CORPORATE SUSTAINABILITY INTERACTIONS AND CORPORATE FINANCIAL PERFORMANCE

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CORPORATE SUSTAINABILITY INTERACTIONS AND CORPORATE FINANCIAL PERFORMANCE

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To my lovely daughter Defne…..

ABSTRACT

There is a large amount of empirical literature focused on the relationship between corporate sustainability and corporate financial performance. Given the mixed results it is hard to evaluate whether sustainability investments have a positive impact on financial performance or companies with good financial position invest in sustainability initiatives to acquire consumer and regulatory goodwill. Modeling errors, measurement issues and endogeneity in the relationship can hinder the discernment of the relationship immediately.

I view the sustainability decisions of companies as strategic decisions and propose a Stackelberg game to model the effect of competition and sustainability spillovers on sustainability interactions between companies. I solve the model analytically and rely on computational methods to analyze the effect of competition and spillover on sustainability initiatives, net benefits and total sustainability outcomes of the market. During the course of the computational experiments I identify the conditions, when the first mover advantage or the second mover advantage arises. The analytical model suggests that the leader has the first mover advantage only for low spillover rates. As spillover increases the leader is compelled to decrease her sustainability level in order to prevent the followers to free ride the leader’s sustainability efforts and defend her position against the followers. Moreover, the first mover advantage is more defendable as the competition level increases. However, for most of the competition and spillover combinations the followers benefit more than the leader. I turn to empirical methods in order to validate the inferences made from the analytical model.

Due to computational complexity, instead of the level of sustainability initiatives I employ the binary variable representing whether the company has invested in sustainability as dependent variable. I estimate the parameters of the discrete choice model using the social performance ratings from MSCI KLD 400 Social Index and financial information from Wharton Research Data Services' COMPUSTAT dataset. Although the interdependence of discrete entry decisions can pose identification and estimation problems, I provide 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. For the first time entrant it is more costly to adopt sustainability initiatives. The possible cause can be internal as well as external to the company. Similar to new technology adoption, sustainability adoption can be met with resistance due to corporate inertia or new entrants' struggle to overcome the market barriers set by incumbent companies.

The combination of analytical solution to the model and parameter estimation provide insight on how companies view sustainability decisions. Companies have to consider the actions of their competitors as well as the costs and benefits associated with taking sustainability initiatives.

Key Words: Corporate sustainability, Strategic interactions, Market entry, Stackelberg game, MSCI KLD 400 Social Index ratings

ÖZET

Sürdürülebilirlik ve finansal performansı inceleyen ampirik pek çok çalışma olmasına rağmen elde edilen bulguların çelişkili olması sebebi ile bu ilişki tam olarak anlaşılamamıştır: Sürdürülebilirlik finansal performansı olumlu etkilemekte midir yoksa finansal olarak güçlü firmalar, tüketiciler ve denetleyici kurumlar nezdinde itibar kazanmak için sürdürülebilirliğe yatırım yapmakta mıdırlar? Literatürdeki çelişkili bulgular ölçümleme ve modelleme hatalarından kaynaklanabileceği gibi tahmin edilmek istenen ilişkide bulunan içselliğin doğru şekilde kontrol edilememesinden de kaynaklanabilir. Ancak kanımca en önemli sebep sürdürülebilirlik ve finansal performans ilişkisini etkileyen firma kaynaklı etkiler dikkate alınırken rekabetin bu ilişki üzerindeki etkisinin analizlerine dâhil edilmemesidir.

Bu sebep ile firmaların sürdürülebilirlik kararlarını stratejik kararlar olarak ele alıp, rekabetin ve yayılma etkisinin firmalar arasındaki sürdürülebilirlik etkileşimlerini nasıl etkilediklerini anlamayı amaçlıyorum ve firmalar arasındaki sürdürülebilirlik etkileşimlerini Stackelberg oyunu olarak modellemeyi öneriyorum. Önerdiğim modeli analitik olarak çözdükten sonra, rekabetin ve yayılma etkisinin, firmaların sürdürülebilirlik girişimlerine, sağlanan net faydaya ve pazarda meydana gelen tüm sürdürülebilirlik girişimlerine etkisini analiz etmek için sayısal yöntemlere başvuruyorum. Bu sayısal deneyler ile ilk hamle ve ikinci hamle avantajlarının oluştuğu koşulları saptıyorum. Analitik modele göre pazar lideri ancak düşük yayılma etkisi olduğunda ilk hamle avantajı yakalayabilmektedir. Yayılma etkisi artıkça pazar lideri yapmış olduğu sürdürülebilirlik girişimlerinden takipçi firmaların faydalanmalarını engellemek için ve kendi pozisyonunu korumak için sürdürülebilirlik girişimlerini azaltmaktadır. Ayrıca, rekabet artıkça pazar liderinin ilk hamle avantajını koruması

kolaylaşmaktadır. Ancak, çoğu rekabet ve yayılma etkisi değerleri için takipçi firmalar lider firmaya göre daha çok fayda sağlamaktadır.

Analitik modelden yapmış olduğum çıkarımları doğrulamak için ampirik yöntemlere başvuruyorum. Hesaplama karmaşıklığı sebebi ile tahminlerde bağımlı değişken olarak firmaların sürdürülebilirlik yatırımlarının değerleri yerine sürdürebilirliğe yatırım yapıp yapmadıkları bilgisini içeren ikili değişken kullanıyorum. Ayrık seçim modelindeki değişkenleri tahmin etmek için sürdürülebilirlik ölçütü olarak MSCI KLD 400 Social Index'i ve finansal bilgiler için Wharton Research Data Services' COMPUSTAT veri setini kullanıyorum. Ayrık seçim modelinde firmaların arasındaki karşılıklı bağımlılık özdeşleştirme ve tahmin etmede sorun teşkil etse bile rekabetin yayılma etkisine göre sürdürülebilirliğe yatırım yapma olasılığını daha çok etkilediğine dair ampirik kanıt sunuyorum. Ayrıca, bu bulgunun ilk defa sürdürebilirliğe yatırım yapacak firmalar için daha şiddetli olduğunu gözlemliyorum. Bu bulgu ilk defa sürdürebilirliğe yatırım yapacak firmalar için sürdürülebilirlik yatırımlarının daha maliyetli olduğuna işaret etmektedir. Olası sebep ise şirket içi ve ya şirket dışı olabilir. Yeni teknoloji adaptasyonlarına benzer bir biçimde sürdürülebilirlik de kurumsal direnç ile karşılanabilir veya yeni firmalar yerleşik firmalar tarafından konulmuş piyasa engellerine takılabilir.

Analitik modelin çözümü ve ampirik modelin tahmini ile elde edilen bulgular firmaların sürdürülebilirlik kararlarını stratejik kararlar olarak gördüklerini ve bu kararları verirken sadece kendi kar zarar hanelerine bakmadıklarını, rakip firmaların sürdürülebilirlik kararlarını da dikkate aldıklarını söylemektedir.

Anahtar Kelimeler: Kurumsal sürdürülebilirlik, Stratejik etkileşimler, Pazara giriş, Stackelberg oyunu, MSCI KLD 400 Social Index dereceleri

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CHAPTER I

INTRODUCTION

The Bruntland Report defines sustainable development as "a development that meets the needs of the present without compromising the ability of future generations to meet their own needs"[1]. John Elkington introduces environmental, social and economic dimensions of sustainable development into consideration and originates the term *triple bottom line* (1). According to this view, a company can achieve sustainable development only when it can satisfy environmental quality, social justice, and profitability simultaneously (2). To achieve triple bottom line, companies undertake sustainability initiatives, which are processes and practices that are created, modified or revised to mitigate and improve social and environmental impact of businesses (3). Examples of sustainability initiatives 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 (4).

As stakeholders' awareness towards environmental and social sustainability increases, more and more companies prefer to commit to sustainability. Companies that choose to undertake sustainability initiatives incur costs as well as gain benefits from adopting. Practitioners and academicians alike ponder whether corporate sustainability investments lead to triple bottom line or just add to companies' costs. Thus sustainability research becomes more relevant. Literature review papers such as (5), (6), and (7) asses the publications addressing the impact of sustainability on financial performance and document an increase in the number of publications over the years.

[1] Report of the World Commision on Environment and Development: Our Common Future published by United Nations in 1987

Early stages of the theory and research on corporate sustainability primarily involve the identification of sustainability initiatives and the conceptual links between corporate sustainability and financial performance (8). There are different views on how sustainability initiatives generate superior financial performance (9) (10). On the one hand stakeholder theory (11) (12) suggest that sustainability initiatives such as engaging in product differentiation regarding environment- friendly characteristics, signaling corporate citizenship or communication of commitment to sustainability to consumers will lead to increased reputations and market shares, which in turn will enhance the financial performance (13) (14). On the other hand, according to the resource- based view of the firm (15) sustainability initiatives might lead to cost advantages since they improve processes and practices of a company (16) (17) (18).

The literature seeks to make a general statement based on empirical analysis. There are a few academic papers that address this question causally and the results from the studies investigating association are mixed (19) (20). I focus on the literature including empirical evidence of causality on financial performance and evaluate publications not only in terms of their data sources, research methods and results but also whether they address endogeneity. The empirical findings do not converge, however, and the direction of this link remains open to further investigation (21). (22) has reviewed 167 studies published between 1972 and 2005 and report that 28% of the studies find a positive, 2% of the studies find a negative, and %59 of the studies find inconclusive relationship between corporate financial performance and corporate sustainability performance. (23) has reviewed 128 studies drawn from academic sources and 31 studies drawn from practitioner literature, which are published between 1972 and 2008 and 2001 and 2008, respectively. 63% of the studies find a positive relationship between corporate sustainability performance and corporate financial performance, while 15% of studies report a negative relationship, and 22% report a neutral or mixed relationship. While (22) considers the reciprocal relationship between corporate sustainability performance and corporate financial performance, (23) is only concerned with the causal effect of CSP on financial performance. Since their focus is different, the publications they include in their sample are different as well leading to very different results.

I conducted a systematic review of publications between 2007-2017, which yielded 28 studies. 19 of the studies find a positive relationship between sustainability and financial performance, 6 of the studies find a negative relationship and 3 studies report inconclusive results. Some results are not conclusive and some present methodological restrictions (21). Modeling errors, measurement issues and endogeneity in the relationship can hinder the discernment of the relationship immediately. Two important aspects in this line of inquiry are the company characteristics and the reverse causality channel. Companies with certain characteristics are more likely to adopt sustainability and become more profitable. The reverse causality channel points out that companies which were profitable in the previous years have more resources and are more likely to invest in sustainability. Two interrelated problems have to be addressed: a selection problem generated by the relationship between the unobserved firm characteristics and the sustainability investment decision; and a simultaneity problem generated by the relationship between sustainability investment decision and financial performance (24).

The most rigorous quantitative evaluations of sustainability policies use a two-stage approach- the first stage controls for the self-selection of sustainability adoption of the firm through an instrumental variable (25), (3) or a matching approach (26), while the second stage compares the sustainability performance of adopting firms against nonadopting firms. When controlled for the firm-specific time-invariant unobserved heterogeneity the results yield a positive relationship. I believe that these results are sufficient to conclude, that the firms those implement policies for sustainable development are not just adding to their costs and are moving towards the triple bottom-line despite the costs.

Sustainability research uses MSCI KLD 400 Social Index dataset[2], CSRHUB[3], GRI (Global Reporting Initiative)[4], Dow Jones Sustainability Index[5] or similar datasets for analyzing the sustainability efforts and ratings of the firms. There is a fairly sizable empirical literature on the determinants of the sustainability score of the firms using MSCI KLD 400 Social Index[6]. Since MSCI KLD 400 Social Index is reviewed on a quarterly basis, it is mostly assumed that the companies in the dataset at the beginning of the fiscal year are in the dataset because of the fundamental economic/sustainable actions that they have taken in the year before. However, a framework based on this assumption lacks the consideration for competitive factors affecting sustainability decisions and the possibility of strategic interactions between the firms.

I consider that this might be an important oversight when the sustainability initiatives are being taken by the firms. I introduce the concept of sustainability market, which is the "competitive" environment that can award or penalize firms according to whether they perform sustainable actions or not. I refer to the situation that a firm undertakes significant amount of sustainability related activities as the single firm's entrance into the sustainability market. The entry into the sustainability market is highly

[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] The MSCI KLD 400 Social Index is a market cap weighted stock index of 400 publicly-tradedcompanies that have met certain standards of social and environmental excellence. Read more: https://www.msci.com/documents/10199/af2f3499-c8fe-497c-afde-4f2fc82465bf

valued by the stakeholders: it can reduce production cost, improve workplace productivity, and potentially increases the financial returns (if the return to sustainability is positive). But the firm's collection of the returns from the sustainability efforts depends on whether the competitor/fellow firms also perform same/similar or different sustainable actions. Therefore, the sustainability return of the single firm in a particular year is a function of the other firms' sustainability decisions. 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.

As stated by (27) the more important question becomes not whether sustainability translates into abnormal profits but instead when and under what circumstances. Both conceptually and empirically the literature views sustainability adoption mostly from a micro perspective, whereas companies make these decisions in a macro business environment. (28) also points out to the paucity of research incorporating the effect of competition on implementation of environmental management (EM) activities. They advocate that EM has strategic and competitive importance and present empirical evidence that firms compete in terms of EM activities. Similarly, I advocate that sustainability actions of a company impacts its marketplace and vice versa. Since I aim to shed light on how strategic interactions between companies affect their sustainability actions, I propose a game theoretical base for sustainability interactions.

I utilize a demand function such that the net benefit of each company depends on both her and the competitor's level of sustainability initiatives. The strategic interaction is modeled as a sequential game, where at the first stage the leader chooses the level of sustainability and at the consecutive stages the followers choose their level of sustainability initiatives. Companies compete for stakeholder payments, which include all incentives provided to sustainable companies by stakeholders such as increase in demand, willingness to pay a price premium, tax benefit or better financing opportunities. Furthermore, I assume that there are sustainability spillovers among companies.

Since sustainability is a multidimensional construct, it is likely that investment in different dimensions will have different effects on the overall competition in the market (29). On the one hand, if the sustainability efforts of a company lead to an improved stakeholder perception of the whole industry, there may be sustainability spillovers and other companies may free ride the sustainability efforts of the leader company. On the other hand if a company imitates the competitors' sustainability initiatives, the implementation cost for that company will be lower compared to the competitors' costs. The follower benefits from the spillovers without bearing the full cost of the investments and again that company free rides the sustainability efforts of her competitors.

I develop a 2 period- sequential single leader-multiple follower game to model the effect of competition level and spillover rate on the sustainability outcomes and net benefits of the leader and followers. I examine how the leader's sustainability efforts affect the followers' sustainability activities for different competition level and spillover rates and identify the conditions, when the leader attains first mover advantage and the followers attain second mover advantage with the help of numerical examples. Furthermore, I show the effect of competition and spillovers on the total sustainability outcome of the market. The results regarding the total market sustainability outcomes provide an important basis for policy makers in design and reinforcement of regulations regarding sustainability.

The decision on sustainability adoption in an oligopolistic market has not been estimated yet. Similar problem formulations have been suggested in a wide variety of settings such as decision on market entry (30), labor force participation (31) (32), long-term care and family bargaining (33) (34), auctions (35) (36), technology adoption (37). I draw parallels with the research stream of market entry and technology adoption models and adapt the framework by (38) to the sustainability context. According to (38) since the companies will compete for the market shares, the entry of a competitor *j* into the market decreases the net benefit of the focal company *i* and predicts the influence of competition on the likelihood of entry as negative. The influence of the competitor's entry into the virtual market of sustainability should be approached cautiously. For sustainability interactions the influence of competition depends both on the competition level and the spillover rate. Thus there is a need to consider the sustainability decisions of companies as strategic interactions and the estimation of the sign of the coefficient becomes an important question.

This thesis is organized as follows. Section 2 presents a comprehensive literature review on related areas. Section 3 develops the theoretical basis for analyzing the influence of competition on sustainability actions and financial outcomes, introduces the game theoretic models which allow the sustainability actions to be interdependent among the firms and discusses the results of the computational experiments and their implications. Section 4 discusses the parameter estimation strategy of the strategic interaction model of sustainability decisions and describes the data. I use social performance ratings from MSCI KLD 400 Social Index[7] and financial information from Wharton Research Data Services' COMPUSTAT dataset. Section 5 concludes with future plans.

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[7] https://www.msci.com/resources/factsheets/index_fact_sheet/msci-kld-400-social-index.pdf

CHAPTER II

CORPORATE SUSTAINABILITY AND CORPORATE FINANCIAL PERFORMANCE: LITERATURE REVIEW

In this section I present a brief theoretical base on the relationship between the sustainability performance and financial performance. Then I focus on the literature on identifying empirical evidence of causality on financial performance. Subsequently, I review studies modeling strategic interactions regarding sustainability activities.

2.1. Corporate Sustainability: Theory

In the literature, there are different theories and results on the mechanism and the direction of the sustainability and financial performance link. There are two categories of mechanisms for explaining the causal direction, which advocates that superior sustainability performance leads to better financial performance. (9) explains the relationship between sustainability and financial performance with "cost savings" and ''market gains'' mechanisms, while (10) explain the relationship from cost-based and demand-based views. The cost- based view advocates that firms undertaking sustainability initiatives enjoy cost savings by lowering their cost structure, avoiding environmental fines and liabilities, and becoming more productive due to reduced energy and material consumption. The demand-based view points out that the companies exploit business opportunities induced by stakeholder demands for better sustainability performance (9) (10). While the cost-based view is aligned with resource based view (RBV) of the firm, the demand-based view relates to the stakeholder theory.

RBV of the firm suggests that intangible resources enhance the performance of the firm (15). Corporate sustainability practices combined with certain complementary assets such process innovation and implementation provide cost advantage, which enables companies to have superior financial performance compared to their counterparts, which do not engage in such activities (16). According to (17) the resource-based view of the firm suggests that companies' complementary resources and capabilities are critical to implement sustainability practices that lead to competitive advantage. (18) move ahead and suggest that corporate sustainability initiatives are intangible resources of the firm, which promote efficiency and lead to better financial performance.

Stakeholder theory claims that stakeholder preferences and orientation drives the firm's financial performance (11) (12). Undertaking corporate sustainability activities enable companies to meet the needs of various stakeholders like employees and customers, which in turn enhance the companies' reputation (13). (14) state that firms engage in sustainability initiatives voluntarily in order to improve their corporate image and relations with stakeholders. Using stakeholder theory (13) propose that favorable sustainability performance leads to favorable financial performance.

The slack resources theory supports the opposite causal direction (39). Firms, which financially outperform their industry average, have slack resources to invest in corporate sustainability activities (40). Due to the cost associated with sustainability activities and the uncertainty of their returns, it is expected that companies with slack resources are more likely to invest in sustainability (41). (42) show that financial performance (returns on assets and Tobin's q) has strong positive effects on sustainability performance (inclusion in Dow Jones Sustainability Index) and present empirical evidence supporting the slack resources theory.

Institutional theory claims that institutional environment can strongly influence the development of formal structures in a firm (43) (44). In the context of this work, regulatory, market, social and ownership pressures might induce or deter the adaptation of sustainability, corporate social responsibility or environmental activities of a firm (18). The level of economic development of the country affects the sustainability performance (45) and the financial performance (46).

To sum up, RBV and stakeholder theory both led researchers to conclude that corporate sustainability affects corporate financial performance positively, but the synergies at work are different. The subscribers of slack resources theory suggest that high corporate financial performance generates favorable corporate sustainability. However both theory and empirical research in the area point out a reciprocal relationship affected by institutional environment constraints as seen in Figure 1.

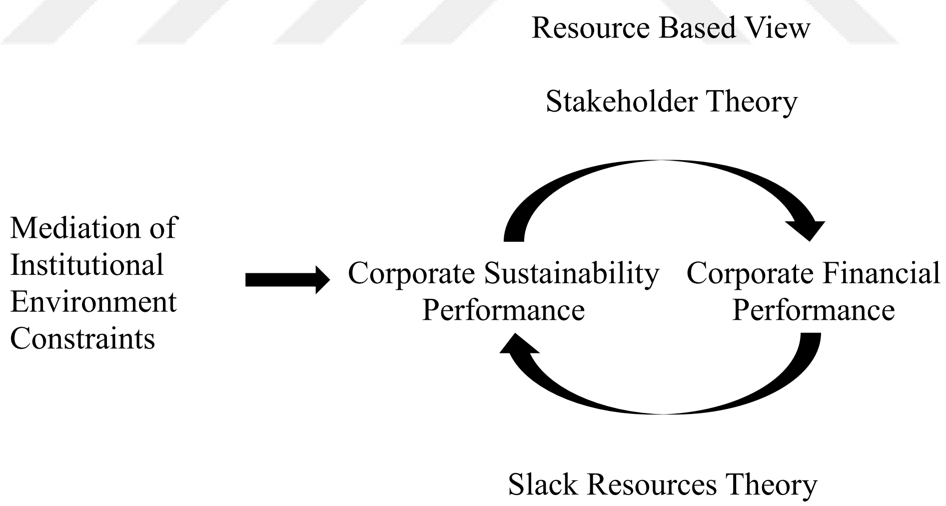

Figure 1: Reciprocal link between corporate sustainability and corporate financial performance

2.2. Corporate Sustainability and Financial Performance: The Empirical Evidence on the Direction of Causality

In this section, I summarize the empirical methods used to evaluate corporate sustainability and financial performance, and present the main findings. Much of the existing empirical literature studies the link between sustainability and financial performance (19) (20). I choose to collect the literature from ISI Web of Knowledge (Web of Science) online database due to its comprehensiveness, since it includes titles from Emerald, Elsevier, Springer, Willey, Taylor & Francis, JStor, among others. I use the following filters: (1) topic: corporate sustainability (2) topic: corporate financial performance (3) year: 2007-2017. The query yielded 571 publications. I restrict the first reading of the papers to title and abstract with the objective of excluding the papers without relevance to present research. I include papers only if the full paper is available. I am confident about the depth of my analysis, since all papers have been read thoroughly and special attention has been given to the source of data, research method, how methodological issues such as endogeneity has been addressed, and results.

The main limitation is that the reviewed papers are only a representation of the whole population of publications addressing sustainability performance and financial performance. Even though I aimed to build a comprehensive sample, I might have excluded relevant papers unintentionally due to filters imposed by the key word search. Even so I have sufficient level of confidence that the papers incorporated capture the majority of the research papers published in the field between 2007-2017. For the papers Table 1 summarizes the unit of analysis, time frame, sustainability and financial performance indicators, control variables, methods used to evaluate the link between sustainability and financial performance, and the results.

Table 1: Review of studies evaluating the link between sustainability performance and financial performance

Publication	Data	Unit of analysis	Sample Size	Country	Data Period	Sustainability Measure	Performance Measure	Control Variables	Method	Endogeneity	Findings
(47) Aras et al. (2010)	Cross Sectional data	Firm	40	Turkey	2005-2007	content analysis of corporate reports	accounting based	firm size, risk, R&D intensity	regression	time lag	inconclusive
(48) Bush and Hoffman (2011)	Cross Sectional data		174	multiple countries	2006-2007	composite measure constructed with survey	accountig based	size, leverage, country, industry	regression	time lag	inconclusive
(49) Callan et al (2009)	Cross Sectional data	Firm	441	North America	2005	KLD social performance ratings	market based/ accounting based	firm size, risk, R&D intensity, advertising intensity, industry	regression	Not accounted	positive link
(50) Chang and Kuo (2008)	Longitudinal/ panel data	Firm	311	global	2003-2005	composite measure constructed with survey	accounting based	firm size, risk, R&D intensity, advertising intensity, industry	variation between two groups	Not accounted	positive link
(51) Dam and Petkova (2014)		environmental event	66	multiple countries	2005-2011	environmental event	stock market reaction	industry	financial event methodology	Not accounted	negative link
(52) Eccles et al. (2014)	Cross Sectional data	Firm	675	USA	1993-2009	Thomson Reuters ASSET4	market based/ accounting based	firm size, industry, book-to-market value, momentum	variation between two groups	firm level heterogeneity in financial returns	positive link
(26) Flammer (2015)		environmental event	2729		1997-2012	Shareholder proposals on social/ environmental issues	stock market reaction	size, industry, market value, profitability, leverage, ownership, past sustainability performance	regression discontinuity	firm fixed effects	positive link

Publication	Data	Unit of analysis	Sample Size	Country	Data Period	Sustainability Measure	Performance Measure	Control Variables	Method	Endogeneity	Findings
(25) Garcia-Castro et al. (2010)	Longitudinal/ panel data	Firm	658	North America	1991-2005	social performance ratings from KLD	market based/ accounting based	firm size, industry, risk, R&D intensity	fixed effect and IV estimation	unobserved firm characteristics	inconclusive link with fix effect and IV estimation
(53) Jacobs et al. (2010)		environmental event	780	USA		environmental event	stock market reaction	firm size, environmental reputation	financial event methodology	Not accounted	inconclusive
(54) Kajander et al. (2010)		environmental event	35	multiple countries	2008-2010	environmental event	market based	no controls	financial event methodology	Not accounted	positive link
(9) Klassen and McLaughlin (1996)		environmental event	110	North America	1985-1991	environmental event	stock market reaction	firm size, environmental performance	financial event methodology	Not accounted	positive link
(55) Konar and Cohen (2001)	Cross Sectional data	Firm	321	USA	1989	# pending environmental law suits, emissions of toxic chemicals	market based	size, industry, market share, industry concentration, sales growth, advertising intensity, R&D intensity, import intensity	regression	Not accounted	positive link
(56) Lee et al. (2009)	Longitudinal/ panel data	Firm- Year Observation	8511	multiple countries	1998-2002	DJ Global sustainability index- binary variable	market based/ accounting based	industry, country, size, leverage, risk, financial slack, liquidty	probit regression model	Not accounted	no direct relationship between CSP and CFP
(57) Lee et al. (2015)	Longitudinal/ panel data	Firm- Year Observation	362 firms (number of firm-year observation not reported)	Japan	2003-2010	CO2 emissions and environmental R&D investment from Environmental Report Plaza	market based/ accounting based	equity ownership, earnings per share, R&D leverage,, expenditure scaled by asset, energy-intensiveness, year	fixed effects and GLS estimation	firm-specific time-invariant unobserved heterogeneity	positive link

Publication	Data	Unit of analysis	Sample Size	Country	Data Period	Sustainability Measure	Performance Measure	Control Variables	Method	Endogeneity	Findings
(58) Lo and Sheu (2007)	Longitudinal/ panel data	Firm- Year Observation	1273 (349 firms)	USA	1999-2002	DJ sustainability index- binary variable	market based: Tobin's q	Firm size, access to financial market, leverage, profitability, sales growth, investment growth, industrial diversification , credit quality, industry	variation between two groups, fixed effects and random effects estimation	firm-specific heterogeneity, reverse causality, time lag	positive link
(59) López et al. (2007)	Longitudinal/ panel data	Firm	110	Europe	1998-2004	Dow Jones Sustainability Index	accounting based	firm size, industry, risk	variation between two groups	time lag	negative link
(60) Lourenco et al. (2012)	Longitudinal/ panel data	Firm- Year Observation	1597 (418 firms)	Canada and USA	2007–2010	DJ sustainability index- binary variable	market based: market value	firm size, book value of equity, leverage, risk industry, finacial performance,	random effects regression	firm-specific factors, time lag	significant positive link (+size and profitability matter in terms of CSP)
(61) Makni et al. (2009)	Cross Sectional data	Firm	179	Canada	2004-2005	KLD social performance ratings	market based/ accounting based	firm size, industry, risk	regression	time lag	inconclusive
(46) Marti et al. (2015)	Longitudinal/ panel data	Firm- Year Observation	153 firms (number of firm-year observation not reported)	Europe	2007–2010	Stoxx Europe Sustainability Index- binary variable	market based/ accounting based	type, country, firm, size, financial slack, risk, R&D investment and year	pooled OLS, random effect, fixed effect estimators, Parks' feasible generalized least squares estimators and panel corrected standard error estimators	time-lag	significant positive link (+ firm size and level of economic developmen t of the country effect CFP)

Publication	Data	Unit of analysis	Sample Size	Country	Data Period	Sustainability Measure	Performance Measure	Control Variables	Method	Endogeneity	Findings
(10) Montabon et al (2007)	Cross Sectional data	Firm	45			content analysis of corporate reports	accounting based	no control variables	canonical correlation	time lag	positive link
(62) Ortas and Moneva (2011)		environmental event	180	Europe		environmental event	stock market reaction	industry growth rate , capital intensity	financial event methodology	Not accounted	inconclusive
(63) Skare and Golja (2012)	Cross Sectional data	Firm	90	multiple countries	2006-2008	DJ Global sustainability index- binary variable	accounting based- binary variable	size, leverage	logit model	Not accounted	positive link
(18) Schoenherr and Talluri (2013)		Firm	402	USA-Europe		composite measure constructed with Survey	operational performance	# of product lines, % of sales from largest selling product line, equipment utilization, age of machinery, international ownership, source of input material	variation between two groups	Not accounted	positive link
(3) Soytaş et al. (2015)	Cross Sectional data	Firm	8523	North America	2010-2013	ratings from CSRHub	accounting based	size, age, past financial performance, industry, market value	OLS estimation, IV estimation	unobserved firm characteristics and firm level heterogeneity in financial returns	positive link
(64) Soytaş et al. (2017)	Cross Sectional data	Firm	214	Turkey	2010-2013	Borsa Istanbul Sustainability Index, CSRHub	accounting based	firm size, past financial performance, ownership, industry	regression	Not accounted	positive link

Publication	Data	Unit of analysis	Sample Size	Country	Data Period	Sustainability Measure	Performance Measure	Control Variables	Method	Endogeneity	Findings
(40) Surroca et al. (2010)	Longitudinal/ panel data	Firm	1204 (599 firms)	global	2001-2005	ratings from Sustainalytics Platform	market based	physical resources, size, leverage, liqudity, risk, industry, country, year, innovation, human capital, reputation, culture	two-stage estimation, fixed effect estimation	unobserved firm characteristics and firm level heterogeneity in financial returns	positive link mediated by intangibles related to sustainabilit y
(65) Wagner and Blom (2011)	Cross Sectional data	Firm	497	Germany-UK	1998-2006	composite measure constructed with Survey	market based	firm size, risk, industry, country, ownership	variation between two groups	time lag, firm level heterogeneity in financial returns	Positive (negative) link for financially good(poor) performing firms
(66) Wang and Choi (2013)	Longitudinal/ panel data	Firm- Year Observation	2356 (622 firms)	USA	1995-2000	KLD social performance ratings	market based	firm size, leverage, industry	time fixed effect regression	time lag	positive link mediated by consistency in sustainabilit y and knowledge intensity
(67) Yadav et al. (2017)	Cross Sectional data	Firm	382	multiple countries	2011-2013	Newsweek's green rankings	accounting based	market value, risk, industry	multivariate regression	time lag	moderately significant positive relationship

There are two research streams that analyze the effect of corporate sustainability performance on corporate financial performance empirically. They utilize different sustainability measures and financial performance indicators. In the financial event study methodology stream, the stock market's reaction on the announcements of environmental events is observed. While (9) and (54) find a positive and statistically significant association between sustainability and financial performance, (51) observe a marginally significant negative stock price reaction to environmental events. (53) and (62) report inconclusive results. (26) estimates the causal effect of the passage of shareholder proposals on social/environmental issues on abnormal returns with regression discontinuity approach and control for firm characteristics. Their main finding is that the passage of corporate sustainability proposals increases shareholder value, which indicates that sustainability, is a valuable resource supporting the RBV. Furthermore they assert that companies with high past sustainability performance benefit less from passing an additional corporate sustainability proposal and infer that marginal returns of sustainability are diminishing.

The second research stream caries out multivariate data analysis measuring the association between some performance measure evaluating sustainability, corporate social responsibility or environmental management; and accounting or market value based financial performance. Composite measures for sustainability can be constructed from primary data which rely on survey data (e.g. (50) (48) (18)) or content analysis of corporate reports (e.g. (10) (47)) as well as ratings(e.g. (49) (61) (25) (40) (66) (3)) , inclusion into a sustainability index (e.g. (59) (58) (56) (60) (63) (46)), number pending environmental law suits (e.g. (55)), emissions of toxic chemicals and CO_2 (e.g. (57))

from secondary data resources such as uses MSCI KLD 400 Social Index dataset[8], CSRHUB[9], GRI (Global Reporting Initiative)[10], Dow Jones Sustainability Index[11]and Thomson Reuters ASSET4[12]. On the one hand researchers using primary data are not bound by the limitations of the databases in terms of sample size and scope of the data (28). On the other hand secondary data minimizes the probability of key informant bias and common methods bias occurring in survey data or expert interviews (68).

Different operationalizations of the independent and dependent variables shape the findings substantially. For example (56) find no direct relationship between sustainability and financial performance, when accounting based measures employed as financial performance, whereas they document a statistically negative relationship between sustainability and financial performance, when marketbased measures are employed as the performance measure. According to (48) different operationalization of sustainability measures leads to different results and inferences about the relationship between sustainability and financial performance. Their results show a positive relationship between sustainability and financial performance, when using carbon emissions as an outcome-based measurement. They find a negative relationship between sustainability and financial performance, when carbon emission management is employed as a process-based measurement to proxy sustainability performance.

Alongside measurement issues, modeling issues jeopardize the generalizability of the effect of corporate sustainability on corporate financial performance documented by the reviewed papers. Thus special attention is given to the method used to estimate

[8] https://www.msci.com/documents/10199/904492e6-527e-4d64-9904-c710bf1533c6
[9] http://www.csrhub.com/
[10] www.globalreporting.org
[11] http://www.sustainability-indices.com/
[12] https://www.thomsonreuters.com/en/about-us/corporate-responsibility-inclusion/esg-performance.html

the effect and whether some aspect of the method attempts to correct for the inherent endogeneity in the relationship.

A number of authors employ regression to evaluate the link between corporate sustainability and corporate financial performance. (55) (69) (49) (63) and (67) observe a positive relationship between sustainability and financial performance. (47) assert that there is no link between environmental performance and profitability and no link between sustainability and financial performance. (61) observe no significant relationship between the sustainability and financial performance, only unidirectional and negative relationship between environmental aspect of sustainability and financial performance. These mixed results suggest that there must be some confounding effects. Under careful consideration of the literature, the possible causes of the endogeneity in the relationship can be attributed to the unobserved firm characteristics and the firm level heterogeneity in financial returns.

There are more recent studies that attempt to address causality by considering the inherent endogeneity between the variables. On one hand some authors assert the link between sustainability and financial performance by showing the variation between two groups of firms different in terms of their sustainability performances ((59) (50) (65)). On the other hand (18) measure the variation in sustainability performance of two groups which are different in terms of their past financial performances. (50) and (18) find a positive link between corporate sustainability performance and corporate financial performance.

(59) claim that expenses related to sustainability during a certain time might exceed the incremental revenue generated by sustainability practices, which manifests itself as a negative relationship between corporate sustainability performance and

corporate financial performance. Furthermore, (10) discuss that due to the time lag between implementation of environmental management practices and their effect on firm performance, the relationship must be stronger than they could document. (66) include a time-fixed effect, where they control effects that may vary over time but are constant across firms and find a positive link between corporate sustainability performance and corporate financial performance.

(58) account for firm-specific heterogeneity, reverse causality, time lag between sustainability investments and financial outcomes by employing fixed effects and random effects estimation. They report positive and significant relationship between sustainability and a firm's value. The empirical evidence in (58) supports the fixed effects model over the random effects model, which controls for a firm's unobserved characteristics that may affect firm value. Furthermore, they observe no significant change in the results when independent variables are lagged; indicating simultaneity bias- time lag between sustainability investments- is not an issue in the proposed fixed effect model.

(65) identify the past financial performance as a confounding factor. They observe a positive (negative) and significant association between sustainability and financial performance for the financially good (poor) performing firms. These findings indicate that financially good performing firms have more resources to invest in sustainability, which in return lead to better financial outcomes. Although, they test for reverse causality and find the effect of sustainability on financial performance insignificant, they conclude that there should be an indirect reverse causality and the relationship between sustainability and financial performance is reciprocal. (60) conduct random effects regression and control for firm-specific factors, time lag between sustainability investments and financial outcomes. They find a significant positive link

and note that firm size and profitability matter in terms of corporate sustainability performance. These results support the reverse causal link and the slack resources theory.

(52) divide their sample into high sustainability and low sustainability groups, which are homogeneous in terms of industry, size, growth opportunities, and leverage. They find that high sustainability companies outperform low sustainability companies both in terms of stock market performance and accounting rates of return. They observe no significant association between past profitability and future adoption policies, which is a contradictory result to slack resources theory.

(25) suggests that companies with certain characteristics such as good management quality, certain values, and a certain culture are more likely to adopt sustainability initiatives and these unobserved firm characteristics are driving the performance. They account for endogeneity by fixed-effect and instrumental variable (IV) estimation. They employ three sets of instrumental variables, which are industry characteristics, corporate governance, and visibility and observe a neutral relationship between sustainability performance and financial performance. (3) propose an empirical framework to address the endogeneity problem using the IV technique and find that the Ordinary Least Squares (OLS) estimates are downward biased, indicating that OLS underestimates the effect of sustainability on financial performance. Furthermore, they assert that companies with certain characteristics such as high efficiency (productivity) have higher adoption costs and are less likely to adopt sustainability initiatives.

(64) mention that the endogeneity may arise from the recursive relationship between sustainability and financial performance. Profitable firms may have more resources to invest in sustainable initiatives, while sustainable companies may have a

competitive advantage, which leads to better financial performance. Besides the observed firm characteristics such as size, age, productivity, past profitability might affect later decisions for sustainability investments. (40) employ a two-stage estimation strategy to determine the relationship between corporate sustainability and corporate financial performance that corrects for endogeneity concerns. They analyze the recursive relationship between sustainability and financial performance and take into account the mediating role of intangibles such as innovation, human capital, culture and reputation in both causal directions. They state that there is no direct relationship between corporate social responsibility and financial performance, only an indirect relationship exists due the mediating effect of a firm's intangible resources.

A limitation of this literature is that sustainability is endogenous with respect to financial performance, i.e., a company's decision to adopt in sustainability initiatives likely correlates with unobservable firm characteristics that may also affect financial performance. Different approaches such as Instrumental Variable (25) (3) approach or Regression Discontinuity Approach (26) have been applied by researches to correct for the endoneigty bias.

(3) present empirical evidence that more productive firms have higher marginal costs of sustainability. (28) find a negative and significant association between profitability and degree of sustainability. (3) point out it is more costly for productive companies to change, since the way they operate is well established. According to (28) more productive companies see less a need to invest in sustainability in order to gain superior financial performance. Regardless of the reasons why profitable/productive firms are reluctant to invest in sustainability, they have to keep in mind that the market penalizes larger firms with a lower level of sustainability more, if they are

profitable(60).Therefore, companies should approach sustainability decisions at a strategic level instead of operational and tactical level.

2.3. Corporate Sustainability: Strategic Interactions

There is a wide range of studies modeling strategic interactions regarding sustainability decisions. Game theory is suitable for analyzing situations in which the decisions of companies affect each company's benefit. I distinguish between studies where cooperative and non-cooperative game players are considered. The cooperative game-theoretic models consider the fair distribution of benefits and costs among stakeholders such as the government, the local authorities, the companies, and the community. In multi-stakeholder cooperative situations, such as life cycle management, water resource sharing or waste management, the outcome is affected by the decisions made by every player (70). Waste management decisions such as selecting a new landfill site (71), division of waste management costs (72), waste disposal (73), selection of sustainable waste treatment options (74) and water resource management decisions such as sanitation (75) have been modeled as cooperative games.

Non-cooperative game players make decisions independently from each other. According to (76) companies have two choices to meet the stakeholder demand for increasing corporate sustainability performance, namely, compliance or active support. They assert that if a company is proactive and changes its business processes in order to become more sustainable, then it will gain competitive advantage over its competitors who are being reactive towards stakeholder demand. Static games such as price or quantity competitions, new product introduction, and competition in remanufacturing can be modeled as non-cooperative games.

There are plenty of different examples for non-cooperative games regarding different sustainability decisions. (77) consider a duopoly market with product differentiation, where consumers are concerned with the emissions. (78) study a standard vertical product differentiation model, where firms simultaneously choose their prices. They assume that the polluting firm has cost advantage over the non-polluting firm. If the consumers are not sensitive to the environment, due to her cost advantage, the polluting firm decreases her price to capture the whole market. The polluting firm's output decreases with increasing environmental awareness. However, until a critical level of environmental awareness is reached the polluting firm still benefits due to the cost advantage. (79) considers the effect of spillovers in a duopoly setting with product differentiation and model a Cournot game, where leader and follower compete for demanded quantities which depend on both prices and the sustainability activities of both players.

(80) study a quantity competition between an Original Equipment Manufacturer (OEM) and independent remanufacturer (IR), where the interdependence is twofold. (*i*) Remanufactured product's cost and quality level depend on the new product's quality level. (*ii*) Similar to (80) in (81) the end-of-life products available for IR are limited to the new products supplied by the OEM. They investigate the impact of remanufacturing and quality choice on consumer surplus and social surplus and find that IR's entry decreases the consumer surplus and social surplus. Moreover, from an environmental perspective it is more favorable that the OEM remanufactures.

(82) model the interactions between consumers and OEM, which remanufactures returned electrical and electronic equipment. Since returned goods are inputs to the remanufacturing operation, the OEM has to control the rate and timing of returns. In order to do so the OEM rewards consumers for participating in the take back program.

In the proposed game-theoretic model the consumers decide on their optimal storage times while OEM decides on the optimal value of the incentive reward. Similarly, (83) study the effect of take-back regulations on the OEM and IR decisions, consumer surplus and the OEM’s profit. They find, that although stringent collection regulations are in favor of the OEM, they lead to decreased remanufacturing.

Sequential order of moves such as incumbency, sequential entry, R&D races, can be captured by the Stackelberg model (84). Sustainability decisions such as disclosure, outsourcing, new product entry, supply chain coordination, price and quantity competition in a remanufacturing setting are modeled as repeated games. In disclosure models, a firm decides to disclose information on its sustainability activities and the opponent decides to strike or not. In the sequential model proposed by (85) the market reacts to both disclosure and strike decisions. (85) report that the environmental performance of a company decreases as the disclosure level increases. (86) considers a game where companies signal their environmental performance. In accordance with the finding of (85), they observe that mandatory disclosure of environmental performance decreases investment in clean technologies. (87) formulate the outsourcing decision as a Stackelberg game, where in the first stage the sustainability buyer decides on the level of economic or technical support to incentivize sellers’ efforts and in the second stage two sustainability sellers decide on their effort levels. (88) formulate and compare a monopoly model and a duopoly model to study the effects of various waste regulations on the new product introduction process, quantity of e-waste, social welfare, consumer surplus, and manufacturer profit.

(89) models a spatial duopoly market, where equilibrium prices and market shares are affected by consumers’ awareness of environment. At the first stage, companies choose product characteristics and at the second stage companies decide on

the price. (90) propose a dynamic two-stage game of production and retail competition that incorporates consumer environmental awareness. In the first stage, the manufacturers decide on the environmental improvement and wholesale price. In the second stage the retailers set the price of the product. They study the impact of consumers' environmental awareness on price competition under the assumptions that production of eco-friendly products is more costly and consumers are willing to pay higher prices for more eco-friendly products. (91) analyze a two-echelon supply chain consisting of one supplier and one manufacturer and model their optimal pricing and carbon emissions intensity decisions as a Stackelberg game. They incorporate the effect of environmental awareness and technological spillovers into their analysis and compare centralized and decentralized supply chains.

(81) model a two stage duopoly game in a remanufacturing setting, where players compete for resource allocation as well as price and quantity. In the first period, the OEM produces and sells new items. Only a fraction of these items is returned and available for the OEM and the IR to remanufacture in the second period. Hence, in the second period each player's competitive response depends on this state variable. They utilize a demand function such that the quantity sold by each player depends on both his own price and the competitor's price. (92) study the effect of regulations on the amount of collected and recycled end-of-life products and the associated profits in integrated and decentralized supply chains. They propose a two stage model, where the supplier sets the wholesale price and recycling rate and the manufacturer chooses the total quantity as a best response. They show that sharing the responsibility for product recovery between the stages can improve total supply chain profit.

(93) introduce a Stackelberg game, where competitors make a strategic decision on whether they are profit maximizing companies or socially responsible companies in

the first stage and in the second stage a quantity competition takes place. They introduce the consumer surplus into the objective function in order to represent socially responsible companies. In the second stage they introduce different reservation prices for profit maximizing and socially responsible companies to capture the vertical product differentiation. If both companies have the same costs, the socially responsible company attains more benefits compared to the profit maximizing company. Similar to (93), (94) account for consumer surplus when formulating the objective function and study a Cournot oligopoly with pollution, where companies decide on their sustainability strategy. They find that the sustainable firm obtains higher profits than its profit-seeking competitors, and generates a higher level of social welfare.

The research questions addressed even in the studies that relate the most to my study as discussed above, differ substantially from my research questions. They model sustainability interactions, where companies decide to produce a more sustainable version of a homogeneous product and compete in quantities or prices, which are decisions more on the operational and tactical level. I model sustainability interactions, where there is a demand for sustainability from various stakeholders and a payoff from being sustainable. Although, the game I model resembles a quantity competition, the quantity I consider is the level of sustainability initiatives undertaken by the companies. The companies decide on their sustainability levels, which maximize their net benefit by taking the opponents actions into account.

CHAPTER III

CORPORATE SUSTAINABILITY AND CORPORATE FINANCIAL PERFORMANCE: A GAME THEORETICAL APPROACH TO SUSTAINABILITY ACTIONS

In this section, I conceptualize sustainability actions of companies as strategic interactions and model the competition among companies in a duopoly and oligopolistic market. The goal of the focal company is to maximize the net benefit obtained from sustainability by regarding the sustainability actions of her competitors. I start my analysis by constructing the net benefit function. According to the RBV, companies obtain benefit from investing in sustainability. The supply-side perspective points out that companies have to allocate other resources in order to satisfy the demand for sustainability. Thus, I can modify the microeconomic concepts of the production and cost functions to include sustainability-related inputs, which incur costs and outputs, which generate benefit (95). I provide the notation used in Table 2.

Table 2: Notation

i:	company index, *i=1,…..,N*
w_i:	level of sustainability initiatives of company *i*, $w_i \geq 0$
$\boldsymbol{w}_{N/i}$:	vector for all players' level of sustainability initiatives, excluding company *i*.
$r_i^{sus}(w_i, \boldsymbol{w}_{N/i})$:	benefit of undertaking sustainability at level w_i given competitors' sustainability levels
$c_i^{sus}(w_i, \boldsymbol{w}_{N/i})$:	implementation cost of undertaking sustainability at level w_i given competitors' sustainability levels
f_i:	fixed amount of fines, if company *i* does not comply with the regulations
$\Pi_i^{sus}(w_i, \boldsymbol{w}_{N/i})$:	Net benefit of undertaking sustainability at level w_i given competitors' sustainability levels

The companies' objective is to choose the level of sustainability $w_i \geq 0$ that maximizes their net benefit function subject to competitors' sustainability levels. The company *i* decides on the best action by anticipating the actions of its competitors.

The net benefit function of focal company *i* is calculated as:

$$\Pi_i^{sus}(w_i, \boldsymbol{w}_{N/i}) = \mathrm{r}_i^{sus}(w_i, \boldsymbol{w}_{N/i}) - \mathrm{c}_i^{sus}(w_i, \boldsymbol{w}_{N/i}) \qquad (1)$$

On the one hand, companies may decide to invest in sustainability voluntarily. These companies undertake sustainability initiatives, if their expected benefits exceed the expected costs of sustainability, since they are assumed to be rational decision makers. Thus company i undertakes sustainability initiatives voluntarily, if the net benefits $\Pi_i^{sus}(w_i, \boldsymbol{w}_{N/i})$ >0. On the other hand, if companies are coerced into investing in sustainability, either they comply with the new regulations or they face fines from not adopting. For these companies the sustainability investment decisions boils down to whether their expected net benefits exceed the fines from not adopting. Thus company *i* complies with regulations and undertakes sustainability initiatives, if the benefits $\Pi_i^{sus}(w_i, \boldsymbol{w}_{N/i}) > |f_i|$. I model sustainability interactions of companies that undertake sustainability initiatives voluntarily. However, the model applies also to companies that are coerced into investing in sustainability. Simply the fixed amount of fines f_i should be incorporated into the analysis as well.

The source of the benefits can be twofold. (*i*) Based on the stakeholder theory, when a company invests in sustainability and these efforts are visible by the stakeholders, then the company is perceived as sustainable and the stakeholders provide incentives such as increased demand, willingness to pay a price premium, tax benefit or better financing opportunities. (*ii*) Drawing on the RBV, sustainability initiatives lead to process improvement and increase in employee productivity, which in return lead to reduction in operating costs.

However both these benefits are expected to diminish. As more companies become sustainable, stakeholders no longer differentiate between companies based on sustainability and the stakeholder incentives diminish. Similarly the reduction in operating costs is expected to go down as the firm increases the level of sustainability. In this model, I do not distinguish between benefits due to stakeholder incentives and cost reduction, and assume that they both diminish as sustainability efforts increase. Therefore, I assume that the benefit function $\mathrm{r}_i^{sus}(w_i, \boldsymbol{w}_{N/i})$ is an increasing concave function in w_i, and the marginal increase in benefits will deteriorate as the firm increases the level of sustainability.

The effect of competition on the implementation costs of company i is not as straightforward as the effect of competition on its benefits. $\mathrm{c}_i^{sus}(w_i, \boldsymbol{w}_{N/i})$ is not only affected by the actions of the focal company but also by the actions of the competitors. For example, if a company simply imitates its competitors' sustainability initiatives, the implementation cost for that company will be lower than to the competitors' costs. I assume that the marginal cost of implementation will increase as the level of sustainability initiatives increase. Thus, the implementation costs of sustainability initiatives $\mathrm{c}_i^{sus}(w_i, \boldsymbol{w}_{N/i})$ are assumed to be increasing and convex in w_i, when learning effects[13] are neglected. The relation among $\Pi_i^{sus}(w_i, \boldsymbol{w}_{N/i})$, $\mathrm{r}_i^{sus}(w_i, \boldsymbol{w}_{N/i})$, and $\mathrm{c}_i^{sus}(w_i, \boldsymbol{w}_{N/i})$ is illustrated in Figure 2.

[13] The learning effects are based on the concept that, as a task is performed repetitively, the time required to perform the task decreases. Similarly the incremental cost of sustainability implementation decreases.

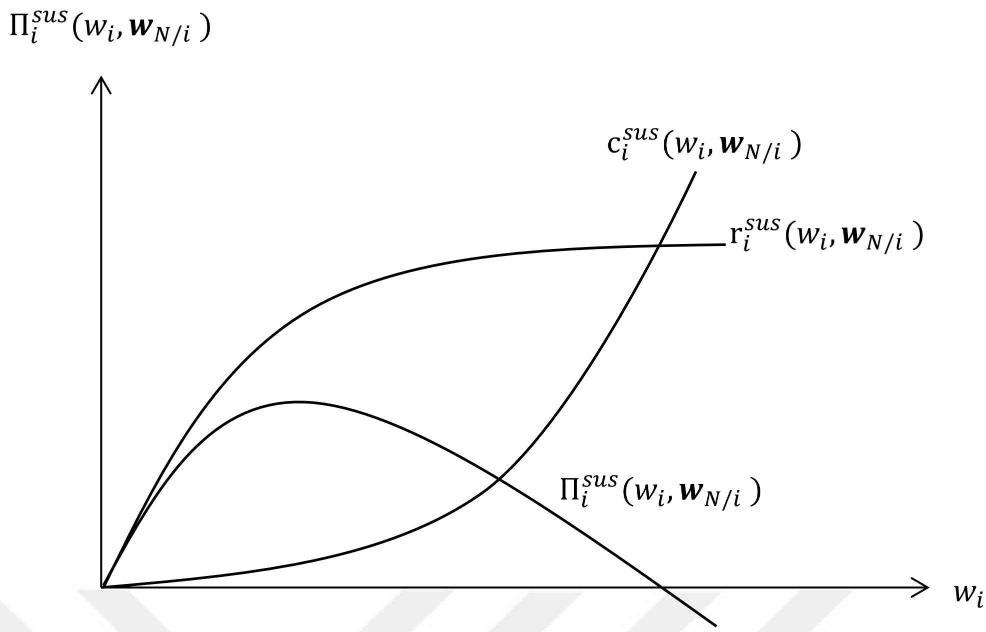

Figure 2: The net benefit function $\boldsymbol{\Pi_i^{sus}(w_i, w_{N/i})}$

Sustainability research has delivered empirical evidence well as anecdotal evidence on the causal link between corporate sustainability and financial performance. (52) report that high sustainability companies outperform the low sustainability ones in terms of both stock market and accounting measures. Further evidence comes from (96), showing that organizations which have made a sustainability-related business model change are twice as likely to report profit from sustainability than are companies that haven't.

Sustainability research has addressed the different mechanisms behind firm behavior regarding sustainability and resulting financial outcomes conceptually. As stated before, a company undertakes sustainability initiatives if the net benefits are positive. Otherwise the company would not invest in sustainability to start with. This assumption, which is aligned with the stakeholder theory is necessary for my analysis and makes economic sense. According to stakeholder theory, stakeholders reward sustainable companies. For example, consumers are willing to pay a price premium for less polluting and environmentally friendly products (77) (89). Stakeholder engagement and transparency around sustainability performance lead to better access to finance and on average, firms with better sustainability performance face lower capital constraints (97). According to (96) investors believe that solid sustainability performance of the company leads to improved revenue performance, reduced risk, lower cost of capital.

Based on RBV, I expect that the operations costs should decrease, as the practices and processes of the company improve due to sustainability initiatives. Unlike (89) who assumes higher costs for producing sustainable goods, I presume that the variable costs will decrease due to process improvement and increase in employee productivity. Examples for sustainability initiatives which lead to decrease in operation costs are product design for environment, responsible sourcing and conservation of natural resources, energy and greenhouse gases reduction, pollution reduction, waste reduction, inventory management and warehousing, packaging and mode of transportation, and extended producer responsibility (4).

The majority of researchers agree that sustainability initiatives influence reduction in operation costs positively. To name a few: (98) presents empirical evidence that the impact of pollution prevention and waste reduction on cost is positive and significant, whereas the impact of recycling of materials prove to be insignificant. (99) studies the conditions, where converting a waste stream into a useful and saleable by-product becomes a process innovation that reduces the marginal cost of the original product. (100) extend the traditional economic order quantity (EOQ) model by incorporating the environmental impact of transportation and inventory and point out that intermodal transportation exhibit cost advantages compared to mono-modal road transportation. (101) identify the interrelationships between capacity utilization, customer satisfaction, energy consumption reduction and costs in a product recovery setting.

As stated by (87) sustainability initiatives such as recycling or reducing energy consumption, which lead to cost reduction may generate more direct net benefit compared to sustainability initiatives, which enhance the social infrastructure such as improve education. While the latter increases the reputation of the company, improves consumer goodwill, and generates financial performance through the mechanisms of the stakeholder theory, the former generates financial performance through the mechanisms of RBV and Stakeholder Theory. If sustainability initiatives such as recycling or energy consumption reduction are communicated to the stakeholder, they should improve reputation as well.

Drawing on the Stakeholder Theory one can argue that sustainability initiatives lead to producer surplus. Companies, which observe that their competitors obtain positive returns by undertaking sustainability initiatives, are inclined to invest in sustainability to exploit the producer surplus as well. Moreover, RBV states that companies investing in sustainability gain competitive advantage. Thus the remaining companies are likely to invest in sustainability to be able to compete with the sustainability pioneers. Several innovations and disruptive technologies[14] have become the norm over the course of time because of the companies' aspiration to gain competitive advantage and producer surplus (102). Since sustainability initiatives should be considered similar to other innovations, I presume leading to Hypothesis 1 that at a certain time, the majority of the companies operating in a particular industry will decide to invest in sustainability. Moreover, the general upward trend for the MSCI

[14] A disruptive technology is one that displaces an established technology and shakes up the industry or a ground-breaking product that creates a completely new industry.

KLD scores of S&P 500/Domini firms documented by (103) supports the view that sustainability has become a necessity by managers over time.

Hypothesis 1: Sustainability becomes the norm over course of time like any other innovation or disruptive technology.

The entry of company *j* into a product market decreases the net profit of the company *i*, since the companies will compete for the market shares. Similarly, if the entry decision of company *j* changes the expectation of stakeholders from company *i* (a sustainable version of the product or a lower price) than the net benefit of company *i* will decrease. Either company *i* does not change her product offering regarding sustainability or price and loses demand and market share or decides to adapt to the shifting expectations of stakeholders and incurs new costs. Either way the net benefits of company *i* will decrease. Thus the entry of company *j* into the sustainability market will negatively influence the net profit of company *i*. I expect that if the goods or services of the competitor companies are substitutable i.e. the level of competition is high (low industry concentration), the negative effect of sustainability competition will be even more profound. Hence I hypothesize that:

Hypothesis 2: The likelihood of undertaking more sustainability initiatives is related to the level of competition in the industry (industry concentration).

On the one hand, companies that invest in innovations before their competitors gain the first-mover advantage (104). (8) discuss the conditions under which the sustainability leader can maintain the first-mover advantage. On the other hand, if the sustainability efforts of company *j* lead to an improved stakeholder perception of the whole industry, there may be sustainability spillovers and company *i* free rides the sustainability efforts of company *j* and may gain a second mover advantage. Moreover, if a company imitates the competitors' sustainability initiatives, the implementation cost for that company will be lower compared to the competitors' costs. The follower benefits from the spillovers without bearing the full cost of the investments and again that company free rides the sustainability efforts of her competitors.

Hypothesis 3: The likelihood of undertaking sustainability initiatives is influenced by the degree of sustainability spillovers.

In the following section I propose game theoretical models to describe the effects of competition and spillovers on the sustainability initiatives and financial performance. I propose sequential models in duopoly and oligopoly settings and quantify the effect of competition and spillovers using illustrative examples to gain insight.

3.1. The Sequential Duopoly Model

I start my analysis with the Stackelberg model of duopoly. I assume that the moves occur in sequence and all previous moves are observed before the next move is chosen (105). As seen in Figure 3, in the first period the leader decides on his/her level of sustainability initiatives, w_L, by anticipating the actions of the follower and in the next period the follower decides on his/her level of sustainability initiatives, w_F, by observing the actions of the leader.

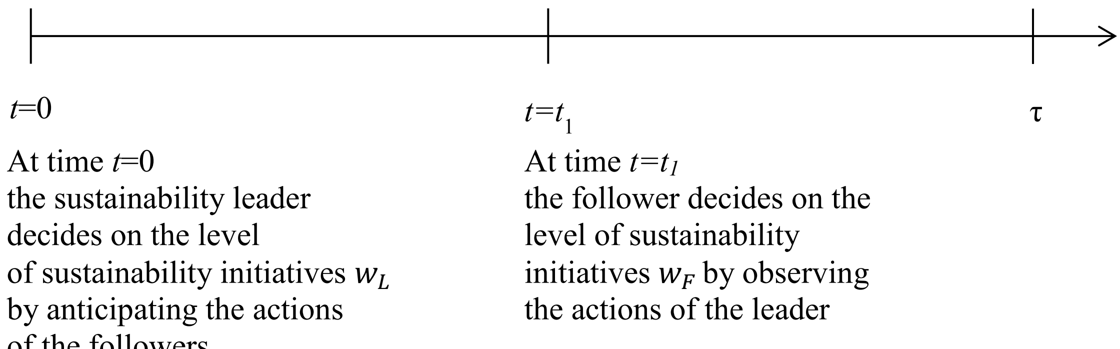

Figure 3: Timeline for the 2 period- sequential single leader- multiple follower game

3.1.1. Analytical Model

In developing the model I will use the notation in Table 3.

Table 3: Notation for the sequential duopoly model

w_L:	level of sustainability initiatives of the leader
w_F:	level of sustainability initiatives of the follower
$p_L(w_L, w_F)$:	stakeholder payments for the leader for sustainability level w_L
$p_F(w_L, w_F)$:	stakeholder payments for the follower for sustainability level w_F
a:	initial willingness of the stakeholder to pay for sustainability initiatives, $a > 0$
b:	rate at which the willingness to pay decreases as sustainability initiatives increase, $b > 0$, price elasticity of demand for sustainability
d:	constant implementation cost for both the sustainability leader and the follower, $d > 0$
γ:	sustainability spill overs, $\gamma \in [0,1]$
θ:	level of competition, $\theta \in [0, 1]$
$R_F(w_L)$:	follower's reaction to sustainability level w_L of the leader
$r_L^{sus}(w_L, w_F)$:	benefit of the leader from undertaking sustainability initiatives
$c_L^{sus}(w_L, w_F)$:	cost of the leader from undertaking sustainability initiatives
$c_F^{sus}(w_L, w_F)$:	cost of the follower from undertaking sustainability initiatives
$\Pi_L^{sus}(w_L \mid p(w_L))$:	net benefit of the leader from undertaking sustainability initiatives
$\Pi_F^{sus}(w_F \mid p(w_F))$:	net benefit of the follower from undertaking sustainability initiatives

The leader and the follower compete for the stakeholder payments. As the number of players investing in sustainability increases, the sustainability payments are expected to decrease. Thus I formulate stakeholder payments

$$p_L(w_L, w_F) = a - b(w_L + \theta w_F) \tag{2}$$

$$p_F(w_L, w_F) = a - b(w_F + (\theta - \gamma)w_L) \tag{3}$$

An increase in the competition level affects the stakeholder payments of the leader and follower negatively. I assume that the spillovers occur only from leader to follower. If sustainability investments of the leader are successful, the follower may free ride the leader's sustainability efforts. Either the stakeholder perception of the whole industry shifts due to the efforts of the leader and follower benefits from increased stakeholder payment. Or the follower imitates the leader's sustainability initiatives and benefits from the spillovers without bearing the full cost of the investments. However for the sake of simplicity I assume that the marginal cost for sustainability investments are constant for both the sustainability leader and the follower and denote it as d. Thus, I do not distinguish between spillovers due to increase in stakeholder payment or decrease in sustainability implementation costs and address the twofold influence of spillover effects as an increase in sustainability spillovers, which affects the stakeholder payment of the follower positively.

The benefit from sustainability initiatives is calculated as

$$r_L^{sus}(w_L, w_F) = p_L(w_L, w_F)w_L \tag{4}$$

$$r_F^{sus}(w_L, w_F) = p_F(w_L, w_F)w_F \tag{5}$$

Leader's decision problem is to choose the level of sustainability initiatives $w_L \geq 0$ that maximizes her net benefit function

$$\Pi_L^{sus}(w_L \,|\, p(w_L)\,) = r_L^{sus}(w_L, w_F) - c_L^{sus}(w_L, w_F) = [p_L(w_L, w_F) - d]w_L \quad (6)$$

The objective function of the follower can be written as

$$\Pi_F^{sus}(w_F \,|\, p(w_F)\,) = r_F^{sus}(w_L, w_F) - c_F^{sus}(w_L, w_F) = [p_F(w_L, w_F) - d]w_F \quad (7)$$

To solve for the backward induction outcome of this game, I first compute the followers reaction $R_F(w_L)$ to an arbitrary sustainability level by the leader.

$R_F(w_L)$ solves the optimization problem

$$\max_{w_F \geq 0} \Pi_F^{sus}(w_F | w_L) = \max_{w_F \geq 0} (a - b(w_F + (\theta - \gamma)w_L) - d)w_F \quad (8)$$

which yields

$$R_F(w_L) = \frac{a - bw_L(\theta - \gamma) - d}{2b} \quad (9)$$

provided that $bw_L(\theta - \gamma) < a - d$. This relation ensures that follower's reaction to sustainability level of the leader is nonnegative, $R_F(w_L) > 0$. Since the leader's sustainability levels should be nonnegative as well, $w_L > 0$. Moreover, b>0 by definition. Since $\theta \in [0, 1]$ and $\gamma \in [0, 1]$, $(\theta - \gamma)$ can take values between -1 and 1. Thus $bw_L(\theta - \gamma) < a - d$ holds for all $(\theta - \gamma) \in [-1, 1]$ values, if $a - d > 0$.

Since the leader can solve the follower's problem as well as the follower, the leader should anticipate that the sustainability level choice w_L will be met with the reaction $R_F(w_L)$. Thus the leader's problem in the first stage becomes

$$\max_{w_L \geq 0} \Pi_L^{sus}\big(w_L \big| R_F(w_L)\big) = \max_{w_L \geq 0} (a - b(w_L + \theta R_F(w_L)) - d)w_L \quad (10)$$

which yields

$$w_L = \frac{(2-\theta)(a-d)}{2b(2-\theta(\theta-\gamma))} \quad (11)$$

as the backwards-induction outcome of the Stackelberg duopoly game.

Plugging in the result from (11) into (9) I get

$$w_F = \frac{(a-d)(4+(2+\theta)(\gamma-\theta))}{4b(2-\theta(\theta-\gamma))} \quad (12)$$

There are four cases to consider in order for the leader's sustainability initiatives, w_L, and the follower's sustainability initiatives, w_F, to be nonnegative.

Case 1: Both the numerator and denominator in w_L and w_F are nonnegative.

i) $a - d > 0$

$2 - \theta > 0$, since $\theta \in [0, 1]$

$2 - \theta(\theta - \gamma) > 0$ should hold in order $w_L > 0$.

Considering the worst case, where $\gamma = 0$, I get $\theta < \sqrt{2}$.

For $\theta = 1$, I get γ <1.

Combining the results $\theta < \sqrt{2}$ and $\gamma < 1$ should hold in order $w_L > 0$.

ii) $a - d$ >0

$4 + (2 + \theta)(\gamma - \theta)$>0 and $2 - \theta(\theta - \gamma) > 0$ should hold in order $w_F > 0$

From $4 + (2 + \theta)(\gamma - \theta)$>0 considering the worst case, where $\gamma = 0$, I get $-1 - \sqrt{5} \leq \theta < \sqrt{5} - 1$.

For $\theta = 1$, I get $\gamma > -\frac{1}{3}$

From $2-\theta(\theta-\gamma) > 0$ considering the worst case, where $\gamma = 0$, I get $\theta < \sqrt{2}$.

For $\theta = 1$, I get γ <1.

Combining the results, $-1-\sqrt{5} \leq \theta < \sqrt{5}-1$ and $-\frac{1}{3} < \gamma < 1$ should hold in order $w_F > 0$.

In order both $w_L > 0$ and $w_F > 0$ to hold, $-1-\sqrt{5} \leq \theta < \sqrt{5}-1$ and $-\frac{1}{3} < \gamma < 1$.

Since $\theta \in [0,1]$ and $\gamma \in [0,1]$ by definition, w_F and w_L are nonnegative for all defined θ and γ values.

Case 2: Both the numerator and denominator in w_L are negative, while the numerator and denominator in w_F are nonnegative.

$a-d > 0$ and $2-\theta > 0$, since $\theta \in [0,1]$. Hence the numerator in w_L is nonnegative. I don't take *case 2* into consideration throughout the analysis.

Case 3: Both the numerator and denominator in w_L are nonnegative, while the numerator and denominator in w_F are negative.

i) $a-d > 0$

$2-\theta > 0$, since $\theta \in [0,1]$

$2-\theta(\theta-\gamma) > 0$ should hold in order $w_L > 0$.

Considering the worst case, where $\gamma = 0$, I get $\theta < \sqrt{2}$.

For $\theta = 1$, I get γ <1.

Combining the results $\theta < \sqrt{2}$ and $\gamma < 1$ should hold in order $w_L > 0$.

ii) $a - d$ >0

$4 + (2+\theta)(\gamma - \theta)$<0 and $2 - \theta(\theta - \gamma) < 0$ should hold in order $w_F > 0$

Considering the worst case, where $\gamma = 1$, $4 - (\theta - 2b)(\theta - \gamma)$<0 holds for nonnegative θ values only if $\theta > 2$.

From $2 - \theta(\theta - \gamma) < 0$ considering the worst case, where $\gamma = 1$, I get $\theta > 2$.

The numerator and denominator in w_F are negative for b>0 values only if $\theta > 2$. Since $\theta \in [0, 1]$ by assumption, I don't take *case 3* into consideration throughout the analysis.

Case 4: Both the numerator and denominator in w_L and w_F are negative.

$a - d > 0$ and $2 - \theta > 0$, since $\theta \in [0, 1]$. Hence the numerator in w_L is nonnegative. I don't take *case 4* into consideration throughout the analysis.

From the model's assumptions and *case 1* I determine that w_L and w_F are nonnegative for all positive b values, $\gamma \in [0, 1]$ and $\theta \in [0, 1]$. Furthermore, I compute the net benefits for both leader and follower as:

$$\Pi_L^{sus} = \frac{(a-d)^2(2-\theta)^2}{8b(2-\theta(\theta-\gamma))} \quad (13)$$

$$\Pi_F^{sus} = \frac{(a-d)^2(4-(\theta+2)(\theta-\gamma))^2}{16b(2-\theta(\theta-\gamma))^2} \quad (14)$$

I compute the first and second order conditions of w_L, w_F, Π_L^{sus} and Π_F^{sus}, which are given in the Appendix A1. I evaluate the behavior of w_L and w_F and Π_L^{sus} and Π_F^{sus} in Table 4 and Table 5, respectively and summarize the implications. As competition level increases, the leader first decreases than increases her sustainability initiatives. The follower decreases her sustainability initiatives, as competition level increases. The shape of the follower's sustainability level function depends on the combination of θ and γ values. As spillover rate increases, the leader decreases her sustainability initiatives, while the follower increases her sustainability initiatives.

The behavior of the net benefit function of the leader depends on θ and γ values. Moreover, the shape of the net benefit functions of the leader depends also on θ and γ values. Thus, I cannot generalize the effect of competition levels on the leader's net benefit. As the competition level increases, the follower's net benefit function decreases, however the shape of the function depends both on θ and γ. The net benefit function of the leader is a decreasing convex function in γ, which indicates that the leader decreases her sustainability efforts as spillover rate increases. The net benefit function of the follower is an increasing concave function in γ, which indicates that the follower increases her sustainability efforts as spillover rate increases. However the shape of follower's net benefit function depends both on θ and γ.

To summarize: the leader's and followers' sustainability levels and the corresponding net benefits depend on the combination of θ and γ values. These results implicate the necessity of an empirical study, which estimates the effect of competition and spillover on the sustainability levels and financial performance. Before proceeding to the empirical study, I present a numerical example to illustrate the effects of θ and γ on w_L and w_F and Π_L^{sus} and Π_F^{sus}.

Table 4: First and second order conditions for $\boldsymbol{w_L}$ and $\boldsymbol{w_F}$

$(\partial w_L)/\partial\theta$	negative if $\lvert\theta(\theta-4)\rvert < 2(\gamma+1)$	decreasing function in θ
	nonnegative if $\lvert\theta(\theta-4)\rvert > 2(\gamma+1)$	increasing function in θ
$(\partial^2 w_L)/\partial\theta^2$	nonnegative	convex
$(\partial w_L)/\partial\gamma$	Negative	decreasing function in γ
$(\partial^2 w_L)/\partial\gamma^2$	Negative	concave
$(\partial w_F)/\partial\theta$	Negative	decreasing function in θ
$(\partial^2 w_F)/\partial\theta^2$	For $\theta<0.4$ nonnegative	convex
	For $\theta>0.4$ nonnegative, if $\gamma^3+\gamma(3\theta^2-3\theta+4)>\lvert\gamma^2(1-3\theta)-\theta^3+3\theta^2-6\theta+2\rvert$	convex
	For $\theta>0.4$ negative, if $\gamma^3+\gamma(3\theta^2-3\theta+4)<\lvert\gamma^2(1-3\theta)-\theta^3+3\theta^2-6\theta+2\rvert$	concave
$(\partial w_F)/\partial\gamma$	nonnegative	increasing function in γ
$(\partial^2 w_F)/\partial\gamma^2$	Negative	concave

Table 5: First and second order conditions for $\boldsymbol{\Pi_L^{sus}}$ and $\boldsymbol{\Pi_F^{sus}}$

$(\partial\Pi_L^{sus})/\partial\theta$	Negative	decreasing function in θ
$(\partial^2\Pi_L^{Sus})/\partial\theta^2$	For $0<\theta\leq 0.694593$ nonnegative	convex
	For $0.694593\leq\theta<1$ nonnegative if $4\gamma^2-4\theta^3+18\theta^2-24\theta+12>\lvert\gamma(\theta^3-12\theta+8)\rvert$	convex
	For $0.694593\leq\theta<1$ negative if $4\gamma^2-4\theta^3+18\theta^2-24\theta+12<\lvert\gamma(\theta^3-12\theta+8)\rvert$	concave
$(\partial\Pi_L^{sus})/\partial\gamma$	negative	decreasing function in γ
$(\partial^2\Pi_L^{sus})/\partial\gamma^2$	nonnegative	convex
$(\partial\Pi_F^{sus})/\partial\theta$	Negative	decreasing function in θ
$(\partial^2\Pi_F^{sus})/\partial\theta^2$	For $0\leq\theta<0.597467$ nonnegative	convex
	For $0.597467\leq\theta<0.844464$ nonnegative if $\gamma^4(\theta+3)+\gamma^2(6\theta^3+14\theta^2-24\theta+17)-\gamma(4\theta^4+6\theta^3-24\theta^2+42\theta-24)+\theta^5-8\theta^3+30\theta^2+36\theta+12)>\lvert-\gamma^3(4\theta^2+11\theta-8)\rvert$	convex
	For $0.844464<\theta\leq 1$ nonnegative if $(\gamma^4(\theta+3)+\gamma^2(6\theta^3+14\theta^2-24\theta+17)+\theta^5-8\theta^3+30\theta^2+36\theta+12)>\lvert-\gamma^3(4\theta^2+11\theta-8)-\gamma(4\theta^4+6\theta^3-24\theta^2+42\theta-24)\rvert$	convex
	For $0.597467\leq\theta<0.844464$ negative if $\gamma^4(\theta+3)+\gamma^2(6\theta^3+14\theta^2-24\theta+17)-\gamma(4\theta^4+6\theta^3-24\theta^2+42\theta-24)+\theta^5-8\theta^3+30\theta^2+36\theta+12)<\lvert-\gamma^3(4\theta^2+11\theta-8)\rvert$	concave
	For $0.844464<\theta\leq 1$ negative if $(\gamma^4(\theta+3)+\gamma^2(6\theta^3+14\theta^2-24\theta+17)+\theta^5-8\theta^3+30\theta^2+36\theta+12)<\lvert-\gamma^3(4\theta^2+11\theta-8)-\gamma(4\theta^4+6\theta^3-24\theta^2+42\theta-24)\rvert$	concave
$(\partial\Pi_F^{sus})/\partial\gamma$	nonnegative	increasing function in γ
$(\partial^2\Pi_F^{sus})/\partial\gamma^2$	For $\theta<0{,}561553$ nonnegative if $\gamma(-\theta^3+4\theta)<\lvert\theta^4-9\theta^2+12\theta-4\rvert$	convex
	For $\theta<0{,}561553$ negative if $\gamma(-\theta^3+4\theta)>\lvert\theta^4-9\theta^2+12\theta-4\rvert$	concave
	For $0{,}561553<\theta<1$ negative	concave

3.1.2. The Effect of Competition and Spillover on the Sustainability Investments of Companies

In order to understand the conditions under which, companies decide to invest in a certain level of sustainability and the difference between the leader and followers' firm actions, I first consider the case $\gamma = 0$ as a benchmark case.

3.1.2.1 The Benchmark Case: No Sustainability Spillovers $\boldsymbol{\gamma = 0}$

Using (11) and (12), for $\gamma = 0$ and $\theta = 0$, I get $w_L = \frac{(a-d)}{2b}$ and $w_F = \frac{(a-d)}{2b}$.

Furthermore, for $\gamma = 0$ and $\theta = 0$, I get $\Pi_L^{sus} = \frac{(a-d)^2}{4b}$ and $\Pi_F^{sus} = \frac{(a-d)^2}{4b}$.

If there are no sustainability spillovers and the products/ services are not substitutable i.e. the markets are separated, both the leader and follower choose the same amount of sustainability investments and attain the same amount of net benefits.

Furthermore, for $\gamma = 0$ and $0 < \theta < 1$, I get $w_L = \frac{(a-d)(2-\theta)}{2b(2-\theta^2)}$ and $w_F = \frac{(a-d)(4-\theta(\theta+2))}{4b(2-\theta^2)}$

I compute the sustainability investments and net benefits of the leader and follower for arbitrary a, b and d values. [15]

As seen in Figure 4, for increasing competition levels, if there are no spillovers from leader to follower, the leader's sustainability investments first decreases, then increases for competition levels θ>0.585786, while the follower's sustainability investments decreases. Furthermore, as the level of competition increases the difference between the investments of leader and follower increases. As seen in Figure 5 the net

[15] $a = 1000$, b=0.7 and d=600

benefit of the follower and the leader are the same, when the competition level θ =0. As the competition level increases both the net benefits of leader and follower decrease, whereas the followers slope is steeper. For all competition levels $\theta > 0$ the leader's net benefits are higher than the follower's net benefits. Thus the leader attains first mover advantage.

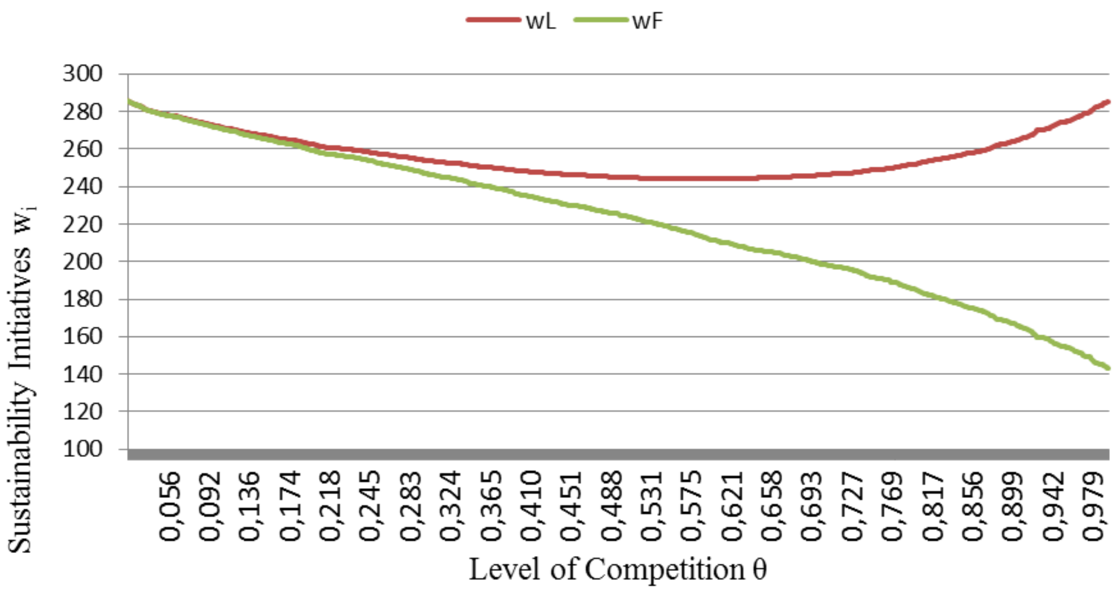

Figure 4: Influence of competition level on the sustainability investments for the benchmark case without sustainability spillovers ($\gamma = 0$)

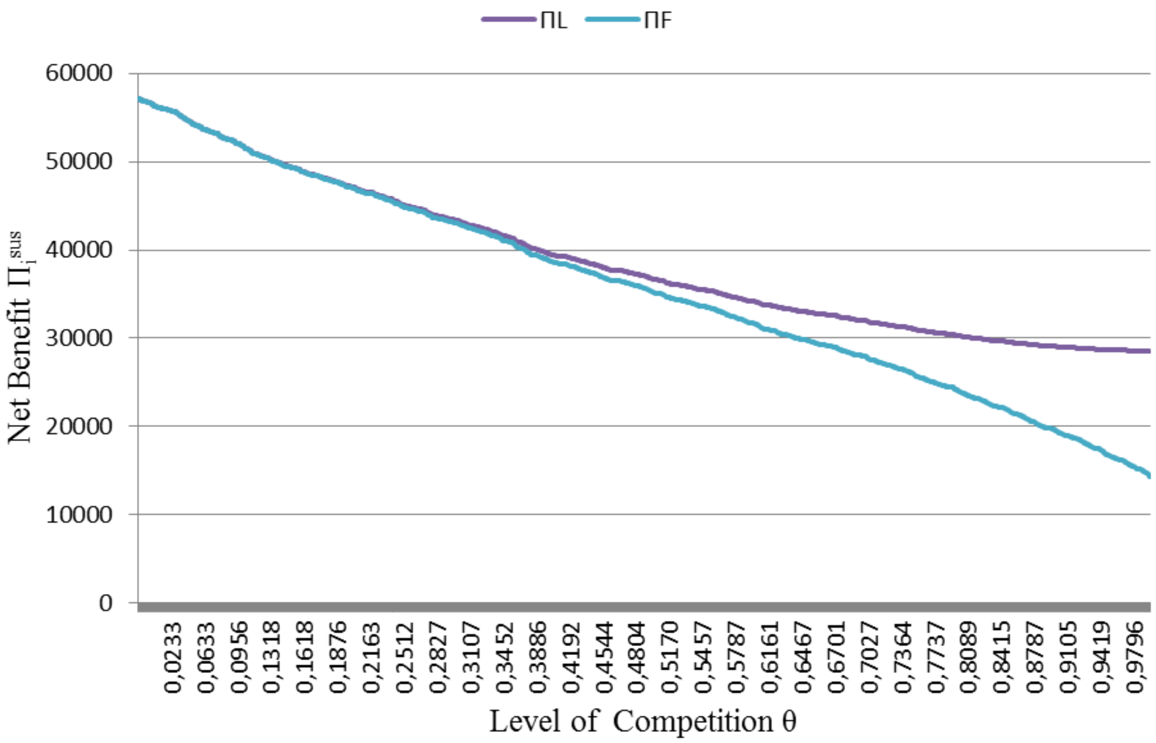

Figure 5: Influence of competition level on the net benefits for the benchmark case without sustainability spillovers ($\gamma = 0$)

3.1.2.2. The Case with Positive Spillovers $\boldsymbol{\gamma > 0}$

In order to understand the influence of level of competition and the sustainability spillovers on the sustainability investments I examine their interactions from different perspectives. First, I consider the influence of competition on the sustainability level for a given spillover rate. Subsequently, I examine the influence of sustainability spillovers on the sustainability level for a given competition level.

(79) proposes that if the degree of the spillover increases, the leader decreases her sustainability efforts in order to prevent the followers benefit from that. In return the follower has to invest more in her sustainability. As seen in Figure 6 for spillover rate γ =0.2 the leader decreases her sustainability initiatives in order to prevent the follower to freeride the leaders' sustainability efforts. As the products become more substitutable

($\theta >$0.740) the leader increases her sustainability initiatives to claim the first mover position. For moderate and high spillover rates as competition level increases both the leader and the follower decrease their sustainability efforts.

As seen in Figure 7 the leaders' sustainability initiatives decrease, as the spillover rate increases. The leader prevents the follower from free riding the sustainability efforts by decreasing them. As a respond the follower increases her sustainability initiatives. As seen in Figure 8 for lower competition levels the leader isn't able to retain her first mover advantage as the spillover rate increases. However, for higher competition levels the first mover advantage is more defendable. As the competition level increases the spillover rate, at which the advantage passes from leader to follower increases.

The follower is able to free ride the leaders sustainability efforts with increasing spillover rates only at low competition levels. The stakeholders differentiate between the companies which invest in sustainability and which free ride other companies sustainability efforts as the competition level increases. I suggest that stakeholders are able to differentiate between companies, since they are more informed about the companies, as their products become more substitutable.

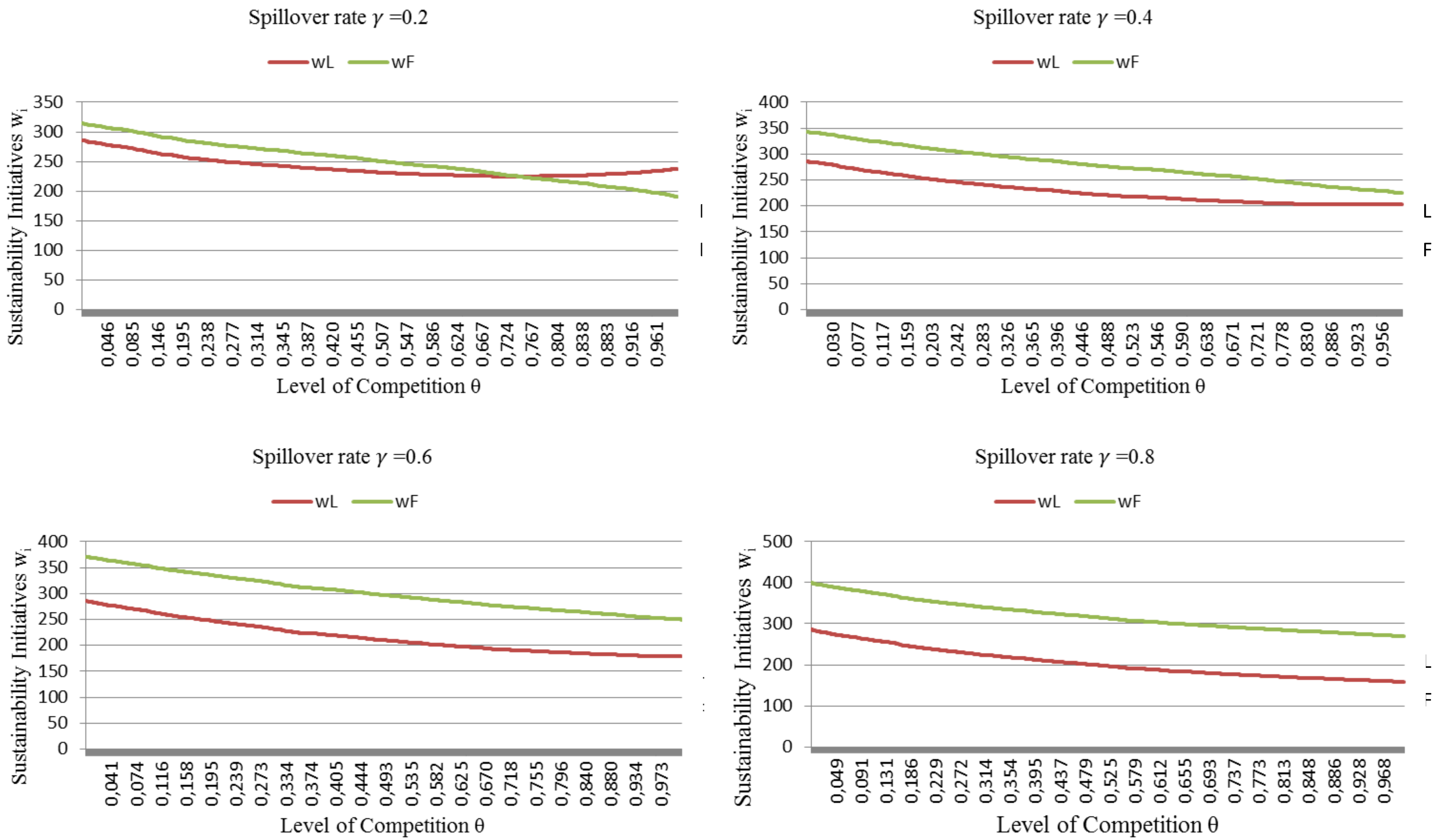

Figure 6: The influence of competition on the level of sustainability initiatives for different spillover rates

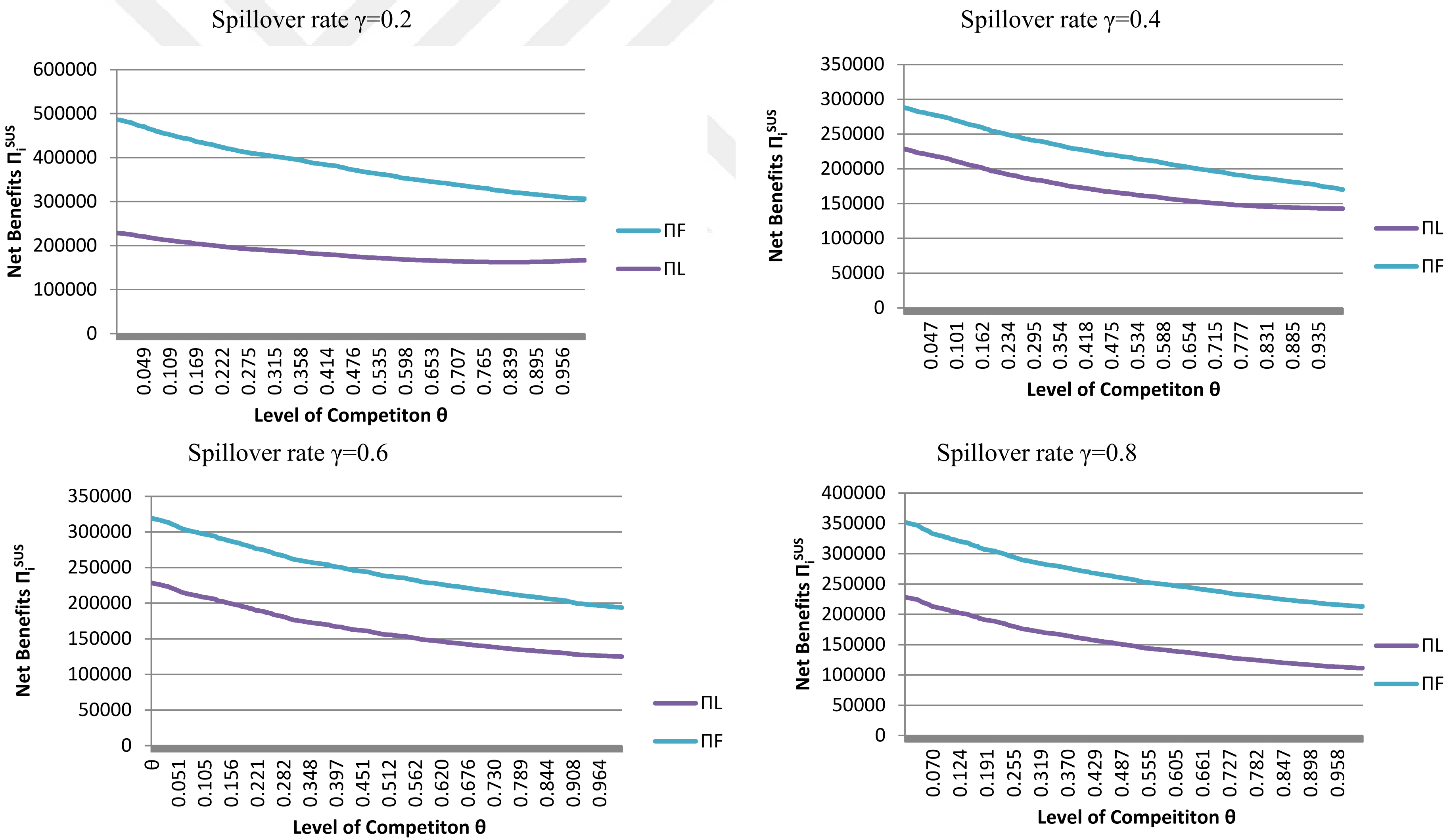

Figure 7: The influence of competition on the net benefits for different spillover rate

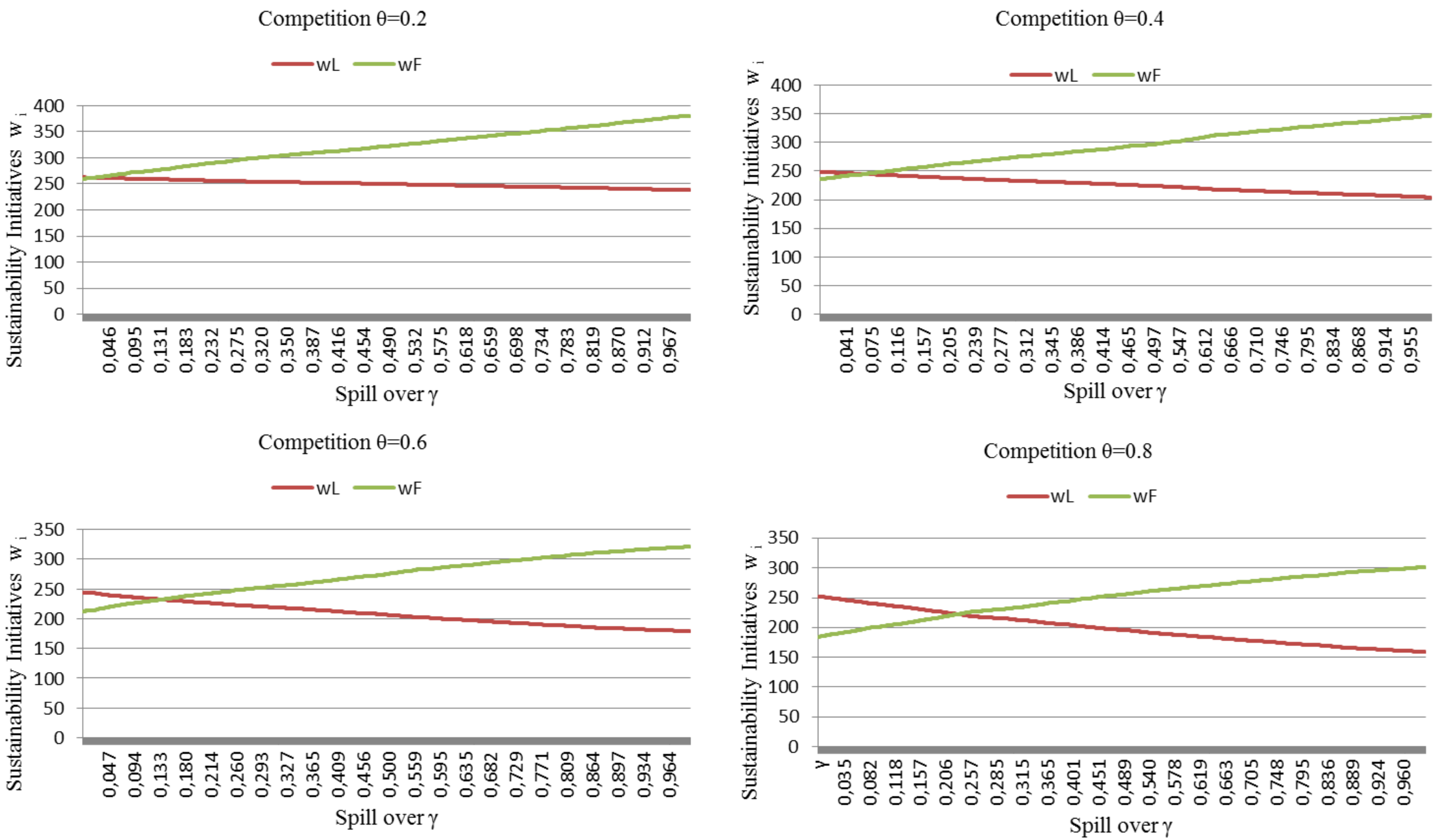

Figure 8 The influence of spillover on the level of sustainability initiatives for different competition levels

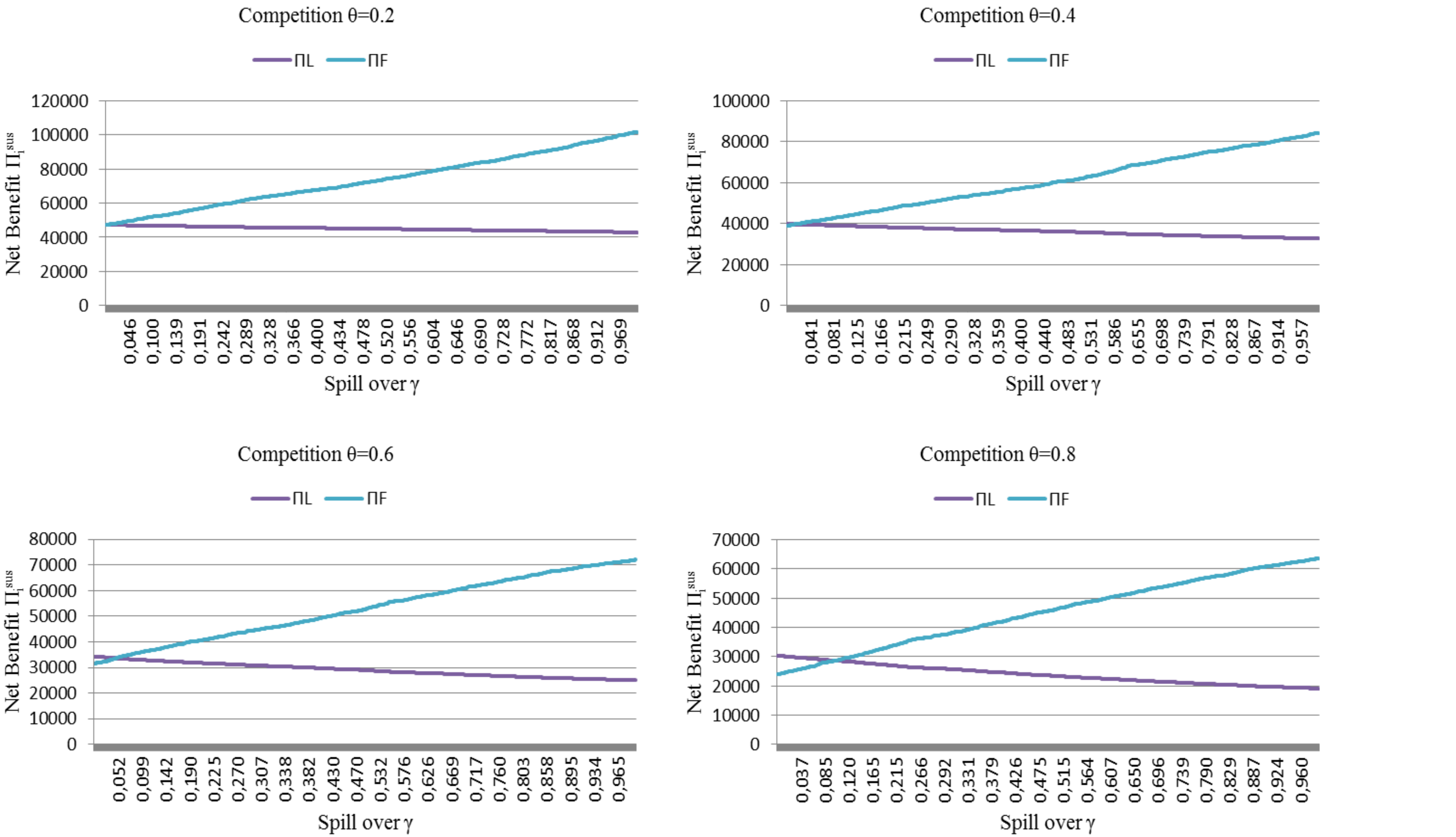

Figure 9: The influence of spillover on the net benefits for different degrees of competition

3.1.2.3. Case with competition level θ=1

I also consider the case where the sustainability offerings of the leader and competitor are perfect substitutes, θ=1. As seen in Figure 10 and 11 for spillover rates γ<0.320 the leader invests more into sustainability compared to the follower. However, the leader retains first mover advantage till spillover rates γ<0.160. The leader decreases her sustainability efforts in order to prevent the follower from free riding the leader's sustainability efforts. For spillover rates γ≥0.320 the follower increases the level of sustainability initiatives. For spillover rates γ≥0.160 the follower attains second mover advantage.

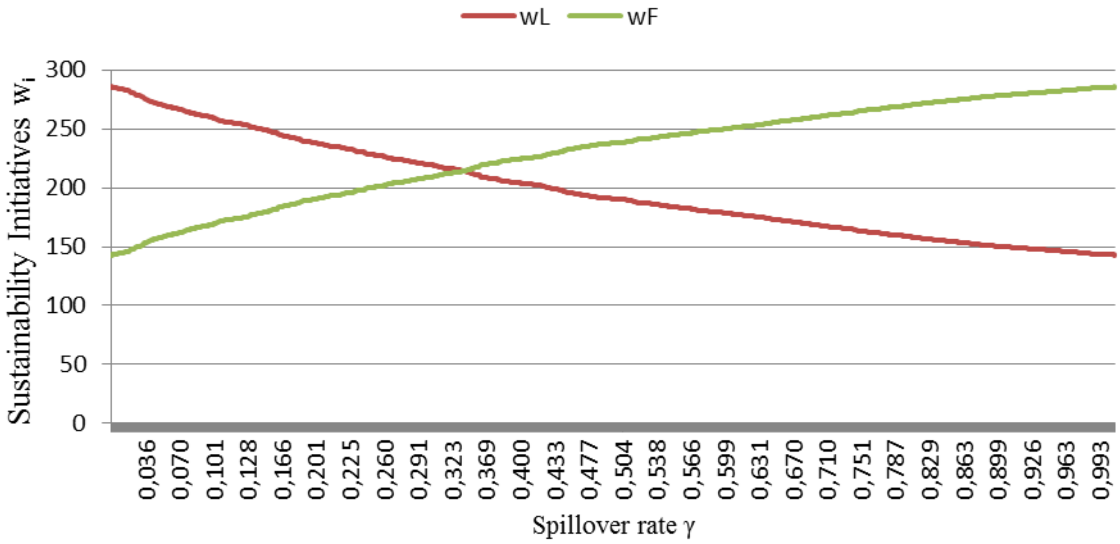

Figure 10: The influence of spillover on the level of sustainability initiatives for θ=1

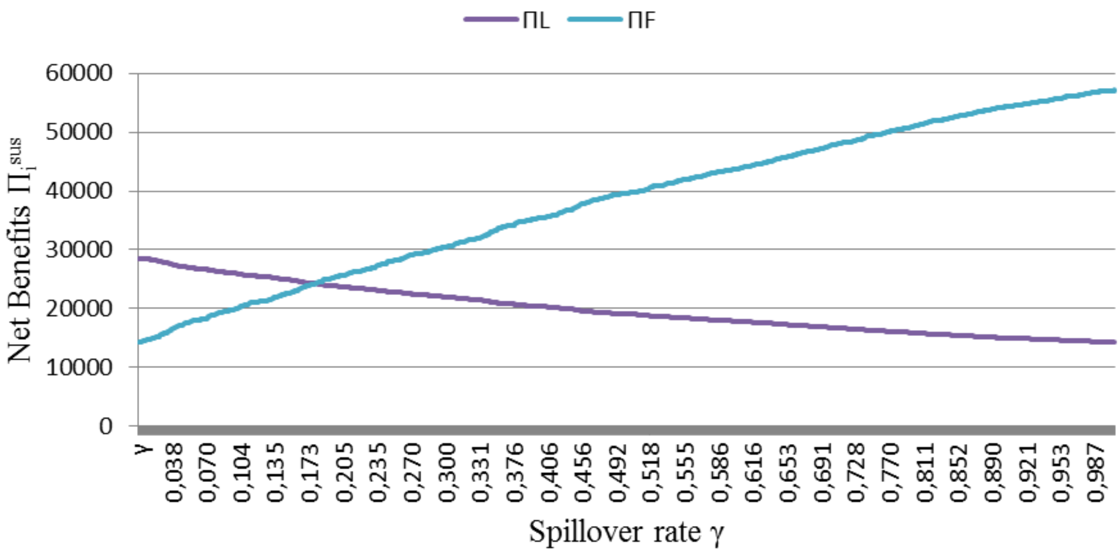

Figure 11: The influence of spillover on the net benefits for θ=1

If I evaluate the influence of competition on the level of sustainability initiatives without sustainability spillovers ($\gamma = 0$) and the influence of spillovers on the level of sustainability initiatives for perfect competition (θ=1) there are some interesting indications. As stated before if there are no sustainability spillovers and the products/ services are not substitutable i.e. the markets are separated, both the leader and follower choose the same amount of sustainability initiatives. As the level of competition increases the leader first decreases then increases her sustainability initiatives, whereas the follower decreases her sustainability initiatives. For all competition levels the leader attains first mover advantage if there are no sustainability spillovers. For ($\gamma = 0, \theta = 1$) the leader achieves the Stackelberg outcome.

For $\theta = 1$ the sustainability market is described as a standard (homogeneous) Stackelberg duopoly, where the leader and follower set sustainability initiatives (quantities) which maximize their net benefits. As stated before if the spillover rate increases the follower becomes reluctant to invest in sustainability. The leader decreases her sustainability investments in order to prevent the follower to free ride her sustainability efforts. As spillover rate increases the follower increases her sustainability initiatives and attains second mover advantage for γ≥0.160. For (γ = 1, θ= 1) the follower achieves the Stackelberg outcome.

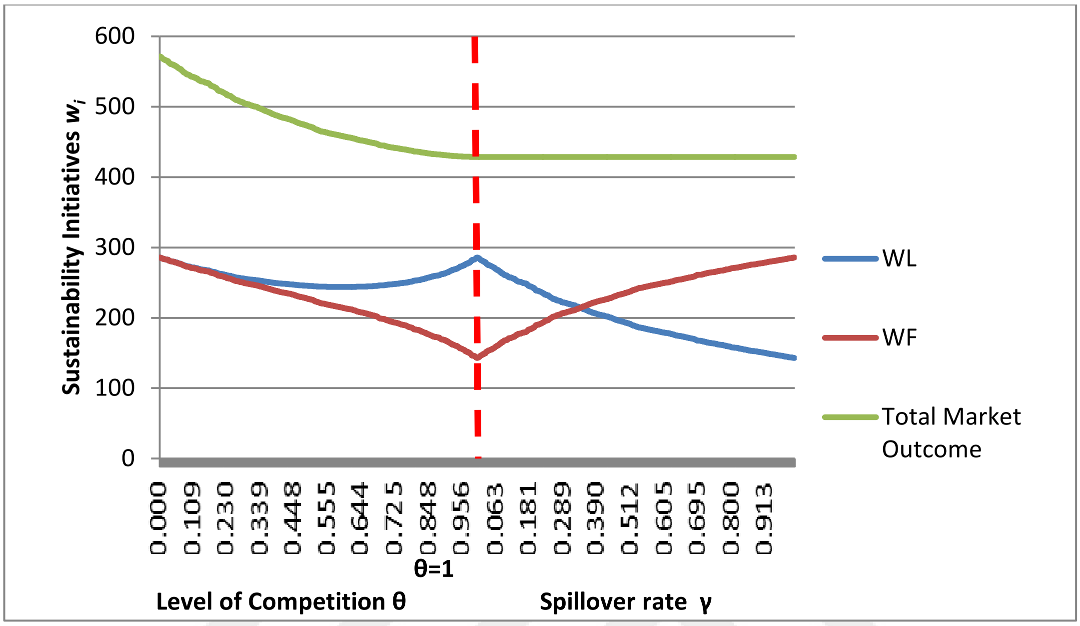

Figure 12: The influence of competition and spillover on the sustainability initiatives for duopoly market

As seen in Figure 12 the relationship between the quantities attained by the leader and follower is ($w_L = w_F$) if (γ = 0, θ= 0), ($w_L = 2\, w_F$) if (γ = 0, θ= 1) and ($w_L = w_F/2$) if (γ = 1, θ= 1). The sustainability initiatives for the leader and follower take the values in between for any combination of θ and γ ($0 < \gamma < 1, 0 <$ θ < 1). Moreover for altering γ and θ values the dynamics between the leader and follower (first mover and second mover advantage) shift. Furthermore, I assess the total market outcome of sustainability initiatives. When there is no spillover effect the total market outcome decreases as the competition level increases. When the offerings of the competitors are perfect substitutes (i.e. θ= 1) the total market outcome is constant with increasing spillover rates. However advantage shifts from leader the follower and gab between them widens as spillover rate increase.

3.1.3. The Effect of Competition and Spillover on the Total Market Outcome

In the introduction of section 3 I discussed that companies are either coerced to invest in sustainability due to a regulation change or decide to invest in sustainability due to market penetration. Actually, for most industries the sustainability interactions are stimulated by a combination of both. Mostly regulatory changes not only initiate mandatory sustainability investments, but also create awareness among stakeholders, which in return induce more sustainability investments. Therefore, if I only focus on the actions of companies, a crucial part of the analysis would be missing. In this section I consider the effect of competition and sustainability spillover on the total market outcome of sustainability initiatives.

As seen in Figure 13 as the competition level increases, the total market output regarding sustainability initiatives decreases. This finding has strong policy implications for the governments in supporting sustainability initiatives. According to competition policy, policy makers have to ensure that competition is not restricted in such way as to reduce economic welfare (106). In general increased competition is perceived to increase economic welfare.[16] If the effect of competition on economic welfare and other public policy factors such as social and environmental reasons are conflicting, the policy makers have to decide which one to prioritize. In this case, the policy makers

[16] On the one hand if more companies operate in the market, consumer surplus increases, which affects economic welfare positively. On the other hand, if more companies operate in the market, fixed costs of operating are duplicated and producer surplus decreases, which affect economic welfare negatively. Thus the effect of competition on economic welfare should be considered carefully.

should decrease competition, if their goal is to improve social and environmental welfare.

As seen in Figure 14 as spillover rate increases, the total market output regarding sustainability initiatives increase. Spillovers are undesirable for the leader, while the follower benefits from spillovers. For the policy maker the spillovers are positive, since they increase the total market output regarding sustainability initiatives. Thus policy makers should incentivize sustainability initiatives that transform the market rather than sustainability initiatives, which are company specific and hard to imitate. One interesting observation is that the market output is at the same level for all spillover rates, when competition level θ=1. In the case of perfect competition (θ=1) the total market output regarding sustainability is independent of spillovers.

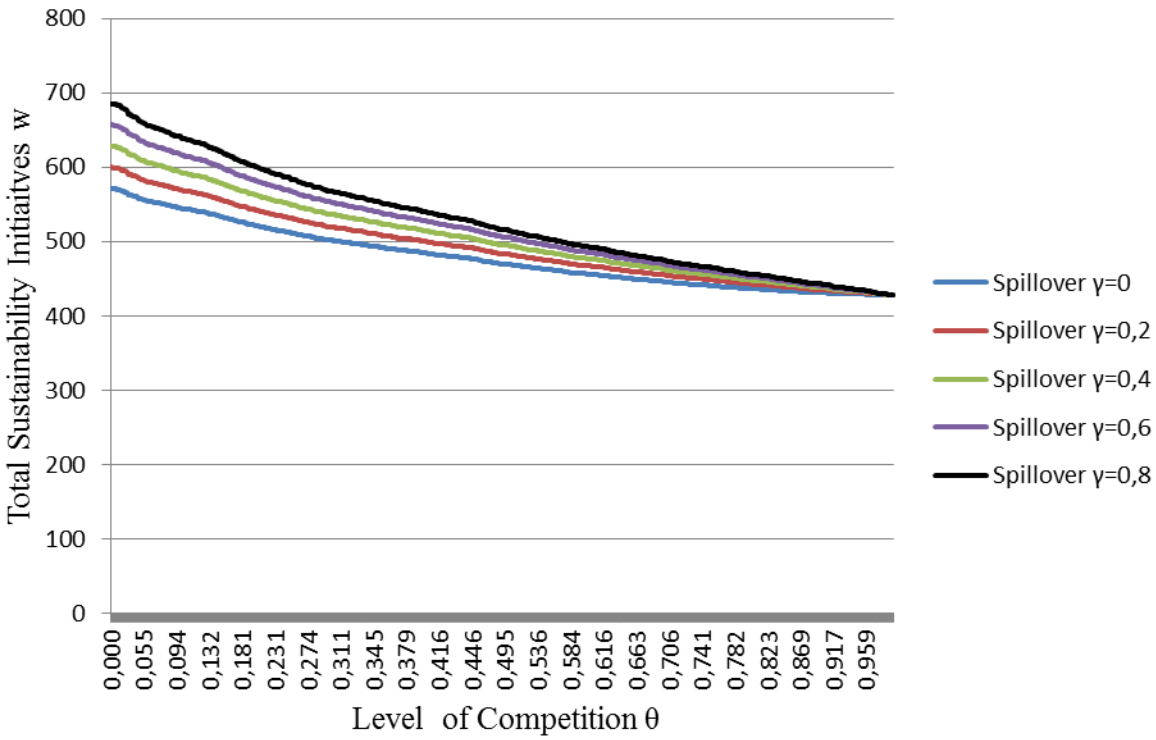

Figure 13: The influence of competition on total sustainability initiatives for different degrees of spillover

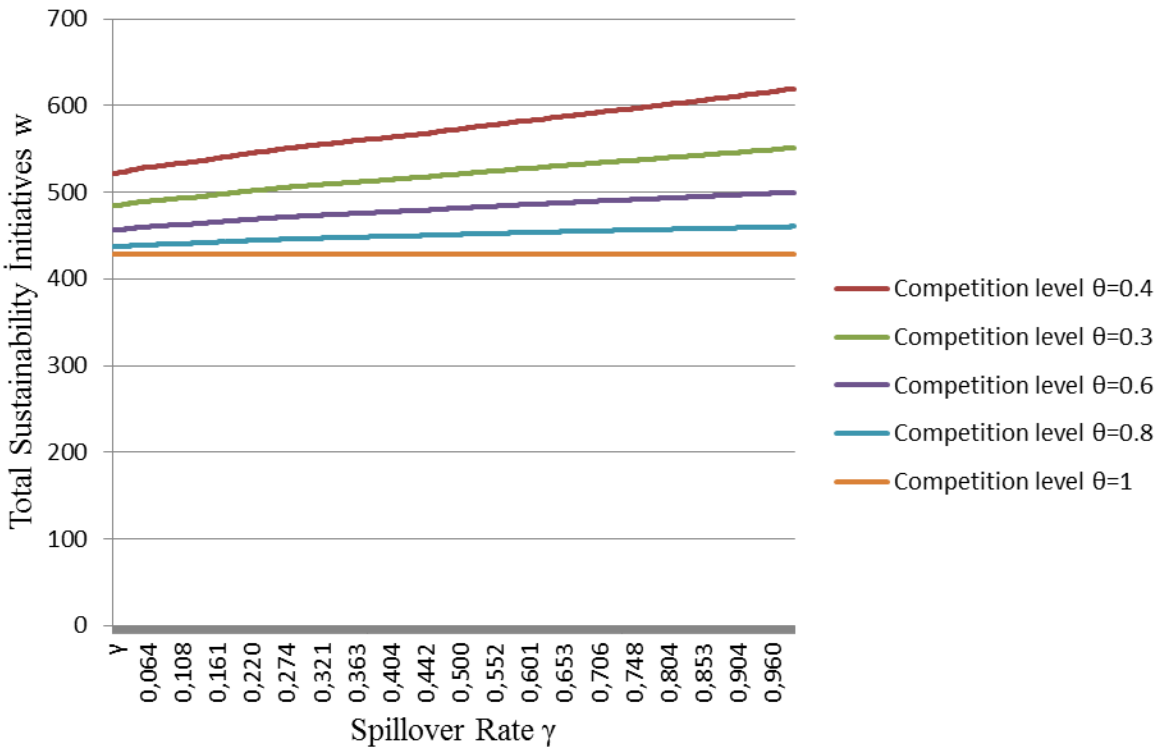

Figure 14: The influence of spillover on total sustainability initiatives for different degrees of competition

3.2. Sequential Oligopoly Model

According to (107) there is a time lag between the observation of a firm's sustainability action and the response of its competitor. Furthermore (28) claim that sustainability activities are not synchronous and the competitive moves of the focal company and her competitors should be analyzed over time. Thus I propose the following model using the notation in Table 6.

Table 6: Notation for the sequential oligopoly model

i:	company index, *i=1,…..,N*
w_L:	level of sustainability initiatives of the leader
w_{F_i}:	level of sustainability initiatives of follower *i*
$p_L(w_L, w_{F_i})$:	stakeholder payments for the leader for sustainability level w_L
$p_{w_{F_i}}(w_L, w_{F_i})$:	stakeholder payments for follower *i* for sustainability level w_{F_i}
a:	initial willingness of the stakeholder to pay for sustainability initiatives, $a > 0$
b:	rate at which the willingness to pay decreases as sustainability initiatives increase, $b > 0$, price elasticity of demand for sustainability
d:	marginal cost for sustainability investment for both the sustainability leader and the followers, $d > 0$
γ_i	sustainability spill overs for follower i, $\gamma_i \in [0,1]$
γ:	sustainability spill overs at constant rate for all followers, $\gamma \in [0,1]$
θ:	level of competition, $\theta \in [0,1]$
$R_{F_i}\left(\sum_{j\neq i}^{N-1} w_{F_j} \middle| w_L\right)$:	follower *i*' s reaction to arbitrary sustainability levels by other followers subject to the leaders sustainability level w_L
$r_L^{sus}(w_L, w_{F_i})$:	benefit of the leader from undertaking sustainability initiatives
$r_{F_i}^{sus}(w_L, w_{F_i})$:	benefit of the follower from undertaking sustainability initiatives
$c_L^{sus}(w_L, w_{F_i})$:	cost of the leader from undertaking sustainability initiatives
$c_{F_i}^{sus}(w_L, w_{F_i})$:	cost of follower *i* from undertaking sustainability initiatives
$\Pi_L^{sus}(w_L \mid p_L(w_L, w_{F_i}))$:	net benefit of the leader from undertaking sustainability initiatives
$\Pi_{F_i}^{sus}(w_{F_i} \mid p_{F_i}(w_L, w_{F_i}))$:	net benefit of the follower from undertaking sustainability initiatives

I consider N firms with identical constant implementation costs d. They make sequential choices of actions; firm 1 first, firm N last. In the first stage of the game, the leader (firm 1) chooses w_L by anticipating the cumulative response of all followers. In the second stage, the follower 1 (firm 2) observes w_L and decides on her level of sustainability investments, w_{F_1} anticipating the opponents' sustainability investment $w_{F_j}, j = 3$. In the nth stage the last follower (firm N) observes w_L and the cumulative sustainability investments of the opponents $\sum_{j=2}^{N-1} w_{F_j}$ and decides on her sustainability investments, w_{F_N}.

An alternative model, where in the first stage of the game the leader decides on her sustainability investments w_L by anticipating the cumulative response of all followers, and in the second stage followers decide on their sustainability investments w_{F_i} simultaneously, may also be considered. However, this model is trivial, since the cumulative response of the followers will be equal to the response of the follower calculated in the sequential duopoly model as per, $\sum_{i=2}^{N} w_{F_i} = w_F$. Moreover, the sustainability investments of the leader in an oligopolistic market would be equal to the sustainability investments of the leader in a duopolistic market. On the one hand, if all followers are affected from the spillovers equally, then the sustainability investments of the followers will be equal to each other, as per w_{F_i}=$w_F/(N-1)$. On the other hand, if the followers are affected differently from the spillovers due to their company characteristics, their sustainability investments should be proportional to their spillover rates. Henceforth, I will proceed with the model presented in Figure 15.

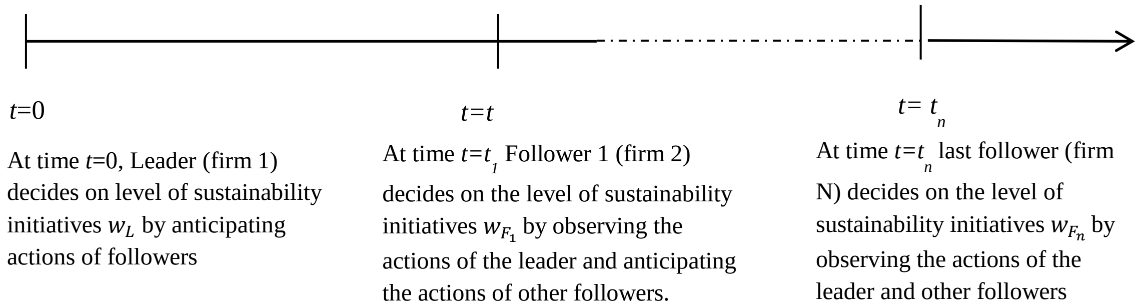

Figure 15: Time line for n Period- Sequential Single Leader- Multiple Follower Game

In the classical game theoretical models, the level of competition is derived by the market shares of the companies. In the corporate sustainability interactions model in this study, the stakeholders' demand is for sustainability, and companies supply for this demand. Thus, sustainability level of a company is the supply of that company to meet the demand for sustainability and should be considered similar to "amount of supply" for the demanded goods or services in the classical sense. Therefore, competition is not for the market share for the products or services of the companies offered, but to meet the demand for sustainability. One can argue that competition among companies for sustainability is not entirely independent of competition among companies for their product and/or service offerings due to the nature of sustainability. Nonetheless, my sustainability construct can be considered as a homogeneous "good" supplied by the companies. Due to the homogeneous goods assumption, the effect of competition is perceived by both the leader and followers and is constant among all players.

Sustainability spillovers should also be considered carefully. If sustainability spillovers are assumed to occur only from leader to followers, follower 1 is expected to be benefitting more from spillovers compared to successor followers. As illustrated in

Figure 16, the spillovers are expected to diminish over time. Thus $\gamma_1 > \gamma_2 > \cdots > \gamma_{n-1} > \gamma_n \geq 0$.

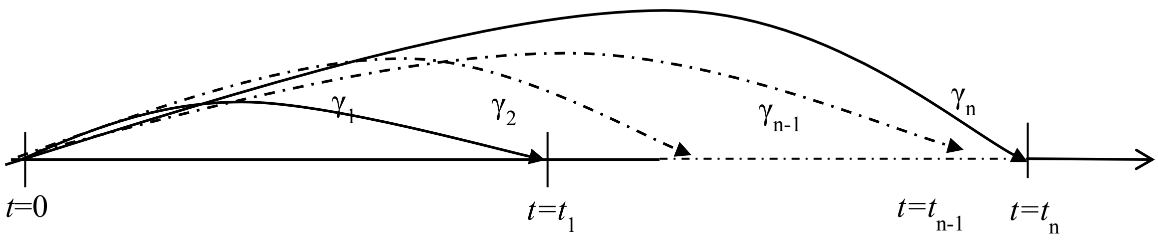

Figure 16: Spillover effects for n-Period Sequential Single Leader-Multiple Follower Game, with Spillovers only from Leader to Followers

However the assumption of spillovers occurring only from leader to followers is a strong assumption and is not realistic. Spillovers γ_{Lj} occur from leader to follower j and spillovers γ_{ij} may occur among followers if $i < j$ as illustrated in Figure 17. For example the cumulative spillover for follower j would be the summation of spillover effect from the leader, γ_{Lj} and spillover effects from all the predecessors to F_j. Thus total spillover for F_j is denoted as $\gamma_j = \gamma_{Lj} + \sum_{i=2}^{j-1} \gamma_{ij}$. I assume that the spillover effects from leader to followers will decrease over time, while the spillovers from predecessor to successor followers will increase. Furthermore, I assume that the rate of decrease in spillover effects from leader to followers and the rate of increase in spillover from predecessor followers to successor followers are at the same degree,and the cumulative spillover for arbitrary follower j is constant

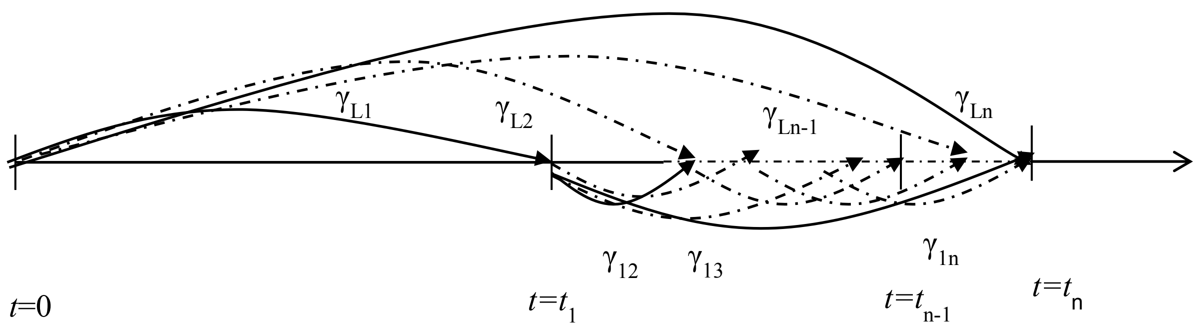

Figure 17: Spillover effects for n-period- sequential single leader- multiple follower game, if spillovers occur from leader to followers and among followers

3.2.1. n-Period Sequential Single Leader-Multiple Follower Game with Leader-Follower-Follower Spillovers at a Constant Rate

As explained in the previous section, the sustainability leader and the followers compete for stakeholder payments for sustainability. As the number of players investing in sustainability increases, sustainability payments are expected to decrease. I begin the analysis with the simplest case, where one leader and two followers compete for the stakeholder payments. I formulate stakeholder payments as:

$$p_L(w_L, w_{F_1}, w_{F_2}) = a - b(w_L + \theta(w_{F_1} + w_{F_2})) \quad (15)$$

$$p_{F_1}(w_L, w_{F_1}, w_{F_2}) = a - b(w_{F_1} + (\theta - \gamma)w_L + \theta w_{F_2}) \quad (16)$$

$$p_{F_2}(w_L, w_{F_1}, w_{F_2}) = a - b(w_{F_2} + (\theta - \gamma)(w_{F_1} + w_L)) \quad (17)$$

An increase in the competition level affects stakeholder payments of the leader and follower negatively. I assume that the spillovers occur only from leader to follower. If sustainability investments of the leader are successful, the follower may free ride the leader's sustainability efforts. Either the stakeholder perception of the whole industry shifts due to the efforts of the leader and the follower benefits from increased stakeholder payment or the follower imitates the leader's sustainability actions and benefits from the spillovers without bearing the full investment costs. For the sake of simplicity, I assume that the marginal cost for sustainability investments are constant for both the sustainability leader and the follower and denote it by *d*. I do not distinguish between the nature of spillovers (increased stakeholder payment or decrease in sustainability investment costs) and incorporate the twofold influence of spillovers as a positive effect on followers' benefits; an increase in sustainability spillovers increases the followers' stakeholder payments.

The benefit from sustainability initiatives is calculated as

$$r_L^{sus}\left(w_{L,}\, w_{F_1}, w_{F_2}\right) = p\left(w_{L,} w_{F_1}, w_{F_2}\right) w_L \tag{18}$$

$$r_{F_1}^{sus}\left(w_{L,}\, w_{F_1}, w_{F_2}\right) = p\left(w_{L,} w_{F_1}, w_{F_2}\right) w_{F_1} \tag{19}$$

$$r_{F_2}^{sus}\left(w_{L,} w_{F_1}, w_{F_2}\right) = p\left(w_{L,} w_{F_1}, w_{F_2}\right) w_{F_2} \tag{20}$$

Leader's decision problem is to choose the level of sustainability initiatives $w_L \geq 0$ that maximizes her net benefit function given as:

$$\Pi_L^{sus}(w_L \,|\, p_L(w_L,\, w_{F_1}, w_{F_2})) = r_L^{sus}\left(w_L,\, w_{F_1}, w_{F_2}\right) - c_L^{sus}\left(w_L,\, w_{F_1}, w_{F_2}\right) =$$
$$\left[p_L\left(w_L,\, w_{F_1}, w_{F_2}\right) - d\right] w_L \tag{21}$$

Then, each follower's decision problem is to choose the level of sustainability investment w_{F_i} that maximizes her benefit function. Thus follower 1 and follower 2's objective functions can be written as:

$$\Pi_{F_1}^{sus}\left(w_{F_1} \middle| p\left(w_L,\, w_{F_1}, w_{F_2}\right)\right) = r_{F_1}^{sus}\left(w_L,\, w_{F_1}, w_{F_2}\right) - c_{F_1}^{sus}\left(w_L,\, w_{F_1}, w_{F_2}\right)$$

$$= \left[p_{F_1}\left(w_L,\, w_{F_1}, w_{F_2}\right) - d\right] w_{F_1} \tag{22}$$

$$\Pi_{F_2}^{sus}\left(w_{F_2}\middle|p(w_L,\ w_{F_1},w_{F_2})\right) = r_{F_2}^{sus}(w_L,\ w_{F_1},w_{F_2}) - c_{F_2}^{sus}(w_L,\ w_{F_1},w_{F_2})$$

$$= [p_{F_2}(w_L,\ w_{F_1},w_{F_2}) - d]w_{F_2} \tag{23}$$

To solve for the backward induction outcome of this game, I first compute the $R_{F_2}(w_{F_1}|w_L)$, the follower 2's reaction to an arbitrary sustainability level by follower 1 subject to the leader's sustainability level w_L as asserted in stage 1.

$R_{F_2}(w_{F_1}|w_L)$ solves the optimization problem:

$$\max_{w_i\geq 0} \Pi_{F_2}^{sus}\left(\left(w_{F_2},w_{F_1}\middle|w_L\right)\right) = \max_{w_i\geq 0} w_{F_2}(\ a - b(w_{F_2} + (\theta-\gamma)(w_{F_1} + w_L)) - d) \tag{24}$$

which yields

$$R_{F_2}(w_{F_1}|w_L) = \frac{a-d-b(\theta-\gamma)(w_{F_1}+w_L)}{2b} \tag{25}$$

provided that $a - d > b\big((\theta-\gamma)(w_{F_1} + w_L)\big)$.

$R_{F_1}(w_{F_2}|w_L)$ solves the optimization problem

$$\max_{w_i\geq 0} \Pi_{F_1}^{sus}\left(\left(w_{F_1},w_{F_2}\middle|w_L\right)\right) = w_{F_1}(\ a - b(w_{F_1} + (\theta-\gamma)w_L + \theta R_{F_2}(w_{F_1}|w_L)) - d) \tag{26}$$

which yields

$$R_{F_1}(w_{F_2}|w_L) = \frac{(2-\theta)((a-d)-w_L b(\theta-\gamma))}{2b(2-\theta(\theta-\gamma))} \tag{27}$$

provided that $a - d > b(\theta-\gamma)w_L$.

Plugging in (27) into (25) I can rewrite the second followers reaction function

$$R_{F_2}\left(w_{F_1}\middle|w_L\right) = \frac{(a-d-bw_L(\theta-\gamma))(4-(2+\theta)(\theta-\gamma))}{4\mathrm{b}(2-\theta(\theta-\gamma))} \tag{28}$$

Leader's decision problem is to choose the level of sustainability initiatives $w_L \geq 0$ that maximizes her net benefit function.

$$\Pi^L(w_L \,|\, p(w_L)\,) = r(w_L) - c(w_L).w_L = w_L\left[a - b(w_L + \theta(w_{F_1} + w_{F_2}))\ - d\right] \tag{29}$$

Since the leader can solve the followers' problem as well as the followers, the leader should anticipate that the sustainability level choice w_L will be met with the cummulative reaction of followers $\sum_{i=1}^{n-1} R_{F_i}\left(\sum_{j\neq i}^{n-1} w_{F_j}\,\middle|w_L\right)$. Thus, the leaders problem in the first stage becomes

$$\max_{w_L\geq 0} \Pi_L\left(w_L, \sum_{i=1}^{n-1} R_{F_i}\left(\sum_{j\neq i}^{n-1} w_{F_j}\,\middle|w_L\right)\right) \tag{30}$$

For the one leader two followers case the leader solves

$$\max_{w_L\geq 0} w_L\left(a - b(w_L + \theta(R_1\left(w_{F_2}\right) + R_2\left(w_{F_1}\right))) - d\right)$$

$$= \max_{w_L\geq 0} w_L\left(a - b(w_L + \theta(\frac{(2-\theta)\left((a-d)-w_L b(\theta-\gamma)\right)}{2b\left(2-\theta(\theta-\gamma)\right)} + \frac{\left(a-d-bw_L(\theta-\gamma)\right)\left(4-(2+\theta)(\theta-\gamma)\right)}{4\mathrm{b}\left(2-\theta(\theta-\gamma)\right)})) - d\right)$$

$$= \max_{w_L\geq 0} w_L(a - d - b\left[w_L + \theta\left[\frac{\left(a-d-bw_L(\theta-\gamma)\right)\left(8+\gamma(2+\theta)-\theta(4+\theta)\right)}{4b\left(2-\theta(\theta-\gamma)\right)}\right]\right]) \tag{31}$$

which yields

$$w_L = \frac{(a-d)(\theta(-8+4\theta+\theta^2-\gamma(2+\theta))+4[2-\theta[-\gamma+\theta]])}{2b(\theta(\gamma^2(2+\theta)-2\gamma(-4+3\theta+\theta^2)+\theta(-8+4\theta+\theta^2))+4[2-\theta[-\gamma+\theta]])} \tag{32}$$

as the backwards-induction outcome of the Stackelberg oligopoly game.

Plugging in the result from (32) into (27) and (28), after some manupulation I get

$$w_{F_1} = \frac{(2-\theta)((\gamma-\theta)\theta(8+\gamma(2+\theta)-\theta(4+\theta))+4(2+\gamma-\theta)[2-\theta[-\gamma+\theta]])]}{4b(2+(\gamma-\theta)\theta)((\gamma-\theta)\theta(8+\gamma(2+\theta)-\theta(4+\theta))+4(2-\theta(\theta-\gamma)))} \quad (33)$$

$$w_{F_2} = \frac{(a-d)(4+(\gamma-\theta)(2+\theta))((\gamma-\theta)\theta(8+\gamma(2+\theta)-\theta(4+\theta))+4(2+\gamma-\theta)[2-\theta[-\gamma+\theta]])}{8b(2-\theta(\theta-\gamma))((\gamma-\theta)\theta(8+\gamma(2+\theta)-\theta(4+\theta))+4[2-\theta[\theta-\gamma]])} \quad (34)$$

There are eight cases to consider in order for the leader's sustainability initiatives w_L and the followers' sustainability initiatives w_{F_1} and w_{F_2} to be nonnegative. Under the restrictions imposed by the model's assumptions only case 1 yields nonnegative sustainability investments for the leader and the followers. The remaining cases are presented in the Appendix A2.

Case 1: Both the numerator and denominator in w_L , w_{F_1} and w_{F_2} are nonnegative.

i) Since $a - d > 0$, $\theta(-8 + 4\theta + \theta^2 - \gamma(2 + \theta)) + 4[2 - \theta[-\gamma + \theta]] > 0$ should hold in order the numarator of $w_L > 0$.

Considering the worst case, where $\gamma = 0$, I get $-3.236 < \theta < 1.236$

For $\theta = 1$, I get $\gamma > -1$.

Since b> 0, $\theta(\gamma^2(2 + \theta) - 2\gamma(-4 + 3\theta + \theta^2) + \theta(-8 + 4\theta + \theta^2)) + 4[2 - \theta[\theta - \gamma]] > 0$ should hold in order for the denominator of $w_L > 0$.

Considering the worst case, where $\gamma = 0$, I get $-0.745 < \theta < 1.143$

For $\theta = 1$, I get $\gamma > -1/3$.

Combining the results in order $w_L > 0$, $-0.745 < \theta < 1.143$ and $\gamma > -1/3$ should hold.

ii) Since $a-d>0$ and 2- $\theta>0$ due to $\theta \in [0,1]$

$(\gamma-\theta)\theta(8+\gamma(2+\theta)-\theta(4+\theta))+4(2+\gamma-\theta)[2-\theta[-\gamma+\theta]]>0$

should hold in order the numerator of $w_{F_1}>0$.

Considering the worst case, where $\gamma=0$, I get $-0.745<\theta<1.143$

For $\theta=1$, I get $\gamma>-1/7$.

Since b> 0, $(2-\theta(\theta-\gamma))((\gamma-\theta)\theta(8+\gamma(2+\theta)-\theta(4+\theta))+4(2-\theta(\theta-\gamma))>0$ should hold in order for the denominator of $w_{F_1}>0$.

Considering the worst case, where $\gamma=0$, I get $-0.629<\theta<1.414$

For $\theta=1$, I get $\gamma>-1$.

Combining the results in order $w_{F_1}>0$, $-0.629<\theta<1.143$ and $\gamma>-1/7$ should hold.

iii) Since $a-d>0$, $(4+(\gamma-\theta)(2+\theta))((\gamma-\theta)\theta(8+\gamma(2+\theta)-\theta(4+\theta))+4(2+\gamma-\theta)[2-\theta[-\gamma+\theta]])>0$ should hold in order the numerator of $w_{F_2}>0$.

Considering the worst case, where $\gamma=0$, I get $-1.002<\theta<1.095$

For $\theta=1$, I get $\gamma>-1/7$.

Since b> 0, $(2-\theta(\theta-\gamma))((\gamma-\theta)\theta\big(8+\gamma(2+\theta)-\theta(4+\theta)\big)+4\big[2-\theta[\theta-\gamma]\big])>0$ should hold in order for the denominator of $w_{F_2}>0$.

Considering the worst case, where $\gamma=0$, I get $-0.745<\theta<1.143$

For $\theta=1$, I get $\gamma>-1/3$.

Combining the results in order for $w_{F_2}>0$, $-0.745<\theta<1.095$ and $\gamma>-1/7$ should hold.

In order for $w_L > 0$, $w_{F_1} > 0$ and $w_{F_2} > 0$ to hold, $-0.629 < \theta < 1.095$ and $\gamma > -1/7$ should hold. Since $\theta \in [0,1]$ and $\gamma \in [0,1]$ by definition, w_L, w_{F_1} and w_{F_2} are nonnegative for all defined θ and γ values.

From the model's assumptions and *case 1* I determine that w_L, w_{F_1} and w_{F_2} are nonnegative for all positive b values, $\gamma \in [0,1]$ and $\theta \in [0,1]$. Furthermore, I compute the net benefits for both leader and follower as:

$$\Pi_L^{sus} = ((a-d)(a-d-$$

$$b[\frac{(a-d)\left(4\left[2-\theta[-\gamma+\theta]\right]+\theta\left[-8+\theta(4+\theta)-\gamma[2+\theta]\right]\right)}{2b\left[4\left[2-\theta[-\gamma+\theta]\right]+\theta\left[-2\gamma[(-1+\theta)(4+\theta)]+\gamma^2[2+\theta]+\theta[-8+\theta(4+\theta)]\right]\right]}$$

$$+$$

$$\theta[\frac{1}{8}(a-d)(4(2+\gamma-\theta)[2-\theta[-\gamma+\theta]]+(\gamma-\theta)\theta[8+\gamma[2+\theta]-$$

$$\theta[4$$

$$+\theta]])(\frac{4+(\gamma-\theta)(2+\theta)}{b\left[2-\theta[-\gamma+\theta]\right]\left(4\left[2-\theta[-\gamma+\theta]\right]+(\gamma-\theta)\theta\left[8+\gamma[2+\theta]-\theta[4+\theta]\right]\right)}$$

$$+$$

$$\frac{2(-2+\theta)}{b[2+(\gamma-\theta)\theta]\left(-8+4\theta[-\gamma+\theta]+(-\gamma+\theta)\theta\left[8+\gamma[2+\theta]-\theta[4+\theta]\right]\right)})]])(4[2$$

$$-\theta[-\gamma+\theta]]+\theta[-8+\theta(4+\theta)-\gamma[2+\theta]]))/(2b[4[2-\theta[-\gamma$$

$$+\theta]]$$

$$+\theta[-2\gamma[(-1+\theta)(4+\theta)]+\gamma^2[2+\theta]+\theta[-8+\theta(4+\theta)]]]]) \quad (35)$$

$$\Pi^{sus}_{F_1} = (4b[2+(\gamma-\theta)\theta](4[2-\theta[-\gamma+\theta]]+\theta[-8+\theta(4+\theta)-\gamma[2+\theta]])(8-4\theta[-\gamma+\theta]+(\gamma-\theta)\theta[8+\gamma[2+\theta]-\theta[4+\theta]])(a-d-\frac{1}{8}b(a-d)(\frac{4(4[2-\theta[-\gamma+\theta]]+\theta[-8+\theta(4+\theta)-\gamma[2+\theta]])}{b[4[2-\theta[-\gamma+\theta]]+\theta[-2\gamma[(-1+\theta)(4+\theta)]+\gamma^2[2+\theta]+\theta[-8+\theta(4+\theta)]]]}+\theta(4(2+\gamma-\theta)[2-\theta[-\gamma+\theta]]+(\gamma-\theta)\theta[8+\gamma[2+\theta]-\theta[4+\theta]])(\frac{4+(\gamma-\theta)(2+\theta)}{b[2-\theta[-\gamma+\theta]](4[2-\theta[-\gamma+\theta]]+(\gamma-\theta)\theta[8+\gamma[2+\theta]-\theta[4+\theta]])}+\frac{2(-2+\theta)}{b[2+(\gamma-\theta)\theta](-8+4\theta[-\gamma+\theta]+(-\gamma+\theta)\theta[8+\gamma[2+\theta]-\theta[4+\theta]])}))))/((2-\theta)(4(2+\gamma-\theta)[2-\theta[-\gamma+\theta]]+(\gamma-\theta)\theta[8+\gamma[2+\theta]-\theta[4+\theta]])(a-d-b(\theta z-\frac{(a-d)(\gamma-\theta)(4[2-\theta[-\gamma+\theta]]+\theta[-8+\theta(4+\theta)-\gamma[2+\theta]])}{2b[4[2-\theta[-\gamma+\theta]]+\theta[-2\gamma[(-1+\theta)(4+\theta)]+\gamma^2[2+\theta]+\theta[-8+\theta(4+\theta)]]]}+\frac{(a-d)(-2+\theta)(4(2+\gamma-\theta)[2-\theta[-\gamma+\theta]]+(\gamma-\theta)\theta[8+\gamma[2+\theta]-\theta[4+\theta]])}{4b[2+(\gamma-\theta)\theta](-8+4\theta[-\gamma+\theta]+(-\gamma+\theta)\theta[8+\gamma[2+\theta]-\theta[4+\theta]])}))) \quad (36)$$

$$\Pi^{sus}_{F_2} = (a-d)(4+\gamma(2+\theta)-\theta(2+\theta))(a-d-b[\frac{1}{8}(a-d)(\frac{(4+(\gamma-\theta)(2+\theta))(4(2+\gamma-\theta)[2-\theta[-\gamma+\theta]]+(\gamma-\theta)\theta[8+\gamma[2+\theta]-\theta[4+\theta]])}{b[2-\theta[-\gamma+\theta]](4[2-\theta[-\gamma+\theta]]+(\gamma-\theta)\theta[8+\gamma[2+\theta]-\theta[4+\theta]])}+2(-\gamma+\theta)(\frac{2(4[2-\theta[-\gamma+\theta]]+\theta[-8+\theta(4+\theta)-\gamma[2+\theta]])}{b[4[2-\theta[-\gamma+\theta]]+\theta[-2\gamma[(-1+\theta)(4+\theta)]+\gamma^2[2+\theta]+\theta[-8+\theta(4+\theta)]]]} \frac{(-2+\theta)(4(2+\gamma-\theta)[2-\theta[-\gamma+\theta]]+(\gamma-\theta)\theta[8+\gamma[2+\theta]-\theta[4+\theta]])}{b[2+(\gamma-\theta)\theta](-8+4\theta[-\gamma+\theta]+(-\gamma+\theta)\theta[8+\gamma[2+\theta]-\theta[4+\theta]])}))])(4(2+\gamma-\theta)[2-\theta[-\gamma+\theta]]+(\gamma-\theta)\theta[8+\gamma[2+\theta]-\theta[4+\theta]]))/(8b[2-\theta[-\gamma+\theta]](4[2-\theta[-\gamma+\theta]]+(\gamma-\theta)\theta[8+\gamma[2+\theta]-\theta[4+\theta]])) \quad (37)$$

3.2.2. The Effect of Competition and Spillover on the Sustainability Investments of Companies

I employ computational methods to gain more insight about the equilibrium solutions. I consider different test cases created by varying competition and spillover rates ranging from industries where all firms innovate ($\gamma = 0$) to industries where follower firms imitate the leader and one another ($\gamma > 0$).I examine the influence of sustainability spillovers on the sustainability level for a given competition level.

Furthermore, I evaluate the influence of price elasticity of demand for sustainability. If changes in stakeholder payment have a relatively large effect on the level of sustainability demanded, then demand for sustainability is elastic and b<1. If changes in stakeholder payment have a relatively small effect on the level of sustainability demanded then demand for sustainability is inelastic and b>1. I compute the sustainability investments and net benefits of the leader and followers for arbitrary a and b values. [17] I set b=0.7 in order to model a setting where demand is elastic. Likewise I set b=1.4 to model a setting where demand is inelastic.

3.2.2.1. The Benchmark Case: No Sustainability Spillovers $\boldsymbol{\gamma = 0}$

Using (19), (20) and (21), for $\gamma = 0$ and $\theta = 0$, I get $w_L = \frac{(a-d)}{2b}$ and $w_{F_1} = w_{F_2} = \frac{(a-d)}{2b}$

If there are no sustainability spillovers and the sustainability offerings are not substitutable i.e. the markets are separated; the leaders and the followers' sustainability investments are the same amount.

As seen in Figure 18, independent of demand elasticity, as competition levels increase the leader's sustainability investments first decreases, then increases at competition level θ≥0.6277, while both followers' sustainability investments decrease. Likewise independent of demand elasticity the first follower's level of sustainability exceeds the second follower's level of sustainability for all competition levels.

[17] $a = 1000$, b=0.7 and d=600

As the level of competition increases, the gap between the investment of the leader and the investments of the followers as well as the gap between follower 1 and follower 2 increases. Furthermore the gap between leader’s and followers’ sustainability investments becomes more prominent if demand for sustainability is elastic.

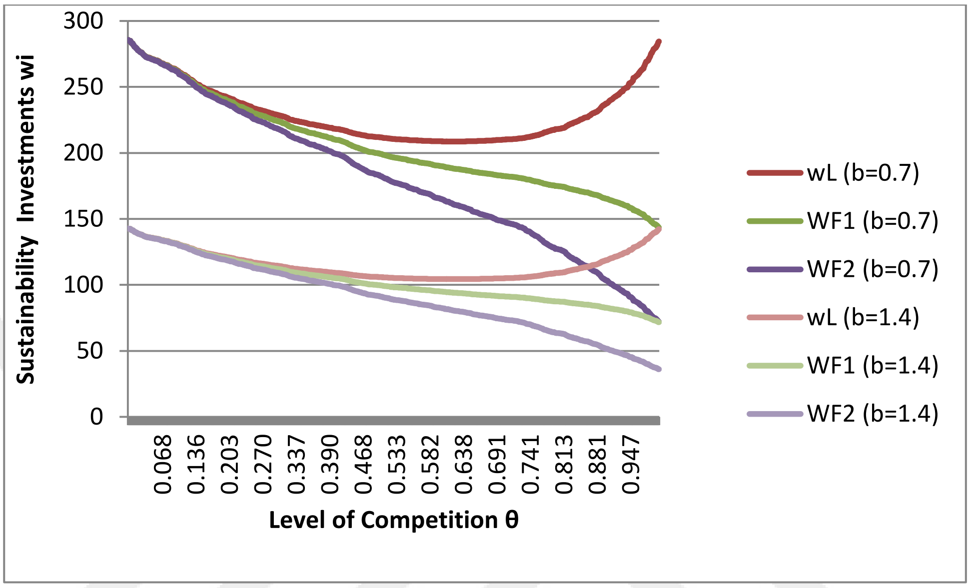

Figure 18: Influence of competition level on the sustainability investments for the benchmark case without sustainability spillovers ($\gamma = 0$)

As seen in Figure 19 the net benefit of the leader and the followers are the same, when competition level θ =0. As the competition level increases both the net benefits of leader and followers decrease, whereas the followers’ slope is steeper. For all competition levels $\theta > 0$ the leader’s net benefits are higher than the followers’ net benefits. Thus the leader attains first mover advantage. Furthermore the gap between leader’s and followers’ sustainability investments becomes more prominent if demand for sustainability is elastic (b<1).

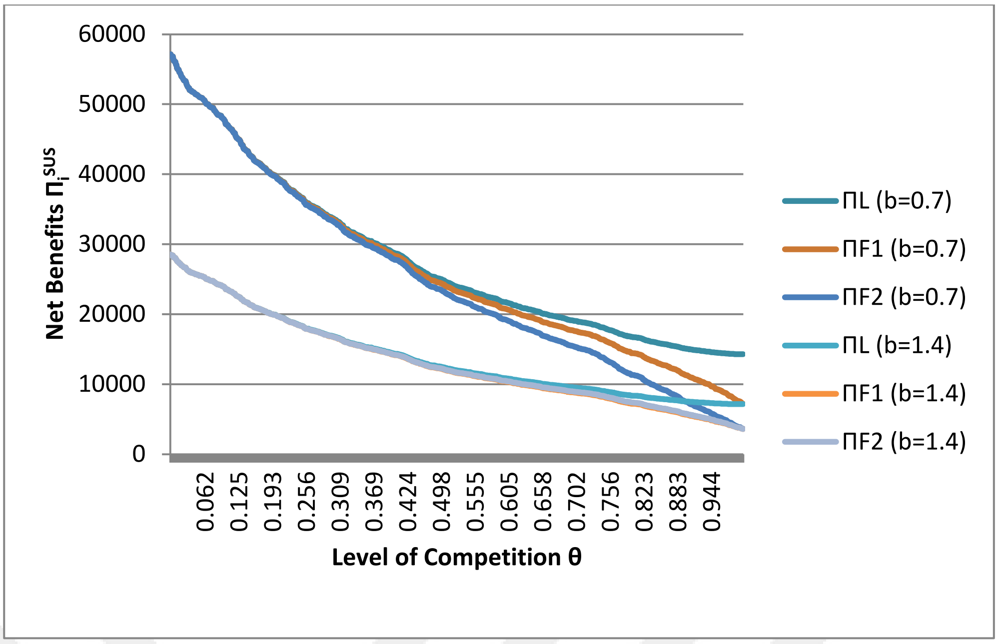

Figure 19: Influence of competition level on the net benefits for the benchmark case without sustainability spillovers ($\gamma = 0$)

3.2.2.2. The Case with Positive Spillovers $\boldsymbol{\gamma} > \mathbf{0}$

As seen in Figure 20, independent from the demand elasticity, the leader's sustainability initiatives decreases, as the spillover rate increases. The leader attempts to prevent the first and second followers from free riding the sustainability efforts by decreasing them. For θ=0.2 and θ=0.4 the first mover increases her sustainability investments. For θ=0.6 and θ=0.8 the first follower first increases then decreases her sustainability investments as spillover rate increases. The first follower attempts to prevent the second follower from free riding the sustainability efforts by decreasing them. The rate of decrease in sustainability initiatives of the leader is more prominent than the rate of decrease in sustainability initiatives of the first follower. As a respond the second follower increases her sustainability initiatives for all competition levels.

For both elastic and inelastic demand at competition level $\theta = 0.2$, the sustainability investments of the second follower exceeds the sustainability investments of the first follower at $\gamma>0.019$. For both elastic and inelastic demand at competition level $\theta = 0.4$ the sustainability investments of the second follower exceeds the sustainability investments of the first follower at $\gamma>0.068$. For both elastic and inelastic demand at competition level $\theta = 0.6$ the sustainability investments of the second follower exceeds the sustainability investments of the first follower at $\gamma>0.141$. For both elastic and inelastic demand at competition level $\theta = 0.8$, the sustainability investments of the second follower exceeds the sustainability investments of the first follower at $\gamma>0.229$. With increasing spillover the gap among the second follower's sustainability investments and the leader's and first follower's sustainability investments widens for all competition levels. Moreover, the gap is more pronounced if the demand is elastic.

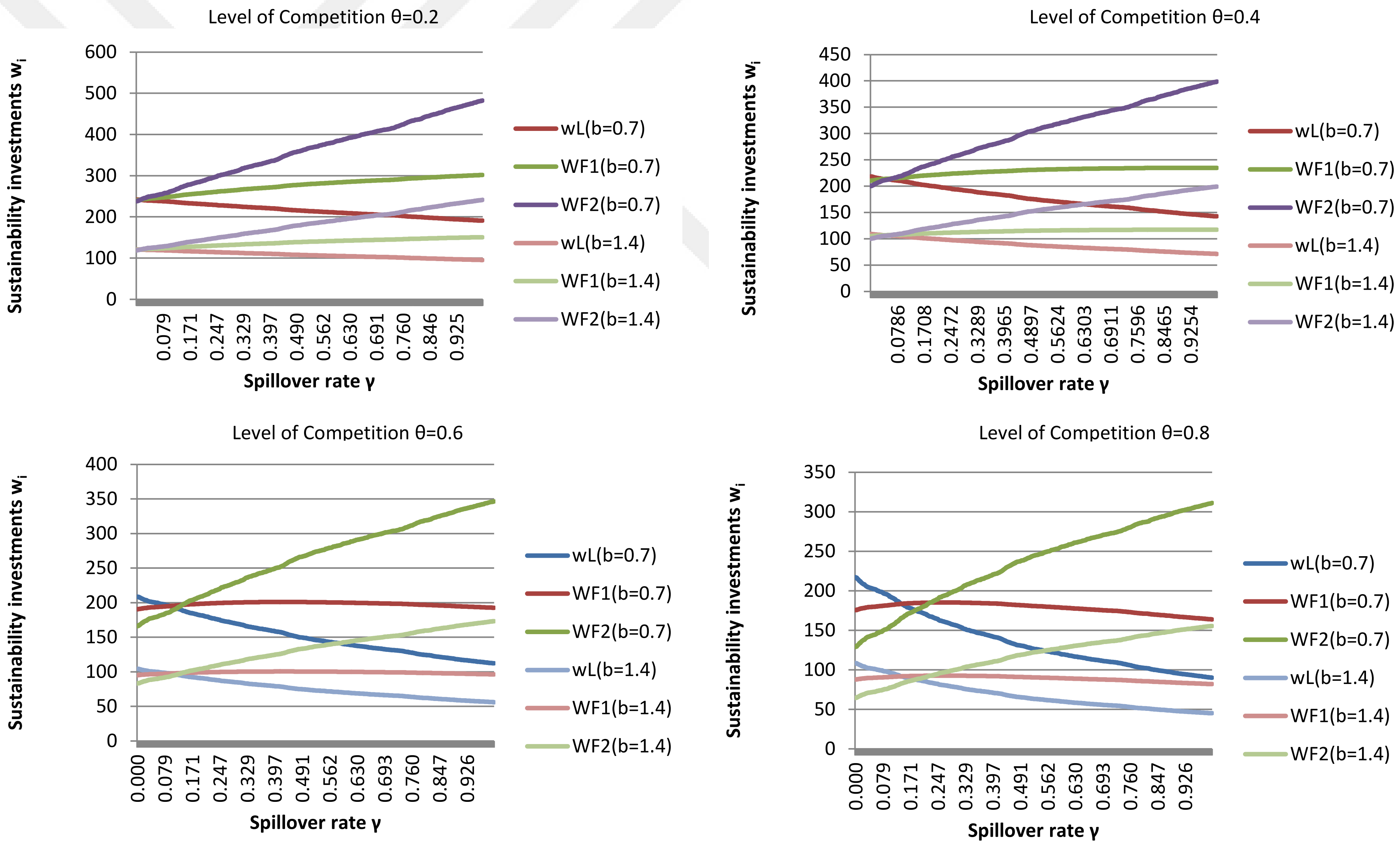

Figure 20: The influence of spillovers on sustainability initiatives for different competition levels

As seen in Figure 21, the leader attains first mover advantage for low spillover rates. However the leader isn't able to retain her first mover advantage as the spillover rate increases. For the elastic demand case at $\theta = 0.2$ the leader attains first mover advantage for low spillover rates. However, the advantage passes from the leader to the second follower at $\gamma<0.0001$. For the inelastic demand case at $\theta = 0.2$ the second follower attains last mover advantage for all spillover rates. For elastic demand case at $\theta = 0.4$ the leader attains first mover advantage at $\gamma<0.0088$. The first follower attains second mover advantage for $0.0088<\gamma<0.0136$. However, the advantage passes from the first follower to the second follower at $\gamma>0.0.136$. Moreover the leader's sustainability investments exceed the second followers sustainability investments for $\gamma<0.0098$. For inelastic demand case at $\theta = 0.4$ the leader attains first mover advantage at $\gamma<0.0027$. At $\gamma>0.0027$ the advantage passes from the leader to the second follower. For $\gamma<0.0088$ the leader retains advantage over he first follower, whereas the second follower has advantage over the first follower for all spillover rates. For elastic demand case at $\theta = 0.6$ the leader attains first mover advantage for $\gamma<0.024$. For $0.024< \gamma<0.044$ the first follower attains second mover advantage. For $0.034< \gamma<0.044$ the leader has advantage only over the second follower. For $\gamma>0.044$ the second follower has last mover advantage. For inelastic demand case at $\theta = 0.6$ the leader attains first mover advantage for $\gamma<0.013$. At $\gamma>0.013$ the advantage passes from leader to second follower. For $0.013<\gamma<0.024$ the leader has only advantage over the first follower. The second follower has advantage over first follower for all spillover rates. For elastic demand case at $\theta = 0.8$ the leader attains first mover advantage for $\gamma<0.050$. For $0.050< \gamma<0.096$ the first follower attains second mover advantage. For $0.050< \gamma<0.073$ the leader has advantage only over the second follower. For $\gamma>0.096$ the second follower has last mover advantage. For inelastic demand case at $\theta = 0.8$ the leader attains first mover advantage for $\gamma<0.031$. At $\gamma>0.031$ the advantage passes from leader to second follower. For $0.031<\gamma<0.05$ the leader has only advantage over the first follower. The second follower has advantage over first follower for all spillover rates.

For the elastic demand case as the competition level increases the spillover rate, at which the advantage passes from leader to first follower and from first follower to second follower increases. Thus for higher competition levels the first and second mover advantage is more defendable. Likewise, for the inelastic demand case as the competition level increases the spillover rate, at which the advantage passes from leader to second follower increases. Thus for higher competition levels the first mover advantage is more defendable.

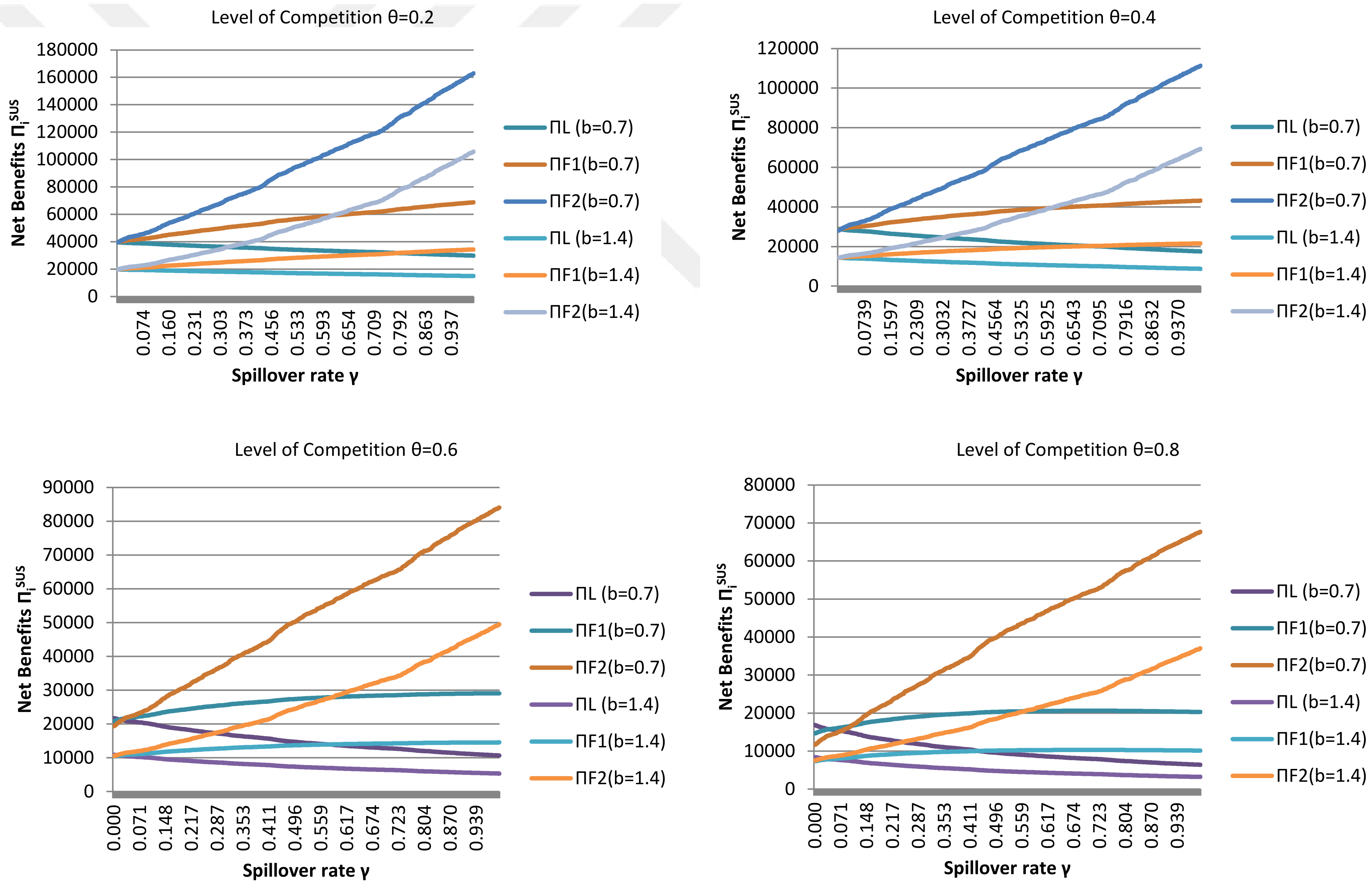

Figure 21: The influence of spillovers on net benefits for different competition levels

3.2.2.3. Case with competition level θ=1

I also consider the case where the sustainability offerings of the leader and of the followers are perfect substitutes, θ=1. As seen in Figure 22 sustainability investments for elastic and inelastic demand differ in magnitude. The gap among the leader's and followers' sustainability investments is wider for the elastic case. Regardless of the demand elasticity, the leader decreases her sustainability investments as spillover rate increases, while the second follower increases her sustainability investments as spillover rate increases. For spillover rates $\gamma<0.199$ the leader invests more into sustainability compared to the followers. For spillover rates $0.199 <\gamma<0.333$ the first follower invests more into sustainability compared to her opponents. The first follower decreases her sustainability investments for $\gamma<0.261$. The first follower increases her sustainability investments for $\gamma<0.261$. I interpret this observation as for low spillover rates the first follower acts like a secondary leader and tries to prevent the second follower from free riding, while for moderate and high spillover rates the first follower free rides the leaders sustainability efforts. For spillover rates $\gamma>0.333$ the second follower invests more into sustainability compared to her opponents.

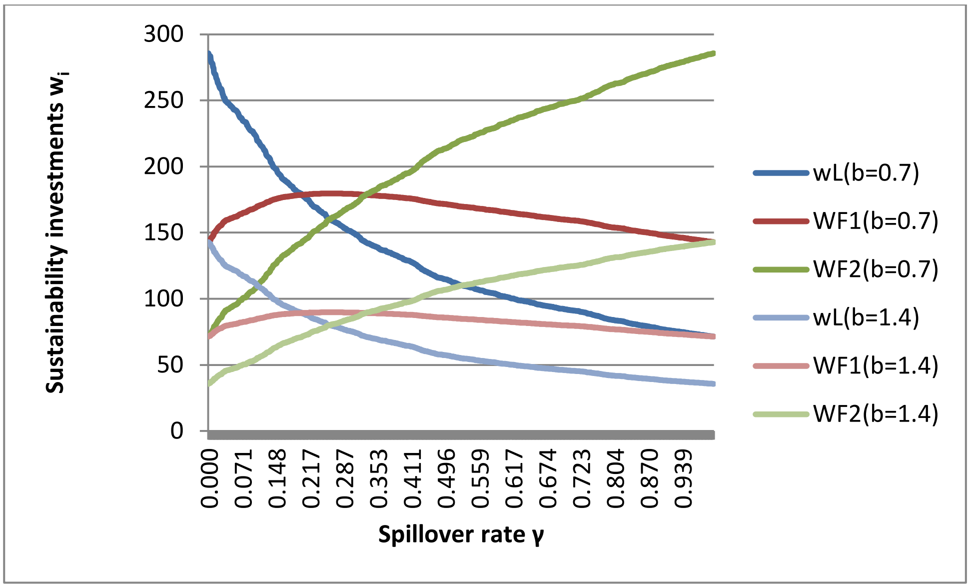

Figure 22: The influence of spillover on the level of sustainability initiatives for θ=1

As seen in Figure 23 the net benefits for elastic and inelastic demand differ in magnitude, whereas the former are greater. The gap among the leader's and followers' sustainability benefits is wider for the elastic case. For elastic demand, the leader attains first mover advantage for spillover rates γ<0.096. The leader only has advantage over the second follower for spillover rates 0.096 <γ<.0.130. The first follower attains second mover advantage for spillover rates 0.096 <γ<.0.178. The second follower attains last mover advantage for γ>0.178. For inelastic demand, the leader attains first mover advantage for spillover rates γ<0.076. The leader cannot defend the first mover advantage over the second follower and only retains advantage over the first follower for spillover rates γ<0.096. For spillover rates γ>0.076, the second follower's net benefits exceeds the leader' as well as the first follower's net benefits.

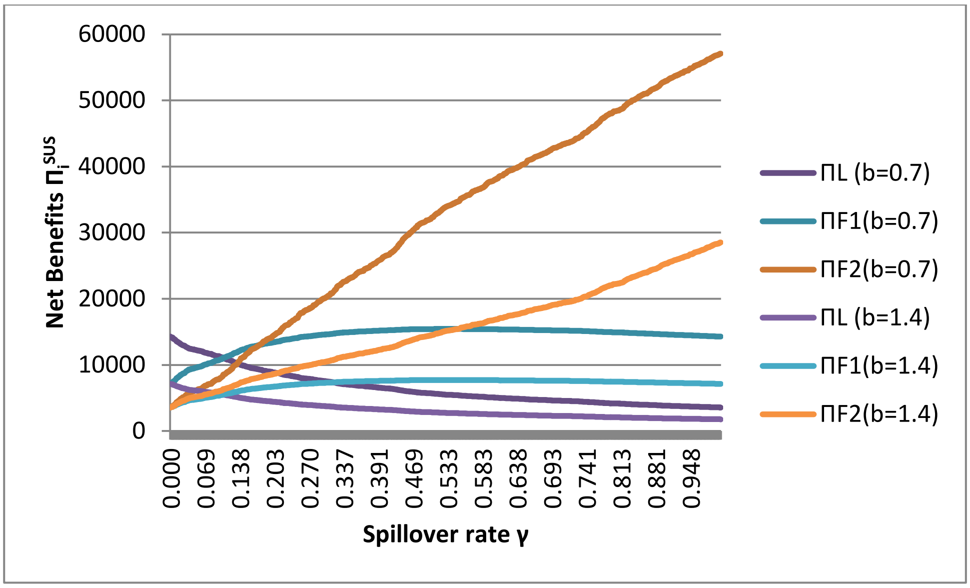

Figure 23: The influence of spillover on the net benefits for θ=1

If I evaluate the influence of competition on the level of sustainability initiatives without sustainability spillovers ($\gamma = 0$) and the influence of spillovers on the level of sustainability initiatives for perfect competition (θ=1) there are some interesting indications. For all competition levels the leader attains first mover advantage if there are no sustainability spillovers. As seen in Figure 24 for ($\gamma = 0, \theta = 1$) the leader achieves the Stackelberg outcome.

For θ= 1 the sustainability market is described as a standard (homogeneous) Stackelberg oligopoly, where the leader and followers set sustainability initiatives (quantities) which maximize their net benefits. The leader decreases her sustainability investments in order to prevent the follower to free ride her sustainability efforts. As spillover rate increases the first follower increases her sustainability initiatives and attains second mover advantage for limited spillover interval. As spillover rate increases further the first follower acts like a secondary leader and decreases her sustainability investments to prevent the second follower from free riding. As seen in Figure 24 for ($\gamma = 1, \theta = 1$) the second follower achieves the Stackelberg outcome.

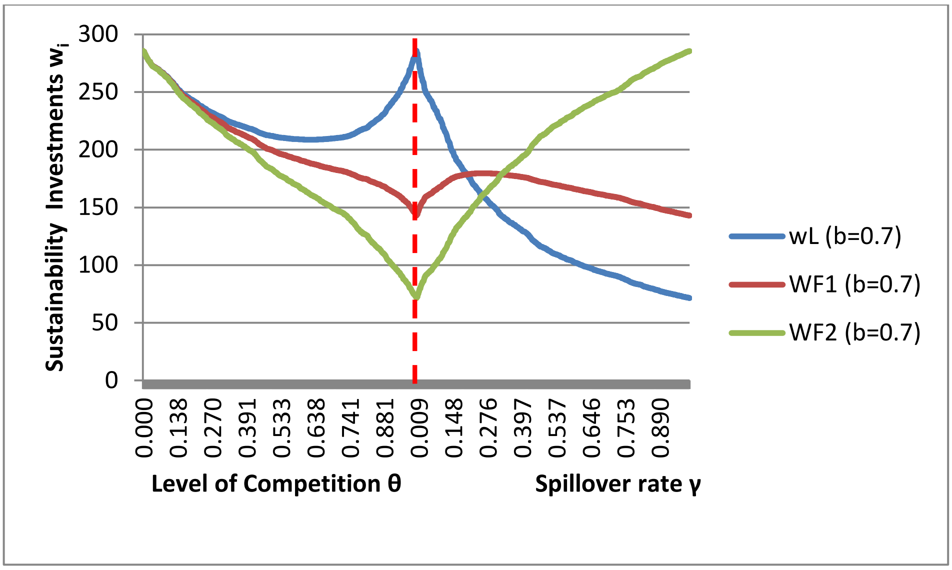

Figure 24: The influence of competition and spillover on the sustainability initiatives for oligopolistic market

Comparing Figure 24 with Figure 12, I determine that in both duopoly and oligopolistic markets the leader attains the Stackelberg outcome for ($\gamma = 0, \theta = 1$). The last mover (follower in the duopoly model and second follower in the oligopoly model) achieves the Stackelberg outcome for ($\gamma = 1, \theta = 1$). Furthermore, the first follower in the oligopolistic market attains sustainability outcomes between the leader and the second follower. I infer that if more players are added in the model, I will obtain similar results. Namely, the leader will attain the Stackelberg outcome for ($\gamma = 0, \theta = 1$) and last mover will attain the Stackelberg outcome for ($\gamma = 1, \theta = 1$), whereas the remaining players will attain sustainability outcomes in between.

3.2.3. The Effect of Competition and Spillover on the Total Market Outcome

I consider the effect of competition and sustainability spillover on the total market outcome of sustainability initiatives. As seen in Figure 25, as the competition level increases regardless of the demand elasticity, the total market output regarding sustainability initiatives decreases. The total sustainability investments for elastic and inelastic demand differ in magnitude. Likewise, as the level of competition increases the cumulative net benefits of the companies decrease independent from demand elasticity. This decrease is more prominent if spillover effect exists. For the no spillover case the slope is much more smoother compared to the cases with different spillover rates. The total net benefits for elastic and inelastic demand differ in magnitude.

Since the total sustainability outcome of the market has a positive impact on social and environmental welfare, the decrease in total sustainability outcome has negative implications on social and environmental welfare.

In most circumstances increasing price which leads to producer surplus does not compensate the reduction in consumer surplus. Thus welfare is lowest if the market price equals to monopoly price and highest if price equals the marginal cost of production. In the sustainability interactions model the stakeholder payment decreases as competition level increases. On the one hand increasing competition levels cause reduction in producer surplus, which manifests itself as decreasing total net benefit. On the other hand increasing competition levels cause to increase in consumer surplus. Thus increasing competition level is more likely to have a positive impact on total welfare.

If the goal of policy makers is to improve economical welfare, they should promote competition. If their goal is to improve social and environmental welfare, they should regulate competition or subsidize companies by derating and compensate the negative influence of competition on the total sustainability outcome of the market.

As seen in Figure 26 as spillover rate increases regardless of the demand elasticity, the total market output regarding sustainability initiatives increases. The total sustainability investments for elastic and inelastic demand differ in magnitude. Likewise as spillover rate increases regardless of the demand elasticity the total net benefits of the market increases as well. The total net benefits for elastic and inelastic demand differ in magnitude. One interesting observation is that the market output is at the same level for all spillover rates, when competition level $\theta=1$. In the case of perfect competition ($\theta=1$) the total market output regarding sustainability is independent of spillovers. The total net benefits- producer surplus- increases as spillover increase although the level of sustainability remains constant.

For the policy maker the spillovers are positive, since they increase the total market output and total net benefits regarding sustainability initiatives. Thus policy makers should incentivize sustainability initiatives that transform the market rather than sustainability initiatives, which are company specific and hard to imitate.

In this section I model duopoly and oligopolistic markets in order to understand the effect of competition and spillovers on the sustainability investments and net benefits. I observe that increase in spillover decreases the leader's sustainability outcomes and net benefits and increases the followers' sustainability outcomes and net benefits. Furthermore, I observe that increase in competition level decreases the sustainability investments and the net benefits for all players. However, these results are bound to the assumptions of the model.

In the next section I estimate a discrete choice model, to further evaluate the effect of competition and spillovers on sustainability and to test the hypothesis developed in the beginning of this section. The empirical model considers both the influence of competition and firm specific characteristics on abnormal returns due to sustainability and estimates the likelihood of sustainability investment of company given the beliefs company has about her competitors' actions and firm specific characteristics, which might influence the sustainability decisions of the company.

The dependent variable in the empirical model, x_i, indicates whether companies invest in sustainability or not, whereas the decision variable in the analytical model level of sustainability w_i is continuous. If a continuous decision variable would be employed as the dependent variable in the empirical model, the set of all possible decisions of the focal company and competitors would become infinitely big and the estimation would become computationally costly.

There are no assumptions on the sequence of entry in the empirical model, whereas the sequence of entry in the analytical model is crucial to identify the effect of spillover. In the empirical model the effect of competition and spillover are estimated with one parameter and the sign of this parameter indicates whether the negative effect of competition or the positive effect of spillover influences the likelihood of sustainability investments more.

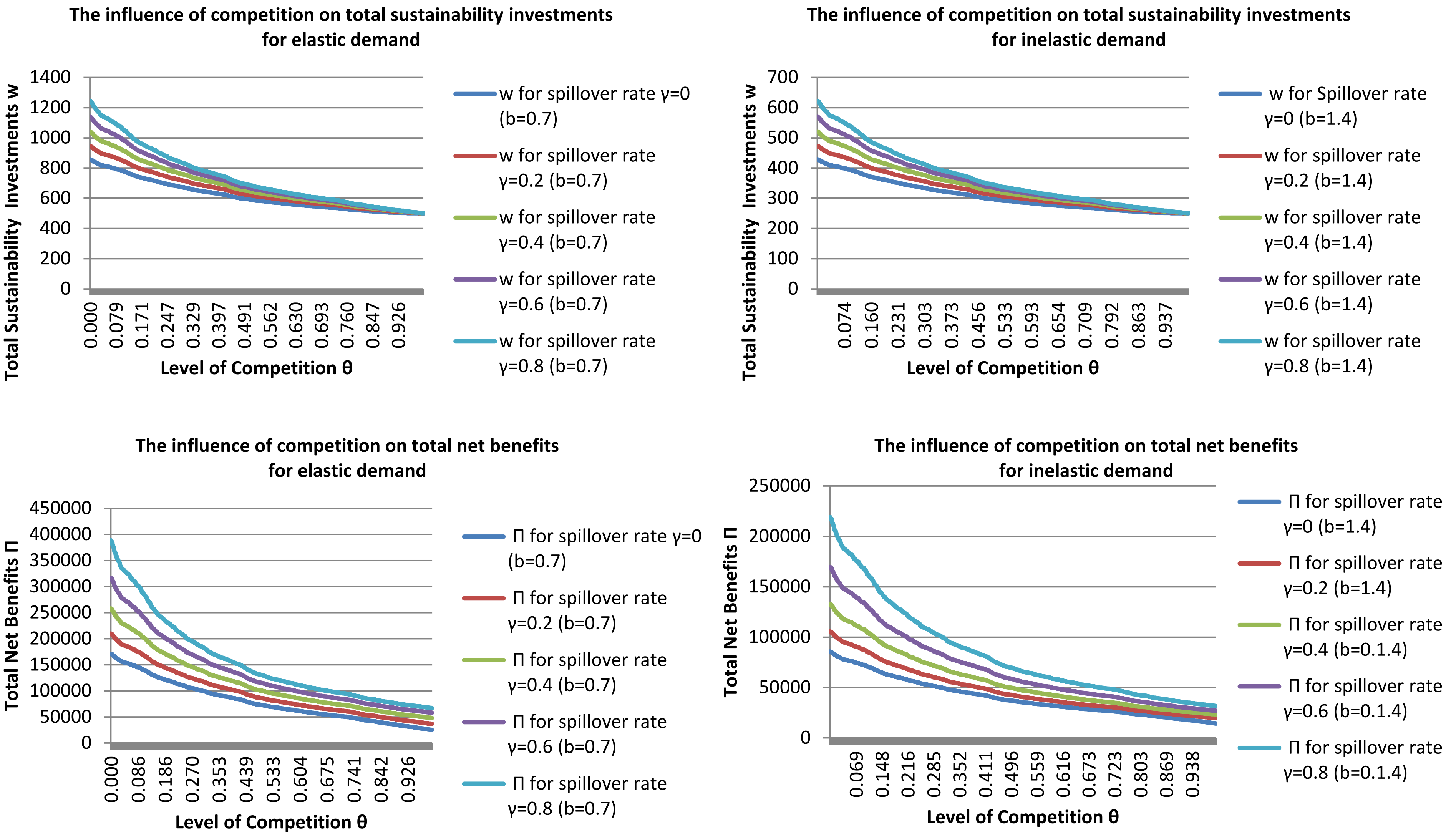

Figure 25: The influence of competition on total sustainability initiatives and on total net benefits for different degrees of spillover and demand elasticity

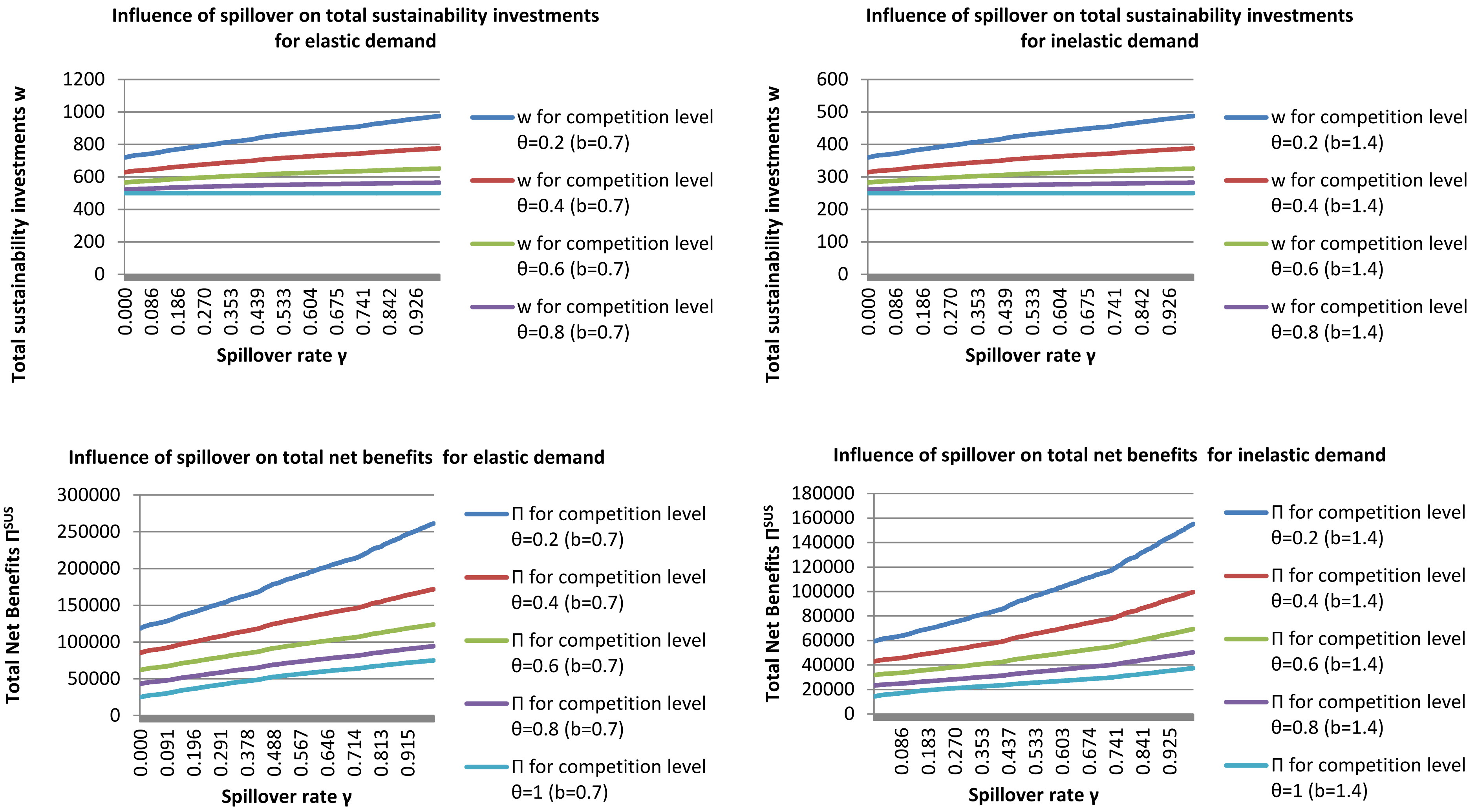

Figure 26: The influence of spillover on total sustainability initiatives and total net benefits

CHAPTER IV

ESTIMATION OF THE STATIC CORPORATE SUSTAINABILITY INTERACTIONS MODEL

4.1. The Estimation Framework

To analyze strategic interactions between companies regarding their sustainability behaviors, I develop a model that resembles the strategic model proposed by (38). Sustainability decisions are strategic decisions which can be approached as discrete choices and should involve the consideration of demand, cost, and competitive factors. As stated by (108) the interrelatedness of firm decisions and the game theoretic nature of the framework complicate the discrete choice estimation.

The nested fixed point algorithm has been used in the estimation of discrete choice models in the context of static games (e.g. (109) (110)). However, the key econometric problem is that, there is at least one fixed point (equilibrium), which has to 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 the computational cost of the nested fixed-point algorithm, alternative methods have been developed, such as the two-step approach of (111) and (38), which I will adopt 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 companies have about their competitors' actions. The recovered probabilities are then plugged into a second—stage model which incorporates strategic interactions.

In the model proposed by (38) 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 (112). In my setting the company obtains some net benefits if it chooses not to enter the sustainability market, since it will still 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 I won't be able to identify the net benefits from adopting sustainability practices and the net benefits from not adopting sustainability practices separately. I can only identify the difference between the net benefit of investing in sustainability as opposed to not investing and recover the difference nonparametrically by inverting the equilibrium choice probabilities. Thus, I assume that the difference in net benefits among adopters and non-adopters stems only from their sustainability practices and control for all other firm characteristics that may lead to differences in net benefits.

4.1.1. 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, I can model companies' sustainability decisions as the level of investment put into sustainability initiatives. On the other hand, I can model companies' sustainability decisions as a discrete choice— whether companies decide to invest into sustainability or not. As a researcher I don't 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, I develop the following discrete choice model[18], where each player simultaneously chooses an action $x_i \epsilon \{0,1\}$.

$$x_i = \begin{cases} 1 \text{ if } w_i > 0 \\ 0 \text{ otherwise,} \end{cases} \tag{38}$$

I assume that there are a finite number of companies (players); N=$\{1, \dots, i, .., n\}$. 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 $s_l \in S_i$

[18] 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.

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. $\boldsymbol{S} = (S_1, \ldots\ldots, S_n)$ 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.

I 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 (iid) 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, $\boldsymbol{\varepsilon_{N/i}} = \left(\varepsilon_1, \ldots\ldots, \varepsilon_{i-1,}\varepsilon_{i+1}, \ldots, \varepsilon_n\right)$ 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. $\pi_i\left(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S};\ \boldsymbol{\vartheta}\right)$ defines the total net benefit of company *i* given $\boldsymbol{S}$. The player *i* solves

$$max_{x_i}\left\{E\left(\pi_i\left(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S};\ \ \boldsymbol{\vartheta}\right) + \varepsilon_i(x_i)\right)\right\} \quad (39)$$

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

$$P_i(x_i = 1|\boldsymbol{S}) = \int 1\{a_i(\boldsymbol{S}, \varepsilon_i) = 1\} f(\,\varepsilon_i(x_i)\,) d\varepsilon_i \tag{40}$$

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. I 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 I 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.

$$V_i(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S}; \boldsymbol{\vartheta}\,) = \sum_{\boldsymbol{x}_{N/i}} \pi_i(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S}; \boldsymbol{\vartheta}\,)\, P_{N/i}(\boldsymbol{x}_{N/i}|\boldsymbol{S}) + \varepsilon_i(x_i), \tag{41}$$

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, ε_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[19] of the expected net benefit function:

$$\Pi_i(x_i, \boldsymbol{S}; \boldsymbol{\vartheta}) = \sum_{\boldsymbol{x}_{N/i}} \pi_i(\,x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S}; \boldsymbol{\vartheta})\, P_{N/i}(\boldsymbol{x}_{N/i}|\boldsymbol{S}) \tag{42}$$

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

[19] 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.

from choosing action $x_i = 0$. For player i to invest in sustainability is optimal, if the following condition is satisfied:

$$P_i(x_i = 1|\boldsymbol{S}) =$$

$$Prob\{\varepsilon_i|\Pi_i(x_i = 1, \boldsymbol{S}; \boldsymbol{\vartheta}) + \varepsilon_i(x_i = 1) > \Pi_i(x_i = 0, \boldsymbol{S}; \boldsymbol{\vartheta}) + \varepsilon_i(x_i = 0)\} \quad (43)$$

4.1.2. Parametrization of the Net Benefit Function

I consider a static entry game, where the net benefit function of entering into 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 $\boldsymbol{S}'$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 δ captures the influence of other companies' choices on the entry decision.[20]

$$\pi_i(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S}; \boldsymbol{\vartheta}) = \begin{cases} \boldsymbol{\vartheta S}' + \delta\left(\sum_{i\neq j}^{n} 1\{x_j = 1\}\right) & \text{if } x_i = 1 \\ 0 & \text{if } x_i = 0 \end{cases} \quad (44)$$

According to (38) δ<0, since entry of a competitor into the market decreases the net benefit of the focal company i. However, for sustainability interactions the parameter δ in (41) depends on both the competition level and the spillover rate.

The random error terms $\varepsilon_i(x_i)$ in the net benefit function (41) 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). I assume that the error terms follow the extreme value type I distribution. If $f_i(\varepsilon_i)$ has an extreme value type-I distribution and the ε_{il}'s are

[20]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.

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[21] and empirical implications[22] (113) and the following relation is well developed and conventionally used as the analytical solution to $P_i(x_i = 1|\boldsymbol{S})$

$$P_i(x_i = 1|\boldsymbol{S}) = \frac{\exp(\boldsymbol{\vartheta S'} + \delta \sum_{i \neq j} P_j(x_j = 1|\boldsymbol{S}))}{1 + \exp((\boldsymbol{\vartheta S'} + \delta \sum_{i \neq j} P_j(x_j = 1|\boldsymbol{S}))} = \Gamma_i\big(\boldsymbol{\vartheta}, \delta, P_j(1|\boldsymbol{S}), \forall j\big). \qquad (45)$$

If I use equation (45) in equation (42), I get $\Pi_i(x_i, \boldsymbol{S}; \boldsymbol{\vartheta}) = \vartheta \boldsymbol{S}' + \delta \sum_{i \neq j} P_j\big(x_j = 1\big|\boldsymbol{S}\big)$. Since the error terms are distributed extreme value, from equation (43), I 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 $\Gamma_i\big(\boldsymbol{\vartheta}, \delta, P_j(1|\boldsymbol{S}), \forall j\big)$ orders the probability of different actions by their expected net benefits. Thus, the reaction function is continuous and monotonically increasing in the choice specific net benefit function Π_i. Since the error terms ε_i have density function $f_i(\varepsilon_i)$ and P_i is continous in Π_i, according to Brouwer's fixed point theorem there is an equilibrium to this model for any finite $\boldsymbol{S}$ (114). I will use the equilibrium in equation (45) in the econometric analysis.

I 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, I use $\boldsymbol{S}_{it}$ for the

[21] 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.

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

values state variables take in period t such that $\boldsymbol{S}_t = \{S_{1t} \dots S_{nt}\}$ and follow a two stage estimation strategy. In the first stage, I estimate the binary response x_{it} conditional on a given set of covarites, S_{it}. By observing the sustainability decisions of a large number of companies, I 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, I estimate the structural parameters of net benefit function $\boldsymbol{\vartheta}$ and δ. Given the first stage estimates $\hat{P}_i(x_i = 1|\boldsymbol{S})$**,** I maximize a pseudo-likelihood function $\Gamma_i\left(\boldsymbol{\vartheta}, \delta, P_j(1|\boldsymbol{S}), \forall j\right)$ and obtain estimates of $\boldsymbol{\vartheta}$ and δ applying a logit model. On the one hand, this two stage estimation strategy has advantages in terms of computational burden, since I 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 δ, since both the first stage estimates $\hat{P}_i(x_i = 1|\boldsymbol{S})$ and $\vartheta\mathbf{S}'$ 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 I exclude the shocks caused by other firms' actions from the term $\boldsymbol{\vartheta}\mathbf{S}'$, I will be able to eliminate collinearity.

4.1.3. Identification

I can identify the deterministic part of the net benefits, without imposing any assumptions on its functional form. Suppose I consider $\boldsymbol{\vartheta}$ to be completely nonparametric, and hereinafter write $\pi_i\left(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S}\right)$ instead of $\pi_i\left(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S}; \boldsymbol{\vartheta}\right)$, and I 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, I 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, I will assume that the error terms are distributed iid with a known distribution function and the error terms $\varepsilon_i(x_i)$ are distributed iid across actions x_i and players i. Moreover, the parametric form of the distribution, F, comes from a known family. I 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, I 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

$$\Pi_i(x_i = 1|\boldsymbol{S}) + \varepsilon_i(x_i = 1) > \Pi_i(x_i = 0|\boldsymbol{S}) + \varepsilon_i(x_i = 0) \qquad (46)$$

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

$$P_i(x_i|\boldsymbol{S}) = Pr\{\Pi_i(x_i = 1|\boldsymbol{S}) - \Pi_i(x_i = 0|\boldsymbol{S}) > \varepsilon_i(x_i = 0) - \varepsilon_i(x_i = 1)\} \qquad (47)$$

From Equation (10) I 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 I assume that $\varepsilon_i(x_i)$ are distributed iid and the distribution comes from a known family, one-to-one mapping is possible. I denote the map from general form choice specific value functions to choice probabilities as: $\Gamma: \{0,1\}\ x\ \boldsymbol{S} \rightarrow [0,1]$.

$$P_i(x_i|\boldsymbol{S}) = \Gamma_i(\Pi_i(x_i = 1|\boldsymbol{S}) - \Pi_i(x_i = 0|\boldsymbol{S})) \quad (48)$$

I denote the inverse mapping as Γ^{-1}:

$$\Pi_i(x_i = 1|\boldsymbol{S}) - \Pi_i(x_i = 0|\boldsymbol{S}) = \Gamma_i^{-1}(P_i(x_i|\boldsymbol{S})) \quad (49)$$

I can recover $\Pi_i(x_i = 1|\boldsymbol{S}) - \Pi_i(x_i = 0|\boldsymbol{S})$ nonparametrically by inverting the equilibrium choice probabilities. I identify the difference between the net benefit of investing in sustainability as opposed to not investing. I won't be able to identify $\Pi_i(x_i = 1|\boldsymbol{S})$ and $\Pi_i(x_i = 0|\boldsymbol{S})$ separately. Thus, I 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 (50) I 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 (42) implies that

$$\Pi_i(x_i|\boldsymbol{S}) = \sum_{\boldsymbol{x}_{N/i}} \pi_i(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S})\ P_{N/i}\left(\boldsymbol{x}_{N/i}\middle|\boldsymbol{S}\right)\ \forall i = 1, \dots, n,\ x_i = 0,1 \quad (50)$$

However, even if I knew $\Pi_i(x_i|\boldsymbol{S})$ and $P_{N/i}\left(\boldsymbol{x}_{N/i}\middle|\boldsymbol{S}\right)$ I 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 I follow (38) and introduce exclusion restrictions. Basically, I 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 (38) identification is achieved under the stated conditions therein. For details of the identification see appendix A3.

I will use the empirical analog of (50) 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, I 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, I describe the data and econometric specifications used to analyze the sustainability decisions of companies.

4.2. Data and Variables

4.2.1. Data

I have collected annual company data on corporate sustainability and corporate financial performance for years 1991–2014. I used social performance ratings from MSCI KLD 400 Social Index database as the sustainability measure. [23] MSCI KLD 400 Social Index considers large, mid and small cap companies in the MSCI US IMI Index. It excludes companies which are involved in sectors such as Nuclear Power, Tobacco, Alcohol, Gambling, Military Weapons, Civilian Firearms, GMOs and Adult Entertainment. They rate eligible companies on regarding their strengths and failures (concerns) in seven categories: Community (Com-), Corporate Governance (Cgov-), Diversity (Div-), Employee Relations (Emp-), Environment (Env-), Human Rights (Hum-), Product (Pro-). Companies are excluded from the index if (i) they are deleted from the MSCI USA IMI Index, (ii) they fail the exclusion screens, (iii) their ratings fall below minimum standards. I obtained 40,485 firm-year observations. Moreover, I extracted sustainability ratings of 4613 companies between 1991 and 2013.

[23] https://www.msci.com/resources/factsheets/index_fact_sheet/msci-kld-400-social-index.pdf

I collected company financial information from the Wharton Research Data Services' COMPUSTAT dataset. I focused on the North American sample of COMPUSTAT. I obtained 12,458 firm-year observations, after the companies with revenues less than 50 million USD are dropped. I 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 I obtained an unbalanced panel of 657 companies over the years 1991-2014.

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. I restricted the sample to manufacturing firms to ensure that the companies in the sample are comparable in terms of sustainability and financial performance. I operationalized sub- industry by using the two digit SIC codes. Furthermore, I excluded companies with $roa \leq -10$ and $roa \geq 10$ so that outliers do not contaminate the results. I restricted the sample to the years between 1999-2014 to ensure the continuity of the time series[24]. The restricted sample consists of 6704 firm-year observations and 419 manufacturing companies over the years 1999-2014. The sample consists of 160 chemicals and allied products (sic 28), 13 petroleum refining and related industries (sic 29), 26 primary metal

[24] MSCI USA IMI Index has been compiled from a variety of sources, which may have followed different index calculation methodologies in some instances. Read more: https://www.msci.com/eqb/methodology/meth_docs/MSCI_KLD_400_Social_Index_Methodology_May_2016.pdf

industries (sic 33), 24 fabricated metal products, except machinery and transportation equipment (sic 34), 137 electronic and other electrical equipment and components, except computer equipment (sic 36) and 53 transportation equipment (sic 37) companies. Since the data for the independent and dependent variables are collected from two completely different sources, common method bias does not affect the analysis.

4.2.2. Variables

I need to evaluate the influence of competition and spillover on the likelihood of entering the sustainability market. I 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, I can deduce that competition level regarding sustainability might be influenced indirectly by the competition level in the goods and/ or services market. I 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. I 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, I consider them as control variables. These control variables are the empirical counterpart of the set of k state variables, $S_i = (s_1, \ldots\ldots, s_k), \forall i = 1, \ldots, n$. I incorporate past years' sustainability decision and denote the variable as *past_entry*.

Furthermore, I control whether or not a company enters the sustainability market for the first time. I denote the related variable as *first_time_entry*.

I 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, I consider the variables; number of employees and total assets in million dollars. 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 I omit this control variable from the final analysis. Since the total assets are skewed to right, I use the natural logarithm and denote the variable as *ln_asset*.

As stated before, 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 (39). Firms that financially outperform their industry average have slack resources to invest in corporate sustainability activities (40). To isolate the influence of slack resources and control for financial performance I 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 I aim to evaluate the influence of sustainability on financial performance from the stakeholder theory channel, I isolate the effect of advertisement on stakeholder returns and include advertising intensity as a control variable. The advertising intensity is calculated as the ratio of advertising expenses to net sales.

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 I control for R&D intensity, as an intangible resource. R&D intensity is calculated as the ratio of R&D expenses to net sales.

Due to missing values in the data adding the control variables advertising intensity and R&D intensity into the analysis decreases the sample size. Furthermore, it does not help much for improving the model fit. Since qualitatively similar results were found for this data set, I 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 4.3.

4.3. Results and Discussion

Table 7 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*) , financial performance (*roa*, *leverage*), firm size (*ln_asset*), market share of the company (*marketshare*) and market size of the industry (*ln_total_market_revenue*). About 52.6 % of the companies in my dataset are identified as invested in sustainability at least once between 1999 and 2014. 37.9 % of the companies are first time entrants into the sustainability market. The average roa is -1,262%. Thus financially good companies are not overrepresented in the sample, which might have prompted misleading results. The average market share in the data is 0,168%, which indicates that the market is highly fragmented. I can infer that the sustainability market is a highly competitive market.

Table 7: Summary statistics

	Mean	Standard deviation	Min	Max
entry	0.5261	0.4994	0	1
past_entry	0.4785	0.4996	0	1
first_time_entry	0.3793	0.4853	0	1
roa	-0.0126	0.3336	-9.2007	4.8328
ln_asset	6.8442	2.0353	0.1613	13.0814
leverage	0.2026	0.2605	0	7.4392
marketshare	0.0017	0.0064	0	0.0859
ln_total_market_revenue	15.192	0.2482	14.709	15.482
Observations	6704			

4.3.1. Evidence for Causality

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

$$P_i(\boldsymbol{x}_i = 1) = \Gamma_i\left(\boldsymbol{\vartheta} S_i + \delta E\left(\boldsymbol{x}_{N/i}\middle|\, \boldsymbol{S}_{N/i}\right)\right) \quad (51)$$

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

In all the estimations in Table 8, 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, I include the control variables *past entry, roa, ln_asset, leverage, market share, first time entry* and *ln_total_market_revenue.* In Model 2, I control for the time trend effects by incorporating time variant variables in addition to the full set of controls. I calculate *trend* as the difference between the year of observation and 1998. I include the variable *trend*^{2}, the squared *trend*, thereby allowing a nonlinear relationship between time trend effects and *entry*. In Model 3, I run a random effects model, since the differences across companies might have some influence on the dependent variable *entry*. I incorporate the full set of controls as well as *trend* and *trend*^{2}. Thereby I control both for individual and time trend effects. In Model 4, I restrict the sample to companies that enter the sustainability market for the first time and control for *roa, ln_asset, leverage, market share* and *ln_total_market_revenue.*

Table 8: Logit estimates of the effect of competition

	Model 1 Coefficient	Model 2 Coefficient	Model 3 Coefficient	Model 4 Coefficient
number_of_competitors	0.0132***	0.0159***	0.0164***	0.0156***
	(0.0009)	(0.0011)	(0.0011)	(0.0021)
past_entry	1.8809***	1.9072***	0.0164***	0
	(0.0880)	(0.0891)	(0.0011)	(omitted)
trend		-0.3297***	-0.3052***	
		(0.0755)	(0.0773)	
trend^2		0.0095***	0.0087***	
		(0.0028)	(0.0029)	
roa	0.4279***	0.3955***	0.3919**	0.1694
	(0.1479)	(0.1482)	(0.1603)	(0.1852)
ln_asset	0.2824***	0.2833***	0.3225***	0.1688***
	(0.0224)	(0.0224)	(0.0282)	(0.0379)
leverage	-0.0864	-0.1003	-0.1565	-0.1157
	(0.1465)	(0.1475)	(0.1678)	(0.3248)
marketshare	-24.4110***	-24.6236***	-25.9269***	-53.0406***
	(5.9221)	(5.9421)	(7.4004)	(20.7308)
first_time_entry	-1.1881***	-1.2302***	-1.1667***	0
	(0.0993)	(0.1004)	(0.1121)	(omitted)
ln_total_market_revenue	-3.2618***	-1.1357**	-1.1590**	-2.0707***
	(0.3298)	(0.5187)	(0.5311)	(0.7946)
cons	44.1141***	13.0460*	12.9515*	25.2143**
	(4.8152)	(7.5758)	(7.7559)	(11.5489)
Fixed effects	None	time trend	individual& time trend	first time entry
Log likelihood	-2801.1624	-2787.7185	-2778.1886	-894.5621
Pseudo- R^2	0.396	0.3989		0.1236
Observations	6704	6704	6704	2543

*Robust standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1*

For all specifications, I 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 3, 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 time like any other innovation or disruptive technology. (115) claims that the sustainability behavior of industry leaders change 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. Moreover, this finding is consistent with the business cases described in Gregory Unruh's Harvard Business Review article (116). He presents anecdotal evidence of companies investing in sustainability because industry peers already invested in sustainability. He names industry-wide sustainability pressures as the green domino effect. To conclude that I have empirical support for the "sustainability dissemination" or "green domino effect", I need to assure that *number_of_competitors* is an unbiased estimator of sustainability competition.

4.3.2. Correcting for Endogeneity Bias with IV Model

The analysis in Table 8 does not indicate a causal relationship. In other words; I 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 8 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. (112) and (117) note that market size is highly correlated with the number of firms in a market. (118) use market size as an instrument for the number of firms. I employ the natural logarithm of total market revenue (*ln_total_market_revenue*) 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.

Table 9: Probit model with endogenous regressors

Variable	Model2 Coefficient	Model2_IV Coefficient
number_of_competitors	0.0159***	-0.0057
	(0.0011)	(0.0056)
past_entry	1.9072***	0.9144***
	(0.0891)	(0.1200)
Trend	-0.3297***	0.3314
	(0.0755)	(0.2140)
$trend^2$	0.0095***	-0.0116
	(0.0028)	(0.0069)
Roa	0.3955***	0.2291***
	(0.1482)	(0.0760)
ln_asset	0.2833***	0.1412***
	(0.0224)	(0.0170)
Leverage	-0.1003	-0.0493
	(0.1475)	(0.0794)
Marketshare	-24.6236***	-12.5209***
	(5.9421)	(3.3678)
first_time_entry	-1.2302***	-0.7578
	(0.1004)	(0.0571)
ln_total_market_revenue	-1.1357**	
	(0.5187)	
cons	13.0461*	-1.3522***
	(7.5758)	(0.3515)
Fixed effects	time trend	time trend
Log likelihood	-2787.7185	-35094.127
Pseudo- R^2	0.3989	5.9
Observations	6704	6704

*Robust standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1*

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 9, when the IV approach is implemented the coefficient of the explanatory variable, which is significant and positive in Model 2, becomes negative though insignificant at the conventional levels of significance. I interpret this result as there is not sufficient variation in the sample as well as the possibility that the instrument is not a perfect one, therefore I fail to reject that the coefficient is zero. However compared to Model 2 the IV result indicates that the coefficient has a negative sign on average. To further investigate the endogeneity in the estimation I incorporate the strategic interaction into the analysis.

4.3.3. Correcting for Endogeneity Bias with Static Model of Strategic Interaction

I assume static competition and employ the two stage analysis described in Section 3. I 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 $\hat{\Pi}_i(x_i = 1|\boldsymbol{S}) - \hat{\Pi}_i(x_i = 0|\boldsymbol{S})$. This can be done by evaluating equation (47) 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:

$$\hat{\Pi}_i(x_i = 1|\boldsymbol{S}) - \hat{\Pi}_i(x_i = 0|\boldsymbol{S}) = \log(\hat{P}_i(x_i = 1|\boldsymbol{S})) - \log(\hat{P}_i(x_i = 0|\boldsymbol{S})) \tag{52}$$

under the assumption that the preference shock has an extreme value type I distribution. I need covariates that influence the net benefits of one particular company, but not other companies.[25] The covariates include financial performance (*roa, leverage*), firm size (*ln_assets*), past sustainability performance (*past_entry*, *first_time_entry*). I 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 $\hat{\Pi}_i(x_i = 0|\boldsymbol{S})$, I use the empirical analog of equation (48) to form an estimate of $\Pi_i(x_i, \boldsymbol{x}_{N/i}, S_i)$ and recover structural parameters. The identification depends crucially on applying appropriate exclusion restrictions. The recovered probabilities are plugged into a second-stage

[25] 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 should be identified depending on a functional form.

model which incorporates competitive interaction which is operationalized as *market share*. Thereby, I estimate the causal effect of competition on the likelihood of entry in the sustainability market consistently.

According to (119) both costs and revenues decrease if more competitors adopt the same pricing strategy. As more companies adopt sustainability initiatives, companies which are not sustainable won't be capable to compete with their sustainable counterparts. With sustainability becoming the norm, even more companies invest in sustainability. However, the value stakeholders assign to sustainability will decrease if almost all firms supply sustainability. For example, consumers won't be willing to pay a price premium for a sustainable product or choose a brand/product over a competing brand/product because of their sustainability. Thus the demand for sustainability will not suffice and similar- to the pricing strategy, with increasing competition a decrease in revenue may be expected, which in turn decreases the likelihood of investing in sustainability and 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. As discussed in Section 3 spillovers occur in the form of 1) improved stakeholder perception towards the whole industry, which result in increased revenues and 2) decreased initial investment costs due to imitability of sustainability investments, which are generally not protected by patents. 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, I expect to obtain positive and significant coefficients.

In Table 10, results of the two-stage estimation are presented. I control for unobserved heterogeneity in several ways. First, in all specifications, I 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, I control for unobserved heterogeneity using both fixed effects and random effects specifications. When I substitute the recovered probabilities into the second-stage, I observe that the coefficient of the explanatory variable is negative and significant. Recall that, it is positive and significant in the logit estimation (Table 8) and negative and insignificant in the IV estimation (Table 9). 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.

The comparison of Table 10 with Table 8 verifies that employing *number_of_competitors* as explanatory variable leads to upward biased results. According to (103) 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. This finding reveals that companies might invest into sustainability due to market share considerations, even though they might not benefit financially in the short term. Thus the decision to implement sustainability initiatives is primarily driven by demand–side factors and is strategic. As a matter of fact, (120) 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.

Table 10: Logit estimates of the effect of strategic interactions (parametric first stage)

Variable	Model1 Coefficient	Model2 Coefficient	Model3 Coefficient	Model4 Coefficient
prob_competitors_entry	-0.0030**	-0.0256***	-0.0253***	-0.0084**
	(0.0014)	(0.0028)	(0.0028)	(0.0038)
past_entry	1.7182***	1.8369***	1.7377***	0
	(0.0847)	(0.0875)	(0.0958)	(omitted)
Trend		1.1347***	1.1345***	
		(0.1117)	(0.1126)	
$trend^2$		-0.0391***	-0.0391***	
		(0.0039)	(0.0039)	
Roa	0.4484***	0.5035***	0.5212***	0.1587
	(0.1470)	(0.1516)	(0.1607)	(0.1893)
ln_asset	0.2676***	0.2660***	0.2879***	0.1621***
	(0.0220)	(0.0223)	(0.0262)	(0.0377)
Leverage	-0.1517	-0.1416	-0.1870	-0.2213
	(0.1486)	(0.1505)	(0.1641)	(0.3262)
Marketshare	-23.583***	-22.8420***	-23.6302***	-52.0667***
	(5.9099)	(6.0237)	(6.9224)	(20.4964)
first_time_entry	-1.3641***	-1.3368***	-1.3153***	0
	(0.0990)	(0.1006)	(0.1074)	(omitted)
ln_total_market_revenue	1.9493***	0.9888	0.9995	6.1954***
	(0.4981)	(0.5393)	(0.5477)	(1.3402)
cons	-30.900***	-17.3264**	-17.7078**	-94.5933***
	(7.2780)	(7.8831)	(8.0072)	(19.5494)
Fixed effects	none	time trend	individual & time trend	first time entry
Log likelihood	-2905.5171	-2851.983	-2848.2566	-920.4541
Pseudo- R^2	0.3735	0.385		0.0982
Observations	6704	6704	6704	2543

*Robust standard errors in brackets, *** p<0.01, ** p<0.05*

(26) finds that the value gains are larger for companies with relatively low levels of sustainability, which indicates that the sustainability–financial relationship is concave. She advocates that in the initial stages of sustainability, companies harvest the low-hanging fruits. Although common sense complies with this finding, she studies companies who already decided to invest into sustainability and have already committed to a minimum threshold of sustainability. Likewise, I build my models on diminishing returns from additional sustainability initiatives, but I don't agree that initial

implementation of sustainability is easy as suggested by (26). I study whether companies decide to invest or not. As proposed in Section 3, 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, I would observe the effect of spillovers, if it were substantial. Thus considering the effect of competition and spillovers as ex ante measures of market entry becomes important. I document that first time entry into sustainability decreases the likelihood of entry .Thus I 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, I refine my analysis by restricting my 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 drastically, which suggests that initial investments are costly and act as market entry barriers. This finding resonates with remark the in (52) on corporate inertia[26] in the strategy literature. Furthermore, it is consistent with the corporate immune system concept[27] in corporate entrepreneurship literature (121). The new comers not only suffer from market entry barriers in the form of corporate inertia within the company but also incumbent firms' forestalling the entry of new competitors. When firms make their entry decisions sequentially, it is well known that early movers can preempt subsequent potential entrants (112) (117).

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[26] 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.

[27] The immune system acts to prevent alien substances from affecting the body in a harmful way. Similarly new initiatives are viewed as harmful by the existing power bases within the company. The corporate immune system is an analogy to model the resistance to advancement of creation-oriented activities such as sustainability initiatives.

(115) claims that companies decide to participate in voluntary environmental programs to signal stakeholders or gain market share. This decision is likely to be strategic and creates selection bias that makes programs appear overly effective. The relationship between observed changes in environmental behavior and unobserved differences in firms that drive both participation and environmental outcomes are estimated Instead of the effect of program effectiveness on observed changes in environmental behavior. The two- stage models intent to correct the selection bias. However, he points out that the researchers might be over-controlling for differences across firms by controlling for the likelihood to invest into voluntary environmental programs and then only examining within-firm changes over time, which might lead to incorrect negative or insignificant findings.

Similarly, entry decision into the sustainability market is a strategic decision and as seen in Table 8 due to selection bias, the results are biased upwards and overestimate the true relationship between number of competitors and likelihood of entry. I document that the number of competitors affect the likelihood of entry negatively with the two-stage models. The empirical findings confirm that firms might decide to invest in sustainability to gain competitive advantage in the long-run regardless the financial return in the short-term. In order to show that over-controlling is not a concern, I perform robustness check.

4.3.4. Robustness

I allow for a more flexible first stage, to evaluate whether the presence of competition effect is robust. I replicate the estimations in Model1 to Model4 in Table 10, 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 11. The results indicate a robust negative relationship between competition and the likelihood of entry into the sustainability market.

Table 11: Logit estimates of the effect of strategic interactions (semiparametric first stage)

Variable	Model1 Coefficient	Model2 Coefficient	Model3 Coefficient	Model4 Coefficient
prob_competitors_entry	-0.0015	-0.0234***	-0.0227***	-0.0005
	(0.0015)	(0.0029)	(0.0030)	(0.0035)
past_entry	1.7069***	1.8215***	1.7160***	0
	(0.08457)	(0.0876)	(0.0957)	(omitted)
trend		1.0472***	1.0470***	
		(0.1163)	(0.1175)	
$trend^2$		-0.0359***	-0.0360***	
		(0.0040)	(0.0040)	
roa	0.4500***	0.5011***	0.5182***	0.1671
	(0.1468)	(0.1505)	(0.1600)	(0.1875)
ln_asset	0.2681***	0.2651***	0.2890***	0.1605***
	(0.0220)	(0.0222)	(0.0263)	(0.0375)
leverage	-0.1450	-0.1311	-0.1788	-0.1889
	(0.1482)	(0.1499)	(0.1640)	(0.3246)
marketshare	-23.567***	-22.9675***	-23.8569***	-52.0635***
	(5.8992)	(5.9704)	(6.9347)	(20.5955)
first_time_entry	-1.3549***	-1.3106***	-1.2856***	0
	(0.09888)	(0.09997)	(0.1073)	(omitted)
ln_total_market_revenue	1.4326***	0.8273	0.8273	3.4782***
	(0.5135)	(0.5454)	(0.5543)	(1.2464)
cons	-23.4021***	-14.9681*	-15.2166*	-55.0203***
	(7.5029)	(7.9727)	(8.1035)	(18.1829)
Fixed effects	none	time trend	individual& time trend	first time entry
Log likelihood	-2907.2832	-2865.682	-2865.6825	-923.0425
Pseudo- R^2	0.3731	0.3821		0.0956
Observations	6704	6704	6704	2543

*Robust standard errors in brackets, *** p<0.01, ** p<0.05*

The empirical findings confirm that firms might decide to invest in sustainability to gain competitive advantage in the long-run regardless the financial return in the short-term. Moreover, I document that for first time entrants the likelihood of entry decreases drastically due to market entry barriers. I revisit the analytical model presented in 3.2.1 and compare the firm behavior documented empirically with the firm behavior predicted in the sequential oligopoly model. Especially for low spillover rates and moderate to high competition levels the numerical results indicate similar behavior. As seen in Figure 27, the leader invests more in sustainability compared to the followers for spillover rates γ<0.199. However, the leader attains first mover advantage only for spillover rates γ<0.096 and has advantage over the second follower for spillover rates 0.096 <γ<0.130. The plausible explanation for the leader to increase sustainability investment despite losing net benefit advantage is the leaders desire to forestall the followers from entering the sustainability market.

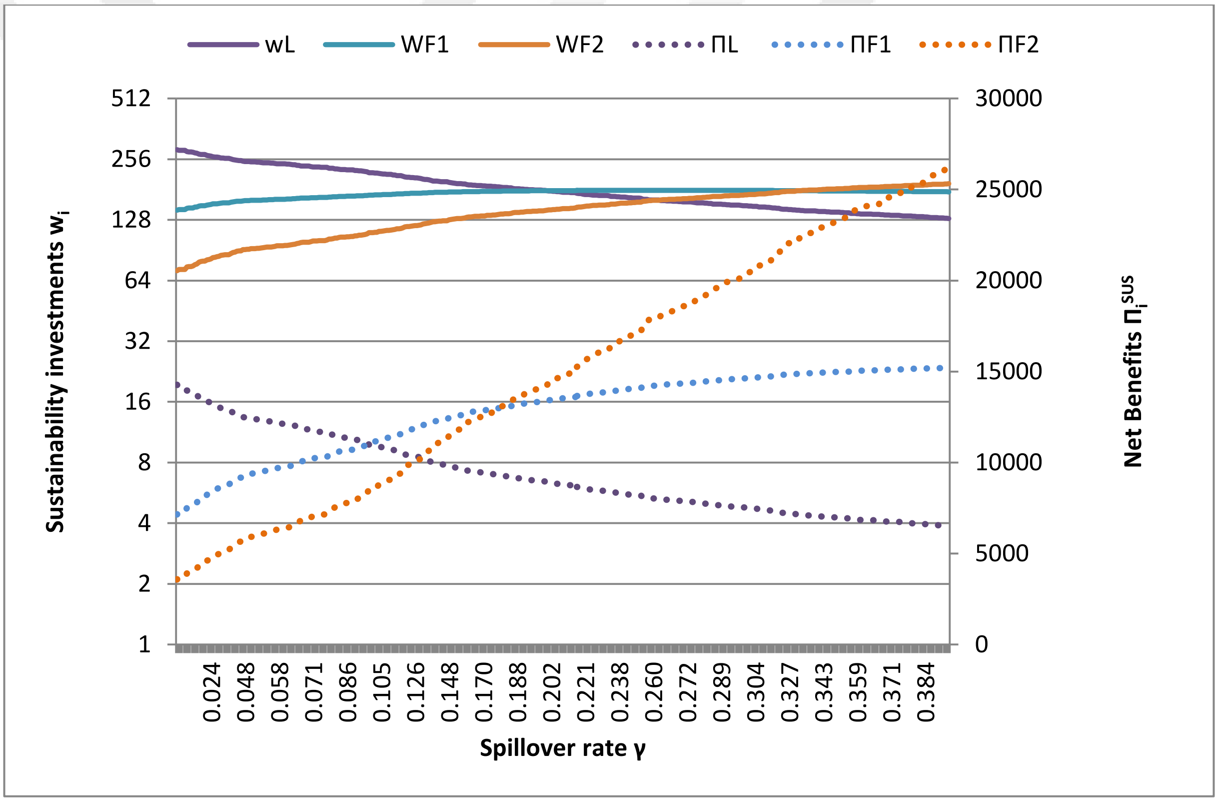

Figure 27. The influence of spillover on the level of sustainability initiatives and the net benefits for θ=1

CHAPTER V

CONCLUSION

My goal was to illustrate how a game-theoretic framework can aid in the construction and estimation of interrelated choice models in the corporate sustainability context. I considered a competitive setting, where companies' sustainability decisions depend not only on the expected net benefits of their own sustainability actions but also on the competitor companies' sustainability actions. In the literature, there are different findings on how sustainability actions affect the net benefits: *i*) Since the costs of sustainability balance out the benefits generated from sustainability, the net benefits of firms that implement sustainability is the same as the net benefits of the firms that do not implement sustainability (95). *ii)* In oligopolistic markets in equilibrium, firms which supply sustainable goods reap abnormal profits (122). I assumed that the net benefits are positive for both duopoly and oligopolistic competition

I approached sustainability interactions as strategic interactions under the assumption of complete information and proposed a multiple period sequential model to understand the effect of competition and spillovers on sustainability interactions. I extended the Stackelberg model of duopoly by allowing more than one follower firm. In the first stage of the game the leader chooses her sustainability level by anticipating the cumulative response of all followers. In the proceeding stages of the game the followers observe the sustainability investments of the leader and the cumulative sustainability outcome of their predecessor followers. The followers choose their sustainability investments based on these observations and by anticipating the successor followers' cumulative sustainability levels. The companies compete for stakeholder payments. I assumed that stakeholders are indifferent which specific company invests in sustainability, as long as stakeholders' demand for sustainability is met. This assumption subjects sustainability to homogeneous good assumptions. Due to the homogeneous goods assumption, the effect of competition is perceived both by the leader and followers and is constant among all players. I assumed that, the sustainability spillovers occur from leader to followers and among followers. Moreover, I assumed that they are constant among followers. I solved the backward induction of the 1 leader-2 followers game.

Due to the analytical intractability of the model I relied on computational methods to analyze the effect of competition and sustainability spillovers on sustainability initiatives, net benefits and total sustainability outcome of the market. Based on my computational experiments I identified the conditions, when the first mover advantage or the second mover advantage arises. Furthermore, I evaluate the influence of price elasticity of demand for sustainability. The elasticity of demand measures whether consumers are price sensitive and how much they react to changes. If changes in stakeholder payment have a relatively large effect on the level of sustainability demanded, then demand for sustainability is elastic. In the case of elastic demand for sustainability, as spillover increases the leader is compelled to decrease her sustainability level in order to prevent the followers to free ride the leader's sustainability efforts and defend her position as leader. The leader has the first mover advantage for low spillover rates. Likewise the first follower decreases her sustainability level since the second follower benefits from the leaders as well as first follower's sustainability efforts. The first follower has the second mover advantage for low spillover rates and the second mover advantage is more defendable as competition level increases. Nonetheless for most of the competition and spillover combinations the second follower benefits the most. Neither the leader nor the first follower is able to defend their position against the second follower.

If changes in stakeholder payment have a relatively small effect on the level of sustainability demanded, then demand for sustainability is inelastic. For inelastic demand the leader has first mover advantage for low spillover rates. However, the leader is not able to defend her first mover advantage. The second follower's net benefits exceed the first follower's net benefits for all competition and spillover combinations. The second follower has the last mover advantage for moderate and high spillover rates.

The analytical model suggests that the leader has the first mover advantage only for low spillover rates. As spillover increases the leader is compelled to decrease her sustainability level in order to prevent the followers to free ride the leader's sustainability efforts and defend her position against the followers. Moreover, the first mover advantage is more defendable as the competition level increases. For most competition and spillover combinations, however, the followers benefit more than the leader. This result is in line with prior empirical research: A leader's sustainability activity is generally lower than her followers' sustainability activities (28) and since the leaders are less competitively aggressive, carry out simpler repertoires of actions, and carry out competitive actions more slowly (107).

I studied the effect of competition and spillover on the total sustainability level of the market, to shed some light on the outcomes of sustainability interactions from the policy makers' point of view. On the one hand increasing competition levels decreases total sustainability investments of the market as well as total benefits of the market. On the other hand increasing spillover rates increase total sustainability investments of the market as well as total benefits of the market. By modeling strategic sustainability interactions in an oligopolistic market I contributed to the ongoing debate about the impact of industry structure on sustainability and financial outcomes generated by sustainability.

I resorted to empirical methods to verify the result discussed above and further investigate the sustainability interactions. I presented a coherent econometric model that incorporates the possibility of the competitors' actions having an impact on the decision of the focal company. I modeled sustainability decisions as discrete choices, where companies, which commit to sustainability above a given threshold, are considered as sustainability market entrants. I operationalized this measure as being graded by MSCI KLD 400 Social Index. I restricted my sample to manufacturing firms to ensure that industry specific effects do not conceal the true effect of competition on sustainability outcomes. Similar to classical industrial organization research, I explored how the number of firms in the sustainability market, firms' sizes, their financial positions and potential competitors affect market entry.

When strategic interaction was not accounted for, I found that increase in the number of competitors increases the likelihood of sustainability investments, which supports Hypothesis 1. Indeed sustainability becomes a norm over time, and companies invest in sustainability in order to become or remain competitive. When I controlled for the strategic interaction of sustainability through an instrumental variable, the relationship between number of competitors and the likelihood of entry into the sustainability market becomes negative but insignificant. When I applied the two stage approach which incorporates competitive interaction, I documented that competition hurts the likelihood of entry into the sustainability market.

Although the interdependence of discrete entry decisions can pose identification and estimation problems, I was able to provide empirical evidence that the effect of competition on the likelihood of entry into the sustainability market dominates the effect of spillover. Thus the empirical analysis favors Hypothesis 2 over Hypothesis 3. Furthermore, this finding is more profound for the first time entrants. This result has substantial regulatory policy implications. Public policy makers should give incentives to new entrants in order to compensate the negative influence of competition on the total sustainability outcome of the market.

Furthermore, I compared the firm behavior documented empirically with the firm behavior predicted in the analytical sequential oligopoly model. On the one hand the analytical model suggests that the leader has the first mover advantage only for low spillover rates. As spillover increases the leader is compelled to decrease her sustainability level in order to prevent the followers to free ride the leader's sustainability efforts and defend her position against the followers. Moreover, the first mover advantage is more defendable as the competition level increases. Nonetheless, for most of the competition and spillover combinations the followers benefit more than the leader.

On the other hand the empirical model indicates that the likelihood of companies adopting sustainability initiatives decreases as the number of sustainability adopters increases. The empirical findings imply that the effect of competition dominates the spillover effects. Moreover, these observations are more profound for first time sustainability adopters. These findings resemble the firm behavior for low spillover rates and moderate to high competition levels as displayed by the analytical model. Thus I inferred that the sustainability market for manufacturing companies has low spillover rates and moderate to high competition levels. My thesis provides both analytical and empirical perspectives on the effect of competition and spillover on sustainability decisions in a competitive setting.

Future research questions arise such as the formalization of sustainability interactions in a multi period model, since investments in sustainability are likely to 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 how strategic interactions influence the sustainability decisions.

APPENDIX A1

$$\frac{\partial w_L}{\partial \theta} = -\frac{(a-d)(\theta^2-4\theta+2\gamma+2)}{2b(2-\theta(\theta-\gamma))^2} \quad (1)$$

Since $(a-d) > 0$ and $2b(2-\theta(\theta-\gamma))^2 > 0$, I have to evaluate $\theta^2 - 4\theta + 2\gamma + 2$.

$$\theta^2 - 4\theta + 2\gamma + 2 = \theta(\theta-4) + 2(\gamma+1)$$

$(\theta - 4) < 0$ since $\theta \in [0,1]$ and $(\gamma+1) > 0$ since $\gamma \in [0,1]$. Thus if $|\theta(\theta-4)|$<$2(\gamma+1)$ then $\theta(\theta-4) + 2(\gamma+1) > 0$. Thereby if $|\theta(\theta-4)|$<$2(\gamma+1)$, then $\frac{\partial w_L}{\partial \theta}$<0.

Moreover if $|\theta(\theta-4)|$>$2(\gamma+1)$, then $\frac{\partial w_L}{\partial \theta}$>0.

$$\frac{\partial^2 w_L}{\partial \theta^2} = \frac{(a-d)\left(2\gamma^2+\gamma(2-6\theta)-\theta^3+6\theta^2-6\theta+4\right)}{b(2-\theta(\theta-\gamma))^3} \quad (2)$$

Since $(a-d) > 0$, I have to evaluate

$(2\gamma^2 + \gamma(2-6\theta) - \theta^3 + 6\theta^2 - 6\theta + 4)$and $b(2-\theta(\theta-\gamma))^3$

Since $\theta \in [0,1]$ and $\gamma \in [0,1]$, $2-\theta(\theta-\gamma)$>0. Thus $b(2-\theta(\theta-\gamma))^3$>0.

$$2\gamma^2 + \gamma(2-6\theta) - \theta^3 + 6\theta^2 - 6\theta + 4 = 4 + 2\gamma(\gamma+1) - \theta^3 + 6\theta(\theta-\gamma-1)$$

Since $\in [0,1]$, $4 + 2\gamma(\gamma+1) > 0$

Since $\theta \in [0,1]$ and $\gamma \in [0,1]$, $(\theta-\gamma-1) < 0$, which leads to $-\theta^3 + 6\theta(\theta-\gamma-1) < 0$

Thus if $4 + 2\gamma(\gamma + 1) > |-\theta^3 + 6\theta(\theta - \gamma - 1)|$ then $(2\gamma^2 + \gamma(2 - 6\theta) - \theta^3 + 6\theta^2 - 6\theta + 4) > 0$. Moreover if $4 + 2\gamma(\gamma + 1) > |-\theta^3 + 6\theta(\theta - \gamma - 1)|$, then $\frac{\partial^2 w_L}{\partial \theta^2} > 0$.

Since $4 + 2\gamma(\gamma + 1) > |-\theta^3 + 6\theta(\theta - \gamma - 1)|$ holds for all defined θ and γ values, $\frac{\partial^2 w_L}{\partial \theta^2} > 0$ holds for all defined θ and γ values as well.

$$\frac{\partial w_L}{\partial \gamma} = \frac{(a-d)\theta(\theta-2)}{2b(2-\theta(\theta-\gamma))^2} \tag{3}$$

Since $(a - d) > 0$ and $2b\big(2 - \theta(\theta - \gamma)\big)^2 > 0$, I have to evaluate $\theta(\theta - 2)$.

Since $\theta \in [0,1]$, $\theta(\theta - 2) < 0$. Thus $\frac{\partial w_L}{\partial \gamma} < 0$ for all defined θ and γ values.

$$\frac{\partial^2 w_L}{\partial \gamma^2} = \frac{(a-d)\theta^2(\theta-2)}{b(2-\theta(\theta-\gamma))^3} \tag{4}$$

Since $(a - d) > 0$ and $b\big(2 - \theta(\theta - \gamma)\big)^3 > 0$, I have to evaluate $\theta^2(\theta - 2)$.

Since $\theta \in [0,1]$, $\theta^2(\theta - 2) < 0$. Thus $\frac{\partial^2 w_L}{\partial \gamma^2} < 0$ for all defined θ and γ values.

$$\frac{\partial w_F}{\partial \theta} = -\frac{(a-d)((\gamma-\theta)^2+2+\gamma-2\theta)}{2b(2-\theta(\theta-\gamma))^2} \tag{5}$$

Since $(a - d) > 0$ and $2b(2 - \theta(\theta - \gamma))^2 > 0$, I have to evaluate $(\gamma - \theta)^2 + 2 + \gamma - 2\theta$.

If $(\gamma - \theta)^2 + 2 + \gamma > 2\theta$, then $(\gamma - \theta)^2 + 2 + \gamma - 2\theta > 0$. Moreover, if $(\gamma - \theta)^2 + 2 + \gamma > 2\theta$, then $\frac{\partial w_F}{\partial \theta} < 0$.

Since $\theta \in [0, 1]$ and $\gamma \in [0, 1]$, $(\gamma - \theta)^2 + 2 + \gamma > 2\theta$ holds for all defined θ and γ values. Thus $\frac{\partial w_F}{\partial \theta} < 0$ holds for all defined θ and γ values as well.

$$\frac{\partial^2 w_F}{\partial \theta^2} = \frac{(a-d)(\gamma^3+\gamma^2(1-3\theta)+\gamma(3\theta^2-3\theta+4)-\theta^3+3\theta^2-6\theta+2)}{b(\theta(\theta-\gamma)-2)^3} \qquad (6)$$

Since $(a - d) > 0$ and $b(2 - \theta(\theta - \gamma))^3 > 0$, I have to evaluate $(\gamma^3 + \gamma^2(1 - 3\theta) + \gamma(3\theta^2 - 3\theta + 4) - \theta^3 + 3\theta^2 - 6\theta + 2)$

$$(\gamma^3 + \gamma^2(1 - 3\theta) + \gamma(3\theta^2 - 3\theta + 4) - \theta^3 + 3\theta^2 - 6\theta + 2)$$

For 0<θ <0.3333 values $1 - 3\theta > 0$

$3\theta^2 - 3\theta + 4 > 0$ for all defined θ.

For 0<θ <0.4 values $-\theta^3 + 3\theta^2 - 6\theta + 2 > 0$

For 0<θ <0.3333 values, $(\gamma^3 + \gamma^2(1 - 3\theta) + \gamma(3\theta^2 - 3\theta + 4) - \theta^3 + 3\theta^2 - 6\theta + 2 > 0$ $\frac{\partial^2 w_F}{\partial \theta^2} > 0$.

For 0.333<θ <0.4 since $\gamma^3 + \gamma(3\theta^2 - 3\theta + 4) - \theta^3 + 3\theta^2 - 6\theta + 2 > |\gamma^2(1 - 3\theta)|$, $\frac{\partial^2 w_F}{\partial \theta^2} > 0$.

For θ >0.4 values if $\gamma^3 + \gamma(3\theta^2 - 3\theta + 4) > |\gamma^2(1 - 3\theta) - \theta^3 + 3\theta^2 - 6\theta + 2|$ then $\frac{\partial^2 w_F}{\partial \theta^2} > 0$.

$$\frac{\partial w_F}{\partial \gamma} = -\frac{(a-d)(\theta-2)}{2b(2-\theta(\theta-\gamma))^2} \qquad (7)$$

Since $(a - d) > 0$ and $2b\left(2 - \theta(\theta - \gamma)\right)^2 > 0$, I have to evaluate $(\theta - 2)$.

Since $\theta \in [0, 1]$, $(\theta - 2) < 0$. Thus $\frac{\partial w_L}{\partial \gamma} > 0$ for all defined θ and γ values.

$$\frac{\partial^2 w_F}{\partial \gamma^2} = \frac{(a-d)\theta(\theta-2)}{b(2-\theta(\theta-\gamma))^3} \tag{8}$$

Since $(a-d) > 0$ and $b\big(2-\theta(\theta-\gamma)\big)^3 > 0$, I have to evaluate $\theta(\theta-2)$.

Since $\theta \in [0,1]$, $\theta(\theta-2) < 0$. Thus $\frac{\partial w_L}{\partial \gamma} < 0$ for all defined θ and γ values.

$$\frac{\partial \Pi_L^{sus}}{\partial \theta} = \frac{(a-d)^2}{8b\big(2-\theta(\theta-\gamma)\big)^2}(\theta-2)(\gamma(\theta+2)-4\theta+4) \tag{9}$$

Since $(a-d)^2 > 0$ and $8b\big(2-\theta(\theta-\gamma)\big)^2 > 0$, I have to evaluate $(\theta-2)(\gamma(\theta+2)-4\theta+4)$.

Since $\theta \in [0,1]$, $(\theta-2) < 0$

$\gamma(\theta+2) > 0$ for all defined θ and γ values.

$-4\theta+4 \geq 0$ for all defined θ values. Thus $\gamma(\theta+2)-4\theta+4 > 0$

Since $(\theta-2)(\gamma(\theta+2)-4\theta+4 < 0$, $\frac{\partial \Pi_L^{sus}}{\partial \theta} < 0$.

$$\frac{\partial^2 \Pi_L^{sus}}{\partial \theta^2} = \frac{(a-d)^2}{4b\big(2-\theta(\theta-\gamma)\big)^3}(4\gamma^2+\gamma(\theta^3-12\theta+8)-4\theta^3+18\theta^2-24\theta+12) \tag{10}$$

Since $(a-d)^2 > 0$ and $4b\big(2-\theta(\theta-\gamma)\big)^3 > 0$, I have to evaluate $4\gamma^2 + \gamma(\theta^3-12\theta+8)-4\theta^3+18\theta^2-24\theta+12$

For $0 < \theta \leq 0.694593$ $\theta^3-12\theta+8>0$

Since $\theta \in [0,1]$, $4\theta^3+18\theta^2-24\theta+12>0$ for all defined θ values.

For $0 < \theta \leq 0.694593$ $4\gamma^2+\gamma(\theta^3-12\theta+8)-4\theta^3+18\theta^2-24\theta+12>0$.

Thus $\frac{\partial^2 \Pi_L^{sus}}{\partial \theta^2} > 0$

For $0.694593 \leq \theta < 1$ if $4\gamma^2 - 4\theta^3 + 18\theta^2 - 24\theta + 12 > |\gamma(\theta^3 - 12\theta + 8)|$, then $\frac{\partial^2 \Pi_L^{sus}}{\partial \theta^2} > 0$.

$$\frac{\partial \Pi_L^{sus}}{\partial \gamma} = -\frac{(a-d)^2}{8b\left(2-\theta(\theta-\gamma)\right)^2}(2-\theta)^2\theta \tag{11}$$

Since $(a-d)^2 > 0$ and $8b\left(2-\theta(\theta-\gamma)\right)^2 > 0$, I have to evaluate $(2-\theta)^2\theta$.

Since $(2-\theta)^2\theta > 0$, $\frac{\partial \Pi_L^{sus}}{\partial \gamma} < 0$.

$$\frac{\partial^2 \Pi_L^{sus}}{\partial \gamma^2} = \frac{(a-d)^2}{4b\left(2-\theta(\theta-\gamma)\right)^3}(2-\theta)^2\theta^2 \tag{12}$$

Since $(a-d)^2 > 0$ and $4b\left(2-\theta(\theta-\gamma)\right)^3 > 0$, I have to evaluate $(2-\theta)^2\theta^2$.

$(2-\theta)^2\theta^2 > 0$ for all defined θ values. Thus $\frac{\partial^2 \Pi_L^{sus}}{\partial \gamma^2} > 0$

$$\frac{\partial \Pi_F^{sus}}{\partial \theta} = -\frac{(a-d)^2}{4b\left(2-\theta(\theta-\gamma)\right)^3}(\gamma^2 - 2\theta\gamma + \gamma + \theta^2 - 2\theta + 2)(\gamma(\theta+2) - \theta^2 - 2\theta + 4) \tag{13}$$

Since $(a-d)^2 > 0$ and $4b\left(2-\theta(\theta-\gamma)\right)^3 > 0$, I have to evaluate $-(\gamma^2 - 2\theta\gamma + \gamma + \theta^2 - 2\theta + 2)(\gamma(\theta+2) - \theta^2 - 2\theta + 4)$.

$$\gamma^2 - 2\theta\gamma + \gamma + \theta^2 - 2\theta + 2 = (\gamma-\theta)^2 + \gamma - 2\theta + 2$$

Since $\theta \in [0,1]$ and $\gamma \in [0,1]$, $(\gamma-\theta)^2 + \gamma + 2 > 2\theta$. Thus $\gamma^2 - 2\theta\gamma + \gamma + \theta^2 - 2\theta + 2 > 0$.

$$\gamma(\theta+2) - \theta^2 - 2\theta + 4 = \gamma(\theta+2) - \theta(\theta+2) + 4$$

Since $\theta \in [0,1]$ and $\in [0,1]$, $\gamma(\theta+2) + 4 > \theta(\theta+2)$. Thus $\gamma(\theta+2) - \theta^2 - 2\theta + 4 > 0$.

Furthermore, $-(\gamma^2 - 2\theta\gamma + \gamma + \theta^2 - 2\theta + 2)(\gamma(\theta + 2) - \theta^2 - 2\theta + 4)<0$.

Thereby $\frac{\partial \Pi_F^{sus}}{\partial \theta} < 0$.

$$\frac{\partial^2 \Pi_F^{sus}}{\partial \theta^2} = \frac{(a-d)^2}{2b\big(2-\theta(\theta-\gamma)\big)^4}(\gamma^4(\theta+3) - \gamma^3(4\theta^2 + 11\theta - 8)$$

$$+ \gamma^2(6\theta^3 + 14\theta^2 - 24\theta + 17)$$

$$-\gamma(4\theta^4 + 6\theta^3 - 24\theta^2 + 42\theta - 24) + \theta^5 - 8\theta^3 + 30\theta^2 + 36\theta + 12) \quad (14)$$

Since $(a-d)^2 > 0$ and $2b\big(2-\theta(\theta-\gamma)\big)^4 > 0$, I have to evaluate

$$(\gamma^4(\theta+3) - \gamma^3(4\theta^2 + 11\theta - 8) + \gamma^2(6\theta^3 + 14\theta^2 - 24\theta + 17)$$

$$-\gamma(4\theta^4 + 6\theta^3 - 24\theta^2 + 42\theta - 24) + \theta^5 - 8\theta^3 + 30\theta^2 + 36\theta + 12)$$

$\gamma^4(\theta + 3) > 0$ for all defined θ and γ values.

For $0.597467<\theta \leq 1$ $4\theta^2 + 11\theta - 8 >0$

$6\theta^3 + 14\theta^2 - 24\theta + 17 > 0$ for all defined θ values.

For $0.844464 <\theta \leq 1$ $4\theta^4 + 6\theta^3 - 24\theta^2 + 42\theta - 24>0$

$\theta^5 - 8\theta^3 + 30\theta^2 + 36\theta + 12 > 0$ for all defined θ values.

For $0 \leq \theta < 0.597467$, $4\theta^2 + 11\theta - 8 <0$ and $4\theta^4 + 6\theta^3 - 24\theta^2 + 42\theta - 24<0$.

Thus, $\gamma^4(\theta + 3) - \gamma^3(4\theta^2 + 11\theta - 8) + \gamma^2(6\theta^3 + 14\theta^2 - 24\theta + 17)$

$-\gamma(4\theta^4 + 6\theta^3 - 24\theta^2 + 42\theta - 24) + \theta^5 - 8\theta^3 + 30\theta^2 + 36\theta + 12)>0.$

Thereby $\frac{\partial^2 \Pi_F^{sus}}{\partial \theta^2} > 0.$

For $0.597467 \leq \theta < 0.844464$, $4\theta^2 + 11\theta - 8 > 0$ and $4\theta^4 + 6\theta^3 - 24\theta^2 + 42\theta - 24 < 0$

If $\gamma^4(\theta + 3) + \gamma^2(6\theta^3 + 14\theta^2 - 24\theta + 17) - \gamma(4\theta^4 + 6\theta^3 - 24\theta^2 + 42\theta - 24)$

$+\theta^5 - 8\theta^3 + 30\theta^2 + 36\theta + 12) > |-\gamma^3(4\theta^2 + 11\theta - 8)|$, then $\frac{\partial^2 \Pi_F^{sus}}{\partial \theta^2} > 0$

For $0.844464 < \theta \leq 1$, $4\theta^2 + 11\theta - 8 > 0$ and $4\theta^4 + 6\theta^3 - 24\theta^2 + 42\theta - 24 > 0$.

If $(\gamma^4(\theta + 3) + \gamma^2(6\theta^3 + 14\theta^2 - 24\theta + 17) + \theta^5 - 8\theta^3 + 30\theta^2 + 36\theta + 12) > |-\gamma^3(4\theta^2 + 11\theta - 8) - \gamma(4\theta^4 + 6\theta^3 - 24\theta^2 + 42\theta - 24)|$, then $\frac{\partial^2 \Pi_F^{sus}}{\partial \theta^2} > 0.$

$$\frac{\partial \Pi_F^{sus}}{\partial \gamma} = \frac{(a-d)^2}{4b\left(2-\theta(\theta-\gamma)\right)^3} (\theta - 2)(\theta^2 - \theta(\gamma - 2) - 2(\gamma + 2)) \quad (15)$$

Since $(a - d)^2 > 0$ and $4b\left(2 - \theta(\theta - \gamma)\right)^3 > 0$, I have to evaluate $(\theta - 2)\left(\theta^2 - \theta(\gamma - 2) - 2(\gamma + 2)\right)$

Since $\theta \in [0, 1]$, $(\theta - 2) < 0$

Since $\gamma \in [0, 1]$, $\gamma - 2 < 0$

$\theta^2 - \theta(\gamma - 2) < 2(\gamma + 2)$ for all defined θ and γ values. Thus, $\left(\theta^2 - \theta(\gamma - 2) - 2(\gamma + 2)\right) < 0$. Furthermore, $(\theta - 2)\left(\theta^2 - \theta(\gamma - 2) - 2(\gamma + 2)\right) > 0$. Thereby $\frac{\partial \Pi_F^{sus}}{\partial \gamma} > 0$

$$\frac{\partial^2 \Pi_F^{sus}}{\partial \gamma^2} = -\frac{(a-d)^2}{2b(2-\theta(\theta-\gamma)^4}(\theta^4 - \theta^3\gamma - 9\theta^2 + 4\theta\gamma + 12\theta - 4) \qquad (16)$$

Since $(a-d)^2 > 0$ and $2b\big(2-\theta(\theta-\gamma)\big)^4 > 0$ and I have to evaluate $\theta^4 - \theta^3\gamma - 9\theta^2 + 4\theta\gamma + 12\theta - 4$.

$$\theta^4 - \theta^3\gamma - 9\theta^2 + 4\theta\gamma + 12\theta - 4 = \theta^4 - 9\theta^2 + 12\theta - 4 + \gamma(-\theta^3 + 4\theta)$$

For 0,561553 $<\theta < 1$ $\theta^4 - 9\theta^2 + 12\theta - 4 > 0$.

$-\theta^3 + 4\theta > 0$ for all defined θ values. Thus $\gamma(-\theta^3 + 4\theta) > 0$.

For $\theta <$0,561553 if $\gamma(-\theta^3 + 4\theta) > |\theta^4 - 9\theta^2 + 12\theta - 4|$, then $\theta^4 - \theta^3\gamma - 9\theta^2 + 4\theta\gamma + 12\theta - 4 > 0.$ Thereby $\frac{\partial^2 \Pi_F^{sus}}{\partial \gamma^2} < 0$.

For 0,561553 $<\theta < 1, \theta^4 - \theta^3\gamma - 9\theta^2 + 4\theta\gamma + 12\theta - 4 > 0.$ Thus $\frac{\partial^2 \Pi_F^{sus}}{\partial \gamma^2} < 0$.

APPENDIX A2

Case 2: Both the numerator and denominator in w_L and w_{F_1} are nonegative, while the numerator and denominator in w_{F_2} are negative.

i) Since $a - d > 0$, $\theta(-8 + 4\theta + \theta^2 - \gamma(2 + \theta)) + 4[2 - \theta[-\gamma + \theta]] > 0$ should hold in order the nominator of $w_L > 0$.

Considering the worst case, where $\gamma = 0$, I get $-3.236 < \theta < 1.236$

For $\theta = 1$, I get $\gamma > -1$.

Since b> 0, $\theta(\gamma^2(2 + \theta) - 2\gamma(-4 + 3\theta + \theta^2) + \theta(-8 + 4\theta + \theta^2)) + 4[2 - \theta[\theta - \gamma]] > 0$ should hold in order the denominator of $w_L > 0$.

Considering the worst case, where $\gamma = 0$, I get $-0.745 < \theta < 1.143$

For $\theta = 1$, I get $\gamma > -1/3$.

Combining the results in order $w_L > 0$, $-0.745 < \theta < 1.143$ and $\gamma > -1/3$ should hold.

ii) Since $a - d$ >0 and 2- $\theta > 0$ due to $\theta \in [0, 1]$

$(\gamma - \theta)\theta(8 + \gamma(2 + \theta) - \theta(4 + \theta)) + 4(2 + \gamma - \theta)[2 - \theta[-\gamma + \theta]]$>0

should hold in order the nominator of $w_{F_1} > 0$.

Considering the worst case, where $\gamma = 0$, I get $-0.745 < \theta < 1.143$

For $\theta = 1$, I get $\gamma > -1/7$.

Since b> 0, $(2 - \theta(\theta - \gamma))((\gamma - \theta)\theta(8 + \gamma(2 + \theta) - \theta(4 + \theta)) + 4(2 - \theta(\theta - \gamma)) > 0$ should hold in order the denominator of $w_{F_1} > 0$.

Considering the worst case, where $\gamma = 0,$ I get $-0.629 < \theta < 1.414$

For $\theta = 1$, I get $\gamma > -1$.

Combining the results in order $w_{F_1} > 0$, $-0.629 < \theta < 1.143$ and $\gamma > -1/7$ should hold.

iii) Since $a - d > 0$, $(4 + (\gamma - \theta)(2 + \theta))((\gamma - \theta)\theta(8 + \gamma(2 + \theta) - \theta(4 + \theta)) + 4(2 + \gamma - \theta)[2 - \theta[-\gamma + \theta]]) < 0$ should hold in order the nominator of $w_{F_2} < 0$.

Considering the worst case, where $\gamma = 1$ there exists no solution.

For $\theta = 0$, there exists no solution.

Hence I don't take *case 2* into consideration throughout the analysis.

Case 3: Both the numerator and denominator in w_L and w_{F_2} are nonnegative, while the numerator and denominator in w_{F_1} are negative.

i) Since $a - d > 0$, $\theta(-8 + 4\theta + \theta^2 - \gamma(2 + \theta)) + 4[2 - \theta[-\gamma + \theta]] > 0$ should hold in order the nominator of $w_L > 0$.

Considering the worst case, where $\gamma = 0,$ I get $-3.236 < \theta < 1.236$

For $\theta = 1$, I get $\gamma > -1$.

Since b> 0, $\theta(\gamma^2(2 + \theta) - 2\gamma(-4 + 3\theta + \theta^2) + \theta(-8 + 4\theta + \theta^2)) + 4[2 - \theta[\theta - \gamma]] > 0$ should hold in order the denominator of $w_L > 0$.

Considering the worst case, where $\gamma = 0,$ I get $-0.745 < \theta < 1.143$

For $\theta = 1$, I get $\gamma > -1/3$.

Combining the results in order $w_L > 0$, $-0.745 < \theta < 1.143$ and $\gamma > -1/3$ should hold.

ii) Since $a - d > 0$ and 2- $\theta > 0$ due to $\theta \in [0, 1]$

$(\gamma - \theta)\theta(8 + \gamma(2 + \theta) - \theta(4 + \theta)) + 4(2 + \gamma - \theta)[2 - \theta[-\gamma + \theta]] < 0$

should hold in order the nominator of $w_{F_1} < 0$.

Considering the worst case, where $\gamma = 1$ there exists no solution.

For $\theta = 0$, I get $\gamma < -2$. However is defined as $\gamma \in [0, 1]$

Hence I don't take *case 3* into consideration throughout the analysis.

Case 4: Both the numerator and denominator in w_L are nonnegative, while the numerator and denominator in w_{F_1} and w_{F_2} are negative.

i) Since $a - d > 0$, $\theta(-8 + 4\theta + \theta^2 - \gamma(2 + \theta)) + 4[2 - \theta[-\gamma + \theta]] > 0$ should hold in order the nominator of $w_L > 0$.

Considering the worst case, where $\gamma = 0$, I get $-3.236 < \theta < 1.236$

For $\theta = 1$, I get $\gamma > -1$.

Since b> 0, $\theta(\gamma^2(2 + \theta) - 2\gamma(-4 + 3\theta + \theta^2) + \theta(-8 + 4\theta + \theta^2)) + 4[2 - \theta[\theta - \gamma]] > 0$ should hold in order the denominator of $w_L > 0$.

Considering the worst case, where $\gamma = 0$, I get $-0.745 < \theta < 1.143$

For $\theta = 1$, I get $\gamma > -1/3$.

Combining the results in order $w_L > 0$, $-0.745 < \theta < 1.143$ and $\gamma > -1/3$ should hold.

ii) Since $a - d$ >0 and 2- $\theta > 0$ due to $\theta \in [0, 1]$

$(\gamma - \theta)\theta(8 + \gamma(2 + \theta) - \theta(4 + \theta)) + 4(2 + \gamma - \theta)[2 - \theta[-\gamma + \theta]] < 0$

should hold in order the nominator of $w_{F_1} < 0$.

Considering the worst case, where $\gamma = 1$ there exists no solution.

For $\theta = 0$, I get $\gamma < -2$. However is defined as $\gamma \in [0, 1]$

Hence I don't take *case 4* into consideration throughout the analysis.

Case 5: Both the numerator and denominator in w_L, w_{F_1} and w_{F_2} are negative.

i) Since $a - d > 0$, $\theta(-8 + 4\theta + \theta^2 - \gamma(2 + \theta)) + 4[2 - \theta[-\gamma + \theta]] < 0$ should hold in order the nominator of $w_L < 0$.

Considering the worst case, where $\gamma = 1$ there exists no solution.

For $\theta = 0$, there exists no solution.

Hence I don't take *case 5* into consideration throughout the analysis.

Case 6: Both the numerator and denominator in w_{F_1} and w_{F_2} are nonnegative, while the numerator and denominator in w_L are negative.

i) Since $a - d > 0$, $\theta(-8 + 4\theta + \theta^2 - \gamma(2 + \theta)) + 4[2 - \theta[-\gamma + \theta]] < 0$ should hold in order the nominator of $w_L < 0$.

Considering the worst case, where $\gamma = 1$ there exists no solution.

For $\theta = 0$, there exists no solution.

Hence I don't take *case 6* into consideration throughout the analysis.

Case 7: Both the numerator and denominator in w_{F_1} are nonnegative, while the numerator and denominator in w_L and w_{F_2} are negative.

i) Since $a - d > 0$, $\theta(-8 + 4\theta + \theta^2 - \gamma(2 + \theta)) + 4[2 - \theta[-\gamma + \theta]] < 0$ should hold in order the nominator of $w_L < 0$.

Considering the worst case, where $\gamma = 1$ there exists no solution.

For $\theta = 0$, there exists no solution.

Hence I don't take *case 7* into consideration throughout the analysis.

Case 8: Both the numerator and denominator in w_{F_2} are nonnegative, while the numerator and denominator in w_L and w_{F_1} are negative.

i) Since $a - d > 0$, $\theta(-8 + 4\theta + \theta^2 - \gamma(2 + \theta)) + 4[2 - \theta[-\gamma + \theta]] > 0$ should hold in order the nominator of $w_L > 0$.

Considering the worst case, where $\gamma = 1$ there exists no solution.

For $\theta = 0$, there exists no solution.

Hence I don't take *case 8* into consideration throughout the analysis.

APPENDIX A3

I aim to invert the following system

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

There are *n* players who choose an action from the set *l*={0, 1} and their benefit depends on the 2^{n-1} possible actions of other players. Thus I have to solve for $n\ x\ 2^{n-1}$ unknowns. However, the Left Hand Side (LHS) contains information on *n x 2* scalars. The system is solvable, if there are cross-equation restrictions across either players or actions (i or *l*). Thus I introduce exclusion restrictions. I 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. I suppose $\pi_i(x_i, \boldsymbol{x}_{N/i}, \boldsymbol{S}) = \pi_i(x_i, \boldsymbol{x}_{N/i}, S_i)$ based on the assumption, that the profit of firm *i* depends on the investment decision of other players but does not depend on the firm characteristics represented as state variables $\boldsymbol{S}_{N/i}$. If such an exclusion restriction can be imposed, I can rewrite equation (13) as:

$$\Pi_i\left(x_i\middle|S_i, \boldsymbol{S}_{N/i}\right) = \sum_{\boldsymbol{x}_{N/i}} P_{N/i}\left(\boldsymbol{x}_{N/i}\middle|S_i, \boldsymbol{S}_{N/i}\right) \pi_i(x_i, \boldsymbol{x}_{N/i}, S_i) \quad (51)$$

As stated in Teorem 1 by Bajari et. al (2010): "Suppose that the assumptions of error terms being distributed iid with a known distribution function and the net benefit of not investing in sustainability is equal to zero hold. The necessary order condition for identifying choice specific net benefit function $\Pi_i\left(x_i, \boldsymbol{x}_{N/i}, S_i\right)$ is that for almost all S_i, there exists 2^{n-1} points in the support of the conditional distribution of $\boldsymbol{S}_{N/i}$ given S_i. A sufficient rank condition for identification is that for almost all values of S_i, the conditional second moment matrix of $E\left[\ P_{N/i}(\ \boldsymbol{x}_{N/i}|S_i\ ,\ \boldsymbol{S}_{N/i})\ P_{N/i}(\ \boldsymbol{x}_{N/i}|S_i\ ,\ \boldsymbol{S}_{N/i})'|S_i\right]$ is nonsingular"

The rank condition holds for both discrete and continuous regressors and can be verified from the data, since the rank condition is stated in terms of the observable reduced form choice probabilities. Moreover, it is analogous to the standard rank condition in a linear regression model. However, it differs from the linear regression model, since the regressors, $P_{N/i}(\boldsymbol{x}_{N/i}|\ S_i,\ \boldsymbol{S}_{N/i})$ have to be estimated from the data in the first stage. To identify the strategic interaction models in which net benefits depend on the expected actions of other players, the reduced form choice probabilities have to depend on the states of other players $\boldsymbol{S}_{N/i}$. In the single-agent model with no strategic interactions, the LHS of equation (14) does not depend on $\boldsymbol{S}_{N/i}$ and the RHS does not depend on $\boldsymbol{x}_{N/i}$. The probabilities $P_{N/i}(\boldsymbol{x}_{N/i}|S_i\ ,\ \boldsymbol{S}_{N/i})$ sum up to 1 and equation (14) becomes an identity.

Since the system of equations obtained by varying the values of $\boldsymbol{S}_{N/i}$ is nonsingular and invertible, for almost all S_i, the sufficient rank condition for identification is satisfied. The necessary order condition for identification -for each S_i there exists 2^{n-1} points in the support of the conditional distribution of $\boldsymbol{S}_{N/i}$ given S_i- holds, as long as $\boldsymbol{S}_{N/i}$ contains a continuously distributed variable with $\Pi_i(x_i, \boldsymbol{x}_{N/i}, S_i)$ sufficiently variable (Bajari, 2010).

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