry enterprises', *International Journal of Production Research*, 45(5), pp. 1063–1088. doi: 10.1080/00207540600635136.

Zhao, Z. (2004) 'Using Matching To Estimate Treatment Effects ', *The Review of Economics and Statistics*, 86(1), pp. 91–107.

Ziegler, A. and Schröder, M. (2010) 'What determines the inclusion in a sustainability stock index?. A panel data analysis for european firms', *Ecological Economics*. Elsevier B.V., 69(4), pp. 848–856.

APPENDIX

Table A.1. Variable names and definitions.

Variables	Definition
Dependent Variables:	
<i>ESG</i>	Sustainability index that quantifies a company's performance to environmental, social and governance matters
<i>EP</i>	Sustainability component that quantifies a company's performance to environmental
<i>SP</i>	Sustainability component that quantifies a company's performance to social
<i>GP</i>	Sustainability component that quantifies a company's performance to governance
Treatment Variables:	
<i>DummyR&D</i>	Dummy variable set to 1 if firms R&D expenses are is over the sample average, else 0.
<i>DummyPatents</i>	Dummy variable set to 1 if firms patent activity is over the sample average, else 0.
<i>DummyTrademarks</i>	Dummy variable set to 1 if firms trademark activity is over the sample average, else 0.
<i>DummyKnowledgeCapital</i>	Dummy variable set to 1 if firms knowledge capital is over the sample average, else 0.
<i>DummyOrganization</i>	Dummy variable set to 1 if firms organization capital is over the sample average, else 0.
Control Variables:	
<i>Sales/Total assets</i>	Firms' sales over total assets
<i>(Sales/Total assets)²</i>	A quadratic term that indicates firms' sales over total assets
<i>Sales growth</i>	The growth of firm's sales
<i>Firm Age</i>	The number of years from the firm's initial incorporation date.
<i>Advertising</i>	The natural log of Firms advertising expenses in millions of dollars
<i>TM/Sales</i>	The number of trademarks of a firm share to total sales
<i>R&D/Total assets</i>	Firms research and development expenses spending in millions of dollars share to total sales
<i>Patents/Total assets</i>	The number of patents of a firm share to total assets.
<i>Intangible Capital/Total assets</i>	Firm's intangible capital share to total assets; It is estimated as the total replacement cost of organization capital and knowledge capital and coming from WRDS database (Peters and Taylor, 2016).
<i>Knowledge Capital/Total assets</i>	The replacement cost of knowledge capital share to total assets; Coming from WRDS database (Peters and Taylor, 2016).
<i>Organization Capital/Total assets</i>	The replacement cost of knowledge capital share to total assets; Coming from WRDS database (Peters and Taylor, 2016).
<i>(TM/ R&D)</i>	The share of trademarks over research and development expenses, indicates TM efficiency
<i>(Patents/ R&D)</i>	The share of patents over research and development expenses, indicates patent efficiency
<i>Crisis</i>	Dummy variable that takes the value of 1 for financial crisis period, else 0.

Table A.2: Estimates of equation (3)**Table A2:** Dependent variable is sustainability (*ESG*)

VARIABLES	(1) ESG	(2) ESG	(3) ESG
<i>(Sales/Total assets)_{t-1}</i>	0.889*** (0.330)	0.880*** (0.330)	0.882*** (0.330)
<i>(Sales/Total assets)²_{t-1}</i>	-0.054 (0.059)	-0.052 (0.059)	-0.052 (0.059)
<i>(Sales growth)_{t-1}</i>	0.026* (0.015)	0.026* (0.015)	0.027* (0.015)
<i>(FirmAge)_{t-1}</i>	-0.067*** (0.005)	-0.067*** (0.005)	-0.067*** (0.005)
<i>Crisis</i>	6.925*** (0.504)	6.904*** (0.504)	6.909*** (0.505)
<i>(Advertising)_{t-1}</i>	-0.008*** (0.001)	-0.008*** (0.001)	-0.008*** (0.001)
<i>(Patents/Total assets)_{t-1}</i>	0.124*** (0.031)	0.128*** (0.033)	0.127*** (0.032)
<i>(TM/Sales)_{t-1}</i>	0.079*** (0.019)	0.075*** (0.019)	0.076*** (0.019)
<i>(TM/ R&D)_{t-1}</i>		0.318*** (0.091)	0.271*** (0.097)
<i>(Patents/ R&D)_{t-1}</i>	0.145** (0.059)		0.045 (0.080)
<i>Observations</i>	6,802	6,802	6,802
<i>R-squared</i>	0.289	0.289	0.289
<i>Year FE</i>	YES	YES	YES
<i>Sector FE</i>	YES	YES	YES
<i>ROBUST</i>	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Figure A.1: Average R&D, 2007 - 2016

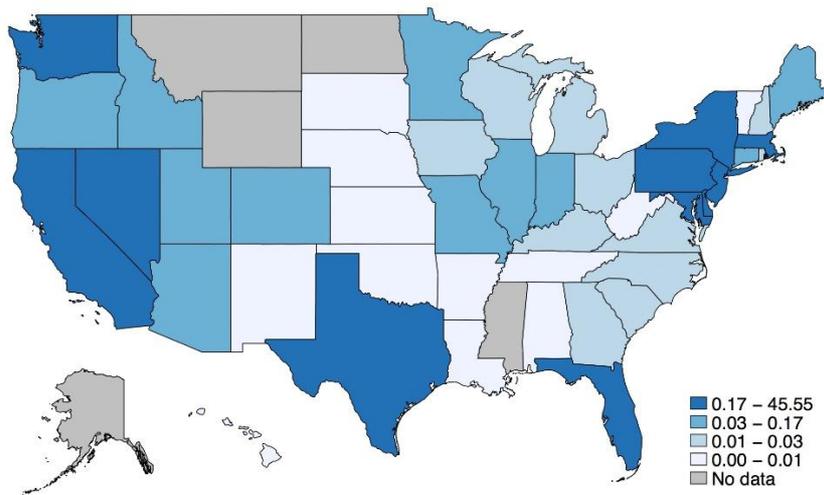


Figure A.2: Average Patents, 2007 - 2016

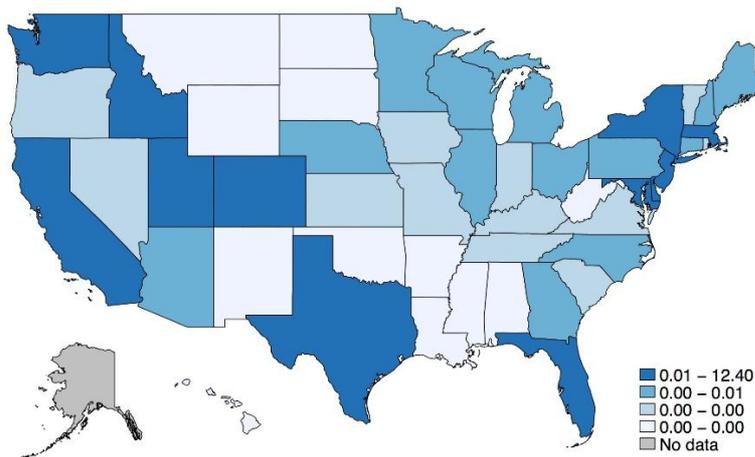


Figure A.3: Average Trademarks, 2007 - 2016

