# Estimation of the static corporate sustainability interactions

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**Abstract**

The empirical literature considers firm specific aspects affecting corporate sustainability decisions but generally omits the influence of the competition. We advocate that sustainability actions of a company impact its marketplace and vice versa. Therefore, the sustainability return of the single firm is a function of the other firms' sustainability decisions. We approach sustainability decisions as strategic decisions and evaluate the effect of competition and spillovers in a static market entry game. We estimate the parameters of the discrete choice model using the social performance ratings from MSCI KLD 400 Social Index as proxy for sustainability decisions and financial information from Wharton Research Data Services' COMPUSTAT dataset. When strategic interaction is not accounted for, we find that the increasing number of competitors increases the likelihood of sustainability investments, seemingly shows the spillover effect dominates the competition. When we apply the multi – stage approach, which incorporates competitive interaction, we provide empirical evidence that the effect of competition on the likelihood of entry into the sustainability market dominates the effect of spillover. We find that strategic motives, typically ignored in the empirical literature, appear to be an important factor in understanding sustainability related decisions.

## 1. Introduction

Strategic interaction of firms in their production and management decisions have attracted increasing interest from the operations management and production research literature in the last two decades. Cooperative strategic interactions among supply chain partners increases collaboration and coordination within the supply chain i.e. supply networks and eliminates suboptimal outcomes for all parties involved (Wei, Zhao, and Hou 2019; Leng and Jiang 2018; Yoon, Rosales, and Talluri 2018; Nair, Jayaram and Das 2015; Sofitra, Takahashi, and Morikawa 2015; Yang et al. 2015; von Massow and Canbolat 2014; Schoenherr, Griffith, and

Chandra 2014; Shen and Yu 2012; Vanpoucke and Vereecke 2010; Lawson et al. 2009). Non-cooperative strategic interactions among competing firms can affect market decisions of the focal company such as production quantity (e.g. Huang et al. 2020; Yang and Hsieh 2020; Ho 2018; Huang and Xie 2015; Zhou, Karmarkar, and Jiang 2015), product price (Chen et al. 2020, Kim, Rhim, and Yang 2020; Yang and Hsieh 2020; Du et al. 2018; Jayaswal and Jewkes 2016), quality (Huang et al. 2020; Kim, Rhim, and Yang 2020; Bae, Yoo, and Sarkis 2010) and operational decisions such as procurement strategy (Xing, Zhu, and Zhao 2019; He, Huang and Yuan 2016; Zhou, Karmarkar, and Jiang 2015; Prince, Geunes, and Smith 2013), outsourcing (Gupta, He, and Sethi 2015; Bae et al. 2010), and lead time (Jayaswal and Jewkes, 2016).

More recently, production research literature paid attention to sustainable development and its implications for the firms, which is conceptualized as corporate sustainability in the related literature. Environmental, social, and economic dimensions of sustainable development reflected in a business framework originated the term *triple bottom line* (Elkington 1998). Companies can achieve sustainable development to the extent that they can satisfy environmental quality, social justice, and profitability simultaneously according to this view (Jeurissen 2000). To achieve the triple bottom line, companies undertake several sustainability initiatives, examples of which include corporate social responsibility projects, improvement of work conditions, occupational health and safety management, product design for environment, responsible sourcing and conservation of natural resources, energy and greenhouse gases reduction and pollution reduction (Hitchcock and Willard 2009).

Production Research literature has been concerned with specific and predominantly environmental objectives such as: remanufacturing (Gong et al. 2020; Kazancoglu and Ozkan-Ozen 2020; Kenger, Koç, and Özceylan 2020; Lechner and Reimann 2020; Qian et al. 2020; Ray 2020; Wang et al. 2020; Yanıkoğlu and Denizel 2020; Huang et al. 2019; Huang and Wang 2019; Sun et al. 2017) and closed loop supply chains (Reddy and Kumar 2020; Zhang, Xu and

Chen 2020; Yuan et al. 2015; Lehr, Thun, and Milling 2013), waste management (Ramesh and Kodali 2012; Le Hesran et al. 2019), scrap management (Carmignani2017) and circular economy (Howard, Hopkinson, and Miemczyk 201; Bressanelli, Perona, and Saccani 201; Batista et al. 2019), energy management in production and logistics (Zhang et al. 2020; Nouiri, Bekrar, and Trentesaux 2019; Hahn-Woernle and Günthner 2018; Aghelinejad, Ouazene, and Yalaoui 2018), renewable energy usage (Mafakheri, Adebanjo, and Genus 2020), green logistics (Goswami et al. 2020) and supplier selection (Goswami and Ghadge 2020), green product (Keivanpour and Kadi 2018) and packaging design (White, Wang, and Li 2015), which can be categorized under the general sustainability umbrella.

Besides the competitive cost advantages of adopting green supply chain practices (Cristmann 2000; Darnall, Henriques, and Sadorsky 2008; Schoenherr and Talluri, 2013), companies also improve in terms of efficiency and innovation (Kumar, Teichman, and Timpernagel 2012). Especially activities targeting environmental sustainability such as minimizing energy and water consumption in production, decreasing resource consumption and producing less waste agree with Lean Principles[1]. Synergies between lean manufacturing and environmental management practices help improve operational performance (Yang, Hong, and Modi 2011).

Similar to environmental performance, social sustainability performance impacts operational efficiency positively. Better workforce management and improvement in working conditions foster health and safety of employees and lead to higher motivation, increased organizational learning, lower absenteeism and attrition rates, more efficient processes and a productive working environment (Chiswick 1986; Waddock and Graves 1997). Sustainability efforts lead to operational efficiency and vice versa, leading to competitive advantage and subsequent

[1]https://www.mckinsey.com/business-functions/operations/our-insights/operations-driven-sustainability?cid=other-eml-alt-mip-mck&hlkid=6e9f6a62040549009363f75a09314d72&hctky=9256414&hdpid=3ff4b99a-bac0-4f33-a0e5-68b08783214c# accessed on 08/09/2020.

financial returns in the long term (Zhu and Sarkis 2004). Apart from internal drivers of sustainability such as productivity increase and cost reduction (Mathiyazhagan, Govindan, and Haq 2014), Kumar, Teichman, and Timpernagel (2012) regard external drivers such as stakeholders and competition and advocate that companies need to adopt sustainable initiatives in all upstream and downstream areas of its supply chain. Detailed literature reviews on sustainable supply chain management are provided in Taticchi et al. (2015) and Sarkis and Zhu (2018).

Both papers call for expanding the scope of sustainability research. Taticchi et al. (2015) notes that production research literature has developed decision aid systems for sustainable supply chains at tactical and operational level, yet the economic aspects of industrial sustainability at a more strategic level have been neglected. As Dolgui, Ivanov, and Sokolov (2020) point out, supply chains have become intertwined and an upstream supplier can be both a supplier and a competitor to the focal company adding to the complexity of modeling strategic interactions between the firms. Although the interplay of regulatory decisions made by legal authorities and managerial decision-making in firms has received attention by the production research community, there remains a gap regarding the competitive factors and the possibility of strategic interactions between the firms for their sustainability decisions.

In this paper, we address the influence of competitors' sustainability decisions on the focal firm's sustainability initiatives, aiming to help fill this gap by addressing sustainability related decisions of companies as strategic interactions in their respective markets. The focal company's sustainability decision will consider the sustainability decision of the competitor in a game theoretic setting. The focal company may be positively or negatively affected by the competition depending on the competition level and the spillover rate in the market (Uşar, Denizel, and Soytaş 2020), therefore it needs to add the effects of fierce competition in its decision making process; i.e. might consider differentiating on sustainable practices, adopt strategies to become superior or competent, and particularly in what kind of sustainable actions (Moraga-González and Padrón-Fumero 2002; Cheng, Ioannou, and Sefafeim 2014). Ultimately, we estimate an empirical model to measure the impact of competition on the firm's sustainability decision.

Various databases such as: MSCI KLD 400 Social Index dataset[2], CSRHUB[3], GRI (Global Reporting Initiative)[4], Dow Jones Sustainability Index[5] are widely used for the sustainability ratings of the firms. For instance, MSCI KLD rates companies based on indicators that concern production research such as emissions and waste, packaging materials and waste, raw material sourcing, energy efficiency, union relations, employee health and safety, employee involvement, supply chain labor standards, labor rights, product quality and safety among others[6]. It is expected that the existence of these ratings and their impacts on various stakeholders lead to a sustainability competition between firms. To incorporate competition through strategic interactions, we built a novel model with the firm sustainability activities incorporated as a market entry game. In this setup, single firm's entrance (which in our case refers to the situation that the firm performs considerable amount of sustainability related activities) to the sustainability market (which we will refer to the 'competitive' environment that can award or penalize firms according to whether or not they take sustainable actions) is highly valued by the stakeholders: it can reduce production cost, improve workplace productivity, and potentially increases the financial returns (if the returns to sustainability is positive). But the firm's collection of the returns from the sustainability efforts depends on whether the competitor/fellow firms also took same/similar or different sustainable actions. Therefore, the sustainability return of the single firm is a function of the other firms'

[2] https://www.msci.com/documents/10199/904492e6-527e-4d64-9904-c710bf1533c6
[3] http://www.csrhub.com/
[4] www.globalreporting.org
[5] http://www.sustainability-indices.com/
[6] https://wrds-www.wharton.upenn.edu/documents/1353/MSCI_ESG_KLD_STATS_1991-2015_Data_Set_Methodology.pdf

sustainability decisions. Or in the language of the market entry literature, a single firm's entry decision to the sustainability market is a function of the entry decisions of the other firms. Our results emphasize the importance of measuring the level of competition in the market for sustainability, as direct effect of competition influences the firms' net benefits negatively, but competition might also create gains in terms of spillovers. To state clearly, the likelihood of undertaking more sustainability initiatives is related negatively to the level of competition in the industry, whereas it is influenced positively by sustainability spillovers[7]. To separate these effects in estimation can be a challenging task. This paper addresses this challenge by employing a three-step estimation procedure that incorporates the competitors' reactions to the focal firm's entry decision as probabilistic outcomes which are obtained from the market entry game (Bajari et al. 2010).

Our paper significantly contributes to both production research theory and practice. Indeed, it fills the content gaps depicting a detailed picture of the effect of competitors' sustainability decisions on the focal company's sustainability decision. Moreover, it presents a strategic interaction framework that encompasses both the positive effect of spillovers and negative effect of competition. The results and discussions can help practitioners in understanding the barriers and anticipating the effects of competition to adoption of sustainability practices.

The rest of the paper proceeds as follows: Section 2 presents a brief theoretical base on the sustainability adoption. Section 3 lays out the estimation framework and introduces the econometric model which allows the sustainability decisions to be interdependent among the firms. Section 4 describes the dataset and the variables. Section 5 discusses the results and their implications. Section 6 concludes with future research opportunities.

[7] For instance, an estimation that does not take this endogeneity into account, will likely obtain a positive coefficient for the cumulative effect. That if interpreted as the effect of competition will lead to incorrect conclusions about the effect of competition.

## 2. Theory and Main Hypothesis

Companies have diverse motivations for adopting sustainability initiatives such as moral or value–based motivations, legitimacy concerns, managerial–agency–based motivation, institutional motivations, responsiveness to activists and strategic motivations (Caroll et al. 2016). In our opinion sustainability decisions are mostly driven by strategic motivations. Companies that observe their competitors obtain positive returns by undertaking sustainability initiatives are inclined to invest in sustainability to exploit the producer surplus as well. Thus, the remaining companies are likely to invest in sustainability to be able to compete with the sustainability pioneers. It is safe to presume that sustainability initiatives are like other innovations and at some future time, the majority of the companies operating in a particular industry will decide to invest in sustainability.

Sustainability research has delivered not only anecdotal evidence but also empirical evidence on diffusion of sustainability practices. In his Harvard Business Review article Unruh (2010) presents anecdotal evidence of companies investing in sustainability because industry peers already invested in sustainability and names industry–wide sustainability pressures as the green domino effect. (Unruh 2010). Matisoff (2015) claims that the sustainability behavior of industry leaders changes the sustainability behavior of followers for the better and draws attention to the evidence supporting dissemination of best practices across the industry in the sustainability literature. The general upward trend for the MSCI KLD scores of S&P 500/Domini firms documented by Carroll, Primo, and Richter (2016) supports the same view.

In goods markets both revenues and costs decrease if more competitors adopt the same pricing strategy (Ellickson and Misra 2012). On the one hand, with increased sustainability competition a decrease in revenues may be expected, which in turn will decrease the likelihood of investing in sustainability. As more companies adopt sustainability initiatives, companies which are not sustainable will not be capable to compete with their sustainable counterparts.

With sustainability becoming the norm, even more companies invest in sustainability. However, with more companies offering sustainability, consumers will be reluctant to pay a price premium for a sustainable product or choose a brand/product over a competing brand/product because of their sustainability. The value stakeholders assign to sustainability will decrease if almost all firms supply sustainability and the demand for sustainability will not suffice, which will reflect negatively on sustainability revenues. On the other hand, increased sustainability competition may increase revenues due to spillovers. If the sustainability efforts of a company lead to an improved stakeholder perception of the whole industry, the total market revenue may increase and companies which did not invest in sustainability may benefit from increased total market revenue. Company $i$ free rides the sustainability efforts of company $j$ and may even gain the second mover advantage if consumers do not differentiate between companies due to homogeneous goods assumption.

Spillovers not only occur in form of increased revenues but also as decreased costs. Similar to pricing strategy cost of sustainability might decrease if more competitors adopt the same sustainability initiatives. If a company imitates the competitors' sustainability initiatives, the initial implementation cost for that company will be lower compared to the competitors' costs. The follower gains second mover advantage without bearing the full cost of the investments and the company free rides the sustainability efforts of her competitors.

When firms make their entry decisions sequentially, it is well known that early movers can preempt subsequent potential entrants (Bresnahan and Reiss 1991a;1991b). However, the newcomers not only suffer from market entry barriers in the form of incumbent firms' forestalling the entry of new competitors but also due to resistance within the company. Birkinshaw and Ridderstrale (1999) propose the corporate immune system as an analogy to model the resistance to advancement of creation–oriented activities such as sustainability initiatives. Similarly, to the immune system acting to prevent alien substances from affecting the body in a harmful way, existing power bases within the company view new initiatives as harmful. Furthermore, Eccles, Ioannou, and Serafeim (2014) document that established companies lag in adapting sustainability initiatives which can be beneficial in the long run and debate whether the cause is corporate inertia[8].

Fernandez- Kranz and Santalo (2010) study the effect of product market competition on corporate sustainability. They estimate the effect of market concentration on sustainability performance by controlling industry, firm size, financial performance, R&D intensity and advertisement intensity and present empirical evidence that firms in highly competitive markets are more socially responsible. These results are supporting the strategic view of sustainability, which regards sustainability as another differentiation strategy implemented for increasing financial return. Meng et al. (2016) estimate whether firm market power and the competition intensity in the industry affect the probability that companies implement sustainability and find a curvilinear relationship between product market competition and corporate sustainability. Too little or too much competition in the industry has negative impact on the likelihood of companies acting environmentally and socially responsible, while the former has less incentive to differentiate themselves from weak competition, while the latter face strong financial pressure and have fewer slack resources to implement sustainability practices. Dupire and M' Zali (2018) empirically show that competition causes more involvement in corporate sustainability, however they also observe that companies under competitive pressure undertake more positive actions toward core stakeholders (consumers and employees) rather than peripheral stakeholders (community and environment). Furthermore, they document that this observation is more pronounced in B2C industries.

Most of the aforementioned papers are concerned with the effect of product market competition on sustainability. The literature has not reached a consensus whether competition

[8] Corporate inertia is a term used to describe established companies' lag in adapting business models, operating conditions, and making strategic decisions which can be beneficial in the long run.

fosters or hinders adoption of sustainability and consequent financial return although more studies point out a positive effect. Especially, the circumstances affecting sustainability decisions at strategic level and their financial return are still ambiguous.

There has been a growing literature in in economics starting from early 1990s. Specifically following Bresnahan and Reiss (1991a; 1991b), characterization of the discrete game as a generalization of a standard discrete choice model where utility depends on the actions of other players, opened up the possibility of applied research in this field. Strategic interactions in different problem settings such as market entry (Berry 1992; Gallant, Han, and Khawaja 2018; Tan 2019), labor force participation (Björn and Vuong 1984; Keane and Wolpin 1997), long–term care and family bargaining (Stern and Heidemann 1999) auctions (Bajari and Hortacsu 2003; Athey, Levin, and Seira 2008), technology adoption (Ryan and Tucker 2012) has been addressed as discrete games.

Whether to model sustainability interactions as a static or a dynamic process, depends both on theoretical and practical applicability. The past decisions of the firms can be (and are) important determinants of the current decisions. However, this dependence itself does not necessarily qualify for a path to model the process as a dynamic process. In the dynamic entry game the firms should be modelled as maximizing the discounted sum of profits, taking into account each firm's market entry decision now and in the future. [9] Yet, still, the static entry model can validate or refute consistently the importance of other players' actions regarding the sustainability decision of the firm. We draw parallels with the research stream of market entry and technology adoption models and adapt the framework by Bajari et. al (2010) to the sustainability context.

[9] More recent papers such as Gallant, Han, and Khawaja (2018) and Tan (2019) estimate a dynamic game of entry decisions of moderate number of entrants with spillover effects in Pharma industry. Similar dynamic setting can be applied to strategic interactions in sustainability market. However, the computational burden and data requirements caused by the large number of entrants in the dynamic version of the sustainability market entry game is a challenge that needs to be solved. Thus, this remains for future research.

## 3. The Estimation Framework

Sustainability decisions are strategic decisions which can be approached as discrete choices and should involve the consideration of demand, cost, and the competitive factors. The interrelatedness of firm decisions and the game theoretic nature of the framework complicate the discrete choice estimation (Draganska et al. 2008). The nested fixed – point method has been widely used in the estimation of discrete choice models in the context of static games (see, e.g., Seim 2006; Orhun 2013). However, the key econometric problem is that there is at least one fixed point (equilibrium), which must be solved at each iteration of the likelihood estimation. Moreover, if there is more than one fixed point, an equilibrium selection rule has to be prescribed. Due to computational cost of the nested fixed–point algorithm, alternative methods have been developed, such as the two–step approach of Hotz and Miller (1993) and Bajari et al. (2010), which we will adapt to estimate the strategic sustainability interactions.

The estimation framework is based on the following idea. Since the equilibrium of sustainability decisions depends on the observable state variables, in the first stage the competitive effects (strategic interactions) are not incorporated into the estimation and firms' choices are modeled as a function of observable state variables. Thereby consistent estimates of the probabilities are obtained. These first–stage probabilities are estimates of the beliefs that companies have about their competitors' actions. The recovered probabilities are then plugged into a multi—stage model which incorporates strategic interactions.

In the model proposed by Bajari et al. (2010), a company obtains zero net benefit if it chooses not to enter the market. This might be a reasonable assumption for new market entries and it is well known that the effect of entering into a market can be identified only relative to not entering in the estimation of market entry games (Bresnahan and Reiss 1991a). In our setting, however, the company still obtains net benefits if it chooses not to enter the sustainability market, since it will continue to operate in its primary line of business. The non–adopter operates in the primary line of business and the decision of the competitor on sustainability can affect the non–adopters' return negatively as well as positively. A company, which chooses not to enter the market, is still affected by the actions of its competitors.

Ideally, the model should be able to identify the level of sustainability influence on net benefits separately. However, empirically we will not be able to identify the net benefits from adopting sustainable practices and the net benefits from not adopting sustainable practices separately. We can only identify the difference between the net benefit of investing in sustainable practices as opposed to not investing and recover the difference nonparametrically by inverting the equilibrium choice probabilities. Thus, we assume that the difference in net benefits among adopters and non–adopters stems only from their sustainable practices and control for all other firm characteristics that may lead to differences in net benefits.

### *3.1. The Model*

Since companies are assumed to be rational decision makers, in each period they make sustainability decisions, which maximize their expected net benefits. There are alternative ways to conceptualize sustainability decisions. On the one hand, we can model companies' sustainability decisions as the level of investment put into sustainability initiatives. On the other hand, we can model companies' sustainability decisions as a discrete choice— whether companies decide to invest into sustainability or not. As researchers, we do not know whether companies approach sustainability decisions as continuous or one – shot decisions.

If the sustainability decisions are defined as continuous sustainability investments $w_i$ for company *i,* then the set of all possible decisions of the focal company and competitors becomes infinitely big and the estimation becomes computationally costly. Thus, we develop the following discrete choice model[10], where each player simultaneously chooses an action $x_i \epsilon \{0,1\}$.

$$x_i = \begin{cases} 1 \text{ if } w_i > 0 \\ 0 \text{ otherwise,} \end{cases} \quad (1)$$

We assume that there are a finite number of companies (players); $N=\{1, \dots, i, \dots, n\}$. Let $\boldsymbol{x}_N = (x_1, \dots, x_{i,}, \dots, x_n)$ denote the vector of actions taken by all players. Player $i$ choses an action $x_i$ by taking the actions of competitors into account. $\boldsymbol{x}_{N/i} = (x_1, \dots, x_{i-1,} x_{i+1}, \dots, x_n)$ denotes the vector of actions for all players, excluding player $i$. Let $S_i = (s_1, \dots, s_k)$ denote the vector of $k$ state variables for player $i$ and $s_l \in S_i$ denote the $l^{th}$ state variable for player $i$. The state variables in $S_i$ may include variables such as firm size, firm age, leverage, R&D intensity and advertisement intensity as well as past sustainability decisions of the players, which are the variables that may affect the current decision on sustainability besides the strategic interaction. $\boldsymbol{S} = (S_1, \dots, S_n)$ denotes the vector of state variables for all $n$ players. $\boldsymbol{\vartheta}$ is a (nx1) vector of parameters measuring the impact of $\boldsymbol{S}$ on the expected total net benefit.

We assume that $\boldsymbol{S}$ is common knowledge to all players in the game as well as observable to the analyst. For each player there is also a $k+1^{th}$ state variable labeled $\varepsilon_i(x_i)$, which is private information for the player and unobservable to the analyst. Thus, each player is subject to a stochastic preference shock $\varepsilon_i(x_i)$ for each possible action $x_i$. These state variables are assumed as distributed identically and independently (i.i.d.) across all players and actions. Player $i$'s vector of stochastic preference shock $\varepsilon_i = (\varepsilon_{i0}, \varepsilon_{i1})$ is distributed according to a joint distribution with some general density function, $f_i(\varepsilon_i)$. Furthermore, $\boldsymbol{\varepsilon}_{N/i} =$

[10] In this model a company is considered as an entrant into the sustainability market if $w_i > 0$. The model can be extended to companies, which have taken substantial sustainability initiatives to enter the sustainability market. Then a company will be considered as an entrant if the sustainability investments $w_i$ exceed a threshold value.

$(\varepsilon_1, \dots, \varepsilon_{i-1,}\varepsilon_{i+1}, \dots, \varepsilon_n)$ denotes the vector of stochastic preference shock for all players, excluding player *i*.

The player *i*'s problem is to maximize the expected net benefits subject to the competitors' actions in each period. $\pi_i(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S};\ \boldsymbol{\vartheta})$ defines the total net benefit of company *i* given $\boldsymbol{S}$. The player *i* solves

$$\max_{x_i}\left\{E\left(\pi_i(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S};\ \boldsymbol{\vartheta}) + \varepsilon_i(x_i)\right)\right\} \tag{2}$$

Since $\boldsymbol{\varepsilon_{N/i}}$ are private information of other players and not observable by the player *i*, the decision of player *i* does not depend on these shocks. Thus, player *i*'s decision rule $a_i$ is a function of $(\boldsymbol{S}, \varepsilon_i)$ only.

Define $P_i(x_i|\boldsymbol{S})$ as

$$P_i(x_i = 1|\boldsymbol{S}) = \int 1\{a_i(\boldsymbol{S}, \varepsilon_i) = 1\} f(\ \varepsilon_i(x_i)\ ) d\varepsilon_i \tag{3}$$

where $1\{a_i(\boldsymbol{S}, \varepsilon_i) = 1\}$ is the indicator function that player *i*'s decision is 1 given the vector of state variables and stochastic preference shock $(\boldsymbol{S}, \varepsilon_i)$. $P_i(x_i = 1|\boldsymbol{S})$ is the probability that player *i*' s decision is to invest in sustainability conditional on the state variables $\boldsymbol{S}$, which are public information. We define the distribution of $\boldsymbol{x_N}$ given $\boldsymbol{S}$ as $P(\boldsymbol{x_N}|\boldsymbol{S}) = \prod_{i=1}^{n} P(x_i|\boldsymbol{S})$.

Next, we define $V_i(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S};\ \boldsymbol{\vartheta})$ as the net benefit for player *i* for choosing action $x_i$ over all possible actions of other players and the preference shock received by player *i* by choosing that particular action.

$$V_i(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S}; \boldsymbol{\vartheta}) = \sum_{\boldsymbol{x}_{N/i}} \pi_i(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S}; \boldsymbol{\vartheta})\, P_{N/i}(\boldsymbol{x}_{N/i}|\boldsymbol{S}) + \varepsilon_i(x_i), \tag{4}$$

where $P_{N/i}(\boldsymbol{x}_{N/i}|\boldsymbol{S}) = \prod_{j\neq i} P_j(x_j|\boldsymbol{S})$. Since player *i* does not observe the private information shocks, $\varepsilon_j$ for $(j \neq i)$, player *i*'s beliefs about her opponents' sustainability actions are captured by $P_{N/i}(\boldsymbol{x}_{N/i}|\boldsymbol{S})$. Since all possible actions of other players are accounted for, the following relation represents the choice specific net benefit function, which is the deterministic part[11] of the expected net benefit function:

$$\Pi_i(x_i, \boldsymbol{S}; \boldsymbol{\vartheta}) = \sum_{\boldsymbol{x}_{N/i}} \pi_i(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S}; \boldsymbol{\vartheta})\, P_{N/i}(\boldsymbol{x}_{N/i} | \boldsymbol{S}) \tag{5}$$

Player $i$ chooses action $x_i = 1$ over action $x_i = 0$, if the summation of choice specific net benefit function and the preference shock from choosing action $x_i = 1$ exceeds the summation of choice specific net benefit function and the preference shock from choosing action $x_i = 0$. For player $i$ to invest in sustainability is optimal, if the following condition is satisfied:

$$P_i(x_i = 1|\boldsymbol{S}) = Prob\{\varepsilon_i | \Pi_i(x_i = 1, \boldsymbol{S}; \boldsymbol{\vartheta}) + \varepsilon_i(x_i = 1) > \Pi_i(x_i = 0, \boldsymbol{S}; \boldsymbol{\vartheta}) + \varepsilon_i(x_i = 0)\} \tag{6}$$

### *3.2.Parametrization of the Net Benefit Function*

We consider a static entry game, where the net benefit function of entering the sustainability market subject to the competitors' sustainability decisions is composed of two parts. In the first term in (7) $\boldsymbol{\vartheta}$ measures the influence of state variables $\mathbf{S}'$on the total net benefit $\pi_i(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S})$ —the conditions that lead the company to adopt sustainability, while the term $\delta$ captures the influence of other companies' choices on the entry decision.[12]

$$\pi_i(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S}; \boldsymbol{\vartheta}) = \begin{cases} \boldsymbol{\vartheta}\mathbf{S}' + \delta\left(\sum_{i \neq j}^{n} 1\{x_j = 1\}\right) & \text{if } x_i = 1 \\ 0 & \text{if } x_i = 0 \end{cases} \tag{7}$$[13]

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[11] The net benefit of player $i$ depending on each possible action taken by the competitors is multiplied by its probability of occurring, and the resulting products are summed to produce the expected value. Thus, the expected value of the random variable net benefit $\Pi_i(x_i, \boldsymbol{S}; \boldsymbol{\vartheta})$ can be calculated.

[12]While $\boldsymbol{S}$ denotes the vector of state variables in the first stage, $\boldsymbol{S}'$ denotes the vector of state variables $\boldsymbol{S}$ with the inclusion of a market– specific component in the second stage.

[13] Entry into the sustainability market is not an entry game in the classical sense, and hence staying in the no sustainability state does not necessarily lead to a zero payoff. However, as explained in section 3.3. in detail we won't be able to identify the net benefit from investing into sustainability and staying in the no sustainability state separately. We can identify the difference between the net benefit of investing in sustainability as opposed to not investing. Thus, we assume that the net benefit of not investing in sustainability is equal to zero.

According to Bajari et al. (2010) $\delta$ <0, since entry of a competitor into the market decreases the net benefit of the focal company *i*. However, for sustainability interactions the parameter $\delta$ in (7) depends on both the competition level and the spillover rate.

The random error terms $\varepsilon_i(x_i)$ in the net benefit function (4) capture the preference shock to the net benefit from choosing action $x_i$, which are private information to player *i*. Player *i*'s error vector $\varepsilon_i = (\varepsilon_{i0}, \varepsilon_{i1})$ is distributed jointly with a density function $f_i(\varepsilon_i)$ and the random error terms are assumed to be independent and identically distributed (iid). We assume that the error terms are distributed extreme value. If $f_i(\varepsilon_i)$ has an extreme value type– I distribution and the $\varepsilon_{il}$'s are independent, then $P_i(x_i = 1|\boldsymbol{S})$ has an analytical solution, which represents the probability of choosing $x_i = 1$.

The type–I extreme value distribution has common applications in the study of discrete choice behavior due to its analytical properties[14] and empirical implications[15] (McFadden, 1984) and the following relation is well developed and conventionally used as the analytical solution to $P_i(x_i = 1|\boldsymbol{S})$

$$P_i(x_i = 1|\boldsymbol{S}) = \frac{\exp(\boldsymbol{\vartheta}\mathbf{S}' + \delta \sum_{i \neq j} P_j\left(x_j = 1\middle|\boldsymbol{S}\right))}{1+\exp((\boldsymbol{\vartheta}\mathbf{S}' + \delta \sum_{i \neq j} P_j\left(x_j = 1\middle|\boldsymbol{S}\right))} = \Gamma_i\left(\boldsymbol{\vartheta}, \delta, P_j(1|\boldsymbol{S}), \forall j\right). \tag{8}$$

If we use equation (8) in equation (5), we get $\Pi_i(x_i, \boldsymbol{S}; \boldsymbol{\vartheta}) = \vartheta\boldsymbol{S}' + \delta \sum_{i \neq j} P_j\left(x_j = 1\middle|\boldsymbol{S}\right)$. Since, the error terms are distributed extreme value, from equation (6), we infer that the choice probabilities $P_i(x_i = 1|\boldsymbol{S})$ take a form similar to a single agent multinomial logit model. Since better actions are more likely to be chosen than worse actions, the statistical reaction function $\Gamma_i\left(\boldsymbol{\vartheta}, \delta, P_j(1|\boldsymbol{S}), \forall j\right)$ orders the probability of different actions by their expected net benefits. Thus, the reaction function is continuous and monotonically

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[14] The limiting distributions for the minimum or the maximum of a very large collection of random observations from the same arbitrary distribution can *only* be described by generalized extreme value distributions models — specifically, the Gumbel, Fréchet, and Weibull distributions also known as type I, II and III extreme value distributions.

[15] The difference of two type–I extreme value distributed variables follows a logistic distribution, of which the logit function is the quantile function.

increasing in the choice specific net benefit function $\Pi_i$. Since the error terms $\varepsilon_i$ have density function $f_i(\varepsilon_i)$ and $P_i$ is continous in $\Pi_i$, according to Brouwer's fixed point theorem there is an equilibrium to this model for any finite $\boldsymbol{S}$ (McKelvey and Palfrey 1995). We will use the equilibrium in equation (8) in the econometric analysis.

We suppose that *t*=1,…,$T$ repetitions of the game are observable and denote the sustainability decision of firm *i* in repetition *t* as $x_{it}$. Furthermore, we use $\boldsymbol{S}_{it}$ for the values state variables take in period *t* such that $\boldsymbol{S}_t = \{S_{1t} \dots S_{nt}\}$ and follow a multi– stage estimation strategy. In the first stage, we estimate the binary response $x_{it}$ conditional on a given set of covarites, $S_{it}$. By observing the sustainability decisions of large number of companies, we can obtain a consistent estimate $\hat{P}_i(x_i = 1|\boldsymbol{S})$ of $P_i(x_i = 1|\boldsymbol{S})$ for all *i*. A probit model suffices to estimate the choice probabilities in the first stage.

In the second stage, we estimate the structural parameters of net benefit function $\boldsymbol{\vartheta}$ and $\delta$. Given the first stage estimates $\hat{P}_i(x_i = 1|\boldsymbol{S})$**,** we maximize a pseudo–likelihood function $\Gamma_i(\boldsymbol{\vartheta}, \delta, P_j(1|\boldsymbol{S}), \forall j)$ and obtain estimates of $\boldsymbol{\vartheta}$ and $\delta$ applying a logit model. On the one hand, this multi – stage estimation strategy has advantages in terms of computational burden, since we have to estimate a probit model in the first stage and a logit model in the second stage. On the other hand, a collinearity problem may arise when estimating $\boldsymbol{\vartheta}$ and $\delta$, since both the first stage estimates $\hat{P}_i(x_i = 1|\boldsymbol{S})$ and $\vartheta\boldsymbol{S}'$ depend on the vector of state variables $\boldsymbol{S}$. In many settings, an exclusion restriction is imposed to overcome the collinearity problem. In this setting, the sustainability decisions of other firms do not directly affect company *i'*s net benefits. The endogenously determined actions of competitors indirectly enter the net benefit function of company *i*. If we exclude the shocks caused by other firms' actions from the term $\boldsymbol{\vartheta S}'$, we will be able to eliminate collinearity.

### *3.3. Identification*

We can identify the deterministic part of the net benefits, without imposing any assumptions on its functional form. Suppose we consider $\boldsymbol{\vartheta}$ to be completely nonparametric, and hereinafter write $\pi_i(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S})$ instead of $\pi_i(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S}; \boldsymbol{\vartheta})$, and we denote the probability that the response is equal to one in the data conditional on $\boldsymbol{S}$ as $P_i(x_i = 1|\boldsymbol{S})$, which corresponds to the probability of company $i$ choosing to invest in sustainability. Similarly, we denote the probability that the response is equal to zero in the data conditional on $\boldsymbol{S}$ as $P_i(x_i = 0|\boldsymbol{S})$, which corresponds to the probability of company $i$ choosing not to invest in sustainability. Since even a single agent discrete choice model is not identified without independence and a parametric form assumption on the error term, we will assume that the error terms are distributed i.i.d. with a known distribution function and the error terms $\varepsilon_i(x_i)$ are distributed i.i.d. across actions $x_i$ and players $i$. Moreover, the parametric form of the distribution, F, comes from a known family. We define $\Pi_i(x_i = 0|\boldsymbol{S}) = 0$ and $\Pi_i(x_i = 1|\boldsymbol{S}) = F^{-1}(P_i(x_i = 1|\boldsymbol{S}))$, where $F^{-1}$ denotes the cumulative distribution function (cdf). Analogous to the notation in the previous section, we define the deterministic part of the expected net benefit function as the choice specific net benefit function $\Pi_i(x_i = 1|\boldsymbol{S})$=$\sum_{\boldsymbol{x}_{N/i}} \pi_i(x_i = 1, \boldsymbol{x}_{N/i}, \boldsymbol{S})\, P_{N/i}(\boldsymbol{x}_{N/i}|\boldsymbol{S})$.

Company $i$ chooses action $x_i = 1$ if and only if the choice specific net benefit and the error term associated with this action is greater than the choice specific net benefit and the error term associated with action $x_i = 0$. Thus, the equilibrium in this model satisfies player $i$'s decision rule $a_i(\boldsymbol{S}, \varepsilon_i) = 1$ if and only if

$$\Pi_i(x_i = 1|\boldsymbol{S}) + \varepsilon_i(x_i = 1) > \Pi_i(x_i = 0|\boldsymbol{S}) + \varepsilon_i(x_i = 0) \quad (9)$$

Furthermore, the equilibrium choice probabilities $P_i(x_i|\boldsymbol{S})$ have to satisfy:

$$P_i(x_i|\boldsymbol{S}) = Pr\{\Pi_i(x_i = 1|\boldsymbol{S}) - \Pi_i(x_i = 0|\boldsymbol{S}) > \varepsilon_i(x_i = 0) - \varepsilon_i(x_i = 1)\} \quad (10)$$

From Equation (10) we can infer that the equilibrium choice probabilities $P_i(x_i|\boldsymbol{S})$ have a one–to–one relationship to the choice specific net benefit functions, $\Pi_i(x_i = 1|\boldsymbol{S}) - \Pi_i(x_i = 0|\boldsymbol{S})$. Since we assume that $\varepsilon_i(x_i)$ are distributed iid and the distribution comes from a known family, one–to–one mapping is possible. We denote the map from general form choice specific value functions to choice probabilities as: $\Gamma\colon \{0,1\}\; x\; \boldsymbol{S} \rightarrow [0,1]$.

$$P_i(x_i|\boldsymbol{S}) = \Gamma_i(\Pi_i(x_i = 1|\boldsymbol{S}) - \Pi_i(x_i = 0|\boldsymbol{S})) \quad (11)$$

We denote the inverse mapping as $\Gamma^{-1}$:

$$\Pi_i(x_i = 1|\boldsymbol{S}) - \Pi_i(x_i = 0|\boldsymbol{S}) = \Gamma_i^{-1}(\, P_i(x_i|\boldsymbol{S})) \quad (12)$$

We can recover $\Pi_i(x_i = 1|\boldsymbol{S}) - \Pi_i(x_i = 0|\boldsymbol{S})$ nonparametrically by inverting the equilibrium choice probabilities. We identify the difference between the net benefit of investing in sustainability as opposed to not investing. We won't be able to identify $\Pi_i(x_i = 1|\boldsymbol{S})$ and $\Pi_i(x_i = 0|\boldsymbol{S})$ separately. Thus, we will assume that the net benefit of not investing in sustainability is equal to zero. Formally written for all *i* and $\boldsymbol{x}_{N/i}$ and $\boldsymbol{S}$, $\Pi_i(x_i = 0,\ \boldsymbol{x}_{N/i},\ \boldsymbol{S})$=0.

Based on this assumption using the mapping given in equation (13) we can recover $\Pi_i(x_i|\boldsymbol{S})$ for all $i, x_i$ and $\boldsymbol{S}$. Recall that the definition of choice specific net benefit $\Pi_i(x_i, \boldsymbol{S}; \boldsymbol{\vartheta})$ from (5) implies that

$$\Pi_i(x_i|\boldsymbol{S}) = \sum_{\boldsymbol{x}_{N/i}} \pi_i(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S})\, P_{N/i}\left(\boldsymbol{x}_{N/i}\middle|\boldsymbol{S}\right) \forall i = 1, \dots, n,\ x_i = 0{,}1 \quad (13)$$

However, even if we knew $\Pi_i(x_i|\boldsymbol{S})$ and $P_{N/i}\left(\boldsymbol{x}_{N/i}\middle|\boldsymbol{S}\right)$ we would not be able to invert this system and identify the total net benefit $\pi_i(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S})$. For the identification we follow Bajari et al. (2010) and introduce exclusion restrictions. Basically, we partition the state variables as: $\boldsymbol{S} = (S_i, \boldsymbol{S}_{N/i})$, which makes sense in terms of the conceptual model as well, since players have different state variables. As stated in Theorem 1 by Bajari et. al (2010) identification is achieved under the stated conditions therein. For details of the identification see Appendix.

We will use the empirical analog of (13) to form an estimate of the total net benefit $\pi_i(x_i,\ \boldsymbol{x}_{N/i}, S_i)$. If there is a nonparametric inversion between choice probabilities and the choice specific net benefit function, we can recover the estimates of the choice probabilities $\hat{P}_i\ (x_i = 1|\boldsymbol{S})$ and of the choice specific net benefit function $\widehat{\Pi}_i(x_i = 1|\boldsymbol{S})$. The structural parameters of the model can be identified, if appropriate exclusion restrictions are imposed on the net benefits. In the next section, we describe the data and econometric specifications used to analyze the sustainability decisions of companies.

### *3.4. Estimation*

Estimation of the model parameters is conducted in 3 steps. In the first step, the empirical counterpart of $P_i(x_i = 1|\boldsymbol{S})$ is estimated conditional on the firm's own characteristics. In the second step, all other $N - 1$ firms' entry probabilities are plugged into the calculation of expected net benefit function for firm $i$ (the empirical counterpart of equation 5). In the empirical specification, this translates into as such one of the variables in the estimation of entry probability is the sum of the other firms' entry probabilities since the net benefit function is additively linear in the entry decisions of other firms and other state variables as described in equation 7. Ideally at this stage, the probabilities estimated from equation 6 are required to be iterated to find the fixed point of the equation system. However, since we rely on the estimated first stage probabilities from the empirical counterpart of $P_i(x_i = 1|\boldsymbol{S})$, we iterated twice to get the firm entry probabilities from equation 6[16]. Finally, in the third step we estimated the model structural parameters that gives us the effect of competition on the firm's entry decision.

## 4. Data and Variables

### *4.1. Data*

We have collected annual company data on corporate sustainability and corporate financial performance for years 1991–2014. We used social performance ratings from MSCI KLD 400 Social Index database as the sustainability measure. [17] MSCI KLD 400 Social Index considers

[16] We thank an anonymous referee for pointing out this. In the earlier version of the paper, probabilities were calculated using just the estimates from the first stage.
[17] https://www.msci.com/resources/factsheets/index_fact_sheet/msci-kld-400-social-index.pdf

large, mid and small cap companies in the MSCI US IMI Index. MSCI KLD 400 Social Index rate companies in seven categories: community, corporate governance, diversity, employee relations, environment, human rights and product. We extracted sustainability ratings of 4613 companies between 1991 and 2013.

We collected company financial information from the Wharton Research Data Services' COMPUSTAT dataset. We focused on the North American sample of COMPUSTAT. We obtained 12,458 firm–year observations, after the companies with revenues less than 50 million USD are dropped. We extracted total assets; total stockholders' equity, revenue, net sales, net income, and market value for 2,371 companies between the fiscal years 1991 and 2013.

Out of 2371 companies 657 companies are both in the COMPUSTAT and the MSCI KLD 400 Social Index data sets. Thus, we obtained an unbalanced panel of 657 companies over the years 1991–2014. We excluded companies with roa≤-2 and roa≥2 so that outliers do not contaminate the results. We restricted the sample by excluding companies with leverage>2 over the sample period. We further restricted the sample between the years 1999-2014 to ensure the continuity of the time series.

COMPUSTAT provides Standard Industrial Classification (SIC) code information on the primary line of business for each firm. Since sustainability initiatives are industry specific, a comparison of companies in different industries such as agriculture, forestry, and fishing, mining, construction, manufacturing, wholesale trade, retail trade, finance, insurance, and real estate and services is not adequate. Besides sector specific sustainability practices financial institutions have idiosyncratic financial reporting practices, which further complicates a comparison of the companies. We restricted the sample to manufacturing firms to ensure that the companies in the sample are comparable in terms of sustainability and financial performance and operationalized subindustry by using the two digits SIC codes.

We obtained a balanced panel of 587 manufacturing companies over the years 1999-2014. Since the data for the independent and dependent variables are collected from two completely different sources, common method bias does not affect the analysis.

### *4.2. Variables*

We need to evaluate the influence of competition and spillover on the likelihood of entering the sustainability market. We assume that companies which are graded by MSCI KLD 400 Social Index have decided to enter the sustainability market and construct a binary variable, which is denoted as *entry* and is the empirical equivalent of $x_i$.

Since not all sustainability initiatives are independent from the industry characteristics, we can deduce that competition level regarding sustainability might be influenced indirectly by the competition level in the goods or/ and services market. We operationalize the sustainability competition as the number of companies in MSCI KLD 400 Social Index for given industry and year, whereas the company itself is excluded. We denote the variable as *number_of_competitors*, which corresponds to $\boldsymbol{x}_{N/i}$ in the empirical model.

Since past sustainability decisions, firm size, financial performance, R&D intensity and advertising intensity can influence the sustainability decisions of the companies, we consider them as control variables. These control variables are the empirical counter part of the set of k state variables, $S_i = (s_1, \ldots\ldots, s_k), \forall i = 1, \ldots, n$. We incorporate past years' sustainability decision and denote the variable as *past_entry*. Furthermore, we control whether or not a company enters the sustainability market for the first time. We denote the related variable as *first_time_entry.*

We also include company size into the analysis as a control variable. To be able to compare companies which are in labor intensive versus capital/technology intensive industries, we consider the variables; number of employees, total revenue in million dollars and total assets. Due to missing values in the data, adding the control variable, natural logarithm of the number of employees into the analysis decreases the sample size and does not improve model fit. Thus, we omit this control variable from the final analysis. Since the total assets and total revenue are skewed to right, we use the natural logarithm and denote the variables as *ln_asset* and *ln_revenue.*

There is a reciprocal relationship between sustainability performance and financial performance. While RBV and stakeholder theory advocate that sustainability, performance affects financial performance positively, the slack resources theory supports the recursive relationship (Waddock et al. 1997). Firms that financially outperform their industry average have slack resources to invest in corporate sustainability activities (Surroca, Tribo, and Waddock 2010). To isolate the influence of slack resources and control for financial performance we employ leverage and return on assets as indicators of financial performance. Leverage is the ratio of debt to total assets and the related variable is denoted as *leverage*. Return on assets is the ratio of net income to total assets and the variable is denoted as *roa*.

Furthermore, since we aim to evaluate the influence of sustainability on financial performance from the stakeholder theory channel, we isolate the effect of advertisement on stakeholder returns and include advertising intensity as a control variable. In the context of sustainability research, RBV suggests that corporate sustainability initiatives are intangible resources of the firm, which promote efficiency and lead to better financial performance. To isolate sustainability from other intangible resources of the firm we control for R&D intensity, as an intangible resource. Due to missing values in the data adding the control variables advertising intensity and R&D intensity into the analysis decreases the sample size. Since qualitatively similar results were found for this data set, we do not report these results in the interest of brevity and exclude the control variables advertising intensity and R&D intensity from the final analysis reported in Section 5.

## 5. Results and Discussion

Table 1 displays the summary statistics for entry into sustainability market (*entry*), past entry into sustainability market (*past_entry*), first time entry into sustainability market (*first_time_entry*), firm size (*ln_asset, ln_revenue*), financial performance (*roa, leverage*), market share of the company (*market_share*) and market size of the industry (*market_size*). About 41.18 % of the companies in our dataset are identified as invested in sustainability at least once between 1999 and 2014. 37.59 % of the companies are first time entrants into the sustainability market. The average roa is 0.1216 %. Thus, financially good companies are not overrepresented in the sample, which might have prompted misleading results. The average market share in the data is 3.4 %, which indicates that the market is highly fragmented. We can infer that the sustainability market is a highly competitive market.

**Insert Table 1 here**

### *5.1. Evidence for Causality*

Since the dependent variable *entry* take only two values, '1'and '0', which represent outcomes invest/ not invest in sustainability initiatives, we assume that the net benefits come from a binary logit model, where the probability of a particular outcome is determined as follows:

$$P_i(\boldsymbol{x}_i = 1) = \Gamma_i\left(\boldsymbol{\vartheta} S_i + \delta E\left(\boldsymbol{x}_{N/i} \middle| \boldsymbol{S}_{N/i}\right)\right) \quad (14)$$

$$P_i(\boldsymbol{x}_i = 0) = 1 - \Gamma_i\left(\boldsymbol{\vartheta} S_i + \delta E\left(\boldsymbol{x}_{N/i} \middle| \boldsymbol{S}_{N/i}\right)\right)$$

In all the estimations in Table 2, the dependent variable *entry* indicates whether a company has entered the sustainability market or not. The explanatory variable *number_of_competitors* is calculated as the number of companies that entered the sustainability market, whereas the focal company is excluded. In Model 1, we include the control variables *past entry, ln_asset, ln_revenue, roa, leverage, market share* and *first time entry.* In Model 2, we control for the time trend effects by incorporating time variant variables in addition to the full set of controls. We calculate *trend* as the difference between the year of observation and 1998. We include the variable $trend^2$, the squared *trend*, thereby allowing a nonlinear relationship between time trend effects and *entry.* In Model 3, we run a random effects model, since the differences across companies might have some influence on the dependent variable *entry*. We incorporate the full set of controls as well as *trend* and $trend^2$. Thereby we control both for individual and time trend effects. In Model 4, we restrict the sample to companies that enter the sustainability market for the first time and control for *trend* and $trend^2$, *ln_asset, ln_revenue, roa, leverage* and *market share.*

**Insert Table 2 here**

For all specifications, we can infer that if more competitors enter the sustainability market the likelihood of the focal company entering the sustainability market will increase. This finding suggests that the spillover effects dominate the competition effect. However, it is not clear whether the spillover effects stem from the demand or supply side. As discussed in Section 2, spillovers may occur in form of improved stakeholder perception of the whole industry and all players in the industry benefit from increased demand or the implementation cost is lower for companies that imitate the competitors' sustainability initiatives. Either way the companies benefit from the spillovers without bearing the full cost of the investments, thus the likelihood of entering in the sustainability market increases compared to the likelihood of entering in a sustainability market, where no spillovers exists.

Nonetheless, this finding suggests that companies are more likely to invest into sustainability if they observe that their competitors invest into sustainability and supports that sustainability becomes the norm over course of time like any other innovation or disruptive technology. This finding is consistent with the 'sustainability dissemination' (Matisoff 2015) or 'green domino effect' (Unruh 2010). However, to measure the casual effect of competition, we need to assure that the coefficient of the number_of_competitors is an unbiased estimator of sustainability competition.

### *5.2. Correcting for Endogeneity Bias with IV Model*

The analysis in Table 2 does not indicate a causal relationship. In other words, we do not observe the likelihood of a company entering the sustainability market, if all else being equal, N+1 companies compete in the sustainability market instead of N companies. Thus, the models in Table 2 do not provide a measure of the causal effect of competition on the entry decision into the sustainability market. They rather exhibit an association between the number of competitors and the likelihood of entry in the sustainability market.

To control for the endogeneity in the relationship, the IV method can be used. If there is an observable instrument, that affects sustainability decisions of competitors, but is uncorrelated with the unobserved factor affecting the sustainability decision of the focal company, then an IV estimator based on this instrument will yield a consistent estimate of the number of competitors on the likelihood of entering into the sustainability market. Assuming the number of competitors in the market is fixed, an increase in the industry size would increase the expected revenue, which makes the entry of the focal company into the market more likely. Bresnahan and Reiss (1991a; 1991b) note that market size is highly correlated with the number of firms in a market. Berry and Waldfogel (1999) use market size as an instrument for the number of firms. We employ the natural logarithm of total market revenue (*market_size*) as a measure of industry size and use it as an instrument. This IV measure, though may not be the ideal instrument, still has the potential to correct some of the endogeneity in the relationship.[18]

[18] The first stage of the IV estimates indicates a significant association between the number of competitors and the market size variables. The corresponding F–statistics is significantly high. Also, the Wald test of exogeneity employed produces 4.95 for the chi–squared (1) with the corresponding p–value of 0.026.

In table 3 we employ *market_size* as a measure of industry size and use it as an instrument. This estimation is presented in column 2 in Table 3. In column 1, we restate the result with endogeneity. We see from the results; in the IV specification the coefficient of the competition is not positive and significant as the logit estimation suggested. The negative and significant relationship between the likelihood of entry and number of competitors indicates that the effect of competition dominates spillover effects. The first stage of the IV estimate indicates a significant association between the number of competitors and the market size variables. The corresponding F-statistics is significantly high. Also, the Wald test of exogeneity employed for IV produce 17.07 for the chi-squared (1) with the corresponding p-values of 0.000.

Since the focal company makes the entry decision conditional on the actions of its competitors, if the unobserved factor affects the sustainability decision of the focal company as well as the sustainability decisions of its competitors positively, then the coefficient of the *number_of_competitors* will be upward biased. As seen in Table 3, when the IV approach is implemented[19], the coefficient of the explanatory variable, which is significant and positive in Model 2, becomes negative and significant. We interpret this result as an evidence of endogeneity in the logit results and therefore the true coefficient can be in fact negative.

**Insert Table 3 here**

Compared to Model 2 in Table 3, the IV result indicates that the coefficient has a negative sign as the literature would suggest about the effect of competition. The endogeneity due to the strategic interactions leads to the upward biased in the logit estimates, and we obtain the positive

[19] In Stata IV–probit is implemented where the variable number_of_competitors is instrumented with the market revenue.

coefficients in Table 2. To further investigate the endogeneity in the estimation we therefore need to incorporate the strategic interaction into the analysis.

### *5.3. Correcting for Endogeneity Bias with Static Model of Strategic Interaction*

We assume static competition and employ the multi – stage analysis described in Section 3. We take the estimates of the equilibrium choice probabilities $\hat{P}_i(x_i|\boldsymbol{S})$ from the first stage as given and form an estimate of the choice specific net benefit function $\widehat{\Pi}_i(x_i = 1|\boldsymbol{S}) - \widehat{\Pi}_i(x_i = 0|\boldsymbol{S})$. This can be done by evaluating equation (10) using $\hat{P}_i(x_i|\boldsymbol{S})$ instead of $P_i(x_i|\boldsymbol{S})$. In the case of the binary logit model the inversion follows as:

$$\widehat{\Pi}_i(x_i = 1|\boldsymbol{S}) - \widehat{\Pi}_i(x_i = 0|\boldsymbol{S}) = \log(\hat{P}_i(x_i = 1|\boldsymbol{S})) - \log(\hat{P}_i(x_i = 0|\boldsymbol{S})) \quad (15)$$

under the assumption that the preference shock has an extreme value type I distribution. We need covariates that influence the net benefits of a particular company, but not other companies.[20] The covariates include past sustainability performance (*past_entry*, *first_time_entry*), firm size (*ln_assets, ln_revenue*) and financial performance (*roa, leverage*).

We obtain consistent estimates of the probabilities in the first stage. After recovering the estimate of $\hat{P}_i(x_i|\boldsymbol{S})$ and estimate of choice specific net benefit function $\widehat{\Pi}_i(x_i = 0|\boldsymbol{S})$, we use the empirical analog of equation (11) to form an estimate of $\Pi_i(x_i, \boldsymbol{x}_{N/i}, S_i)$ and recover structural parameters. We iterate twice to get the firm entry probabilities The identification depends crucially on applying appropriate exclusion restrictions. The recovered probabilities are plugged into third step incorporating the competitive interaction which is operationalized as *market_share*. Thereby, we estimate the causal effect of competition on the likelihood of entry in the sustainability market consistently.

[20] In general, this is not required for the model identification but incorporating an extra variable into the estimation, that supplies independent variation for each company will make the identification easier. Otherwise the model is identified depending on a functional form.

As discussed in Section 2 increasing competition decreases the likelihood of investing in sustainability and will manifest itself as a negative and significant coefficient. However, due to the spillovers, the effect of increasing competition on net benefits is not that clear. Spillovers occur in the form of 1) decreased initial investment costs due to imitability of sustainability investments, which are generally not protected by patents and 2) improved stakeholder perception towards the whole industry, which results in increased revenues. Regardless of the channel —revenue increase or cost reduction —spillovers increase the expected net benefits, which in turn increases the likelihood of entry. If the spillover effect dominates the competition effect, we expect to obtain positive and significant coefficients.

In Table 4, the results of the three-step estimation are presented. We control for unobserved heterogeneity in several ways. First, in all specifications, we include a full set of firm and year fixed effects to control for factors that remain fixed in a year that influence sustainability decisions of companies. Second, we control for unobserved heterogeneity using both fixed effects and random effects specifications. When we substitute the recovered probabilities into the third step, we observe that the coefficient of the explanatory variable is negative and significant. Recall that, it is positive and significant in the logit estimation (Table 2) and negative and significant in the IV estimation (Table 3). While the IV estimation corrects for the endogeneity bias to some extent, incorporating strategic interactions yield unbiased results. The negative and significant relationship between the likelihood of entry and number of competitors indicates that the effect of competition dominates spillover effects.

As proposed in Section 2, competition increases the cost of market entry, while spillover effects decrease these costs. Since sustainability initiatives, which are easy to implement are prone to disseminate to all market participants, we would observe the effect of spillovers if it were substantial. The comparison of Table 4 to Table 2 verifies that employing *number_of_competitors* as explanatory variable leads to upward biased results. Thus, considering the effect of competition and spillovers as ex ante measures of market entry becomes important.

**Insert Table 4 here**

According to the bandwagon effect companies see sustainability investments as necessity due to market share even though they might not benefit financially in the short term. Lourenco et al. (2012) present empirical evidence that if firms with a lower level of sustainability are profitable, market penalizes larger firms more. Managerial implication of this finding is that companies do not invest in sustainability out of necessity. Cassimon, Engelen, and Van Liedekerke (2016) point out that companies relying solely on the net present value or cost–benefit approach, which ignore the strategic value of sustainability investments, often decide not to invest into sustainability. We observe a negative effect of number of competitors on the likelihood of entry only when controlled for strategic interactions and infer that for sustainability innovations the bandwagon effect is supported.

We document that market share influences the likelihood of entry into the sustainability market negatively. According to Hofer, Cantor, and Dai (2012) more productive companies see less a need to invest in sustainability to gain superior financial performance. Soytaş, Denizel, and Uşar (2019) present empirical evidence that more productive firms have higher marginal costs of sustainability and point out it is costlier for productive companies to change, since the way operate is well established. Similarly, companies which have established market share are likely to see less a need to invest in sustainability.

We document that first – time entry into sustainability decreases the likelihood of entry, hence we infer that initial sustainability investments are costly due to competition. As seen in Model 1, Model 2 and Model 3 the variable *past_entry* increases the likelihood of entry, whereas the variable *first_time_ entry* decreases the likelihood of entry. Moreover, we refine our analysis by restricting our sample to the companies which enter for the first time. The change in the coefficient in Model 4 reveals that the first – time entry of a company decreases the likelihood of entry at a noticeably, which suggests that initial investments are costly and act as market entry barriers. This finding it is consistent with the corporate immune system concept in corporate entrepreneurship literature (Birkinshaw et al. 1999) and Eccles, Ioannou, and Serafeim (2014) remark on corporate inertia in the strategy literature.

Entry decision into the sustainability market is a strategic decision and creates selection bias. As seen in Table 2 due to selection bias, the results are biased upwards and overestimate the true relationship between number of competitors and likelihood of entry. The multi– stage model intents to correct the selection bias and we document that the number of competitors affect the likelihood of entry negatively. However, a limitation of multi– stage models is that the researchers might be over–controlling for differences across firms by controlling for the likelihood to invest into sustainability and then only examining within–firm changes over time, which might lead to incorrect negative or insignificant findings (Matisoff 2015). To show that over–controlling is not a concern, we perform robustness check.

### ***5.4. Robustness***

We allow for a more flexible first stage, to evaluate whether the presence of competition effect is robust. We replicate the estimations in Model1 to Model4 in Table 4, using the probabilities recovered from a semiparametric first stage instead of the parametric first stage used in the main estimation and estimate the same effect for the specifications in Table 5. The results indicate a robust negative relationship between competition and the likelihood of entry into the sustainability market.

**Insert Table 5 here**

## 6. Conclusion

This paper investigated how a game–theoretic framework can aid in the construction and estimation of interrelated choice models in the corporate sustainability context. The first contribution of this paper consists of presenting a new coherent econometric model that incorporates the possibility of the competitors' actions having an impact on the sustainability decision of the focal company. Like classical industrial organization research, we have explored how the number of firms in the sustainability market, firms' sizes, their financial positions, and potential competitors affect market entry. When strategic interactions are not accounted for, we find that the increase in the number of competitors rises the likelihood of sustainability investments, seemingly shows the spillover effect dominates the competition. However, when we control for the strategic interaction of sustainability, the relationship between number of competitors and the likelihood of entry into the sustainability market becomes negative. As the second contribution, we applied a multi – stage estimation approach, which incorporates competitive interaction structurally into the estimation and document that competition hurts the likelihood of entry into the sustainability market. Our analysis demonstrates that using the number of competitors as a measure for competition without controlling for the strategic interactions does not capture the pure competition effect. Instead it captures an effect that is contaminated with both competition and spillover, i.e. endogeneity due to the strategic interactions shadows the coefficient estimate of competition and produces an upward biased coefficient if strategic interactions are not controlled. With the multi- stage estimation framework only, this 'causal' effect of competition in the sustainability market can be estimated. The results demonstrate that our findings are aligned with the conventional effect of competition on market entry.

The practical contribution of this research is to understand how strategic interactions of firms' sustainability decisions affect the overall sustainable initiatives. This new game theoretic formulation incorporates competition through strategic interactions where a novel model with the firm sustainability activities are viewed as a market entry game. In this setup, single firm's entrance to the sustainability market is rewarded as a function of the other firms' sustainability decisions. With this new view, companies' sustainability decisions are not only based on the isolated cost benefit analysis but also are affected by the sustainability decisions of competitor companies. Firms might decide to invest in sustainability to gain competitive advantage in the long–term regardless of the financial return in the short–term. We believe modelling sustainability decisions as market entry decisions, and therefore conceptualizing sustainability as a 'market' has the potential to contribute to the growing literature on sustainability and modeling the strategic interactions between the firms. In fact, a way to promote sustainability is by undertaking market wide policies to curb negative effect of competition rather than focusing on individual firms that are lagging in their sustainability performance.

We provided empirical evidence that the effect of competition on the likelihood of entry into the sustainability market dominates the effect of spillover. Furthermore, this finding is more profound for the first–time entrants. Classical industrial organization research has well established that in the case of fierce competition it is more beneficial for companies to resort to product differentiation instead of price regulation (Motta, 2004). Similarly, in the sustainability market companies have to differentiate their sustainability initiatives. This study encourages companies to invest in sustainability investments that are unique to them such as process improvements instead of easily imitable initiatives with high spillover effects. An implication of this result to production researchers is that they should address how companies can make unique product and process changes to incorporate sustainability in their production activities. This will not only increase sustainability performance of companies, but it will also help them be more competitive.

This result also has substantial regulatory policy implications for production sustainability outcomes where the market regulator influences the cost. Based on the assumption that policy makers would aim to increase the sustainability outputs of the entire sector, they will be expected to support initiatives that will transform the whole sector. However, there may be resistance from companies to invest in such sustainability investments. For this reason, public policy makers should consider giving incentives to companies to compensate the negative influence of competition on the total sustainability outcome of the market. Therefore, higher sustainability outcome without increasing the cost just can be achieved by market-based policies targeted correctly. In addition, policy makers should arrange incentives for first-time entrants, so that they can overcome market entry barriers imposed by incumbent firms.

This study has some limitations, as with any study. We model firms' sustainability decisions as static decisions; our econometric estimation assumes the market entry game is played only once. Whether the strategic decisions of firms related to sustainability are better modelled as static or dynamic decisions is debatable. The past decisions of the firms are important determinants of the current decisions, however whether this dependence qualifies for a path to model the process as a dynamic process is an open research question. Thus, future research questions arise such as the formalization of sustainability interactions in a multi period model since investments in sustainability might have dynamic effects over time, which the static model does not capture. Moreover, the decomposition of latent profits into revenue and costs components would provide a better understanding of how strategic interactions influence the sustainability decisions and what kind of sustainable actions lead to superior financial outcomes. Furthermore, we have modelled the strategic sustainability interactions from a non-cooperative viewpoint, however the sustainability decisions of companies are also heavily affected from the supply chain partners. For future research, there is a need to develop an integrated model which incorporates both the effect of competitors and supply chain partners. However, this is not an easy task since supply chains have become intertwined and an upstream supplier can be both a supplier and a competitor to the focal company (Dolgui et al. 2020). We believe that strategic sustainability interactions have high potential for further exploration and conceptualizing sustainability decisions as market entry decisions creates a potential tool to investigate similar problems with different datasets.

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

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