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PROGRAMA DE DOCTORADO en DERECHO Y ECONOMÍA

Impact of Corporate Venture Capital on sustainability knowledge transfer in the European mobility sector to achieve open innovation
-
Impacto del capital riesgo corporativo en la transferencia de conocimiento en materia de sostenibilidad en el sector europeo de la movilidad para lograr la innovación abierta

TESIS DOCTORAL

Presentada por:
Nadine Ladnar
Dirigida por: Prof. Dr. Ricardo Javier Palomo Zurdo y
Prof. Dr. Alexander Zureck

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Nadine Ladnar

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Resumen

El objetivo de esta investigación es mejorar la Perspectiva Basada en los Recursos (PBR) investigando si el Capital Riesgo Corporativo (CVC) influye significativamente en la creación de conocimiento en materia de sostenibilidad por parte de los inversores en el sector europeo de la movilidad. La laguna en la investigación se aborda con un enfoque cuantitativo que aplica un modelo de regresión binomial negativa mediante la investigación de la influencia de las inversiones en startups en los índices de patentes de los inversores del STOXX Europe 600. Las conclusiones son que el CVC conduce a una transferencia de conocimiento en materia de sostenibilidad y general en el sector europeo de la movilidad y transectorial. Los resultados ayudan a las organizaciones europeas a comprender la importancia del CVC para la creación de conocimiento que permita la innovación. Las empresas de movilidad pueden aplicar el CVC para innovar y alcanzar objetivos de calificación medioambiental, social y de gobernanza (ESG).

Abstract

The purpose of this research is to enhance the Resource Based View (RBV) by investigating if Corporate Venture Capital (CVC) significantly influences sustainability knowledge creation of investors in the European mobility sector. The research gap is addressed with a quantitative approach applying a negative binomial regression model by investigating the influence of investments in startups on the patent rates of STOXX Europe 600 investors. Findings are that CVC leads to green and general knowledge transfer in the European mobility sector and cross-sectorial. The results help European organizations to understand the relevance of CVC for knowledge creation to enable innovation. Mobility companies can apply CVC to innovate and achieve Environmental, Social, Governance (ESG) rating objectives.

1 Introduction

1.1 Problem statement, objective, and hypotheses

1.1.1 Problem statement

COVID-19 pandemic, Ukraine, and Israel war lead to food, energy, humanitarian, and refugee crises. These have a destructive impact on the achievement of the United Nations (UN) sustainable development goals (SDGs). Progress on more than 50 percent of targets of the SDGs is weak or insufficient. 30 percent of the objectives are stalled or gone into reverse (United Nations, 2023).

The European mobility sector is weakened due to Asian and US competition including patent registrations, supply chain disruptions like the semiconductor crisis and changing customer requirements. At the same time, the sector is of importance to the European economy. The automotive sector made seven percent of the European Union (EU)'s gross domestic product (GDP) in 2023 and provides direct and indirect employment to 14 million European citizens, representing six percent of total EU employment. Furthermore, the automotive industry is relevant for other industries like steel, chemicals, and textiles due to interdependencies (European Commission, 2024; Martin et al., 2023).

New customer focus and governmental obligations require companies in the mobility sector to change their business models. Mobility companies are asked to offer sustainable transport solutions with a focus on Mobility as a Service (MaaS) and green solutions. Established mobility companies offer such products and services but tend to be static due to complex internal processes. Their transformation takes time. As opposed to this, customers request changes at short notice. To meet these customer needs and stay competitive, mobility companies are required to adapt to a flexible and innovative market environment (Narayanan & Antoniou, 2023).

Environmental requirements for the mobility sector are focused on achieving CO_2 neutrality in transportation with a significant impact on the mobility sector. Sustainable mobility is pursued by consumers and governmental organizations. Objectives require disruptive changes due to regulatory environmental requirements such as the CO_2 emission requirements, the EU Roadmap 2050 and ESG requirements (Herbrand et al., 2023).

An investment type which pursues to support flexibility through knowledge transfer and open innovation in a changing market environment is Corporate Venture Capital (CVC). CVC refers to (mobility) corporations that invest in startups to achieve strategic and financial objectives. Increased flexibility and open innovation are what mobility corporations need to offer sustainable technologies, products, and services. BMW and Porsche are two examples of investors that pursue strategic advantages with CVC (Bendig et al., 2024; Krüger Ruiz, 2019; Le, 2024).

Journal articles are available about CVC, sustainability, and mobility trends apart from each other. However, there is no research on correlation between CVC investments and sustainability knowledge transfer in the mobility sector.

In the United States (US), a U-shaped relationship between the number of CVC investments and patent rates was found in 2015. The patent rate reflects knowledge transfer which can support open innovation. A research gap is found to be if this relationship is applicable to Europe under changed economic conditions since 2015. Furthermore, it is not yet investigated if the relationship can be applied to the mobility sector and sustainability knowledge transfer (Fels et al., 2021; S. M. Lee et al., 2015).[1]

1.1.2 Research gap and objective

A research gap identified is if the relationship described by S. M. Lee et al. (2015) is applicable to sustainable knowledge transfer in the European mobility sector.[2] Derived from this research gap, the objective is to answer the following research question: Does CVC investment impact open innovation through sustainability knowledge transfer in the European mobility sector?

The following hypotheses reflect the research question of this doctoral dissertation. To achieve the objective of this dissertation, the hypotheses are tested. Based on the research results, proposals for actions to European mobility corporations and governmental organizations are provided.

[1] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.
[2] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

1.1.3 Hypotheses

1.1.3.1 General impact of CVC on (green) knowledge transfer

H1: The number of CVC investments is positively related to the level of knowledge transferred **between** investee and corporate investor.

H2: The number of CVC investments is positively related to the level of knowledge transferred **from** the investee to the corporate investor.

H3: The number of CVC investments is positively related to the level of **green** knowledge transferred **between** investee and corporate investor.

H4: The number of CVC investments is positively related to the level of **green** knowledge transferred **from** the investee to the corporate investor.

1.1.3.2 Mobility sector impact of CVC on (green) knowledge transfer

H5: The number of CVC investments is positively related to the level of knowledge transferred **between** investee and **mobility** corporate investor.

H6: The number of CVC investments is positively related to the level of knowledge transferred **from** the investee to the **mobility** corporate investor.

H7: The number of CVC investments is positively related to the level of **green** knowledge transferred **between** investee and **mobility** corporate investor.

H8: The number of CVC investments is positively related to the level of **green** knowledge transferred **from** the investee to the **mobility** corporate investor.

1.2 Structure of work

The introduction of this doctoral thesis provides a problem statement that describes the relevance of the researched topic. From the relevance and the research gap, hypotheses are derived, and the research objective is described. To describe how this objective is reached, the structure of the doctoral dissertation is described. An overview is provided in Table 1.

The theoretical foundations are described in chapter 2. These consist of CVC, knowledge creation, innovation, sustainability, and mobility definitions, theories, and descriptions.

In chapter 3, sustainable Corporate Venture Capital (SCVC) in the mobility sector is analyzed. First, the sustainability focus of CVC is analyzed based on existing scientific findings. After an overview of the mobility sector is provided, the sustainability progress of this sector is analyzed in detail.

In chapter 4, a critical appraisal is applied. In this context, the state of research and the applied method are presented. The sample and applied variables for the applied negative binomial Poisson regression model are described before the model is presented. The research results are illustrated referring to the hypotheses of this doctoral thesis. The results are discussed critically to derive proposals for action. The state of research and critical discussion are split into CVC, sustainability, and mobility research. Moreover, the limitations of the empirical study and this work are described in this chapter.

A conclusion of the research results and proposals is provided in chapter 5. Practical implications, a conclusion of proposals for action, and implications for scientific research are described. This chapter also includes an outlook to future research opportunities.

Table 1: Structure of work

Chapter	Focus	Short description
1	Introduction	In this chapter, the relevance of the topic, research objective, and hypotheses are presented. To describe how the objective is reached, the structure of work is described.
2	Theoretical background	This chapter provides an overview of economic theories, concepts, and definitions related to CVC, knowledge creation, innovation, sustainability, and mobility.
3	Analysis	The three key-topics relevant for the methodology of this doctoral dissertation are analyzed including relations between them. The three key-topics are CVC, sustainability, and mobility.
4	Empirical study	This chapter includes the state of research, the applied quantitative approach, research results. State of research and research results are discussed critically to derive proposals for action and describe the research limitations.
5	Conclusion and outlook	Research results are presented, and the target achievement is referred to. Practical implications and proposals for action are described before implications for scientific research are concluded and an outlook to future research opportunities is provided.

Source: Own elaboration

2 Theoretical basics of sustainable Corporate Venture Capital (SCVC)

In the following, an overview of economic theories, concepts, and definitions are provided. These are related to CVC, knowledge creation, innovation, sustainability, and mobility.

2.1 Concept of Corporate Venture Capital (CVC)

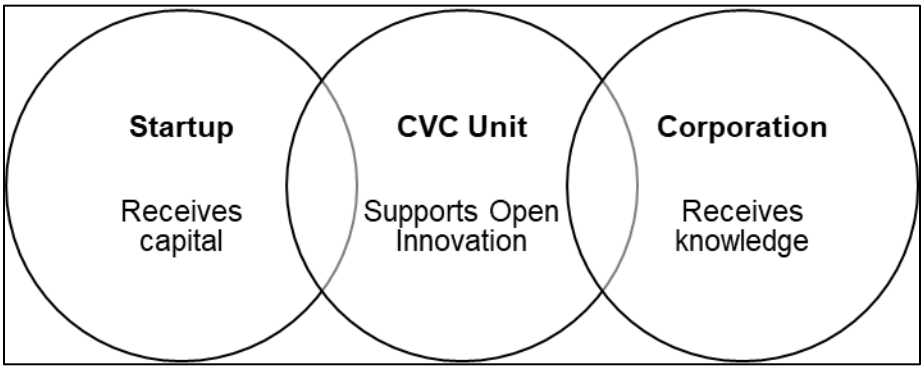
2.1.1 Corporate Venture Capital (CVC) description and objectives

2.1.1.1 Corporate Venture Capital (CVC) definition

CVC is a type of private equity and Venture Capital (VC). CVC investments are minority equity investments by established companies in entrepreneurial ventures. Established companies invest in startups to achieve financial and strategic objectives (Bendig et al., 2024; Bertoni et al., 2010; Dushnitsky & Lenox, 2005).

The investment organization presented in Figure 1 is a standard structure for CVC investments. An investee company collects capital provided by an established company. Established companies invest directly in startups or have dedicated legal CVC units to invest which link startups and corporate investors to support open innovation. CVC investors pursue financial and strategic objectives (Anokhin & Morgan, 2023).

Figure 1: Corporate Venture Capital (CVC) structure



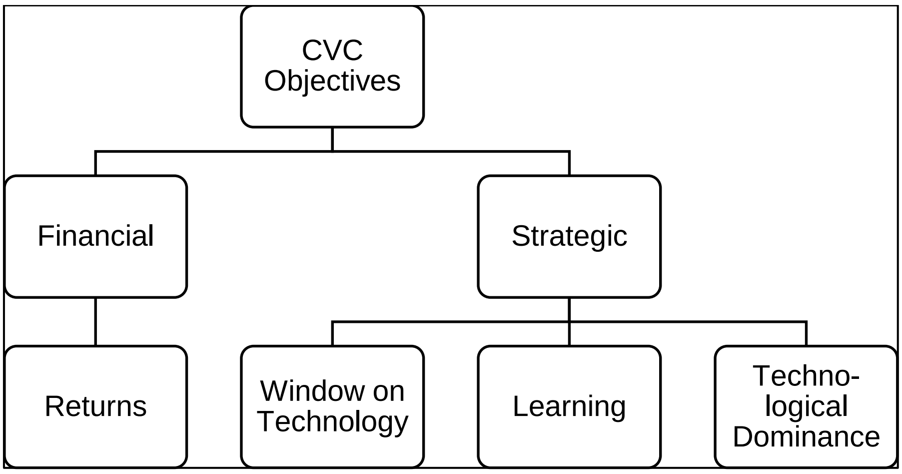
Source: Own elaboration

2.1.1.2 Strategic objectives

Two types of CVC objectives are differentiated in scientific literature. These are financial and strategic objectives complementing each other. Although the majority of investors pursue strategic as well as financial objectives, for certain CVC investors strategic objectives have higher priority (Chesbrough, 2002; Dushnitsky & Lenox, 2006; Ernst & Young, 2008; Kunz et al., 2017; Sahut et al., 2011; Weber, 2005).

As illustrated in Figure 2, the primary financial objective is the achievement of returns. Strategic objectives can be clustered into three categories. These are a window on technology, learning, and technological dominance. CVC investors' windows on technology can be subdivided into trend monitoring and acquisitions. By investing CVC, corporate investors generate knowledge about market mechanisms, enlarge Research and Development (R&D) competencies, and adapt the investee company's entrepreneurial spirit. System standards can lead to the achievement of technical predominant in sales- and supplier markets (Golla, 2010; S. Ma, 2020; Maula et al., 2005; Röper, 2004; Zu Knyphausen-Aufseß, 2005).

Figure 2: Corporate Venture Capital (CVC) objectives



Source: Own elaboration according to Golla (2010)

2.1.1.3 Financial objectives

Financial objectives are achieved through exits and long-term financial benefits from intangible resources. The basis for CVC financial calculations is the compensation of risk compared to expected returns. Exits can be third-party acquisitions, acquisitions by the parent, Initial Public Offerings (IPOs), sales of interest, or absolute write-offs. Strategic and financial objectives are complementary rather than substitutional. There is an indirect relation between strategic and financial objectives as strategic orientation enables long-term financial value creation (Drover et al., 2017; Ernst & Young, 2008; Kunz et al., 2017; Park & Steensma, 2012; Sahut et al., 2011; Weber, 2005).

CVC investments increase investors' market value under the condition that they are made for strategic reasons. CVC financial success depends on the organizational structure of the investing firm and the munificence of its environment (Bendig et al., 2024; Dushnitsky & Lenox, 2006; Titus & Anderson, 2018).

2.1.1.4 Ambidexterity, exploration, and exploitation

Strategic ambidexterity is defined to be the ability of a company to explore and exploit at the same time. Exploitation refers to strengthening and developing the core business whereas exploration is open to new products and business models. In the context of CVC, this approach is relevant because CVC units enable companies to apply ambidexterity. A standard approach is that they exploit with corporate activities such as R&D and explore by investing in startups (Anokhin & Morgan, 2023; Rossi et al., 2020, 2021; Weiss et al., 2023; Weiss & K. Kanbach, 2022).

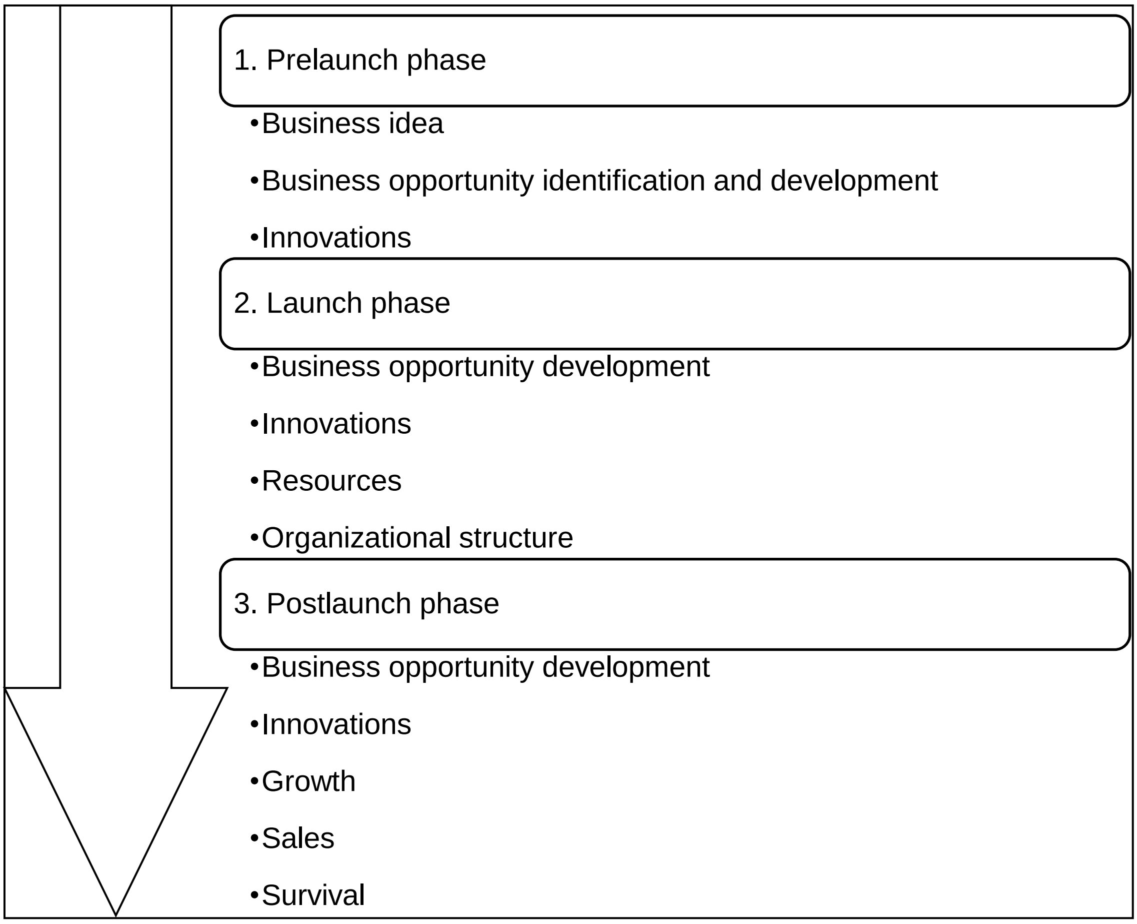
Goal ambidexterity refers to the objectives of a company. Companies can either pursue financial or strategic objectives, or both. Goal ambidexterity means commitment to pursuing both financial and strategic goals (Anokhin & Morgan, 2023; Vazquez & Rocha, 2018). More details about ambidexterity are provided in the analysis in chapter 3.1, the state of research in chapter 4.1.1, and the discussion in chapter 4.4.1, and chapter 4.4.3.

2.1.1.5 Entrepreneurship, Startups, and Venturing

Entrepreneurship refers to establishing a new company with an innovative business idea. Figure 3 presents the performance outcomes of entrepreneurial processes. These are separated by the three phases prelaunch, launch, and postlaunch. (Frese & Gielnik, 2023; Kollmann, 2006; Paul et al., 2023).

During the prelaunch phase, business ideas are developed, business opportunities identified and developed, and innovation outcomes are generated. In the launch phase, business opportunities are developed further, innovations, resources, and an organizational structure are established. After launching, business opportunities are still developed and a focus is on generating innovation, growth, sales, and surviving. During these phases, entrepreneurs set goals, seek information, plan actions, execute and monitor feedback again and again. During the phases named, entrepreneurs can benefit from CVC investors' resources, knowledge, and feedback (Bendig et al., 2024; Frese & Gielnik, 2023).

Figure 3: Performance outcomes of entrepreneurial processes



Source: Own elaboration according to Frese and Gielnik (2023)

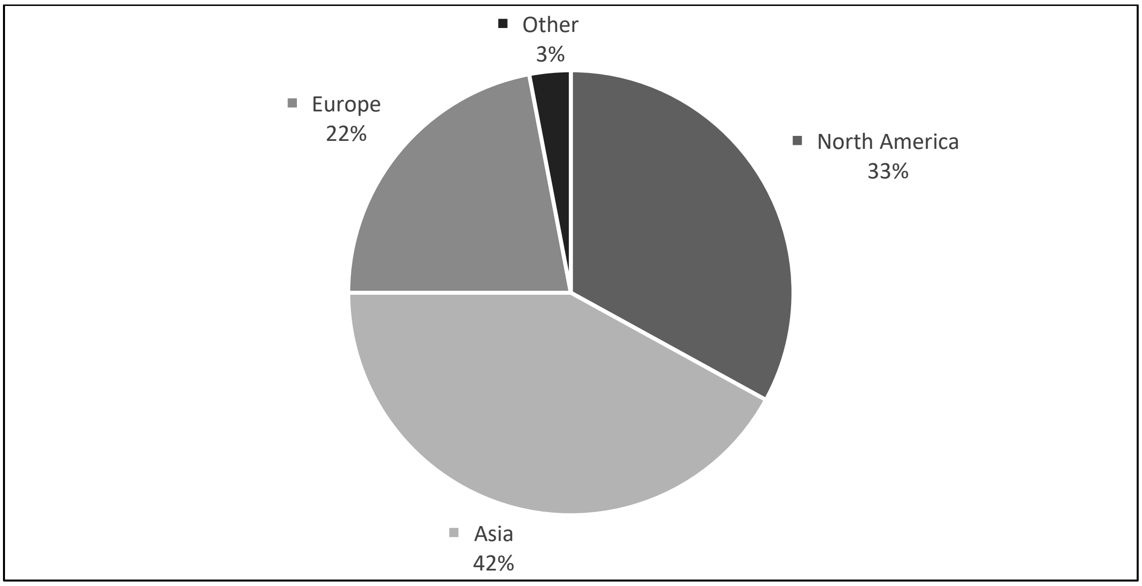
Entrepreneurship in the context of digital business and the net economy is referred to as Digital Entrepreneurship, techno-entrepreneurship, internet entrepreneurship and E-entrepreneurship. In case of E-entrepreneurship, electronic platforms in data networks are utilized to offer products and services based on electronic value creation (Kollmann, 2006; Kollmann et al., 2022; Paul et al., 2023).

2.1.2 Corporate Venture Capital (CVC) market and trends

2.1.2.1 Development of Corporate Venture Capital (CVC)

In 2023, about € 51.0 billion[3] were invested worldwide in 3,545 CVC deals. Figure 4 presents the CVC deal share by region in Q4 2023. The North American CVC-backed deal share made 33 percent from which 29 percent of the deals are made in the US and two percent each in Canada and Latin America. Asia's CVC deal share is 42 percent and Europe's deal share is 22 percent (CB Insights, 2024).

Figure 4: Corporate Venture Capital (CVC) deal share by region in Q4 2023



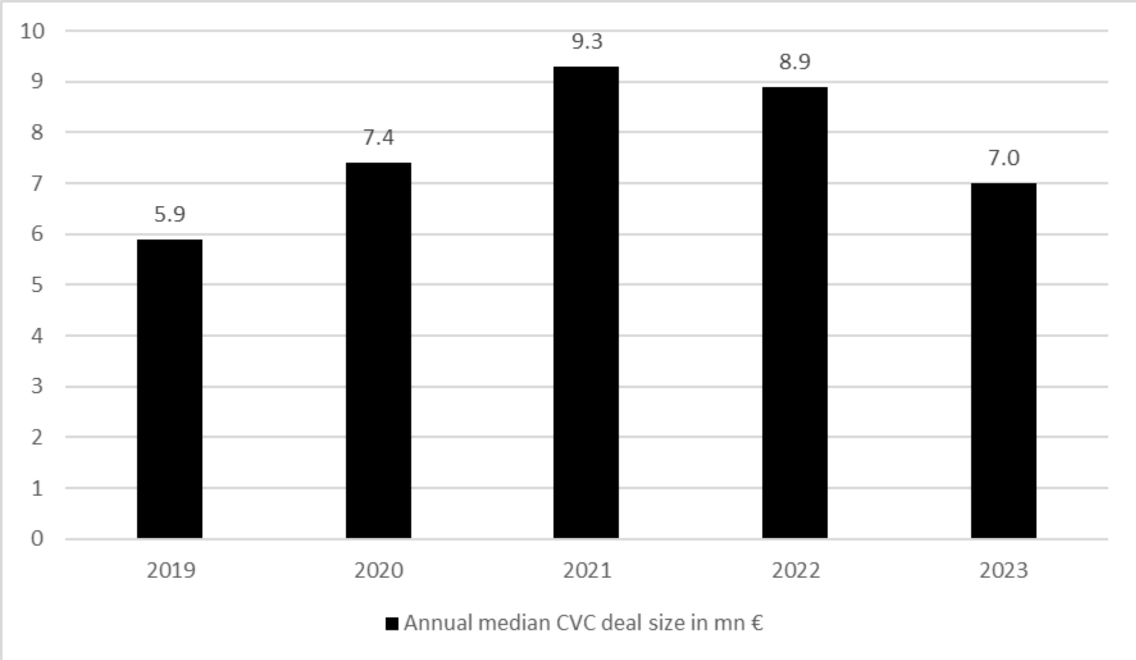
Source: Own elaboration according to CB Insights (2024)

Figure 5 presents the European annual median CVC deal size between 2019 and 2023. The median deal sized increases from € 5.9 million in 2019 to € 7.4 million in 2020 and reaches a maximum in 2021 with € 9.3 million. The median deal size decreases to € 8.9 in 2022 and 7.0 in 2023.[4]

[3] Calculated from USD with the exchange rate (USD 1 = EUR 0.9248) provided by the European Central Bank on average between 01/01/2023 and 31/12/2023 (European Central Bank, 2024).

[4] Calculated from USD with the average exchange rate (USD 1 = EUR 0.8933 in 2019; USD 1 = EUR 0.8755 in 2020; USD 1 = EUR 0.8455 in 2021; USD 1 = EUR 0.9497 in 2022; USD 1 = EUR 0.9248 in 2023) provided by the European Central Bank (European Central Bank, 2024).

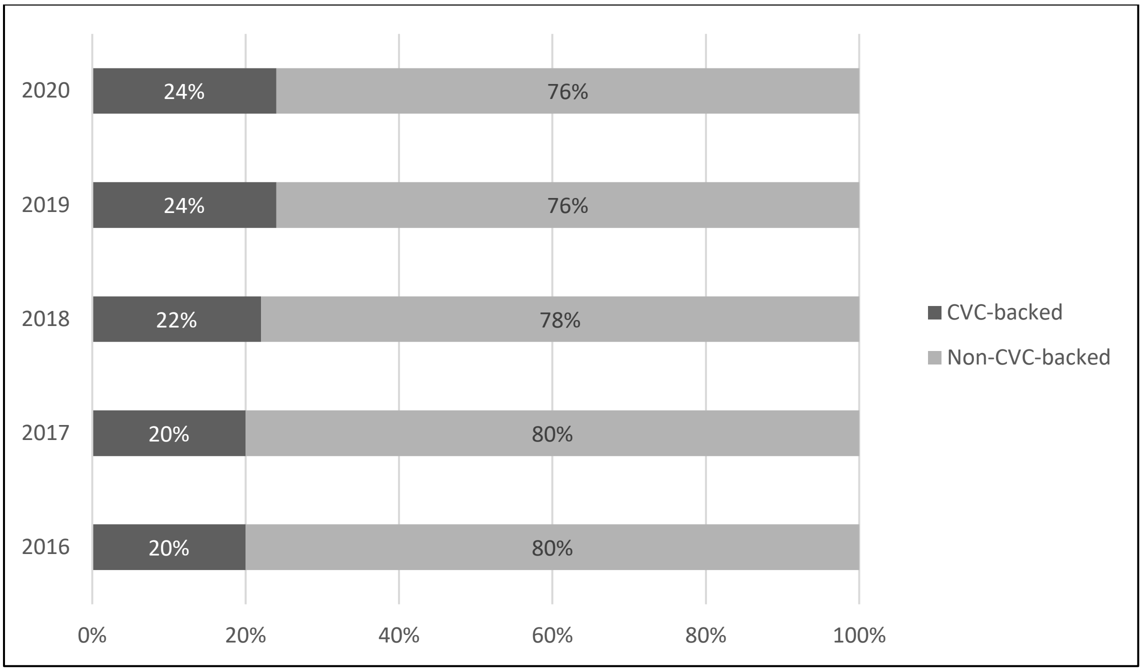
Figure 5: European annual median Corporate Venture Capital (CVC) deal size



Source: Own elaboration according to CB Insights (2024)

Figure 6 shows the development of CVC participation in VC-backed deals from 2016 to 2020. It is visible that there is an increase of 4 percent from 20 percent in 2016 and 2017 to 24 percent in 2020. About 33 percent of all CVC investments did not include another VC investor at all. Salesforce Ventures, Mitsubishi UFJ Capital, and Habo Investment participated in the most deals without an institutional VC investor in 2020 (CB Insights, 2021). Information about the CVC share in VC deals between 2021 and 2024 is not available.

Figure 6: Corporate Venture Capital (CVC) share in Venture Capital (VC) deals



Source: Own elaboration according to CB Insights (2021)

As presented in Table 2, the three most active European CVC investors in Q4 2023 according to investment count are Porsche Ventures, Innvierte, and Unilever Ventures. These are followed by Btomorrow Ventures, Robert Bosch Venture Capital, Shell Ventures, Swisscom Ventures, and TX Ventures. The investors made between three and seven investments in Q4 2023 and are based in Germany, Spain, the UK, Netherlands, and Switzerland (CB Insights, 2024).

Table 2: Q4 2023 top investors by investment count in Europe

Rank	Investor	Investment Count	Country
1	Porsche Ventures	7	Germany
2	Innvierte	4	Spain
2	Unilever Ventures	4	United Kingdom
3	Btomorrow Ventures	3	United Kingdom
3	Robert Bosch Venture Capital	3	Germany
3	Shell Ventures	3	Netherlands
3	Swisscom Ventures	3	Switzerland
3	TX Ventures	3	Switzerland

Source: Own elaboration according to CB Insights (2024)

2.1.2.2 Corporate Venture Capital (CVC) trends

75 percent of the Fortune 100 companies invest CVC, and more than half of the Fortune 100 companies have their own CVC business units to invest. New trends and different focus areas emerge depending on the investing industry. Artificial Intelligence (AI), cybersecurity, digital health, fast-moving consumer goods, Fintech, and advanced manufacturing are relevant trends (CB Insights, 2021, 2024).

Table 3 provides an overview of the top ten CVC deals in Europe in Q4 2023. Robert Bosch Venture Capital and Burda Principal Investments invested € 465 million in the German AI startup Aleph Alpha (CB Insights, 2024; Kamalloo et al., 2023).

This deal is followed by Prosperity7 Ventures' investment in the startup PragmatIC with € 192 million. This deal supports the UK semiconductors industry (CB Insights, 2024).

The third rank is made by MRL Ventures' investment in VectoryTx Therapeutics with € 128 million. With this investment, the biotechnology sector in the Netherlands is supported (CB Insights, 2024).

Rank four is made by a startup called Blockchain. This startup got €102 million from Google Ventures and Coinbase Ventures in Q4 2023 (CB Insights, 2024).

The investment by Google Ventures and Coinbase Ventures is followed by SBI Investment's CVC investment in Oxford Quantum Circuits with € 93 million. This investment supports the UK supercomputers industry (CB Insights, 2024).

Rank six and seven support the biotechnology sectors in Denmark and Switzerland. NMD Pharma received € 74 million from the Roche Venture Fund and Nouscom got € 67 million from M Ventures (CB Insights, 2024).

Further deals were made between Quantum Systems and Airbus Ventures in Germany with € 62 million funding and between biotechnology startup EyeBio and MRL Ventures in the UK with € 60 million. These are followed by Novartis Venture Funds investing in AstronauTx with € 57 million (CB Insights, 2024).[5]

[5] Calculated from USD with the average exchange rate (USD 1 = EUR 0.9301 in Q4 2023) provided by the European Central Bank (European Central Bank, 2024).

Table 3: Q4 2023 top ten CVC deals in Europe

	Company	Amount	CVC Investors	Country	Industry & Subindustry
1	Aleph Alpha	€ 465 mn	Robert Bosch Venture Capital, Burda Principal Investments	Germany	Internet Software and Services
2	PragmatIC	€ 192 mn	Prosperity7 Ventures	UK	Semiconductors
3	VectoryTx Therapeutics	€ 128 mn	MRL Ventures	Netherlands	Biotechnology
4	Blockchain	€ 102 mn	Google Ventures, Coinbase Ventures	UK	Blockchain
5	Oxford Quantum Circuits	€ 93 mn	SBI Investment	UK	Supercomputers
6	NMD Pharma	€ 74 mn	Roche Venture Fund	Denmark	Biotechnology
7	Nouscom	€ 67 mn	M Ventures	Switzerland	Biotechnology
8	Quantum Systems	€ 62 mn	Airbus Ventures	Germany	Aerospace & Defense
9	EyeBio	€ 60 mn	MRL Ventures	UK	Biotechnology
10	AstronauTx	€ 57 mn	Novartis Venture Funds	UK	Drug Development

Source: Own elaboration according to CB Insights (2024)

2.1.3 Knowledge transfer through Corporate Venture Capital (CVC)

To pursue innovation, companies can focus on internal R&D activities or source external knowledge. They need to develop knowledge and capabilities to compete in changing market environments. To source external knowledge, companies use mechanisms such as CVC, strategic alliances, joint ventures, licensing agreements, mergers and acquisitions, open innovation, and collective intelligence (S. M. Lee et al., 2015; March, 1991; Rossi et al., 2022).[6]

To operationalize innovation outcomes and knowledge transfer, patent rates are analyzed in CVC-related scientific literature. A U-shaped relationship between the number of CVC investments and investors' knowledge creation is present in the US (Bendig et al., 2024; Drover et al., 2017; S. M. Lee et al., 2015; Wadhwa & Kotha, 2006).[7]

The U-shaped relationship between the number of CVC investments and knowledge transfer depends on different factors. These are portfolio diversity, the degree of involvement, tie strength, and knowledge diversity (Bendig et al., 2024; S. M. Lee et al., 2015; Wadhwa et al., 2016).[8]

2.1.3.1 Patent structures to measure (green) knowledge transfer

Patent documents belonging to one invention are concluded on patent family level. Within a patent family, all patents are based on the same invention. Thus, the contents of these patents are close to each other and the technical content is considered to be identical (European Patent Office, 2017; Rieti Zhu et al., 2020).

The patent families used in this doctoral dissertation are defined by the European Patent Office (EPO). EPO patent families are based on the priorities claimed and the technical content (European Patent Office, 2017).

The right of priority is a right which is time limited. It is triggered by the first filing of a patent application. The applicant can claim the priority during the application process.

[6] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.
[7] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.
[8] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

After this first filing, the applicant can "claim priority" from the first application for subsequent applications on the same invention within a twelve-month period. In case that the priority claim is valid, the date of filing of the first application is the effective date of filing for the subsequent applications (European Patent Office, 2017). These priorities claimed dates are referred to in the methodology of this doctoral dissertation described in chapter 4.2.

Green patent classification refers to classification codes of the International Patent Classification Green Inventory. Patent families are assigned to these classification codes. Thus, patent families can be subdivided into green or non-green patents (World Intellectual Property Organization, 2023a).

2.1.3.2 Role of Corporate Venture Capital (CVC) for open innovation

New ventures tend to build their innovation activities based on existing technologies. However, the required resources and expertise for the commercialization is missing in a majority of new enterprises (Agarwal et al., 2004, 2007; J. Y. R. Kim et al., 2019; Klepper & Sleeper, 2005).[9]

CVC is integrated into the open innovation activities of corporate investors. It can be used by investors to open innovation activities from closed towards Outside-In innovation processes. It especially supports investors to identify destructive technological discontinuity. This means that the opening of the innovation process supports investors to prepare themselves for their digital transformation (Dushnitsky, 2012; Kunz et al., 2017; S. U. Lee & Kang, 2015). More details including advantages and disadvantages about open innovation in the context of knowledge creation are presented in chapter 2.2.[10]

[9] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

[10] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

2.1.3.3 Venture Client model

In case of applying the Venture Client model , startups are considered as suppliers rather than investee companies. Procurement departments of established corporations usually stick to standardized processes and supplier requirements. In certain cases, startups do not meet these requirements. In case of Venture Client, established corporations buy startup products and services if startups do not meet usual supplier requirements (Ladnar et al., 2023; Mais et al., 2023).

Venture Client enables companies to learn from startups even if they do not require investment. Furthermore, it can be considered as an alternative if CVCs decide not to invest in a certain startup but pursue open innovation (Ladnar et al., 2023; Mais et al., 2023).

2.2 Knowledge creation and sustainability theories

In the following, the Resource Based View (RBV) Theory is described. As the Knowledge Based View (KBV) is an integral part of the RBV, the KBV is explained as well. Furthermore, the concept of open innovation is described. As theories referring to sustainability, Shareholder Theory, Stakeholder Theory, and Institutional Theory are described.

Table 4 provides an overview of the concepts and theories described in this chapter. These are the main concepts and theories related to knowledge creation and sustainability which are relevant for this doctoral thesis.

Table 4: Knowledge creation and sustainability concepts and theories

Concept overview	**Concept description**
Resource Based View	Heterogeneity of resource availability to companies leads to different company performance.
Knowledge Based View	The transferability of knowledge within a company leads to a competitive advantage.
Inbound open innovation	External ideas are identified, selected, and utilized. These are included in business activities.
Outbound open innovation	Internally created knowledge is transferred outside the company.
Shareholder Theory	Companies' social responsibility is assumed to be the increase of profits.
Stakeholder Theory	It is assumed that companies do not only pursue profit maximization, but also moral responsibility.
Institutional Theory	The theory includes functional, but also symbolic drivers for founding and changing companies.

Source: Own elaboration

2.2.1 Resource Based View (RBV)

The RBV defines a heterogeneity of resource availability to companies leading to different company performance within the same industry over time (Barney, 1991; Branco & Rodrigues, 2006; Kraaijenbrink et al., 2010; Ogutu et al., 2023; Wernerfelt, 1984). Especially the resources characterized as valuable, rare, imperfectly imitable and non-substitutable (VRIN) enable competitive advantage generation if they are managed strategically well (Barney, 1991; Bates & Flynn, 1995; Battisti et al., 2022; Le, 2024). The resource categories are physical, organizational, human and knowledge (Pereira & Bamel, 2021; Priem & Butler, 2001). The transferability of knowledge within a company leads companies to a competitive advantage. This finding leads to the KBV (Grant, 1996; Le, 2024).

A critical RBV perspective is that resources, skills, and organizations are constantly changing. With the present assumptions, sustainability is not applicable to competitive advantage according to the RBV (Fiol, 1991, 2001). This critical perspective is resolved by the definition of dynamic capabilities. Distinctive resources can be used by companies for change and quick adaption to new competitive conditions (Santoro et al., 2020). Thus, dynamic capabilities enable a sustainable competitive advantage as companies evolve (Battisti et al., 2020; Teece, 2018).

To evolve and increase corporate performance, companies are required to innovate and acquire new internal and external skills and resources (Anning-Dorson, 2018; Ferraris et al., 2017). Internal and external innovations are created through continuous process development and strategic decision making to manage VRIN resources. These are relevant to avoid competitive advantage risks (Bates & Flynn, 1995; Le, 2024).

2.2.2 Knowledge Based View (KBV) and open innovation

2.2.2.1 Knowledge Based View (KBV)

Knowledge is referred to as a strategic corporate resource. Companies' innovation capability and competitive advantage are related to their management of knowledge capital (Grant, 1996; Le, 2024). A competitive advantage can be achieved by companies though leveraging unique knowledge and expertise (Ogutu et al., 2023).

Thought the emergence of the KBV, knowledge is considered as a relevant strategic resource for improving corporate capabilities. Furthermore, knowledge is relevant for developing products and services as an antecedent for competitive advantage creation (Anthony, 2021; Liu et al., 2023).

According to the KBV, a corporate knowledge base refers to the sum of all knowledge type elements. These relate to corporate departments and fields which reflect existing knowledge structures and corporate contents (Kogut & Zander, 1992; Liu et al., 2023; Sujatha, 2021).

The KBV also describes that organizational performance depends on intellectual property initiatives. These are, for example, administrative skills, research capabilities, excellence programs, quality assurance programs, and collaborations (Rehman et al., 2023; Zapp, 2022).

A model derived from the KBV is the "knowledge inputs" → "processors" → "knowledge outputs" (I → P → O) model. This model considers knowledge inputs from intellectual property initiatives like human, structural, and relational capital. Based on these knowledge inputs, processors are strategic innovation and process capabilities. Knowledge outputs from these processors are reflected in the performance of organizations. Intellectual capital initiatives, Open innovation, and thus CVC are considered as "knowledge inputs" (Bontis, 2000; Guerrero et al., 2021; Rehman et al., 2023).

As employees hold corporate knowledge, knowledge-based human resource management is a relevant field in the context of innovation capability (Le, 2024). The focus of this doctoral dissertation is on knowledge transfer though CVC as an open innovation tool. Thus, knowledge-based human resource management is not a focus of this dissertation.

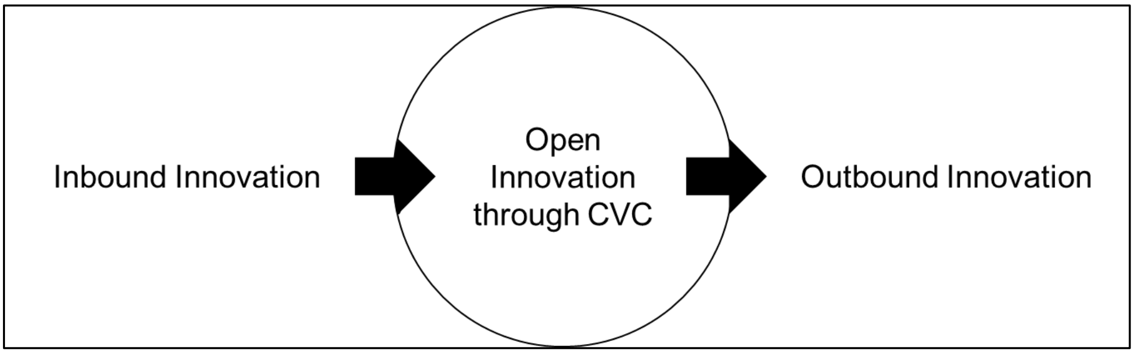
2.2.2.2 Open innovation

Two distinct kinds of processes to innovate are differentiated. These are open and closed innovation to pursue competitive advantage (Almirall & Casadesus-Masanell, 2010; Chesbrough & Bogers, 2014). In case of closed innovation, companies rely on internal skills and knowledge following own strategies in own research projects (Battisti et al., 2020).

As presented in Figure 7, two different types of open innovation are differentiated.

These are inbound and outbound open innovation. These types of open innovation are conducted simultaneously. Inbound open innovation includes external ideas which are identified, selected, and utilized. These are included in business activities. Outbound open innovation transfers internally created knowledge outside the company (Battisti et al., 2022; Brunswicker & Vanhaverbeke, 2015; Santoro et al., 2019). Open innovation can be achieved through acquisitions and CVC (Da Gbadji et al., 2015).

Figure 7: Inbound and outbound innovation



Source: Own elaboration

In the context of CVC, different types of collaboration between corporate CVC and open innovation units are differentiated. The first one is the application of Venture Client-based open innovation activities. In this case, a CVC team includes a dedicates, smaller team responsible for Venture Client. In such a case, a team can decide whether startup investments should be applied, or venturous purchasing of startups' products are applied. Thus, open innovation is achieved through buying startup products and using them for corporate innovation activities (Ladnar et al., 2023; Mais et al., 2023).

A second opportunity is to integrate CVC activities in decentral open innovation activities. In this case, one dedicated CVC team or unit reports to relevant business departments. These can be business lines with own innovation activities (Ladnar et al., 2023).

Third, central CVC units and central open innovation units can collaborate. For example, regular meetings can enable that knowledge generated through CVC is transferred to the core organization through the open innovation unit (Ladnar et al., 2023).

A fourth integration possibility is that a CVC unit includes a dedicated team which is responsible for open innovation. In this case, the open innovation team uses knowledge and transfers it to the core organization or directly applies the generated knowledge to innovate. The CVC and open innovation activities should be aligned according to corporate organizational structures (Ladnar et al., 2023).

Open innovation advantages and disadvantages are discussed in scientific literature. Knowledge creation is an advantage which is relevant for this dissertation. A disadvantage is that open innovation has limits. Failures, risks, and costs are three categories which are considered by companies about open innovation (Dabić et al., 2023).

2.2.3 Environmental, Social, Governance (ESG)-related theories

Environmental, Social, Governance (ESG) research is based on two theories (T. T. Li et al., 2021). These are Stakeholder Theory developed from the Shareholder Theory (Flammer & Kacperczyk, 2019; Kölbel et al., 2017; Muller & Kräussl, 2011; Surroca et al., 2010) and Institutional Theory (Chatterji & Toffel, 2010; Flammer et al., 2019; Jayachandran et al., 2013; Koh et al., 2014).[11]

2.2.3.1 Shareholder Theory

The Shareholder Theory assumes companies' social responsibility to be the increase of profits (Friedman, 1970). This approach considers companies as responsible for materialistic wealth and the government for social wealth. Due to different stakeholders (investors, employees, suppliers, and customers), Corporate Social Responsibility (CSR) leads managers to face conflicts of interests. The Shareholder Theory proposes that CSR leads to lower returns for stakeholders, higher salaries for employees and higher product prices. Due to this decrease in shareholder value caused by CSR, a manager does not fulfill the task of profit maximization in a role of an agent for shareholders (Goss & Roberts, 2011). It is concluded that the benefits of CSR according to the Shareholder Theory are employer branding or reasons for higher prices, so-called "window-dressing".

[11] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

2.2.3.2 Stakeholder Theory

Different from the Shareholder Theory, it is assumed in the Stakeholder Theory that companies do not only pursue profit maximization, but also moral responsibility (R. E. Freeman, 2010; R. E. Freeman et al., 1984). The stakeholder perspective assumes that companies have relationships with different economic actors and that these economic actors have their own interests (T. T. Li et al., 2021). In addition to investors, employees, suppliers, and customers, political groups, executives, trade associations and municipalities are considered as relevant in terms of ethic responsibility. Companies connect their objectives to the interests of these stakeholders for a maximization of shareholder value because shareholder needs are only satisfied if stakeholder needs are also satisfied (Damodaran, 2010; Hawkins, 2006).[12]

This positively effects employee satisfaction, companies' reputation, and market position. In the stakeholder theory, CSR activity and profit maximization can be pursued jointly. Pursuing economic, social and environmental objectives is concluded as "Triple Bottom Line" and understood as sustainable capitalism (Elkington, 1998, 2008).

2.2.3.3 Institutional Theory

The Institutional Theory is a relevant topic referred to in ESG research (T. T. Li et al., 2021). The theory includes drivers for founding and changing companies (Meyer & Rowan, 1977). Over the time, it was found that drivers were not only functional, but also symbolic and that external influence factors need to be considered (Hawn & Ioannou, 2016).[13]

Concepts of bounded rationality which are essential to Behavioral Theory are considered and it was found that change processes examined by Behavioral Theory are influenced by the institutional context (Wezel & Saka-Helmhout, 2006). The institutional theory provides institutional logics which are relevant for decision making and actions carried out (Fogarty & Dirsmith, 2001).

The Institutional Theory of CSR is a special part of the Institutional Theory which speci-

[12] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

[13] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

fies conditions under which a company is likely to behave in socially responsible ways. Such conditions are regulations and the existence of nongovernmental and other independent organizations which monitor corporate behavior (Campbell, 2007).

2.3 Definition of mobility and sustainability terms and ratings

2.3.1 Mobility definition and terms framework

2.3.1.1 Mobility terms

In the following, terms are defined which are utilized in this doctoral thesis referring to mobility and technologies relevant to the mobility sector. Due to the economic focus of this dissertation, the focus on technical term definitions is on their economic impact rather than on technical details.

2.3.1.2 Mobility

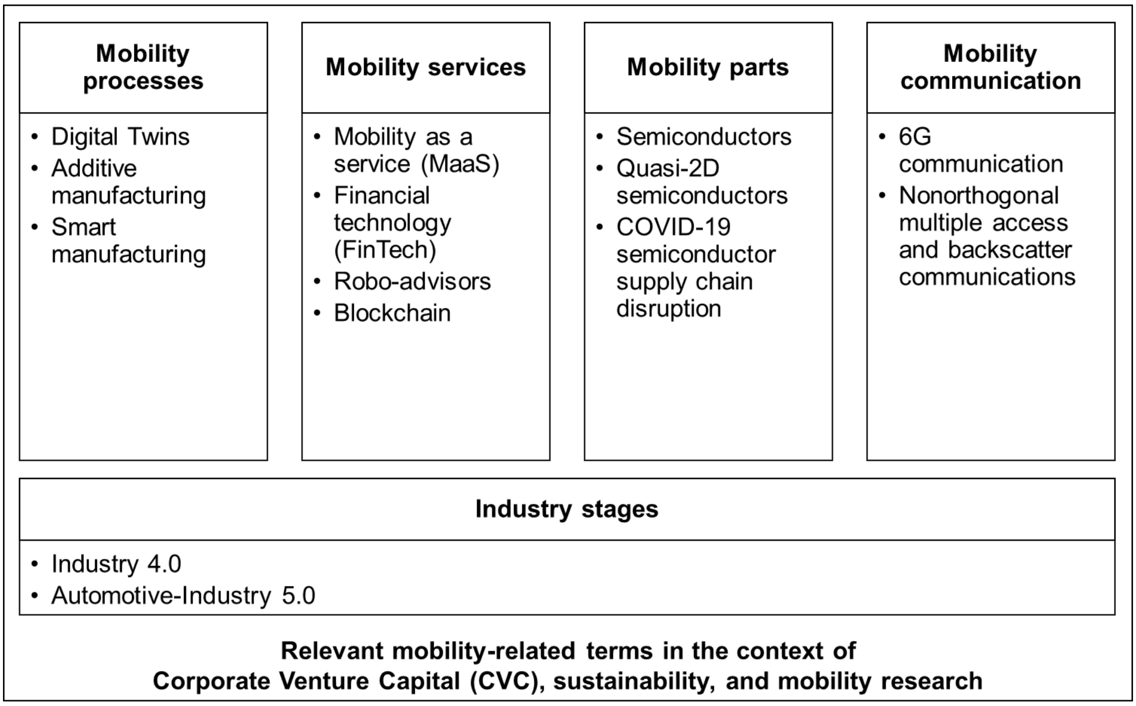
In this doctoral thesis, the term mobility refers to transportation, related technologies, production, and industries. Transportation types includes walking, cycling, public transit, and vehicles. Related technologies and production involve MaaS, semiconductors, and communication technologies. Digital Twins and additive manufacturing as described in the following refer to production of mobility components and parts (Muhammad et al., 2022; Shukla et al., 2018; Thomas-Seale et al., 2018).

Excluded from the definition of mobility in this dissertation are socioeconomic references such as labor mobility, social mobility, and the health care sector (J. Kim & Marschke, 2005; Pal et al., 2023).

2.3.1.3 Mobility-related terms framework

Figure 8 presents a framework for mobility terms used in this dissertation. These terms are used in the context of CVC and sustainability research and reflect mobility research focus areas. Process-related terms are Digital Twins, additive manufacturing, and smart manufacturing. Mobility service terms are MaaS, Financial technology (FinTech), Robo-advisors, and Blockchain. Mobility parts research is focused on semiconductors and Quasi-2D semiconductors due to COVID-19 semiconductor supply chain disruptions. Mobility communication terms are 6G communication and nonorthogonal multiple access and backscatter communications. Industry stages defined are Industry 4.0 and Automotive-Industry 5.0. These terms are defined and described in the following.

Figure 8: Mobility terms framework



Source: Own elaboration

2.3.2 Definition of mobility-related terms

2.3.2.1 Mobility processes: Digital Twins

Digital Twins are nonphysical models which pursue to reflect artificial or physical systems. Sensors are utilized to generate data analyzing the performance of the system. Based on these data, a digital copy is created and regularly updated. Digital Twins are used to for simulations (Mukherjee & DebRoy, 2019; Piromalis & Kantaros, 2022; Qi et al., 2018; Schleich et al., 2017; Stark et al., 2019).

Digital Twins can be beneficial for certain use cases but are not necessary for every physical product. They are useful if a certain complexity is present. Otherwise, financial, and other company resources needed for the implementation do not cover the value of Digital Twins. Once they are implemented and individual aspects of real-life objects are reflected, users can predict real-life objects in a greater degree applying changes to Digital Twins (Anshari et al., 2022; Botín-Sanabria et al., 2022; Martínez-Olvera, 2022; Piromalis & Kantaros, 2022; Qian et al., 2022).

Digital Twins are used in various industries since 2022. The demand for Digital Twins is expected to grow further (Piromalis & Kantaros, 2022).

2.3.2.2 Mobility processes: Additive manufacturing

The method Additive Manufacturing generated three-dimensional objects from digital models. These are created through layer-by-layer deposition guided by a computer (Frazier, 2014; Hegab et al., 2023; Raval et al., 2022).

The method is environmentally friendly because it uses just the quantity of material required for the product. Furthermore, Additive Manufacturing enables repairing and remanufacturing defective tools. Thus, it allows to eliminate supply chain processes involved with the production of new tools (Hegab et al., 2023; Morrow et al., 2007).

Additive manufacturing is applied by global vehicle suppliers such as GM, BMW, Ford, Daimler, and Volkswagen. They utilize additive manufacturing to produce vehicle components or parts (Muhammad et al., 2022; Shukla et al., 2018; Thomas-Seale et al., 2018).

2.3.2.3 Mobility processes: Smart manufacturing

Smart manufacturing refers to collecting and analyzing a large quantity of manufacturing data to find rules and knowledge. It is driven by new generation information technologies like the Internet of Things, big data, cloud computing, and AI (Qi et al., 2018; Qi & Tao, 2018).

Manufacturing is developing towards socialization and servitization. Services become increasingly important to manufacturing. This is referred to as service-oriented smart manufacturing (Qi et al., 2018; Tao & Qi, 2019).

2.3.2.4 Mobility services: Mobility as a service (MaaS)

MaaS is a system with a comprehensive range of mobility services offered to customers allowing efficient allocation of transport resources (Arias-Molinares & García-Palomares, 2020; Schikofsky et al., 2020). The platforms can be used to plan, book, and pay trips. New services are integrated with traditional transportation modes (Butler et al., 2021).

MaaS pursues environmentally friendly resource allocation. The services are associated with increased trip awareness and improved social equity, but reduced parking, vehicle ownership, and number of vehicle kilometers (Butler et al., 2021). MaaS frameworks include factors for success to be perceived usefulness, perceived ease to use, and emotional factors such as pleasure, fun, and enjoyment (Schikofsky et al., 2020; Y. Zhang & Kamargianni, 2023).[14]

Despite these advantages and antecedents, MaaS barriers are present. MaaS supply barriers are public and private cooperation, business support, service coverage, shared vision, data, and cyber security. One demand barrier is lacking acceptance of older generations, public transport users, and private vehicle users. Further demand barriers are present with the perceived attractiveness of the digital platform, and user willingness to pay (Butler et al., 2021).

Examples of MaaS platforms used in the EU are Whim, Moovit, and Uber (Arias-Molinares & García-Palomares, 2020; Hensher, 2017; Kakderi et al., 2021; W. Li et al., 2022). MaaS is also referred to as Transport as a service (TaaS) in scientific literature. Both terms can be used synonymously (Butler et al., 2021; Ho et al., 2018).[15]

[14] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

[15] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

2.3.2.5 Mobility services: Financial technology (FinTech)

FinTech adoption drives innovative financial services. These innovative financial services can be accessed through smartphones. Artificial intelligence and data are utilized to create financial services according to customer needs. Results are new business models, applications, processes, products, and services. These impact financial markets and organizations (Anshari et al., 2021, 2022; Schindler, 2017).

Solutions are applicable to information and communications technology. Examples are financial services in market infrastructure, payments, settlements, digital currencies, and data analytics. FinTech can be applied for MaaS, Digital Twins, and further mobility solutions (Anshari et al., 2022; Méndez-Suárez et al., 2020).

2.3.2.6 Mobility services: Robo-advisors

Robo-advisors majorly refer to the financial sector. In this context, robo-advisors are digital platforms that use AI to automatically generate and maintain users' portfolios (Abraham et al., 2019; Anshari et al., 2022).

In the context of mobility, smart manufacturing, and Digital Twins, robo-advisors are applied for manufacturing rather than portfolio creation and -optimization. Digital twin technology and robo-advisors can be combined to simulate real-world events virtually. Based on these simulations, proposals can be presented by robo-advisors (Anshari et al., 2022).

2.3.2.7 Mobility services: Blockchain

Blockchain refers to a database which is distributed in a decentralized network. Network participants possesses a copy of the database with transaction information. In doing so, they increase tamper security. In case that one database is hacked, there are a number of further databases communicating with each other to determine the legitimacy of a transaction (Friedhoff et al., 2023). Two use cases of Blockchain in the mobility sector are described in the following.

To recharge their batteries, electric vehicles use power grid energy or a battery exchange mechanism. The continuous power grid use causes a significant load on power grids. Thus, power grids are inadequate to fulfill the increasing future electric vehicle demands of electric vehicles. A solution to this is Blockchain Enabled Energy Trading. Blockchain Enabled Energy Trading outperforms compared to state-of-the-art frameworks to address the renewable energy demand problem to realize E-mobility (Bhawana et al., 2024).

Blockchain can provide citizens with a privacy preserved, transparent, and confidential architecture for mobility services. To improve interaction and communication between vehicles, tracking, and smart city traffic management, Blockchain based Internet of Vehicles architecture can be utilized (Paiva et al., 2021).

2.3.2.8 Mobility parts: Semiconductors

Semiconductors are small chips consisting of conductive materials like silicon. They control electronic devices' critical functions. They are, for example, used in computers and smartphones, and vehicles (Ochonogor et al., 2023).

Success in the semiconductor industry depends on the ability to create smaller, faster, and cheaper products. The advantage of small semiconductors is that more power can be placed on the same chip enabling faster processing. Quasi-2D semiconductors are one of the technologies to meet these requirements (Ochonogor et al., 2023; Zheng et al., 2023).

2.3.2.9 Mobility parts: Quasi-2D semiconductors

Silicon complementary metal-oxide-semiconductors face challenges at sub-10 nm nodes. These challenges are, for example, increased short-channel effects, reduced carrier mobility, and power consumption surge (A. Chen, 2022; Xiong et al., 2023).

The objective or electronics is to meet the needs of big data analytics, Internet of Things, intelligent terminals, ultra-large-scale computing, and health monitoring. Furthermore, it needs to serve efficient industrial production and daily life. Thus, the need of electronics to comprise more integrated, high-speed, and low-power field-effect transistors increases (A. Chen, 2022; Xiong et al., 2023).

Quasi-2D semiconductors are defined to have weakly bonded atomic thin layers. They have intrinsically low thermal conductivity resulting from the weak interactions between atomic thin layers (Zheng et al., 2023).

2.3.2.10 Mobility parts: COVID-19 semiconductor supply chain disruption

The COVID-19 pandemic caused supply chain disruptions (Ishak et al., 2023). COVID-19 lockdowns in the second quarter (Q2) of 2020 increased the demand for work-from-home technology exponentially. In parallel to this growing demand, automotive suppliers competed for the semiconductor capacity located in Asian countries (Ochonogor et al., 2023). As a result, almost a million fewer vehicles were produced and a € 93 billion[16] loss in income were recorded in 2021 (Ishak et al., 2023; Kidder Mathews, 2021).

At the same time, Taiwan drought in 2021 led to supply limitations as semiconductor manufacturing requires a lot of water. Furthermore, an electricity shutdown after a storm in Austin forced Samsung to shut down its semiconductor production for one month in February 2021. Apart from the increased demand, these occurrences limited supply and caused less semiconductor availability for automotive suppliers (Ochonogor et al., 2023).

Proposals for automotive suppliers to mitigate the risk of supply chain disruption are building production outside of Asia and re-think the just-in-time inventory model. Furthermore, collaborative planning across the stakeholders of a supply chain can lower risks (Ochonogor et al., 2023).

2.3.2.11 Mobility communication: 6G communication

6G communications refers to providing robust and high-speed communications. This is required to meet the needs of large data sharing between vehicle sensors and the cloud as required from the Automotive-Industry 5.0. Furthermore, 6G will support ener-

[16] Calculated from USD with the exchange rate (USD 1 = EUR 0.8455) provided by the European Central Bank on average between 01/01/2021 and 31/12/2021 (European Central Bank, 2024).

gy-efficient green communication (Gundall et al., 2021; W. U. Khan et al., 2022; Lucas-Estan et al., 2021; Sherazi et al., 2021).

Traditionally, one cycle of cellular generation (e.g., from 4G to 5G) takes around ten years until it is replaced by a new generation. 6G is expected to be standardized and ready for deployment by 2030. Scientific literature is already available on a shift toward 6G communication systems (Anandakumar & Arulmurugan, 2019; Malik et al., 2022; Piran & Suh, 2019)

2.3.2.12 Mobility communication: Backscatter communications

Nonorthogonal multiple access and backscatter communications are two techniques of 6G communication expected by 2030 as described above. They enhance spectrum and energy efficiency and support to realize green transportation objectives (W. U. Khan et al., 2022; Van Huynh et al., 2018; Wu et al., 2020).

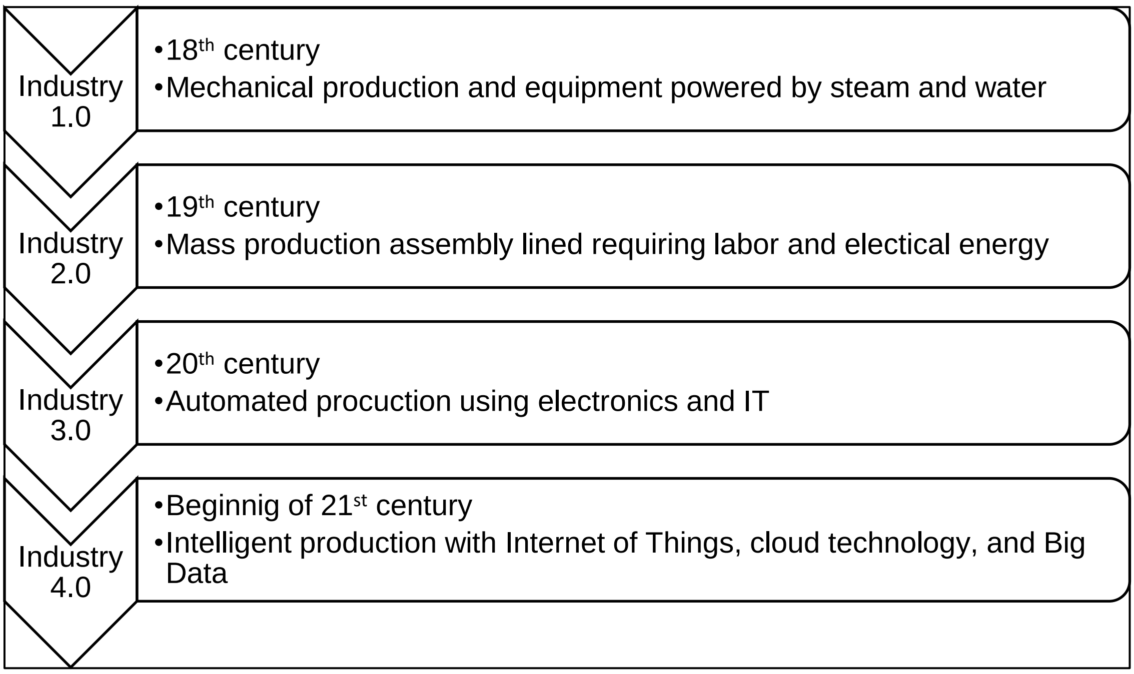
Backscatter communications allows smart devices to communicate by using ambient radio frequency signals without requiring active radio frequency transmission (Van Huynh et al., 2018). Nonorthogonal multiple access allows energy-efficient multitask multiaccess mobile edge computing (Wu et al., 2020).

2.3.2.13 Industry stages: Industry 4.0

The term Industry 4.0 was invented in 2011 referring to the fourth generation of industry and the computerization of the manufacturing industry (Aazam et al., 2018; Jazdi, 2014). Industry 4.0 combines technologies like the Internet of Things, Big Data, cyber-physical systems, and Digital Twins to integrate industrial value creation process chains (Martínez-Olvera, 2022; Müller et al., 2017).

Figure 9 presents the development from Industry 1.0 to Industry 4.0. Industry 1.0 refers to the 18th century when production was mechanical and equipment powered by steam and water. In the Industry 2.0, mass production assembly lined required labor and electrical energy. The Industry 2.0 is assigned to the 19th century whereas the Industry 3.0 refers to the 20th century. Industry 3.0 used electronics and Information Technology (IT) for automated production. Industry 4.0 refers to the beginning of the 21st century and means intelligent production with Internet of Things, cloud technology, and Big Data (Martínez-Olvera, 2022; Oztemel & Gursev, 2020).

Figure 9: Timeline from Industry 1.0 to Industry 4.0



Source: Own elaboration according to Oztemel and Gursev (2020)

2.3.2.14 Industry stages: Automotive-Industry 5.0

Automotive-Industry 5.0 refers to future development. The Automotive-Industry 5.0 is expected to improve the robustness of wireless connectivity and allow humans to share data with vehicles. Furthermore, the Automotive-Industry 5.0 is expected to develop reliable autonomous driving applications (W. U. Khan et al., 2021, 2022).

6G communications are forecasted to enable that vehicles' resources can be leveraged to construct Vehicular Cloudlet in the Automotive-Industry 5.0. Vehicles' resources include processing, storage, sensing, and communication units. Vehicular Cloudlet resources are a solution to meet computing requirements of vehicles as computing is becoming more important for connected and autonomous vehicles (Ahmed et al., 2023).

Another focus of the Automotive-Industry 5.0 is on sustainability. It will focus on preparing an ecosystem with minimum carbon dioxide emissions and green transportation (W. U. Khan et al., 2022).

2.3.3 Sustainability terms and frameworks

2.3.3.1 Corporate Social Responsibility (CSR)

Two components of CSR strategies are differentiated. These are the governance that distinguishes the strategies and investment results. CSR governance includes core strategies and control mechanisms. The according core strategies pursue stakeholder interaction. Control mechanisms are adopted for the integration of social and environmental activities and objectives as part of business operations (Z. Wang & Sarkis, 2017).

CSR results are either social or environmental. In the social dimension, CSR majorly results in employee rights, gender equality, and working conditions. In the environmental dimension, the main results are related to the supply chain and impact on the environment (e.g., CO_2 reduction and waste reduction) directly or indirectly (Battisti et al., 2022; Nirino et al., 2020).

Reasons for the CSR strategy implementation can be normative or business cases. In a normative case, external laws, or guidelines force companies to pursue CSR. This pressure leads to a strategic role of CSR for the company which avoids facing sanctions. This can be done by pollution reduction or other activities to stick to the certain laws and guidelines. The business case leads to adoption of CSR in corporate strategy in case that positive impacts on corporate performance are expected. Such impacts can be direct or indirect (Branco & Rodrigues, 2006).

Considering objectives apart from corporate benefit, CSR includes multiple dimensions like environmental protection, working conditions and stakeholder relationships (Battisti et al., 2022; Branco & Rodrigues, 2006). Although this multidisciplinarity is not focused on profits, there is an influence of CSR on corporate performance, value creation, risk and cost of capital (El Ghoul et al., 2011; Gillan et al., 2021; Nirino et al., 2020; Surroca et al., 2010). On the other hand, CSR is also influenced by financial performance, corporate strategy, management decision making and employee values (K. H. Kim et al., 2018; Renwick et al., 2013).[17]

Success is dependent on the level of CSR activity. This activity level can be influenced by executives' engagement and values in terms of environmental protection and employee rights. For example, if companies with CSR-focused managers pursue CSR, they tend to show fewer outbreaks of legal disputes. This leads to better corporate performance (Nirino et al., 2021; Surroca & Tribó, 2008).

Determination factors for corporate engagement in CSR are various. Corporate organization can, for example, include a Chief Sustainability Officer (CSO) and make sure that executives' objectives and CSR objectives match (Fu et al., 2020; F. Gao et al., 2014; Hubbard et al., 2017; Y. Kim et al., 2012). Moreover, CEO characteristics like arrogance or narcissism affect CSR activities (Petrenko et al., 2016; Tang et al., 2015, 2018). Ideologies which influence CSR engagement are politically orientated. CEOs with a liberal orientation tend to engage in CSR more than conservative ones (Chin et al., 2013; Gupta et al., 2017, 2019, 2021). Also, demographics and CEO experience influence corporate engagement in CSR (Bertrand et al., 2021; Han et al., 2019; Kang, 2016; Lai et al., 2020; Luo et al., 2021). Details are provided in chapter 4.1.[18]

CSR is based on the stakeholder theory and RBV (Branco & Rodrigues, 2006; Carroll, 2017; R. E. Freeman, 1994). Apart from a higher performance, CSR increases the reputation of a company among stakeholders (Nguyen & Adomako, 2021; Stickel, 1992).

As demonstrated, companies with high investments in CSR have a higher reputation among stakeholders and higher performance (Nguyen & Adomako, 2021; Stickel, 1992). It can be derived that less CSR activity or even ethical controversies decline the share price and shareholder value due to a declining reputation and negative prospects about future company performance (Nirino et al., 2021). In terms of reputation, especially an increase through CSR in consumer loyalty enables the positive influence of CSR on company performance (Bianchi et al., 2019).

[17] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.
[18] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

2.3.3.2 Environmental, Social, Governance (ESG) ratings

The ESG principle has been proposed in 2004 and developed since then (T. T. Li et al., 2021). ESG ratings influence portfolio construction and ratings based on the three ESG categories. To make decisions, a majority of organizations rely on external ESG rating agency data (Dimson et al., 2020).[19]

The largest three ESG rating providers are Morgan Stanley Capital International (MSCI), Sustainalytics, and Thomson Reuters Asset 4 (Serafeim & Yoon, 2022). But due to the ratings' multidimensional setup, different raters provide different rating results and there is low correlation between the rating results of different agencies (Chatterji et al., 2016; Dimson et al., 2020). The MSCI ESG ratings are considered the largest ESG data vendor in the investment sector (Christensen et al., 2022; Welch & Yoon, 2022). This rating ranges from 0 to 10. The ratings from Sustainalytics and Thomson Reuters Asset 4 range from 0 to 100 (Serafeim & Yoon, 2022).

2.3.3.3 Paris Agreement and European Union (EU) Taxonomy

In 2015, the Paris Agreement has been signed by 189 nations. As a turning point in recognizing global warming, it aimed "holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change" (Y. Gao et al., 2017; Joshi et al., 2011; UNFCC, 2015). Issues in this context were the channeling of flows towards green and climate-resilient economy with low CO_2 emissions and the according classification of organizations (Lucarelli et al., 2020).[20]

With the course of discussions about environmental issues, the European Commission prioritized this topic. To classify the extent to which a company is environmentally sustainable, the EU classification system naming EU Taxonomy has been presented in March 2020. This guidance is dedicated to financial market participants, financial investors, large companies, and national regulators (Lucarelli et al., 2020).

[19] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

[20] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

2.3.3.4 Sustainable Development Goals (SDGs)

Figure 10 shows an overview of the SDGs defined by the UN (United Nations Department of Global Communications, 2020). The mobility sector is related to good health and well-being, affordable and clean energy, decent work and economic growth, industry, innovation, and infrastructure and sustainable cities and communities and responsible consumption and production (Turoń & Kubik, 2021). It can be derived that the main types of transport associated with the SDGs are electromobility and alternative fuels (e.g., hydrogen fuels) as well as MaaS (Arias-Molinares & García-Palomares, 2020; Okraszewska et al., 2018; Schikofsky et al., 2020).

Further SDGs are the elimination of poverty and hunger, quality education and gender equality, clean water and sanitation, reduced inequalities, climate action, life below water and on land, peace, justice, and strong institutions, and partnerships for the goals also belong to these objectives. The objectives are part of the UN 2030 Agenda (Nilsson et al., 2016).

Figure 10: United Nations (UN) Sustainable Development Goals (SDGs)

Source: United Nations Department of Global Communications (2020)

3 Analysis of sustainable Corporate Venture Capital (SCVC)

In the following, the sustainability focus of CVC is analyzed based on existing scientific findings. After an overview of the mobility sector is provided, the sustainability progress in this sector is analyzed in detail.

3.1 Sustainability focus of Corporate Venture Capital (CVC)

As mentioned in chapter 1, CVC and sustainability are researched apart from each other in a majority of scientific research articles. There is less literature about the relationship of CVC and sustainability. Thus, a wider perspective is chosen in the following. First, sustainable business models are described in the context in an entrepreneurship context. Then, it is analyzed how startups consider ESG, what VC investment means for sustainability and how it supports sustainability. Then, existing findings about the relationship between CVC and sustainability are described.

3.1.1 Sustainable business models and Venture Capital (VC)

3.1.1.1 Sustainable business models

The number of publications on sustainable business models is increasing yearly and the business model is the basis for value creation of non-sustainable and sustainable businesses (Battisti et al., 2022; Chesbrough & Rosenbloom, 2002; Franceschelli et al., 2018). Conventional corporations are rethinking their own purpose and consider different solutions for the creation of sustainable innovation. Common and individual goals are adjusted, and sustainability is integrated on a network level. Apart from the collaboration with suppliers and customers, society and the natural environment are becoming an integral part of company networks. New economic, social, and environmental value forms are used to transform traditional business models into sustainable business models (Evans et al., 2017; Nosratabadi et al., 2019).

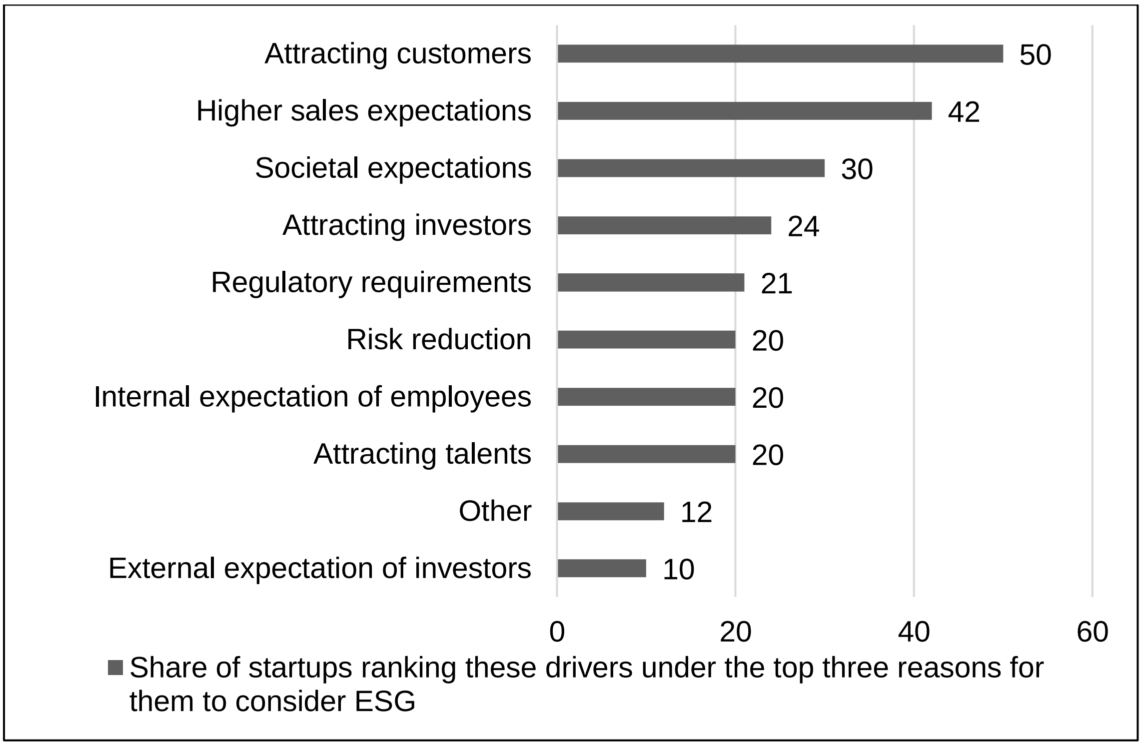
Based on new values, methods like design thinking can be used differently. Value ideation, value opportunity selection, and value proposition prototyping are methods including these values in a different way. These lead to sustainable innovations which can be used in the automotive industry (Geissdoerfer et al., 2016; Nosratabadi et al., 2019).

Employees in corporations notice that a traditional mindset does not lead to sustainable innovation. Managers work on a shift in the employees' mindset. Companies work on openness and sustainability. Such a shift can be enabled through collaboration with entrepreneurs who are focused on sustainability (Nosratabadi et al., 2019; Oskam et al., 2018).

3.1.1.2 Venture Capital (VC) enabling sustainable business development

An overview of startups' drivers for ESG consideration is provided in Figure 11. Main drivers are customer attraction (50 percent), higher sales expectations (42 percent), and societal expectations (30 percent). 24 percent of the startups try to attract investors with ESG consideration and 21 percent pursue to fulfil regulatory requirements. 20 percent of the startups consider ESG to reduce risk, fulfil expectations of employees or attract talents. Twelve percent of the startups are driven by other factors and ten percent pursue to fulfil external investor expectations (BCG, 2021).

Figure 11: Startups' drivers for sustainability attention in percent



Source: Own elaboration according to BCG (2021)

VC investments are applied to leverage startups' potentials to build sustainable business models (Maiti, 2022). To make sure that sustainable investments are carried out accordingly, sustainable VC funds use monitoring tools and sustainability data during the investment life cycle. For example, in the fund raising, investment, and exit phase, tracking of ESG criteria is relevant to ensure that startups keep sustainability promises (Lin, 2022).

In comparison to other investment types, VC shows a high benefit for sustainable investments due to its characteristics (Lin, 2021). Sustainable VC funds are provide technical knowledge, industry relationships and management skills which support sustainable startups apart from the monetary benefit (Lin, 2021). This supports sustainable startups to commercialize sustainable technologies and accelerate the availability of sustainable solutions on the market (N. M.P. Bocken, 2015).

3.1.2 Sustainability benefit and industry experience

3.1.2.1 Corporate Social Responsibility (CSR) benefit for investors

Reasons to focus on environmentally favorable actions are pursued competitiveness, legitimization, and ecological responsibility. Corresponding activities are required through regulations and stakeholders such as venture capitalists seeking for sustainable companies (Bansal & Roth, 2000; Bento et al., 2019; Döll et al., 2022; Paulraj, 2009).

As described in chapter 2.3, there is a relationship between CSR and financial performance of companies (Surroca et al., 2010; Waddock & Graves, 1997a). This relationship can be described as a virtuous cycle in which CSR leads to financial performance and positive financial results also enable CSR activities (Battisti et al., 2022; T. T. Li et al., 2021).[21]

To ESG objectives like pollution and waste reduction, innovation of products and services is necessary (McWilliams & Siegel, 2011). Thus, the innovation process of a company is of importance the virtuous cycle of CSR and performance (Surroca et al., 2010).

[21] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

This underlines the relevance of innovation management for CSR strategy success. As described in chapter 2.2, open innovation enhances corporate innovation processes (Chesbrough, 2003; Santoro et al., 2018). CVC activities pursue open innovation objectives following the corporate strategy (Da Gbadji et al., 2015).

Combining these relations, CVC can support innovation performance leading to an achievement of CSR activities under the condition that the innovations are CSR focused (Bos-Brouwers, 2010; J. J. Li et al., 2021; Wadhwa et al., 2016).[22]

Relating to the RBV, CVC can be used to build new VRIN resources which can influence CSR results positively. Furthermore, financial performance is enhanced (Battisti et al., 2022; Benson & Ziedonis, 2009). It can be concluded that R&D and CVC programs positively affect social and environmental CSR outcomes (Battisti et al., 2022; Branco & Rodrigues, 2006).

One example of green CVC focus is Cleantech. Cleantech refers to products, services or processes that work with nonrenewable resources adequately, or which generates less pollution than conventional solutions. The four main sectors are energy, transportation, water, and materials. CVC investment in Cleantech is increasing (Cumming et al., 2016; Dhayal et al., 2023; Döll et al., 2022).

3.1.2.2 Entrepreneurship based on corporate industry experience

A common path to entrepreneurship in high-technology industries involves prior employment in established companies. Three possible processes enable spawning. Spawning is a process of corporate employees founding startups in the same industry. In the context of mobility and sustainability, this means that employees of companies focused on mobility and sustainability fund with a similar focus (Balachandran, 2024; J. Freeman, 1986; Gompers et al., 2005).

The first process is that corporate employees obtain skills and knowledge through their work that they can employ in entrepreneurial ventures. In a second process, entrepreneurs benefit from a network to suppliers and potential customers accessed during the time as employees. The third possible process is that corporate employees found

[22] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

startups because bureaucratic companies fail supporting the development of entrepreneurial ideas internally (Balachandran, 2024; Gompers et al., 2005).

Successful entrepreneurial activities require abovementioned knowledge as well as product or service complementary assets. Such complementary assets can be physical like laboratories and factories. They can also include supplier, customer, and regulators relationships as well as intellectual property. Accessing complementary assets is a substantial barrier for entrepreneurs (Åstebro & Serrano, 2015; Balachandran, 2024).

Corporate experience is heterogeneous. This is because technical knowledge and complementary assets tend to be in different departments of corporations. Technical knowledge-holders tend to be in technology-focused departments like R&D, engineering, and product development. Complementary assets tend to be controlled by commercially oriented corporate departments. CVC can allow startups focused on mobility and sustainability to access complementary assets and knowledge from corporate investors. If knowledge from the startup to a corporate investor is also transferred is the subject of this doctoral dissertation (Almeida & Phene, 2004; Balachandran, 2024).

3.1.3 Corporate venture and sustainability department collaboration

Corporate venture building units are referred to as units creating and implementing new business models for parent companies. This can be achieved through incremental and radical innovations. CVC can belong to corporate venture building units apart from other venturing activities like corporate accelerators but does not necessarily need to. 90 percent of corporations belonging to Germany's primary stock index DAX have dedicated CV building units (Hill & Birkinshaw, 2014; Schönwälder & Weber, 2023).

Corporate venturing activities can contribute to a sustainability transition of companies. Furthermore, corporate venturing positive effects companies' environmental and financial performance (Dickel, 2018; Kuratko & Audretsch, 2013; Niemann et al., 2020; Schönwälder & Weber, 2023).

Despite the positive effects of corporate venturing, different organizational functions tend to be responsible for sustainability management and corporate venturing. This separation leads to a challenge of overcoming silo thinking and restrictive functional focus. To enable sustainable business model innovation, reduction or rather elimination of institutional, strategic, and operational barriers should be focused. Corresponding drivers should be enabled. As CVC is one kind of corporate venturing, these results can be applied to CVC as well (Nancy M.P. Bocken & Geradts, 2020; Schönwälder & Weber, 2023).

As presented in Figure 12, institutional barriers to sustainable business model innovation are a focus on maximizing shareholder value, uncertainty avoidance, and short-term focus. Strategic barriers are functional strategies, dominant focus on exploitation rather than exploration, and prioritizing short-term growth (Schönwälder & Weber, 2023).

Furthermore, six operational barriers are shown in Figure 12. These are functional excellence, standard innovation processes and procedure, fixed resource planning and allocation, short-term focused incentive systems, and financial performance metrics (Schönwälder & Weber, 2023).

Figure 12: Sustainable business model innovation barriers

Institutional barriers	**Strategic barriers**	**Operational barriers**
• Focus on maximizing shareholder value • Uncertainty avoidance • Short-terminism	• Functional strategies • Dominant focus on exploitation • Prioritizing short-term growth	• Functional excellence • Standard innovation processes and procedure • Fixed resource planning and allocation • Short-term focused incentive systems • Financial performance metrics

Source: Own elaboration according to Schönwälder and Weber, 2023

Figure 13 shows sustainable business model innovation drivers. Institutional drivers are balancing shareholder and stakeholder value, embracing ambidexterity, and valuing business sustainability (Schönwälder & Weber, 2023).

Strategic drivers are collaborative innovation, strategic focus on sustainable business model innovation, and patient investment. Operational drivers are employee capability development, enabling innovation structures, ring-fenced resources for sustainable business model innovation, sustainability-focused incentives, and performance metrics (Schönwälder & Weber, 2023).

Figure 13: Sustainable business model innovation drivers

Institutional drivers	Strategic drivers	Operational drivers
• Balancing shareholder and stakeholder value • Embracing ambidexterity • Valuing business sustainability	• Collaborative innovation • Strategic focus on sustainable business model innovation • Patient investments	• People capability development • Enabling innovation structure • Ring-fenced resources for sustainable business model innovation • Incentive scheme for sustainability • Performance metrics for sustainability

Source: Own elaboration according to Schönwälder and Weber, 2023

3.2 Mobility sector overview and requirements

3.2.1 Mobility market analysis

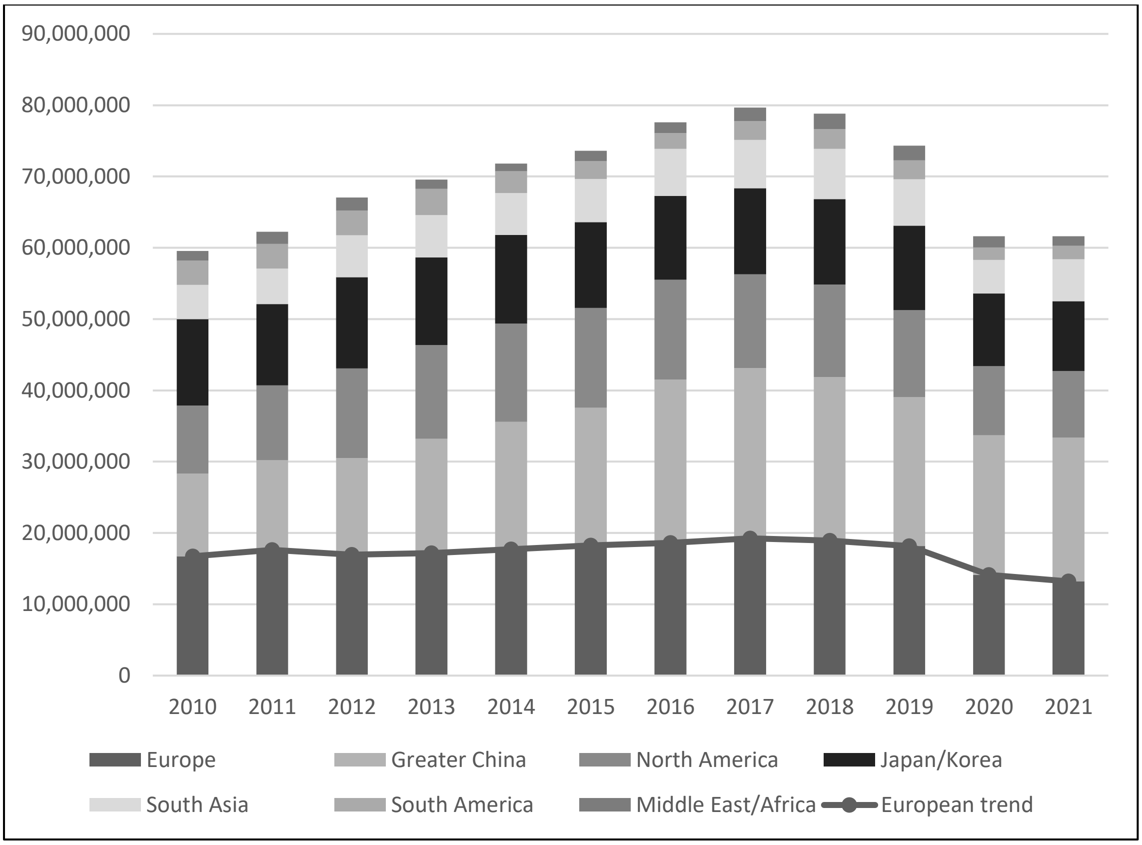
The automotive sector is a competitive sector (Saha et al., 2023). In 2021 in total 61.6 million motor vehicles were produced worldwide. With 13.2 million vehicles the EU represents 21.4 percent of the global vehicle production (IHS MARKIT, 2022).

In 2018, motor vehicles worth € 135.9 billion have been exported and € 62.0 billion imported to the EU making a trade surplus of € 73.9 billion. € 60.9 billion have been invested in automotive R&D leading to innovations described in the context of industry development and trend analysis (European Automobile Manufacturers Association, 2021).

The largest players in the world according to sales in decreasing order in 2019 were VW, Toyota, GM, Hyundai, Ford, Nissan, Honda, Fiat Chrysler Automobiles (FCA), Renault, Peugeot Société Anonyme (PSA), Suzuki, Mercedes, BMW, Geely, Mazda, Mitsubishi, Subaru, Land Rover, and Tesla. It should be considered that Tesla's sales increase is above average. Moreover, there are Mergers and Acquisitions (M&A) deals carried out in the market. One example is the merger of FCA and PSA in year 2021 (European Automobile Manufacturers Association, 2021; Welt, 2020).

As presented in Figure 14, there was a continuous increase of passenger car productions until 2017. Since then, there is a decrease in the production of passenger cars due to industry development, innovations, and crises. Europe produced 21.4 percent of the total number of passenger cars in 2021. Greater China produced another 32.7 percent, Japan and Korea 15.8 percent and North America 15.2 percent. Data from 2022 and 2023 on the produced number of passenger cars per region are not available (IHS MARKIT, 2022).

Figure 14: Produced number of passenger cars per region from 2010 to 2021



Source: Own elaboration according to IHS MARKIT (2022)

Table 5 presents the produced number of passenger cars per region from 2010 to 2021 which are visualized in in Figure 14. The cells marked in white highlight an increase in the region compared to the year before whereas the cells marked in grey highlight a decrease. The produced number of passenger cars decreased in all regions from 2018 to 2019 and 2020. The first regions which started to recover in 2021 are Greater China, South Asia, and South America (IHS MARKIT, 2022).

Table 5: Produced number of passenger cars per region from 2010 to 2021

	Europe	Greater China	North America	Japan/ Korea	South Asia	South America	Middle East/ Africa
2010	16,718,104	11,586,826	9,558,966	12,133,706	4,782,259	3,426,255	1,350,274
2011	17,618,332	12,572,692	10,531,003	11,380,033	4,968,479	3,494,140	1,689,683
2012	16,968,050	13,549,629	12,585,369	12,758,908	5,885,235	3,474,011	1,846,317
2013	17,184,351	16,025,351	13,148,467	12,286,663	5,925,831	3,693,446	1,323,619
2014	17,737,915	17,836,205	13,795,841	12,418,210	5,873,469	3,064,628	1,074,076
2015	18,247,739	19,293,128	14,026,737	12,039,022	6,059,283	2,506,119	1,450,429
2016	18,639,046	22,866,715	14,010,299	11,743,614	6,624,102	2,190,496	1,527,519
2017	19,251,247	23,892,910	13,127,949	12,071,065	6,811,426	2,643,692	1,849,965
2018	18,953,020	22,937,890	12,969,055	11,974,017	7,052,462	2,754,002	2,165,296
2019	18,178,517	20,882,569	12,173,713	11,881,898	6,478,410	2,666,766	2,065,538
2020	14,118,338	19,569,017	9,688,737	10,190,395	4,747,486	1,752,090	1,549,139
2021	13,212,441	20,177,202	9,349,683	9,767,638	5,865,794	1,901,197	1,358,616

Source: Own elaboration according to IHS MARKIT (2022)

Although Europe is not the region with most car productions, the largest amount of R&D investment is made in Europe in comparison to other regions resulting in most of the patents registered within Europe. In 2018, about € 60 billion have been invested in vehicles and parts in the EU. This is followed by Japan with about € 30 billion and the US with less than € 20 billion. From the patents registered from 2009 to 2018 related to self-driving vehicles, European registrations make 33.3 percent (European Automobile Manufacturers Association, 2021).

The automotive industry has a high significance of employment in the EU is reasonable considering the number of people working in the manufacturing of motor vehicles.

About 14 million people in the EU are employed in the automotive sector representing six percent of EU employment. Nevertheless, the downside of the car manufacturing and usage is an average new car emission is about 123g CO_2 per km (European Automobile Manufacturers Association, 2021; European Commission, 2024).

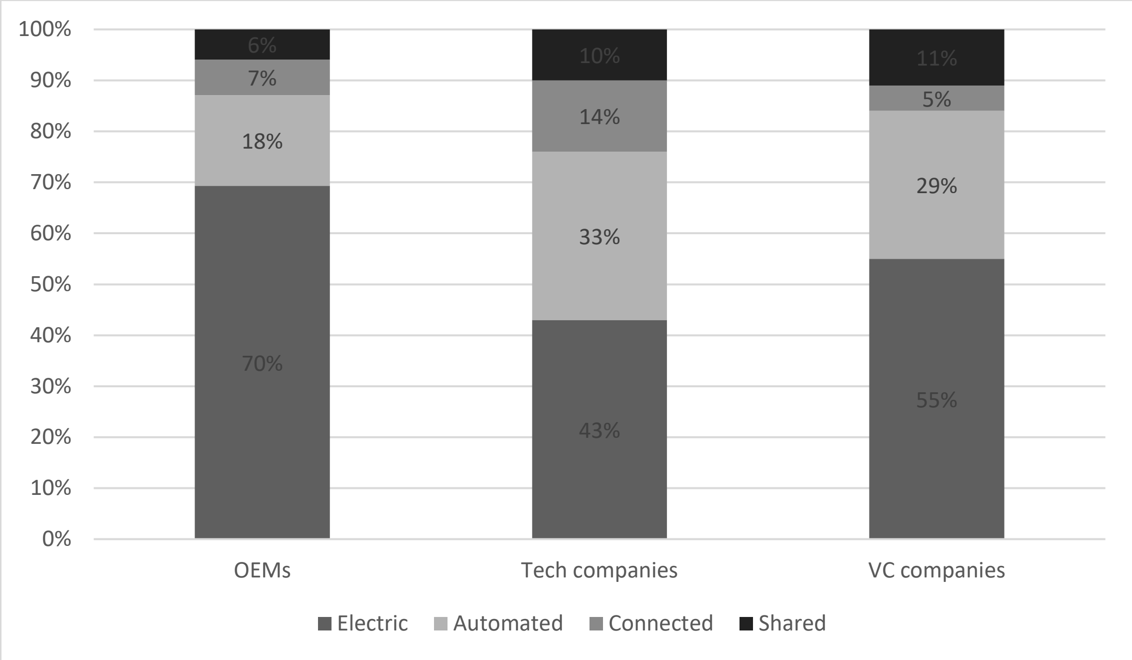
Figure 15 presents the investment allocation by focus and company type in 2022. Mobility focus areas electric, automated, connected, and shared. It is visible that Original Equipment Manufacturers (OEMs) focus on electric vehicles with 70 percent compared to 43 percent by tech companies and 55 percent by VC companies (Amico et al., 2023).

Tech and VC companies focus more on automated vehicles than OEMs. Investments are allocated with 33 percent of investments by tech companies, 29 percent by VC companies, and 18 percent by OEMs (Amico et al., 2023).

Connected vehicles receive the highest investment attention by tech companies with 14 percent investment. This is followed by OEMs with seven percent investment and VC companies with five percent investment (Amico et al., 2023).

VC companies are the only company type analyzed with more investment focus on shared than on connected vehicles with eleven percent investment allocation towards shared vehicles. They are followed by tech companies with ten percent and OEMs with six percent (Amico et al., 2023).

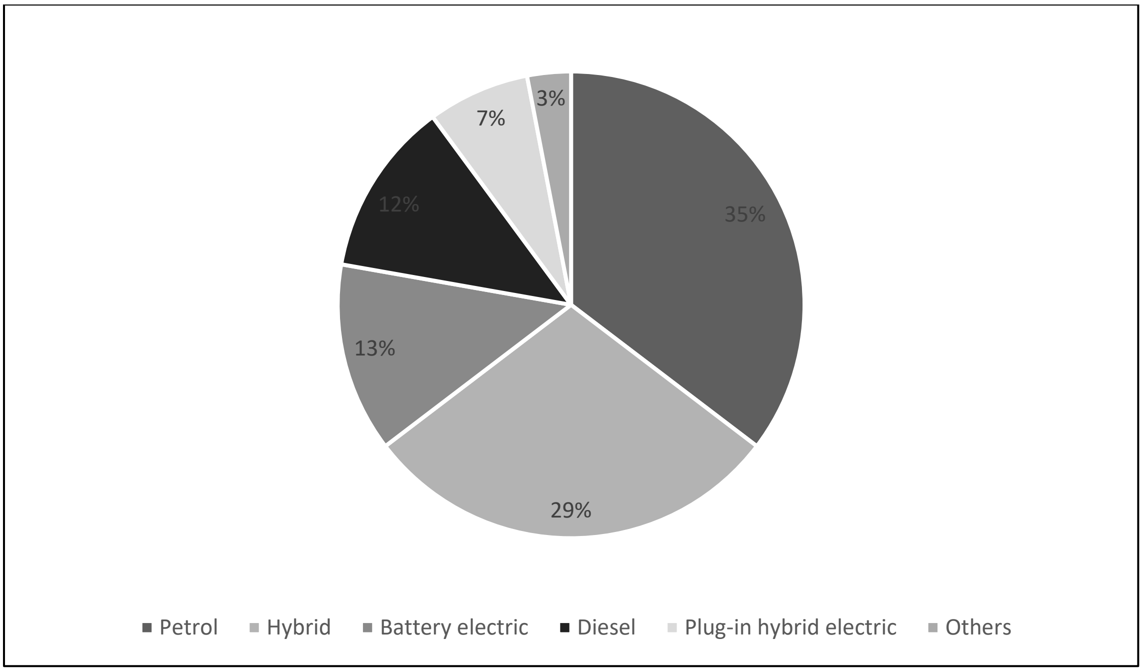
Figure 15: Investment allocation by focus and company type in 2022



Source: Own elaboration according to Amico et al. (2023)

Figure 16 presents new EU car registrations by power source in March 2024. In March 2024, 35 percent of the new car registrations had petrol power sources. 29 percent of the registrations were hybrid electric vehicles and 13 percent were battery electric. Diesel made twelve percent of the new registrations and plug-in hybrid electric cars another seven percent. Three percent were other power sources like gas (European Automobile Manufacturers' Association, 2024).

Figure 16: New European Union (EU) car registrations by power source



Source: Own elaboration according to European Automobile Manufacturers' Association (2024)

3.2.2 Industry development

During the last two decades, there has been a rapid change in the mobility sector's development. Factors forcing this transformation are the greenhouse effect, issues with public health, and implications on social equity. These factors make the current transport system unsustainable and require a shift in trends related to this topic. The main challenges can be concluded as mobility and traffic (jams), climate change and pollution, road safety, and urbanization (Banister, 2005; Boston Consulting Group, 2021; Chapman, 2007; Hrelja, 2011; Mackett & Thoreau, 2015; Pangbourne et al., 2020). Furthermore, the supply chain challenges described in chapter 2.3.2.10 influence the European mobility sector development.

From 2010 to 2019, the main investment activities aimed for e-hailing, semiconductors, autonomous vehicle (AV) sensors, and advanced driver-assistance system (ADAS) components. Moreover, investments in connectivity, infotainment, electric vehicles, charging, batteries, AV software, AV mapping, telematics, intelligent traffic, back end, cybersecurity, human-machine interface (HMI), and voice recognition have been carried out (Möller et al., 2019a).

In the industry 4.0, smart automation with machine-to-machine connectivity, intelligent computing, and big data analytics were of major relevance. The automotive industry 5.0 focuses on smart interaction between autonomous vehicles and humans. Main technologies in this context are 6G communication, AI, fog computing, and Blockchain (Aazam et al., 2018; Bhatia & Kumar, 2022; Friedhoff et al., 2023; W. U. Khan et al., 2022; Mahmud et al., 2021; Malik et al., 2022; Peres et al., 2020; Qu et al., 2021).

3.2.3 Mobility sector trend overview

Two trends which are discussed in the context of current and future mobility are Smart Mobility and MaaS. Especially in this context, Blockchain smart contracts technology is considered to solve issues of secure data transfer. The main transformation driver in mobility and transportation is carbon emission. It causes consumers to re-think their behavior. An emerging sharing economy is interested in new solutions. Examples of such sustainable solutions are car-pooling, electric vehicle usage, bikesharing, intelligent mobility, and eco-safe driving. These are presented in Figure 17 (Audouin & Finger, 2018; Davis, 2018; Docherty et al., 2018; Dowling, 2018; Hensher, 2017; Jittrapirom et al., 2017; Kamargianni et al., 2016; Karlsson et al., 2016; Y. Li & Voege, 2017; Mulley, 2017; Pangbourne et al., 2020; Rantasila, 2016; Smith et al., 2019).

Figure 17: Sustainable solutions for a sharing economy

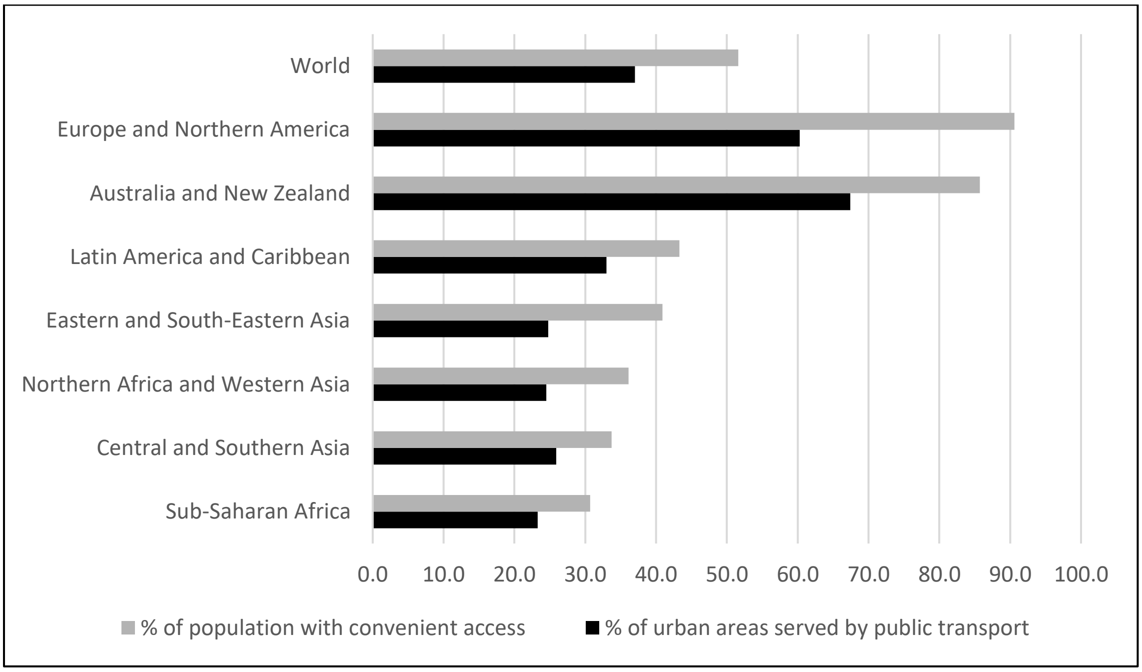
Sustainable solutions for a sharing economy	• Car-pooling • Electric vehicle usage • Bikesharing • Intelligent mobility • Eco-safe driving • …

Source: Own elaboration

A shift towards sustainability in the urban mobility can be recognized. Solutions tend to be app-based and are developed jointly by corporations and startups. The following table provides an overview of mobility companies and their CVC units. These CVC units invest in different startups offering sustainable solutions described above (J. Lee & Rakotonirainy, 2009; Y. Ma et al., 2018; Rakotonirainy, 2004).[23]

Figure 18 provides an overview of urban areas which are served by public transport and the share of population with convenient access to public transport. It is visible that compared to Africa and Asia, there is a higher share of both in Europe, Northern America, Australia and New Zealand (United Nations, 2022). This indicates a higher degree of mobility development and suggests a higher number of innovations in Europe which are analyzed in this doctoral dissertation.

Figure 18: Public transport accessibility in urban areas in 2020

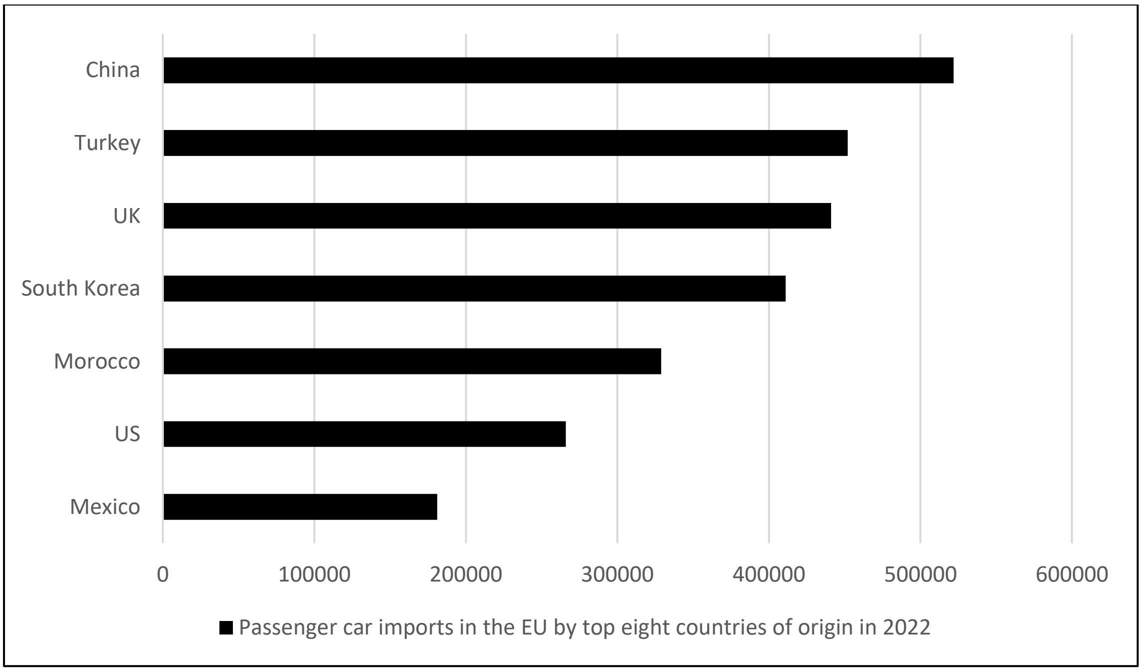


Source: Own elaboration according to United Nations (2022)

[23] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Figure 19 provides an overview of passenger car imports in the EU by top eight countries of origin in 2022. In this year, 35 percent of passenger cars sold in the EU were imported. The main EU import country is China. 522,000 passenger cars were imported to the EU in 2022 from China. China is followed by Turkey with 452,000 passenger cars. The UK imported 441,000 cars and South Korea 411,000 cars. Japan imported 391,000 passenger cars is 2022 and Morocco 329,000 ones. These countries are followed by the US with 266,000 and Mexico with 181,000 passenger cars. The consultancy PwC expects EU regulations to decrease import quotas. Expected regulations for this impact can be a Carbon Border Adjustment Mechanism, Digital Product Passports, and Data Privacy (Amico et al., 2023).

Figure 19: EU Passenger car imports by top eight countries of origin in 2022



Source: Own elaboration according to Amico et al. (2023)

3.3 Mobility sector sustainability progress

3.3.1 Sustainability focus areas of the mobility sector

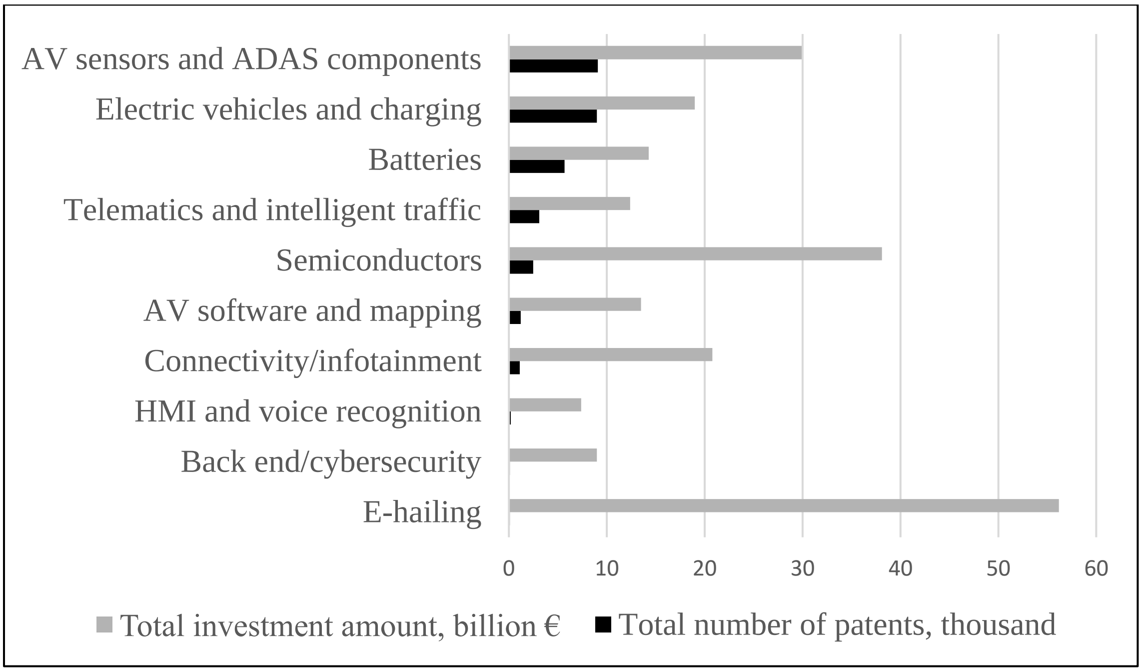
In the following, an overview of patents and investments in the mobility sector are described. After this, the concept of automation, connectivity and digitalization, electrification, and shared ownership (ACES) is concluded and the current state in the mobility sector is described. Moreover, mobility development due to the COVID-19 crisis is described.

As visualized in Figure 20, between 2010 and March 2019, 9100 patents are disclosed with a focus on autonomous vehicles (AV) sensors and advanced driver-assistance system (ADAS) (Hamid & Al-Turjman, 2021; Modi et al., 2018; Möller et al., 2019b; Suck et al., 2022). These are followed by 9000 patents with a focus on electric vehicles and charging and 5700 patents with battery focus. AV sensors and ADAS components are in the top three of patent disclosure and in the top three of investments carried out in the mobility sector. The highest investment amount is spent on E-hailing and semiconductors. During the presented time, 100 patents have been disclosed with a focus on E-hailing (Möller et al., 2019a).

Further focus categories visible in Figure 20 are telematics and intelligent traffic, AV software and papping, connectivity/infotainment, HMI, and back end/cybersecurity. These categories can be used to classify the mobility sector. Numbers after 2019 are not available (Möller et al., 2019a).

The difference between investment amount and patent disclosure shows that these topics cannot be considered separately to define current trends. In the context of CVC, this means that investment amount and patent creation should be compared and not considered separately as well. This emphasizes the applied method of this paper as the relation between CVC investment and sustainable patent creation in the mobility sector is analyzed.

Figure 20: Global mobility investments and patents between 2010 and March 2019



Source: Own elaboration according to Möller et al. (2019b)

Another classification of mobility development is presented with ACES vehicles (Adler et al., 2019; Hamid & Al-Turjman, 2021; Modi et al., 2018; Suck et al., 2022). These topics are considered with a special focus because they are expected to lead to disruptions in the mobility sector, especially as they are combined (Dijk et al., 2016; Pinkse et al., 2014). From 2040, it is expected that most vehicle will fulfil all four ACES criteria (Adler et al., 2019; Kaas, 2016; Leech et al., 2015; Ranft et al., 2016; Suck et al., 2022).

3.3.2 Autonomous driving

As presented in Table 6, autonomous driving is classified into six levels. These lead form no driving automation (level 0) to full driving automation (level 5) (Noble et al., 2021). In 2022, vehicles operate longer distances without the assistance of a driver classified as level 3 (Adler et al., 2019; Noble et al., 2021). The automotive industry works on introducing level 4 autonomous driving (Noble et al., 2021).

Table 6: Autonomous driving classification

Classification	Autonomous Driving Description
Level 0	A human driver should be present and should perform the Dynamic Driving Task (DDT) all the time.
Level 1	Constant presence of a driver is mandatory. Like Level 1, in case of any automated driving feature failure, the driver takes control of the vehicle to achieve the required DDT performance.
Level 2	A system is responsible for lateral and longitudinal vehicle motion in a limited Operational Design Domain (ODD).
Level 3	Resumption of human intervention could be requested by the system in case of an Automated Driving System (ADS) failure. The automated vehicle can perform DDT in a busy traffic zone but cannot perform the same procedure in case of an accident or crash site.
Level 4	The ADS is responsible for any lateral or longitudinal vehicle motion. ADS is responsible for sensing, monitoring, and responding to events. ADS is responsible for achieving minimal risk condition in the response of any vehicle failure or approaching an ODD exit. However, ADS may request the passengers to intervene and perform the DDT.
Level 5	The scope of ODD is unlimited. Meaning thereby, in any condition, the ADS is responsible for DDT performance and undertakes DDT fallout procedure if required.

Source: Own elaboration according to Khan et al. (2023)

3.3.3 Renewable energies and further sustainable mobility solutions

3.3.3.1 Electric vehicles and renewable energy usage in transport

A rapid increase of electric and hybrid vehicles can be observed in the mobility industry. After China, Europe is the second largest market for electric vehicles followed by the US. At the same time, the majority of battery providers is based in China (Adler et al., 2019; International Energy Agency, 2019).

The electrification of vehicles is in line with the Paris Climate Agreement (Adler et al., 2019). Due to reach sustainability objectives, certain countries like Spain provide incentives for the purchase of new cars (Kakderi et al., 2021).

To support reaching the UN global energy and climate objectives, the usage of renewable energy in the mobility sector is reviewed. From 2010 to 2019, the share of renewable energy increased from 2.6 percent to 3.6 percent. The UN describe the need of capital for further improvement of renewable energy usage (United Nations, 2022). Due to this recommendation, CVC can be an opportunity to reach UN SDGs.

3.3.3.2 Connected vehicles and shared transport

Connectivity and digitalization are necessary for efficient car- and ridesharing. Anyway, opinions differ on the question if vehicles should continuously be connected. Alphabet, the parent corporation of Google argues not to have a continuous internet connection due to security threats. On the other hand, automotive producers such as Audi and BMW plan to continuously connect cars to the internet (Adler et al., 2019; Condliffe, 2017). Connectivity is of special importance in order to communicate to use road space efficiently (Van Arem et al., 2006).

Shared ownership can be split into distinct categories. These are ridehailing, ridesharing, shared ownership and MaaS. Examples for ridehailing are Uber, Lyft, and FREE NOW. Ridesharing (e.g., with BlaBlaCar) includes carpooling. Examples for shared ownership are Car2go and Greenwheels (Adler et al., 2019).

An increase of shared transport is expected as autonomous driving develops further. With an increase of shared transport, private ownership will decline leading due to drivers' cost savings (Litman, 2020). It is expected that by 2030, every tenth vehicle sold is shared and used for some sort of carsharing (Kaas, 2016). By 2035, shared, autonomous transport is predicted to be accessible to 70 percent of the population living in urban centers (Adler et al., 2019; Johnson & Walker, 2016). MaaS in general is expected to account for 40 percent in 2035 and 80 percent between 2040 and 2050 (Schmidt et al., 2018). It should be considered that these predictions have been made before crises such as COVID-19, Ukraine war and energy crisis in Europe. Such crises impact the development of ACES (United Nations, 2023).

3.3.3.3 COVID-19 influence on mobility sector development

COVID-19 significantly affected transport during the crisis. Especially economics and the threat for virus infections are considered as drivers for this development. Moreover, restrictions influenced the development of new mobility innovations. Due to such regulations, companies applied new logistics services, for example new mobility solutions. Especially carsharing and ridesharing services adopted their services. In bikesharing, the fewest number of innovations is present (Turoń & Kubik, 2021). The influence of COVID-19 on lifestyle, daily routines, and population freedom accelerated the smart city paradigm through smart growth and sustainable mobility. Although emerging strategies in terms of smart growth and sustainable mobility were majorly meant to be temporary, they are transformational (Kakderi et al., 2021).

Another significant effect of COVID-19 is the rise of individual mobility such as walking or cycling (Benhard, 2020; Cosnard, 2020; Kakderi et al., 2021; Reid, 2020; Vandy, 2020). Furthermore, lightweight vehicles such as e-scooters, e-bikes and mopeds have emerged. Such sustainable transportation modes complement existing networks of transport and ensure physical distancing (Benita, 2021; Bruzzone et al., 2020; Bui et al., 2020; Choi, 2020).

COVID-19 also effected supply chains and the availability of components which were necessary for the production. Consequences were for instance the shortage of semiconductor chips with a remarkable effect on the automotive sector (Bader et al., 2022). Europe's manufacturing capacity in 2020 was nine percent of the global capacity. China (24 percent), Taiwan (21 percent), and South Korea (19 percent) had the highest shares. It is expected that until 2030, Europe's share decreases to eight percent and

China’s share increases to 24 percent (Varas et al., 2020). This dependency led to delivery shortages in 2020 so that car producers lost billions of dollars in earnings during this year (Marinova & Bitri, 2021). From a European perspective, the chip crisis indicates the relevance of economic independence to keep local business operating.

From an economic business perspective, higher-technology manufacturing recovered faster from the pandemic than lower-technology industries. Although motor vehicle and other transport equipment manufacturing are considered lower-technology industries, they are an exception. Due to worldwide disruptions of resources and intermediate goods, supply chains in motor vehicle and other transport equipment manufacturing faced larger challenges and did not return back to pre-pandemic production levels as fast as other higher-technology industries (United Nations, 2022).

3.3.3.4 Role of sustainable cities in future mobility

Urban areas contribute to 80 percent of the global GDP, but also lead to more than 70 percent of the global greenhouse gas emissions. This displays the meaning of urban development to reduce greenhouse gas emissions (United Nations, 2022).

On the other hand, rapid and poor urbanization planning lead to challenges. In this context, especially public transport planning is substantial to reduce air pollution, greenhouse gas emissions, as well as climate and disaster risks. Apart from direct transportation planning, the availability of services is relevant to decrease citizens’ needs to move far for reaching services. This is because less distance reduces the total need of energy for mobility (United Nations, 2022).

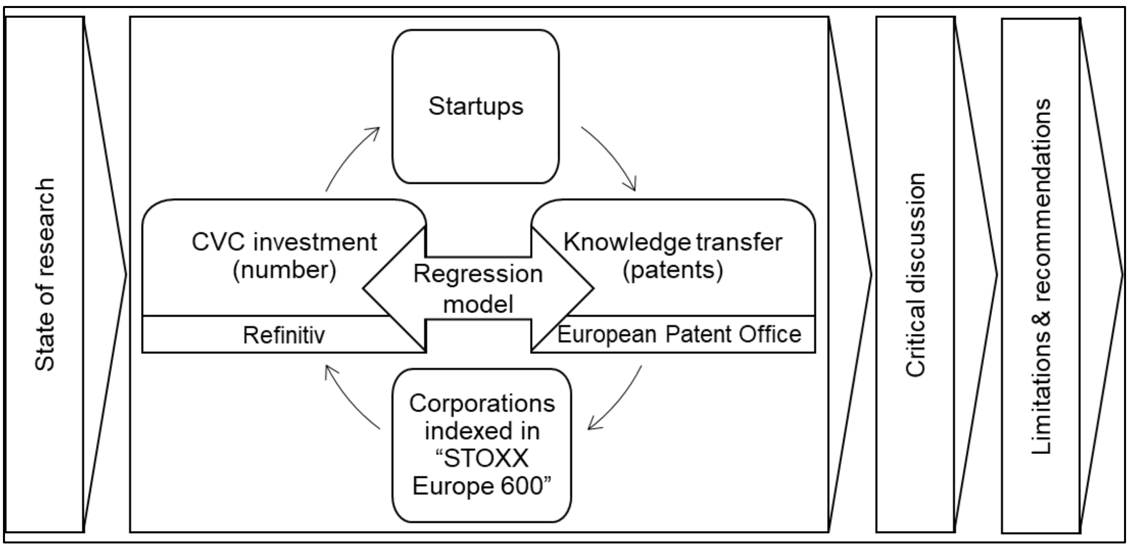
4 Empirical study of sustainable Corporate Venture Capital (SCVC)

Figure 21 presents the research design of the present doctoral dissertation. The state of research and results of the methodology build the basis for the critical discussion. Proposals for action are derived from the critical discussion under consideration of the research limitations.

The empirical methodology of this doctoral dissertation is specified in chapter 4.2. A negative binomial Poisson regression model is applied to analyze the influence of CVC investments on knowledge transfer. Knowledge transfer is operationalized as the number of patents registered by CVC investors which are related to the investee companies.

As this dissertation analyzes the relationship in Europe, STOXX Europe 600 companies which invest CVC are used for the sample. Different models are specified according to cross-sectorial investor and mobility sector investors as well as general and green knowledge transfer. Furthermore, the models are differentiated by joint knowledge creation and knowledge transfer from the startup to the investor. An overview of the models is provided in Table 47 in chapter 4.2.3.

Figure 21: Research design



Source: Own elaboration

4.1 State of research

The state of research includes main sustainability, CVC, and mobility literature. In scientific literature, these topics partly overlap, but are majorly researched apart from each other. The subchapters of the state of research are structured by literature focus.

The methods and findings of authors who publish journal articles with this literature focus are described. Furthermore, a tabular overview of the journal articles is provided per literature focus category. The tables include author(s), year, title, journal, and research type per journal article.

4.1.1 Corporate Venture Capital (CVC) research

4.1.1.1 Corporate Venture Capital (CVC) antecedents research

Turetta and Junior (2022) apply a qualitative approach to identify reasons whether or not companies invest CVC. They observe risk aversion, anxiety for financial return and different vocabulary between startup and corporate to be barriers to an effective adhesion to CVC.

With their quantitative research, Sears et al. (2022) investigate startup concerns towards intellectual property misappropriation of CVC investors. They find credibility to be related to prior investment quantity and continuity. In case of higher investment quantity and continuity, the likelihood of CVC-startup investment relationship establishment is increased. This effect is enlarged in case that investor and startup are in the same industry. The reason for this is that startups fear investors that understand their intellectual property and have complementary capability of competitiveness.

Table 7 provides an overview of CVC antecedents-related research. The table includes the methods applied and results found by Turetta and Junior (2022) and Sears et al. (2022).

Table 7: Corporate Venture Capital (CVC) antecedents research

Author(s)	Year	Title	Journal	Research method
Turetta and Junior	2022	Corporate Venture Capital for establishing links between large and traditional industrial companies and startup firms: a regional innovation system survey	Brazilian Journal of Management & Innovation	Qualitative
Sears et al.	2022	Alleviating concerns of misappropriation in corporate venture capital: Creating credible commitments and calculative trust	Strategic Organization	Quantitative

Source: Own elaboration

4.1.1.2 Corporate Venture Capital (CVC) performance factors research

Fels et al. (2021) identify the factors directly related to the performance of CVC. They apply a literature review of 36 publications published between 1986 and 2018. Fels et al. (2021) identify portfolio composition, corporate knowledge, organizational relationship, and managerial influence and focus to be of major relevance.

Bugl et al. (2022) refer to hampered value creation due to different strategic agendas of corporate investors, startups, and corporate business units. They apply a qualitative research approach finding mission, backing, organization, financing, autonomy, involvement, resources, and attractiveness to influence value creation.

With a quantitative research approach, Anokhin et al. (2022) investigate CVC investors' ability to attract potential investments. They find reputation for experience, active involvement in the investee, and misconduct positively associated with the CVC ability to attract investments. In addition, they find that reputation for misconduct does not frighten startups if the investor has a reputation for experience. In case of the reputation for active involvement, they find misconducts to lead to a loss of investees.

Due to the number of journal articles about CVC performance influence factors, the literature overview is split to Table 8 and Table 9. An overview of the first three journal articles is provided in Table 8.

Table 8: Corporate Venture Capital (CVC) performance influence research: Part 1

Author(s)	Year	Title	Journal	Research method
Fels et al.	2021	Revealing the underlying drivers of CVC performance— a literature review and research agenda	Venture Capital	Literature review
Bugl et al.	2022	Leveraging smart capital through corporate venture capital: A typology of value creation for new venture firms	Journal of Business Venturing Insights	Qualitative
Anokhin et al.	2022	Is a reputation for misconduct harmful? Evidence from corporate venture capital	Journal of Business Research	Quantitative

Source: Own elaboration

With a systematic literature review, Jeon and Maula (2022) find three main conflicts in CVC. One of these is championing of CVC-based exploration versus core business-focused exploitation by multiple stakeholders. The second tension they find is that CVC programs simultaneously belong to the corporate parent versus the startup and VC ecosystem. The third tension is that startups and VCs view CVC programs as a threat rather than an opportunity.

Rossi et al. (2022) apply a quantitative approach. They investigate the contribution of CVC to regional and international innovation eco flows finding a positive correlation for the US, Asia, and Europe.

Based on systematic literature review of 190 articles Brinkmann and Kanbach (2022) identify 41 factors influencing VC performance. Their investigation is based on the fact that CVC has a shorter lifespan than institutional VC. Literature is clustered into the four dimensions “decisions about strategies”, “exploitation of venture capital resources and characteristics”, “active involvement in the venture capital environment”, and “limited underlying room for maneuvering”. They find a significant influence on CVC lifespan through investment objectives, organizational autonomy, structure, interorganizational relationships, commitment of corporate parent, and parent company size.

Wang et al. (2023) build a model for the relationships between heterogeneous VC investment, corporate reputation and technological innovation network evolution. Based on a survey of 500 companies, they find independent VC to be more favorable to enhancing the internal corporate reputation. Furthermore, they find independent VC to be more beneficial to promoting the evolution of technological innovation networks towards being self-centered. In contrast, CVC is more favorable to consolidating external reputation of companies and promoting the holistic evolution of technological innovation networks.

Bendig et al. (2024) find that CVC and alliance activity effect product safety. They describe an inverted U-shaped relationship between CVC and alliance activity and product recall likelihood based on quantitative panel research.

Table 9 provides an overview of the next five of eight journal articles about CVC performance influence factors. Literature includes articles with a mix of quantitative and qualitative research and literature reviews.

Table 9: Corporate Venture Capital (CVC) performance influence research: Part 2

Author(s)	Year	Title	Journal	Research method
Jeon and Maula	2022	Progress toward understanding tensions in corporate venture capital: A systematic review	Journal of Business Venturing	Literature review
Rossi et al.	2022	Corporate venture capitalists as entrepreneurial knowledge accelerators in global innovation ecosystems	Journal of Business Research	Quantitative
Brinkmann and Kanbach	2022	Lifespans of corporate and independent venture capitalists: a systematic review	Venture Capital	Literature review
Wang et al.	2023	Heterogeneous venture capital and technological innovation network evolution: Corporate reputation as mediating variable	Finance Research Letters	Quantitative
Bendig et al.	2023	Beneficial, harmful, or both? Effects of Corporate Venture Capital and alliance activity on product recalls	Entrepreneurship: Theory and Practice	Quantitative

Source: Own elaboration

4.1.1.3 Corporate Venture Capital (CVC) objectives research

Haslanger et al. (2022) investigate CVC investments' impact on strategic and financial outcomes. They find a positive impact of CVC on strategic outcomes of startups and investors. They do not find a significant relationship between CVC and financial outcomes.

Based on a literature review of 39 peer reviewed scientific articles, Pinkow and Iversen (2020) develop a framework about strategic CVC objectives. These strengthen the core business, leverage the ecosystem, and explore new markets and technologies. These strategic objectives enable ambidextrous organizations.

With quantitative research, Tawiah and O'Connor Keefe (2022) find that CVC investing companies hold less debt and more cash than non-VC investing companies. Furthermore, companies with growth or investment opportunities maintain financial flexibility.

Ladnar et al. (2023) apply a qualitative research approach to analyze impact of CVC on digital business transformation. They interview eleven experts to present three findings. The first one is that after CVC units collaborate with open innovation units, the CVC activities are integrated into the decentralized open innovation activities. A dedicated team in the CVC unit can be responsible for open innovation and Venture Client-based open innovation activities, thus achieving digital open innovation. The second finding is that CVC is used to pursue ambidexterity, digital exploration, and exploitation. The third finding is that CVC supports digital business transformation at organizational, social, and technical levels.

Table 10 presents an overview of the described journal articles. Four research articles include quantitative and qualitative research and literature reviews.

Table 10: Corporate Venture Capital (CVC) objectives research

Author(s)	Year	Title	Journal	Research method
Haslanger et al.	2022	The performance effects of corporate venture capital: a meta-analysis	Journal of Technology Transfer	Quantitative
Pinkow and Iversen	2020	Strategic objectives of corporate venture capital as a tool for open innovation	Journal of Open Innovation: Technology, Market, and Complexity	Literature review
Tawiah and O'Connor Keefe	2022	Financing a corporate venture capital program	Journal of Banking and Finance	Quantitative
Ladnar et al.	2023	Impact of Corporate Venture Capital on Digital Business Transformation: A Case Study in Germany	Journal of Intelligent Management Decision	Qualitative

Source: Own elaboration

4.1.1.4 Corporate Venture Capital (CVC) ambidexterity research

Rossi et al. (2020) develop a theoretical model for ambidexterity based on an analysis of the 15 most active CVCs and institutional VCs in 2019. An analysis of correlations between numbers of deals, prevailing entrepreneurial intensity, and potential ambidexterity is described. It leads to a model with three dimensions. These dimensions are the knowledge to explore, exploit, and cumulate.

Weiss and Kanbach (2022) apply a systematic literature review with a sample of 172 studies. They find four different types of corporate venturing setups based on organizational ambidexterity enabling abilities and approaches. These are differentiated by the ambidexterity on system, unit, or function level and dynamic capabilities in structures, processes, behavior, or routines.

With qualitative research of interlinked-ambidextrous units in 16 European companies, Weiss et al. (2023) create an exploratory model about strategic corporate venturing. This model consist of organizational antecedents for strategic corporate venturing, enablers, and mediators. Enablers are process activities, relational mechanisms, and dynamic capabilities. Ambidextrous orientation is found to be a mediator.

Anokhin and Morgan (2023) apply a quantitative research approach to investigate the role of CEOs for ambidexterity in CVC investment. They define CEO duality to refer to situations where the CEO simultaneously functions as the board chairperson. Anokhin and Morgan (2023) explore that CEO duality affects the adoption of goal ambidexterity. However, CEO tenure has a negative influence on the likelihood of goal ambidexterity adoption.

Table 11 shows an overview of the described journal articles. Four articles referring to CVC ambidexterity research include quantitative and qualitative research and literature reviews.

Table 11: Corporate Venture Capital (CVC) ambidexterity research

Author(s)	Year	Title	Journal	Research method
Rossi et al.	2020	Knowledge management behaviors in venture capital crossroads: a comparison between IVC and CVC ambidexterity	Journal of Knowledge Management	Quantitative
Weiss and Kanbach	2022	Toward an integrated framework of corporate venturing for organizational ambidexterity as a dynamic capability	Management Review Quarterly	Literature review
Weiss et al.	2023	Strategic corporate venturing in interlinked ambidextrous units: An exploratory model	European Management Journal	Qualitative
Anokhin and Morgan	2023	CEO duality and tenure, and the adoption of goal ambidexterity in corporate venture capital	Journal of Business Venturing Insights	Quantitative

Source: Own elaboration

4.1.1.5 Corporate Venture Capital (CVC) patent research

S. M. Lee et al. (2015) find a U-shaped relationship between CVC investments and knowledge transfer for the US information and communication technology industry. Furthermore, they find this relationship to be moderated by the level of knowledge diversification.[24]

Shuwaikh and Dubocage (2022) research the patent outcome of US biotechnology

[24] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

companies founded between 1998 and 2013 and financed by institutional VC or CVC. They find that CVC-backed companies have a higher innovation output than institutional VC-backed companies.

K. Lee et al. (2023) research the influence of CVC on startup innovation in Korea. Based on a quantitative patent research approach they observe that VC-backed firms are more innovative than non-VC-backed firms. This is explained by the ability of VC firms to reduce information asymmetry between startups and investors resulting from the following finding. VC funds managed by independent VCs significantly enhance investee innovation, but VC funds managed by governmental VCs do not significantly enhance investee innovation. The positive relation between independent VC and investee innovation increases with greater information asymmetry. This research show a positive relation between VC and startup innovation but is limited to be applied to CVC and corporate innovation.[25]

An overview of these journal articles is provided in Table 12. Three articles referring to CVC patent research include quantitative and qualitative scientific methods.

[25] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Table 12: Corporate Venture Capital (CVC) patent research

Author(s)	Year	Title	Journal	Research method
S. M. Lee et al.	2015	Inter-Organizational Knowledge Transfer through Corporate Venture Capital Investment	Management Decision	Quantitative
Shuwaikh and Dubocage	2022	Access to the Corporate Investors' Complementary Resources: A Leverage for Innovation in Biotech Venture Capital-Backed Companies	Technological Forecasting and Social Change	Quantitative
K. Lee et al.	2023	Does venture capital investment enhance corporate innovation? Evidence from Korea	Journal of Business Finance and Accounting	Quantitative

Source: Own elaboration

4.1.1.6 Corporate Venture Capital (CVC) sustainability research

Battisti et al. (2022) apply a quantitative research approach on 100 American and European Fortune Global 500 companies and their CSR. They find that CVC positively impacts investors' environmental and social performance.

Schönwalder and Weber (2023) apply a qualitative research approach to maturity levels of sustainable corporate entrepreneurship. They find that companies with dedicated units for entrepreneurship are more likely to have a stronger sustainable corporate entrepreneurship focus. Furthermore, they identify five maturity levels for sustainable corporate entrepreneurship. These are Non-Existent, Occasional, Expert, Collaboration, and Strategic Collaboration. As this research is applied in Germany, it suggests a relevance of sustainability in corporate entrepreneurship in Germany.

An overview of the abovementioned journal articles is provided in Table 13. Battisti et al. (2022) and Schönwalder and Weber (2023) thematize sustainability-related CVC.

Table 13: Corporate Venture Capital (CVC) sustainability research

Author(s)	Year	Title	Journal	Research method
Battisti et al.	2022	Corporate venture capital and CSR performance: An extended resource-based view's perspective	Journal of Business Research	Quantitative
Schönwalder and Weber	2023	Maturity levels of sustainable corporate entrepreneurship: The role of collaboration between a firm's corporate venture and corporate sustainability departments	Business Strategy and the Environment	Qualitative

Source: Own elaboration

4.1.2 Sustainability research

4.1.2.1 Environmental, Social, Governance (ESG) research

T. T. Li et al. (2021) provide a systematic ESG literature review based on statistical measures of importance, frequency, and research hotspot attention. They differentiate literature by the ESG database, theoretical basis of ESG, interaction between the three ESG dimensions and ESG impact on economic consequences (T. T. Li et al., 2021).[26]

[26] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

4.1.2.2 Environmental, Social, Governance (ESG) measurement

T. T. Li et al. (2021) find research on ESG measurement to increase. The majority of scientific literature is based on the Kinder, Lydenberg, and Domini (KLD) database and Thomson Reuters ASSET4 database. Other measurements related to ESG are used as well.[27]

S. Kim et al. (2021) introduced a method to identify the risk-management benefit of CSR. They find CSR to be associated with low implied volatility. Moreover, the CSR insurance benefit is larger for companies with high leverage, growth opportunities, or uncertainty. The CSR insurance benefit is lower for companies with high market value, good accounting, and financial performance. According to these factors, an evaluation of the risk-management benefit of CSR can be applied.[28]

Referring to CSR rating in general, Chatterji et al. (2016) suggest caution when relying on such ratings. They compare social ratings of six well-established raters which are used by companies to make strategic decisions and describe that companies implicitly assume that these ratings are valid. They find a lack of agreement across the ratings leading to a proposal for managers and researchers to exercise caution when interpreting results. Moreover, a proposal to raters is to regularly evaluate their ratings.

Table 14 summarizes these journal articles. ESG evaluation and measurement research is covered by quantitative and qualitative methods as well as literature research.

[27] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.
[28] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Table 14: Environmental, Social, Governance (ESG) evaluation and measurement

Author(s)	Year	Title	Journal	Research method
T. T. Li et al.	2021	ESG: Research progress and future prospects	Sustainability	Literature review
S. Kim et al.	2021	Risk management and corporate social responsibility	Strategic Management Journal	Quantitative
Chatterji et al.	2016	Do ratings of firms converge? Implications for managers, investors and strategy researchers	Strategic Management Journal	Quantitative

Source: Own elaboration

4.1.2.3 Literature based on Kinder, Lydenberg, and Domini (KLD)

Key facts on the KLD database in a scientific context are provided by T. T. Li et al. (2021). They describe that the KLD database was created in 1991 and tracked 3100 companies between 2003 and 2021. Thus, it covers more industries over a larger time frame than other databases with sustainability data, like Thomson Reuters ASSET4. Moreover, the KLD database uses a standardized form.[29]

It should be considered that the KLD data were acquired by Riskmetrics in 2009 and subsequently by Morgan Stanley Capital International (MSCI) in 2010. These acquisitions led to changes in CSR items but is still referred to as KLD (Gupta et al., 2019).

The KLD database has been used by many researchers to conduct CSR-related studies over the time (e. g., Godfrey et al., 2009; King & Lenox, 2002; Russo & Fouts, 1997; Shiu & Yang, 2017; Waddock & Graves, 1997b). These are related to ESG, CSR, companies' commitment to social good and insider trading, CSR performance,

[29] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

and the impact on financial performance (Deckop et al., 2006; F. Gao et al., 2014; Ioannou & Serafeim, 2015; Shiu & Yang, 2017).[30]

Shiu and Yang (2017) describe the advantages and disadvantages of the KLD database. They describe that the KLD 400 Social Index dataset has been used by several prior researchers. They add that KLD is an independent rating agency suggesting independent results. Moreover, all S&P 500 companies are rated on several attributes relevant to corporate social performance.

Moreover, an exhibit robust construct validity is found by Godfrey et al. (2009). Another advantage is the availability of the KLD database over a long time. During this time, it has permanently been developed from 33 items in the database before 2001 to 40 items in 2007.

As stated by Shiu and Yang (2017), the number of items can also be a disadvantage. This is because the rating might not be permanent over time. This leads to a score in different years which may represent different levels of CSR engagement. Thus, the score must be adjusted. Moreover, KLD item scores should not be combined because they are individually constructed, and some CSR key components are missing. In this context, Shiu and Yang (2017) refer to Entine (2003) and Mattingly and Berman (2006).

Referring to Johnson-Cramer (2004) and Mattingly and Berman (2006), Kacperczyk (2009) describe that the KLD's strengths and concerns lack convergent validity. According to Chatterji et al. (2016), the KLD index can be used for simple CSR assessment and as a comprehensive index for the assessment of the degree of CSR effort.

An overview of literature referring to evaluation and measurement based on the KLD score is provided in Table 15. It should be noted that this table includes primary literature and does not include secondary literature referred to above. Table 15 refers to four journal articles applying quantitative research with the KLD database and one literature review referring to this database.

[30] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Table 15: Kinder, Lydenberg, and Domini (KLD) database research

Author(s)	**Year**	**Title**	**Journal**	**Research method**
T. T. Li et al.	2021	ESG: Research progress and future prospects	Sustainability	Literature review
Shiu and Yang	2017	Does engagement in corporate social responsibility provide strategic insurance-like effects?	Strategic Management Journal	Quantitative
Godfrey et al.	2009	The relationship between corporate social responsibility and shareholder value: An empirical test of the risk management hypothesis	Strategic Management Journal	Quantitative
Kacperczyk	2009	With greater power comes greater responsibility? takeover protection and corporate attention to stakeholders	Strategic Management Journal	Quantitative
Chatterji et al.	2016	Do ratings of firms converge? Implications for managers, investors and strategy researchers	Strategic Management Journal	Quantitative

Source: Own elaboration

4.1.2.4 Evaluation and measurement based on Thomson Reuters ASSET4

Thomson Reuters ASSET4 is described by T. T. Li et al. (2021) referring to scientific ESG literature. Thomson Reuters ASSET4 is focused on offering objective, relevant, and systematic non-financial ESG information. It is also used as an investment analysis tool by professional investors. It includes CSR data from companies in the Russell 1000 index since 2002. Data sources include stock exchange literature, financial reports, sustainability reports, websites of non-governmental organizations and news. Based on objectives and public data, 900 evaluation criteria are collected. The quantification of qualitative aspects includes finance, corporate governance, environmental, and social criteria.[31]

Following Chatterji et al. (2009), Ioannou and Serafeim (2012), and Cheng et al. (2014), S. Kim et al. (2021) use the three ESG pillars from the Thomson Reuters ASSET4 database. On average, these pillars are considered as the general ESG index. Cheng et al. (2014) and Surroca et al. (2020) equally weight the three ESG dimension scores to conduct their studies. The Thomson Reuters ASSET4 database also enables to choose only certain of these dimensions. This is applied by Lys et al. (2015) through a study which only includes the environmental and social dimension scores and by S. Kim et al. (2021) referring only to the social dimension score of the Thomson Reuters ASSET4 database.[32]

Table 16 summarizes these journal articles referring to Thomson Reuters ASSET4. It refers to six journal articles applying quantitative research with the Thomson Reuters ASSET4 database and one literature review referring to this database.

[31] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.
[32] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Table 16: Thomson Reuters ASSET4 database research

Author(s)	**Year**	**Title**	**Journal**	**Research method**
T. T. Li et al.	2021	ESG: Research progress and future prospects	Sustainability	Literature review
Chatterji et al.	2009	How Well Do Social Ratings Actually Measure Corporate Social Responsibility?	Journal of Economics & Management Strategy	Quantitative
Ioannou and Serafeim	2012	What drives corporate social performance the role of nation-level institutions	Journal of International Business Studies	Quantitative
Cheng et al.	2014	Corporate social responsibility and access to finance	Strategic Management Journal	Quantitative
S. Kim et al.	2021	Risk management and corporate social responsibility	Strategic Management Journal	Quantitative
Surroca et al.	2020	Is managerial entrenchment always bad and corporate social responsibility always good? A cross-national examination of their combined influence on shareholder value	Strategic Management Journal	Quantitative
Lys et al.	2015	Signaling through corporate accountability reporting	Journal of Accounting and Economics	Quantitative

Source: Own elaboration

4.1.2.5 Environmental, Social, Governance (ESG) theories

In the context of theoretical ESG basics, two main theories are focused on. These are the institutional theory and the stakeholder theory.

4.1.2.6 Sustainability research related to the institutional theory

Jayachandran et al. (2013) analyze the impact of corporate social performance on company performance. They describe that the information on corporate social performance provided to stakeholders varies. Jayachandran et al. (2013) find that product social performance has a stronger positive impact on corporate performance than environmental social performance.

From a risk management perspective, Koh et al. (2014) underline the positive impact of social performance enhancing company value. Creating a new CSR contracting database, Flammer et al. (2019) find that integrating CSR into executive contracting increases long-term orientation, company value, social and environmental initiatives, green innovation and reduces emissions. Referring to the institutional theory, a positive influence of ESG focus in management on company performance can be derived.

Table 17 provides an overview of these journal articles. It includes three journal articles applying quantitative research with a focus on ESG and the institutional theory.

Table 17: Environmental, Social, Governance (ESG) institutional theory research

Author(s)	Year	Title	Journal	Research method
Jayachandran et al.	2013	Product and environmental social performance: Varying effect on firm performance	Strategic Management Journal	Quantitative
Koh et al.	2014	Firm litigation risk and the insurance value of corporate social performance	Strategic Management Journal	Quantitative
Flammer et al.	2019	Corporate governance and the rise of integrating corporate social responsibility criteria in executive compensation: Effectiveness and implications for firm outcomes	Strategic Management Journal	Quantitative

Source: Own elaboration

4.1.2.7 Sustainability research related to the stakeholder theory

Gathering implications for the stakeholder theory, Kölbel et al. (2017) find a relation between corporate social irresponsibility and financial risk based on an analysis of 539 companies during five years. They recommend balancing CSR programs with operational safety programs.

Surroca et al. (2010) find that there is no direct relationship between financial performance and corporate responsibility. Rather than this, there is an indirect relationship relying on the mediating effect of a company's intangible resources.

Muller and Kräussl (2011) analyze the relation between company value, reputation, and donations by U.S. Fortune 500 company in times of crises. Based on three different research designs, Flammer and Kacperczyk (2019) find that CSR is perceived to mitigate a threat of knowledge leakage. Based on the stakeholder theory, it is derived that companies responding to stakeholders' ESG requirements perform better in comparison to irresponsible companies (T. T. Li et al., 2021).[33]

An overview of these articles is provided in Table 18. This tabular overview includes four journal articles applying quantitative research with a focus on ESG and the stakeholder theory. Furthermore, it includes one literature review referring to this topic.

Table 18: Environmental, Social, Governance (ESG) stakeholder theory research

Author(s)	Year	Title	Journal	Research method
Kölbel et al.	2017	How Media Coverage of Corporate Social Irresponsibility Increases Financial Risk	Strategic Management Journal	Quantitative
Surroca et al.	2010	Corporate responsibility and financial performance: the role of intangible resources	Strategic Management Journal	Quantitative
Muller and Kräussl	2011	Doing good deeds in times of need: a strategic perspective on corporate disaster donations	Strategic Management Journal	Quantitative
Flammer and Kacperczyk	2019	Corporate social responsibility as a defense against knowledge spillovers: Evidence from the inevitable disclosure doctrine	Strategic Management Journal	Quantitative
T. T. Li et al.	2021	ESG: Research progress and future prospects	Sustainability	Literature review

Source: Own elaboration

[33] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

4.1.2.8 Environmental, Social, Governance (ESG) dimensions relations

T. T. Li et al. (2021) apply a systematic literature review. They find that research on ESG contains a considerable number of papers analyzing the interaction between the three dimensions.[34]

4.1.2.9 Environmental dimension interaction research

T. T. Li et al. (2021) state that the interaction between the environmental and governance dimensions is a hot spot of ESG research. In this context, they refer to Flammer et al. (2019) describing the influence of CSR executive contracting on company value. The attention of executives to stakeholders improves corporate governance.[35]

Davidson et al. (2019) find that companies led by materialistic executives have lower CSR scores, less strengths, and more weaknesses. Cheng et al. (2014) find that the access to finance can be improved through CSR strategies. This relationship is supported by the environmental and social dimensions of ESG. T. T. Li et al. (2021) state that the environmental dimension is usually considered as part of the social dimension. Thus, there is few research on the relationship between these dimensions.[36]

An overview of environmental dimension interaction research is provided in Table 19. This tabular overview lists journal articles approaching quantitative research and literature review.

[34] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.
[35] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.
[36] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Table 19: Environmental dimension interaction research

Author(s)	Year	Title	Journal	Research method
T. T. Li et al.	2021	ESG: Research progress and future prospects	Sustainability	Literature review
Flammer et al.	2019	Corporate governance and the rise of integrating corporate social responsibility criteria in executive compensation: Effectiveness and implications for firm outcomes	Strategic Management Journal	Quantitative
Davidson et al.	2019	CEO Materialism and Corporate Social Responsibility	The Accounting Review	Quantitative
Cheng et al.	2014	Corporate social responsibility and access to finance	Strategic Management Journal	Quantitative

Source: Own elaboration

4.1.2.10 Interaction research of the social and governance dimensions

T. T. Li et al. (2021) find the interaction between the social and governance dimensions to be a highly researched topic with numerous studies. Literature is focused on the relation between the social dimension and executive factors and the social dimension and stakeholders.[37]

4.1.2.11 Relationship between the social dimension and executive factors

Y. Kim et al. (2012) analyze if companies with a focus on behaving responsible con-

[37] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

strain earnings management. Furthermore, they focus on the objective of delivering more transparent and reliable financial information to investors. This happens in comparison to companies which do not meet the same social criteria. They find that socially responsible companies are less likely to manage earnings through discretionary accruals, manipulate real operating activities, and be the subject of US Securities and Exchange Commission (SEC) investigations.[38]

F. Gao et al. (2014) find that executives of CSR-conscious companies profit less from insider trades and are less likely to trade prior to future news than executives of non-CSR-conscious companies. Especially when executives' personal objectives are aligned with company objective, this is the case.[39]

Hubbard et al. (2017) carried out a study about Chief Executive Officer (CEO) dismissal suggesting that CSR provides context during the interpretation of companies' financial performance. The results point out that in case of a poor financial performance, the likelihood of CEO dismissal increases with past investments in CSR. In case of good financial performance, the likelihood of CEO dismissal decreases with past investments in CSR.

Fu et al. (2020) research the integration of a Chief Sustainability Officer (CSO) into a corporate structure. Based on a sample of Standard & Poor's (S&P) 500 companies for the period of 2005 to 2014, they figured out that the presence of a CSO increases CSR and decreases socially irresponsible activities. Especially in case that a company has a sustainability committee, this effect is strengthened.

Based on a longitudinal dataset of S&P 1500 indexed companies for the period of 2001 to 2010, Tang et al. (2015) link CSR and CEO arrogance. They find a positive relation between CEO arrogance and social irresponsibility activities. On the other hand, they find a negative relation between CEO arrogance and social responsibility activities. This relationship is stronger in case that companies rely less on resources from stakeholders and markets are more certain and less competitive.

Since CSR activities can be carried out due to CEOs' needs for attention and reinforcement of image, Petrenko et al. (2016) research CEO narcissism. Based on a

[38] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.
[39] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

sample of Fortune 500 CEOs and a database including CEO characteristics with validated psychometric scales, they find a positive relationship between CEO narcissism and CSR activity. On the other hand, they find a negative relationship between CEO narcissism and the effect of CSR on performance due to the objectives pursued with CSR.

Tang et al. (2018) investigate CEO character in terms of a differentiation between narcissistic and hubristic CEOs. Apart from the fact that narcissistic CEOs care more about CSR than hubristic CEOs, they find a dependency on peer companies' behavior. If peer companies engage in CSR to a certain extent, narcissistic CEOs tend to engage in CSR in the opposite manner. For example, if peer companies engage less, CEOs engage more. Hubristic CEOs behave differently. In case that peer companies do not emphasize CSR, they engage even less.

As described previously, Davidson et al. (2019) research CEOs' materialism. They figure out that materialistic CEOs tend to have lower CSR scores.

Table 20 lists journal articles researching the relationship between the social dimension and executive factors. This relationship is researched by applying quantitative research methods.

Table 20: Relation between the social dimension and executive factors research

Author(s)	**Year**	**Title**	**Journal**	**Research method**
Y. Kim et al.	2012	Is Earnings Quality Associated with Corporate Social Responsibility?	The Accounting Review	Quantitative
F. Gao et al.	2014	Commitment to social good and insider trading	Journal of Accounting and Economics	Quantitative
Hubbard et al.	2017	Higher Highs and Lower Lows: The Role of Corporate Social Responsibility in CEO Dismissal	Strategic Management Journal	Quantitative
Fu et al.	2020	Chief sustainability officers and corporate social (Ir)responsibility	Strategic Management Journal	Quantitative
Tang et al.	2018	The differential effects of CEO narcissism and hubris on corporate social responsibility	Strategic Management Journal	Quantitative
Petrenko et al.	2016	Corporate social responsibility or CEO narcissism? CSR motivations and organizational performance	Strategic Management Journal	Quantitative
Davidson et al.	2019	CEO Materialism and Corporate Social Responsibility	The Accounting Review	Quantitative

Source: Own elaboration

4.1.2.12 Chief Executive Officers' (CEOs') beliefs and sustainability

Hafenbradl and Waeger (2017) figured out that managers believing in a business case for CSR do not engage more in CSR than managers not believing in the business case. The reason is that managers believing in the business case follow a fair market ideology. To follow this ideology, they tend to justify and idealize the market economy system. At the same time, such managers feel weaker moral emotions when they are confronted with ethical problems leading to less CSR engagement.

Chin et al. (2013) research CEOs' political ideology in terms of a comparison between liberal and conservative CEOs. Based on an analysis of 249 CEOs' political donation in the ten years before they became CEOs, the political orientation was measured. It is found compared to conservative CEOs, liberal CEOs emphasize CSR more. This relationship increases with a CEO's relative power. Moreover, Chin et al. (2013) find that conservative CEOs pursue CSR as financial performance allows whereas liberal CEOs also pursue CSR in financially weak times.

Further authors who research the political ideology in the context of CSR are Gupta et al. (2017). Apart from CEO focus, they research the influence of the body politic of a company. To do so, they analyze Fortune 500 companies' employees' donations to the two major US political parties. They find that companies which tend to be liberal engage more in CSR than companies which tend to be conservative. This effect is stronger in industries where peers have weaker CSR records, in Human Resources (HR) intense industries and in companies with long organizational tenure of the CEO.

In another analysis on Fortune 500 companies, Gupta et al. (2019) compare the choice of strategies by CEOs. Differentiating between the two strategies CSR and workforce downsizing, they figure out that liberal oriented CEOs tend to lead companies with a CSR strategy. Opposed to this, conservatively oriented CEOs tend to lead companies with a workforce downsizing strategy. These relationships are strengthened by extraversion of CEOs. Narcissism strengthens the relation that liberal oriented CEOs tend to lead companies with a CSR strategy. On the other hand, narcissism does not significantly influence conservative CEOs in their choice of workforce downsizing strategy.

Two years later, Gupta et al. (2021) publish another study analyzing peer company behavior. They find that CEOs' political orientation influences the likelihood of peer companies to imitate the implementation of CSR executive position. If a conservative CEO implements a CSR executive position, peers are more likely to do the same than in case that a liberal CEO implements a CSR executive position. Table 21 provides an overview of these five research articles applying quantitative methods. These journal articles contribute to CEO's beliefs and sustainability research.

Table 21: Chief Executive Officers' (CEOs') beliefs and sustainability research

Author(s)	**Year**	**Title**	**Journal**	**Research method**
Hafenbradl and Waeger	2017	Ideology and the micro-foundations of CSR: Why executives believe in the business case for CSR and how this affects their CSR engagements	Academy of Management Journal	Quantitative
Chin et al.	2013	Political Ideologies of CEOs: The Influence of Executives' Values on Corporate Social Responsibility	Administrative Science Quarterly	Quantitative
Gupta et al.	2017	Red, blue, and purple firms: Organizational political ideology and corporate social responsibility	Strategic Management Journal	Quantitative
Gupta et al.	2019	Dispositional Sources of Managerial Discretion: CEO Ideology, CEO Personality, and Firm Strategies	Administrative Science Quarterly	Quantitative
Gupta et al.	2021	Out of character: CEO political ideology, peer influence, and adoption of CSR executive position by Fortune 500 firms	Strategic Management Journal	Quantitative

Source: Own elaboration

4.1.2.13 Chief Executive Officers' (CEOs') demographics

Kang (2016) use the three databases COMPUSTAT Fundamental Annual, COMPUSTAT Execucomp, and KLD Social Ratings. They analyze CEO retirement influencing CSR. He finds a negative effect of CEOs' nearing retirement on company commitment to CSR. This effect is weakened in case that CEOs are relatively older and in case that they remain part of the board of directors of their own companies.

Lai et al. (2020) analyze the difference between local and non-local CEOs. They figure out that CEOs working near their childhood homes tend to have a stronger focus on CSR by making decision with a long-term growth focus. They add that there are less information asymmetries with local CEOs in labor markets. Less information asymmetries lead to less pressure on delivering short-term results and enable a long-term orientation. In detail, CEOs are less likely to decrease R&D expenditure to improve financial results and tend to pay more state tax. The described effect is stronger in companies with embedded business interests and general strength of local social bonds.

Table 22 lists one of seven journal articles about CEO's demographics. Table 22 and Table 23 are split to enable visualization of corresponding authors close to descriptions and reduce the table size to one page.

Table 22: Chief Executive Officers' (CEOs') demographics research: Part 1

Author(s)	Year	Title	Journal	Research method
Kang	2016	Labor market evaluation versus legacy conservation: What factors determine retiring CEOs' decisions about long-term investment?	Strategic Management Journal	Quantitative
Lai et al.	2020	East, West, Home's Best: Do Local CEOs Behave Less Myopically?	The Accounting Review	Quantitative

Source: Own elaboration

Different from Lai et al. (2020), Bertrand et al. (2021) analyze the corporate social performance instead of CSR in general. Bertrand et al. (2021) publish a study with a sample of 1001 local companies based in 18 developed countries over eight years. They argued that for foreign CEOs in local companies, there is a higher need to build trustworthiness and legitimacy. Thus, they need to achieve a higher level of corporate social performance than local CEOs.

Church et al. (2019) publish an article about the influence of financial measurement on CSR decision making of CSR-supportive managers. They figured out that nonfinancial measures lead to a higher attention to the society and that nonfinancial measures lead to higher CSR investment than financial measures.

Focusing on the academic and professional background of executives, Han et al. (2019) research the influence of education and training abroad on CSR. They figure out that executives who previously spent time abroad tend to lead companies with a higher level of CSR than of companies led by local executives. Luo et al. (2021) also research the background of executives who spent time abroad. In terms of social responsibility, they also come to the result that executives who spent time abroad participate more, especially by making corporate donations.

S. Li and Lu (2020) research the likelihood of companies to take more CSR actions as a response to governmental CSR activities. They figure out that it increases with the CEO interest in legitimacy. Especially under social pressure of building credibility, CEOs respond with CSR. This happens in cases that time periods in which CEOs need to deliver results are short.[40]

Table 23 lists another five of seven journal articles about CEO's demographics. The seven articles about CEO's demographics apply quantitative research methods.

[40] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Table 23: Chief Executive Officers' (CEOs') demographics research: Part 2

Author(s)	**Year**	**Title**	**Journal**	**Research method**
Bertrand et al.	2021	Are firms with foreign CEOs better citizens? A study of the impact of CEO foreignness on corporate social performance	Journal of International Business Studies	Quantitative
Church et al.	2019	A Dollar for a Tree or a Tree for a Dollar? The Behavioral Effects of Measurement Basis on Managers' CSR Investment Decision	The Accounting Review	Quantitative
Han et al.	2019	Going home and helping out? Returnees as propagators of CSR in an emerging economy	Journal of International Business Studies	Quantitative
Luo et al.	2021	Coming Back and Giving Back: Transposition, Institutional Actors, and the Paradox of Peripheral Influence*	Administrative Science Quarterly	Quantitative
S. Li and Lu	2020	A dual-agency model of firm CSR in response to institutional pressure: Evidence from Chinese publicly listed firms	Academy of Management Journal	Quantitative

Source: Own elaboration

4.1.2.14 Relation between the social dimension and stakeholder factors

Madsen and Rodgers (2015) publish a paper based on the stakeholder theory. According to the stakeholder theory, CSR impacts the corporate financial performance. The reason for this is that stakeholders reward certain CSR types. This hypothesis implies that stakeholders pay attention to CSR activities. Madsen and Rodgers (2015) close this research gap with an analysis of antecedents and consequences of stakeholder attention to corporate disaster relief CSR. They figure out that stakeholder attention is driven by the legitimacy, urgency, and enactment of disaster relief CSR initiatives.

In a laboratory experiment, Balakrishnan et al. (2011) find that employee motivation significantly increases with corporate giving activities. This engagement increase can be a benefit for companies. With a focus on employee retention, Carnahan et al. (2017) come to similar results. They figure out that employees with a focus on meaningful work are more motivated than others. This subjective level of meaningfulness can be increase with CSR activities.

Farooq et al. (2017) research internal and external CSR influence on employee identification in terms of mechanisms. In this context, outcomes of identity and boundary conditions on these effects are analyzed. They find differences between internal and external stakeholder orientation with a stronger impact of internal stakeholder orientation on employee behavior. Moreover, there are different degrees of impact due to social and cultural factors. Especially CSR activities focusing on employee welfare increase the organizational identification of employees.

Table 24 lists four of nine journal articles describing the relationship between the social dimension and stakeholders. Table 24 and Table 25 are split to reduce the table size to one page and enable visualization of corresponding authors close to descriptions.

Table 24: Relation between social dimension and stakeholder research: Part 1

Author(s)	Year	Title	Journal	Research method
Madsen and Rodgers	2015	Looking good by doing good: The antecedents and consequences of stakeholder attention to corporate disaster relief	Strategic Management Journal	Quantitative
Balakrishnan et al.	2011	Contracting benefits of corporate giving: An experimental investigation	Accounting Review	Experimental
Carnahan et al.	2017	When does corporate social responsibility reduce employee turnover? evidence from attorneys before and after 9/11	Academy of Management Journal	Quantitative
Farooq et al.	2017	The multiple pathways through which internal and external corporate social responsibility influence organizational identification and multifoci outcomes: The moderating role of cultural and social orientations	Academy of Management Journal	Quantitative

Source: Own elaboration

With another perspective, Muller et al. (2014) research CSR and employee behavior with a focus on psychological factors. They find that employees have an impact on charitable efforts of enterprises under the condition that corporate decision-making is based on psychological factors like compassion. Flammer and Luo (2017) research the dependency of company reaction with CSR to employee behavior. They research if companies use CSR as a tool to improve employee engagement. They figure out that CSR can be used as an employee governance tool and that companies react with CSR to increased risk of adverse behavior.

Elliott et al. (2014) research the influence of CSR performance on investors' assessment. They differentiate investors with a clear CSR assessment and such that decide unintentionally based on emotional response with a proposal to use index or evaluation systems.

Mun and Jung (2018) analyze the influence of institutional investors and local CSR managers on workplace gender diversity. They carry out an analysis of more than 800 Japanese companies from 2001 to 2009 and figure out that the impact is present. The number of women in board or management positions increases with the presence of institutional investors and local CSR managers. Institutional investors and local CSR managers do not have a significant impact on the number of non-managerial or entry level positions. The reason for this is that board or management positions are more visible to HR managers and investors than non-managerial or entry level positions. This fact has an impact on CSR-related decision making.

Naughton et al. (2019) conduct a sentiment analysis on the relationship between CSR and investor activity. They find that companies' CSR activity announcement leads to a positive abnormal return if investors place a valuation premium on CSR. Moreover, they find that companies respond to investor sentiment with CSR. This is especially the case if companies face investor valuation uncertainty. It can be concluded that CSR activities are dependent on investor sentiment.

Table 25 presents the remaining five of nine journal articles that refer to factors describing the relation between social dimension and stakeholders. Experimental, quantitative, and qualitative methods are applied in this scientific field of research.

Table 25: Relation between social dimension and stakeholder research: Part 2

Author(s)	Year	Title	Journal	Research method
Muller et al.	2014	A theory of collective empathy in corporate philanthropy decisions	Academy of Management Journal	Qualitative
Flammer and Luo	2017	Corporate social responsibility as an employee governance tool: Evidence from a quasi-experiment	Strategic Management Journal	Quantitative
Elliott et al.	2014	The Unintended Effect of Corporate Social Responsibility Performance on Investors' Estimates of Fundamental Value	The Accounting Review	Experimental
Mun and Jung	2018	Change above the Glass Ceiling: Corporate Social Responsibility and Gender Diversity in Japanese Firms	Administrative Science Quarterly	Quantitative
Naughton et al.	2019	Investor Sentiment for Corporate Social Performance	The Accounting Review	Quantitative

Source: Own elaboration

4.1.2.15 Sustainability influence on economics

T. T. Li et al. (2021) find a focus and high attention on financial performance, company performance and value in scientific research on ESG between 2006 and 2020. The influence of ESG on economic consequences is a highly discussed scientific topic.[41]

Khan et al. (2016) carry out a study based on a materiality classifications of sustainability topics. They find that companies with good ratings on material sustainability issues significantly outperform companies with poor ratings on material sustainability. As opposed to this, companies with good ratings on immaterial sustainability issues do not significantly outperform companies with poor ratings on immaterial sustainability.

An analysis executed by Awaysheh et al. (2020) describes the relationship between CSR and company performance. This relationship has an influence on CSR-related decision-making in companies' management and on investors' decisions to invest in companies. What they find is that for best-in-class CSR companies within certain industries, investors place higher valuations.

Different from the authors mentioned previously, Kölbel et al. (2017) focus on the negative effects of corporate social irresponsibility. They figured out that corporate social irresponsibility significantly increases credit risks of companies and financial risks.

Table 26 lists journal articles which thematize ESG influence on economics. Quantitative and a literature review are available on this field of research.

[41] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Table 26: Environmental, Social, Governance (ESG) and economics research

Author(s)	**Year**	**Title**	**Journal**	**Research method**
T. T. Li et al.	2021	ESG: Research progress and future prospects	Sustainability	Literature review
Khan et al.	2016	Corporate sustainability: First evidence on materiality	Accounting Review	Quantitative
Awaysheh et al.	2020	On the relation between corporate social responsibility and financial performance	Strategic Management Journal	Quantitative
Kölbel et al.	2017	How Media Coverage of Corporate Social Irresponsibility Increases Financial Risk	Strategic Management Journal	Quantitative

Source: Own elaboration

4.1.2.16 Types of relationships in sustainability research

According to T. T. Li et al. (2021), scientific ESG research results can be divided into four types of relationships. These are positive correlation, negative correlation, non-linear relationship, and indirect relationship. Based on these types, the research is clustered in the following.[42]

4.1.2.17 Positive correlations

Mackey et al. (2007) research positive correlation between ESG activities and corporate values using the KLD database. Management decisions in publicly traded companies fund CSR activities that do not maximize the present value of company's future cash flows. As opposed to this, CSR activities maximize the market value of the company.

Jayachandran et al. (2013) find a positive correlation between the corporate social performance and the corporate performance. Analyzing the social and environmental dimensions of ESG, they find that the social dimension has a stronger positive impact on corporate performance than the environmental dimension has on corporate performance.

Barnett and Salomon (2006) demonstrated the importance of in-depth examination of different social screening strategies advantages. As described previously, Flammer et al. (2019) find a positive influence of executive CSR contracting on company value.

Eight journal articles finding positive ESG correlations results are discussed critically in this chapter. To simplify the overview, these articles are split to four each in Table 27 and Table 28.

[42] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Table 27: Positive Environmental, Social, Governance (ESG) relations: Part 1

Author(s)	Year	Title	Journal	Research method
Mackey et al.	2007	Corporate social responsibility and firm performance: Investor preferences and corporate strategies	Academy of Management Review	Qualitative
Jayachandran et al.	2013	Product and environmental social performance: Varying effect on firm performance	Strategic Management Journal	Quantitative
Barnett and Salomon	2006	Beyond dichotomy: the curvilinear relationship between social responsibility and financial performance	Strategic Management Journal	Quantitative
Flammer et al.	2019	Corporate governance and the rise of integrating corporate social responsibility criteria in executive compensation: Effectiveness and implications for firm outcomes	Strategic Management Journal	Quantitative

Source: Own elaboration

Based on S&P 500 company data from 2006 to 2008, Matsumura et al. (2014) study the influence of carbon emissions and voluntary disclosure of carbon emissions on company value. They figure out that company value decreases by € 155,000 with every additional thousand metric tons of carbon emissions. Moreover, they find the median value of companies that disclose their carbon emissions to be about € 1.7 billion higher than that of comparable non-disclosing companies. This shows that lower carbon emissions and higher transparency on this topic are favorable to company value.[43]

Godfrey (2005) find a positive correlation between corporate philanthropy and positive moral capital among communities and stakeholders. He figures out that moral capital can provide shareholders with insurance-like protection for a company's relationship-based intangible assets and that this protection contributes to shareholder wealth.

Six years later, Wang and Qian (2011) publish a paper based on analyses of data on Chinese companies listed on stock exchanges between 2001 and 2006. They describe the positive correlation between corporate philanthropy and corporate financial performance. This effect is enhanced for companies with a greater public visibility and better performance in the past. Moreover, companies which are not government-owned or politically well-connected tend to benefit more from philanthropy.

Kaul and Luo (2018) find the benefit of CSR activities to depend on the relation to the core business and the relation to other non-profit organizations. In this context, they differentiate between financial benefit and social benefit. To achieve financial benefit, CSR activities should be related to the core business or should not overlap with activities of non-profit organizations. To achieve social benefit, both criteria should be fulfilled.

Table 28 presents the remaining four journal articles about positive ESG relations. Due to the nature or correlation research, only quantitative research is included.

[43] Calculated from USD with the exchange rate (USD 1 = EUR 0.7322) provided by the European Central Bank on average between 01/01/2006 and 31/12/2008 (European Central Bank, 2024).

Table 28: Positive Environmental, Social, Governance (ESG) relations: Part 2

Author(s)	Year	Title	Journal	Research method
Matsumura et al.	2014	Firm-Value Effects of Carbon Emissions and Carbon Disclosures	The Accounting Review	Quantitative
Godfrey	2005	The relationship between corporate philanthropy and shareholder wealth: A risk management perspective	Academy of Management Review	Quantitative
Wang and Qian	2011	Corporate philanthropy and corporate financial performance: The roles of stakeholder response and political access	Academy of Management Journal	Quantitative
Kaul and Luo	2018	An economic case for CSR: The comparative efficiency of for-profit firms in meeting consumer demand for social goods	Strategic Management Journal	Quantitative

Source: Own elaboration

4.1.2.18 Negative correlations

Manchiraju and Rajgopal (2017) and Chen et al. (2018) research the negative correlation between CSR and economics. The analysis of Manchiraju and Rajgopal (2017) is based on an Indian law implemented in 2013. This law requires Indian companies to spend a minimum of two percent of the net income to CSR under conditions based on profitability, net worth, and company size. With an event study, they find that this regulation caused a 4.1 percent drop in the stock price of companies. This shows a negative impact of CSR on shareholder value with an exception for companies spending more on advertising. Instead of a law to spend money on CSR, China's 2008 mandate required companies to disclose CSR activities.

Chen et al. (2018) research the impact of this requirement on shareholder value and find a negative impact of the disclosure on company profitability. Moreover, a decrease in industrial wastewater and sulfur dioxide emission is found suggesting an influence of CSR disclosure on company behavior and shareholder expenses.

Table 29 lists the journal articles by Manchiraju and Rajgopal (2017) and Chen et al. (2018). The authors apply quantitative research methods to find negative relationships.

Table 29: Negative Environmental, Social, Governance (ESG) relations research

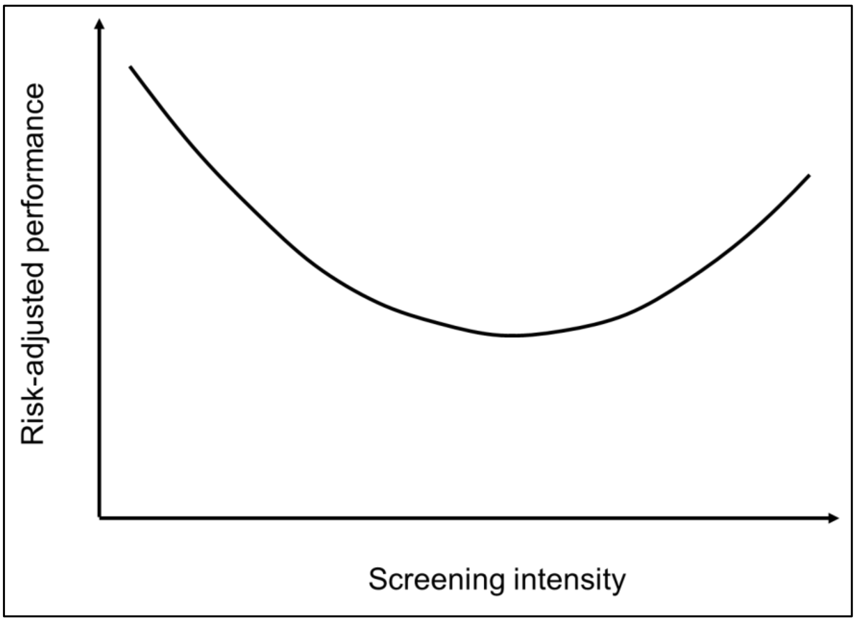
Author(s)	Year	Title	Journal	Research method
Manchiraju and Rajgopal	2017	Does Corporate Social Responsibility (CSR) Create Shareholder Value? Evidence from the Indian Companies Act 2013	Journal of Accounting Research	Quantitative
Chen et al.	2018	The effect of mandatory CSR disclosure on firm profitability and social externalities: Evidence from China	Journal of Accounting and Economics	Quantitative

Source: Own elaboration

4.1.2.19 Non-linear relationships

Barnett and Salomon (2006, 2012) as well as Zhao and Murrell (2016) find non-linear relationships. As mentioned before, Barnett and Salomon (2006) find a relationship between financial and social performance. With a higher screening intensity, financial returns decline at first and then increase again as the screen intensity reaches its maximum. This effect is shown in Figure 22.

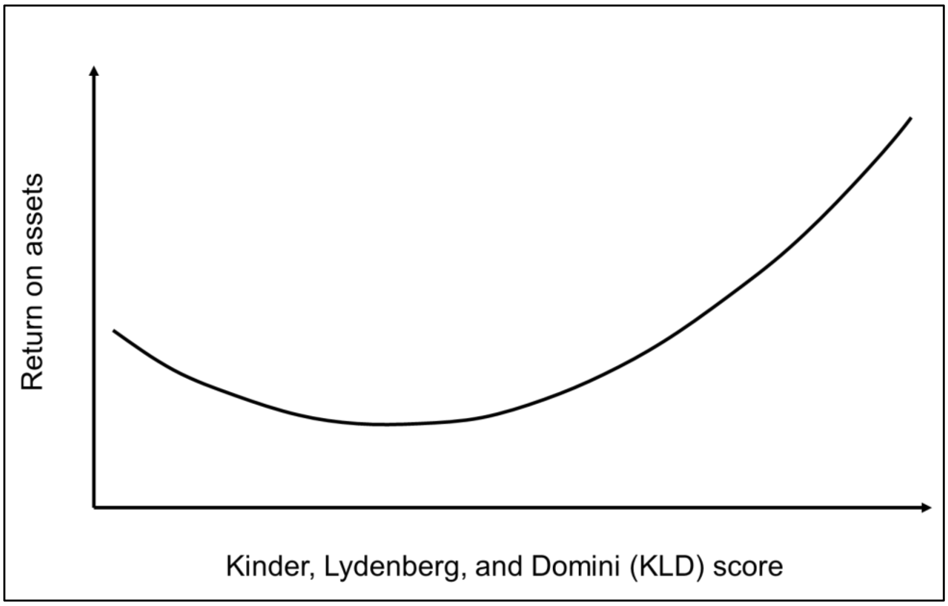
Figure 22: U-shaped relationship between performance and screening intensity



Source: Own elaboration according to Barnett and Salomon (2006)

Six years later, Barnett and Salomon (2012) publish another paper presenting U-shaped relationships. They used the KLD score as independent variable. This score of an independent agency tracks and rates companies based on several CSR dimensions. They find that the KLD score has an impact on return on assets and net income. The U-shaped relationships are reflected in Figure 23 and Figure 24.

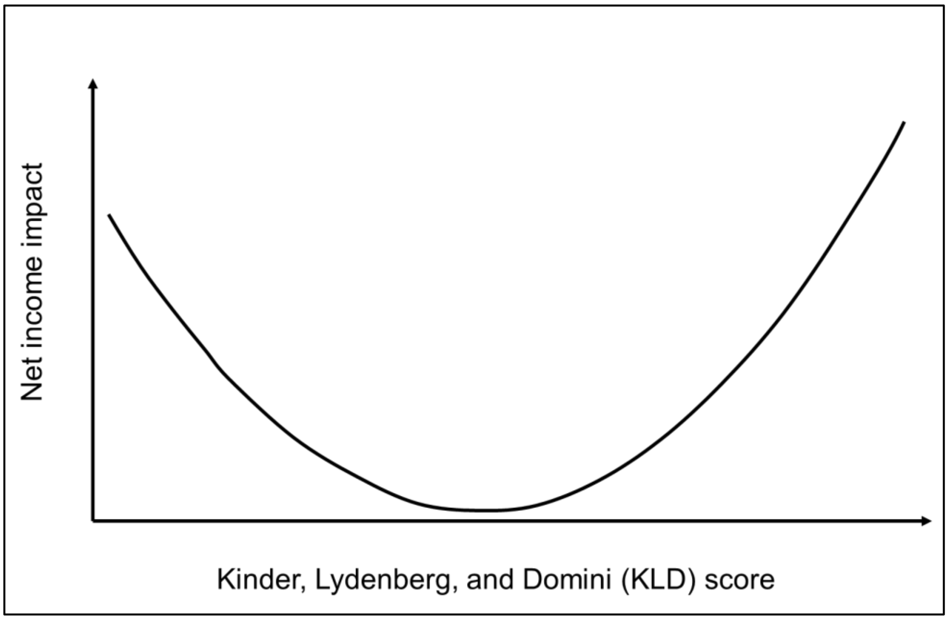
Figure 23: Corporate Social Responsibility (CSR) influence on return on assets



Source: Own elaboration according to Barnett and Salomon (2012)

Comparing Figure 23 and Figure 24, both decline at first and after a turning point, return on assets and net income increase again. This turning point is reached for the return on assets earlier (KLD score 9) than for the net income (KLD score 12). Moreover, it is visible that the companies which are strongest in CSR benefit most in terms of financial (return on assets and net income) performance.

Figure 24: Corporate Social Responsibility (CSR) influence on net income



Source: Own elaboration according to Barnett and Salomon (2012)

Conducting a replication of a study by Waddock and Graves (1997b), Zhao and Murrell (2016) find a complex relationship between corporate social and financial performance. Like Barnett and Salomon (2006, 2012), they refer to the original study using KLD ratings for corporate social performance measures.

Zhao and Murrell (2016) had the opportunity to challenge the original study with a sample of a longer time and figured out that there is not a simple relationship. It cannot be simplified that doing good leads to doing well and they suggest revision of several studies and an extension of the original study by Waddock and Graves (1997b).

Table 30 lists four journal articles that find non-linear ESG relationships. The authors finding this type of relationship apply quantitative research methods.

Table 30: Non-linear Environmental, Social, Governance (ESG) relations research

Author(s)	**Year**	**Title**	**Journal**	**Research method**
Barnett and Salomon	2006	Beyond dichotomy: the curvilinear relationship between social responsibility and financial performance	Strategic Management Journal	Quantitative
Barnett and Salomon	2012	Does it pay to be really good? addressing the shape of the relationship between social and financial performance	Strategic Management Journal	Quantitative
Zhao and Murrell	2016	Revisiting the corporate social performance-financial performance link: A replication of Waddock and Graves	Strategic Management Journal	Quantitative
Waddock and Graves	1997b	Quality of management and quality of stakeholder relations: Are they synonymous?	Business and Society	Quantitative

Source: Own elaboration

4.1.2.20 Indirect relationships

Surroca et al. (2010, 2020), Hull and Rothenberg (2008), Ramchander et al. (2012), Lys et al. (2015), Hawn and Ioannou (2016) find indirect ESG relationships. These are described in the following.

Surroca et al. (2010) find that the relationship between corporate responsibility and financial performance is indirect. The mediating effects of intangible resources (e.g., innovation, human capital, reputation, and culture) should be considered. Since previous research on the impact of corporate social performance on financial performance shows mixed results, Hull and Rothenberg published an article on moderating factors in

2008. They find two moderating factors to be related to company differentiation. According to them, these moderating factors are the level of differentiation in the industry and innovation, because innovation drives company differentiation. According to Hull and Rothenberg (2008), financial performance is strongly affected by social performance of low-innovation companies in industries with little differentiation.

Ramchander et al. (2012) research the meaning of external social monitoring agencies. Carrying out an event study, they find that additions and deletions to the Domini Social 400 index led to changes of the share price. Especially in industries with a high degree of information asymmetries, index additions lead to increases in share prices and negative reactions by competitive companies. In case of company removals, the opposite happens, and the share price drops.

Lys et al. (2015) research the causality between CSR expenditure and financial performance. They find that CSR expenditure does not lead to financial performance, but that these expenditures are undertaken in a certain period when companies expect stronger financial performance in the future.

Hawn and Ioannou (2016) carry out a study based on the market-value equation and a sample of 1,492 companies in 33 countries from 2002 to 2008. They find that internal and external CSR jointly support an association of better market value due to increased intangible resources. On average, the amount of internal CSR actions is higher than the amount of external CSR actions and a wider gap between both decreases market value.

Surroca et al. (2020) study the impact of the simultaneous adoption of managerial entrenchment provisions and CSR on financial performance. They differentiate the impact between liberal market economies and coordinated market economies. In liberal market economies, they find a positive impact as the adoption of managerial entrenchment provisions and CSR create shareholder value, especially in international CSR projects. In contrast, they find the adoption of managerial entrenchment provisions and CSR destroying shareholder value in coordinated market economies, especially when this CSR is external.

Indirect ESG relations are found in six journal articles which are listed in Table 31. The authors apply quantitative methods to find these relationships.

Table 31: Indirect Environmental, Social, Governance (ESG) relations research

Author(s)	**Year**	**Title**	**Journal**	**Research method**
Surroca et al.	2010	Corporate responsibility and financial performance: the role of intangible resources	Strategic Management Journal	Quantitative
Hull and Rothenberg	2008	Firm performance: the interactions of corporate social performance with innovation and industry differentiation	Strategic Management Journal	Quantitative
Ramchander et al.	2012	The informational relevance of corporate social responsibility: evidence from DS400 index reconstitutions	Strategic Management Journal	Quantitative
Lys et al.	2015	Signaling through corporate accountability reporting	Journal of Accounting and Economics	Quantitative
Hawn and Ioannou	2016	Mind the gap: The interplay between external and internal actions in the case of corporate social responsibility	Strategic Management Journal	Quantitative
Surroca et al.	2020	Is managerial entrenchment always bad and corporate social responsibility always good? A cross-national examination of their combined influence on shareholder value	Strategic Management Journal	Quantitative

Source: Own elaboration

4.1.2.21 Risk prevention through sustainability

T. T. Li et al. (2021) find risk prevention role of ESG in business activities to be a hotspot of ESG research and research results in all three dimensions of ESG. These results are split according to the dimension focus mentioning that they cannot be viewed completely apart from each other. These are described in the following.[44]

4.1.2.22 Risk prevention through social activities

Koh et al. (2014) research if corporate social performance serves companies as valuable insurance mechanism. Using the KLD database, they standardize multiple ESG dimensions of community relations, diversity, employee relations, environment, and products. Using these dimensions, they create an overall measurement index of corporate social performance.

Koh et al. (2014) find that the corporate social performance depends on the fact if a company gained pragmatic or moral legitimacy. Pragmatic legitimacy refers to a company's financial health and moral legitimacy refers to operating in socially contested industries. This differentiation is relevant as the pragmatic legitimacy adds two to four percent to company value and serves as an ex-ante insurance mechanism. On the other hand, CSR activities less likely lead to value creation in case of moral legitimacy in socially contested industries or if the company is in financial distress.

Mithani (2017) carry out a study on the impact of philanthropy on mitigation of the liability of foreignness after national disasters. Based on a sample of 190 multinational enterprises and 660 domestic companies, he finds that multinational enterprises can contribute to recovery and relief efforts after local disasters. Doing so, they can strengthen their position in the local community and mitigate liability of foreignness. It is found that the post-disaster philanthropy for multinational enterprises is stronger than for domestic companies.

Zhou and Wang (2020) also research the liability of foreignness, but in a different context. They research the relationship of parent companies and subsidiaries in relation to risk and CSR. Due to high visibility of multinational parent companies, the control of

[44] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

parent companies over subsidiaries and liability of foreignness, subsidiaries resort to CSR for spillover reduction. A positive relation is found between parent company reputation risk and foreign subsidiary CSR activities based on a sample of Chinese subsidiaries of large multinationals from 2009 to 2016. This positive relation is stronger for foreign subsidiaries that do not directly report to the parent company, shorter operations in the host country and a smaller distance between home and host countries.

Referring to the social dimension of ESG, Shiu and Yang (2017) research if companies can benefit from CSR activities as an insurance-like effect during negative event occurrence. Based on the KLD database, they find that a long-term engagement in CSR can be beneficial as an insurance-like effect, but only for one negative event. After a second negative event, the insurance-like effect disappears. It can be derived that managers facing negative events should be careful in crisis communication because they can only use the insurance-like effect once.

Jia et al. (2020) also research the relationship between CSR activity and an insurance-like effect, but with another perspective. They conduct a study and find that companies facing stock price risks increased their CSR activities.

Bertrand et al. (2021) focus on risk prevention for CEOs based on the ESG social pillar scores of the Thomson Reuters ASSET4 database. They find that to achieve legitimacy and trustworthiness, local companies with foreign CEOs need to achieve a higher corporate social performance level than local companies with local CEOs. This difference between local and foreign CEOs of local companies is stronger for more authentic and trust-increasing CSR activities. Furthermore, the difference is stronger where the need to build trustworthiness with locals is higher.

Table 32 concludes journal articles about risk prevention through social activities. The authors apply quantitative research methods.

Table 32: Risk prevention through social activities research

Author(s)	Year	Title	Journal	Research method
Koh et al.	2014	Firm litigation risk and the insurance value of corporate social performance	Strategic Management Journal	Quantitative
Mithani	2017	Liability of foreignness, natural disasters, and corporate philanthropy	Journal of International Business Studies	Quantitative
Zhou and Wang	2020	Foreign subsidiary CSR as a buffer against parent firm reputation risk	Journal of International Business Studies	Quantitative
Shiu and Yang	2017	Does engagement in corporate social responsibility provide strategic insurance-like effects?	Strategic Management Journal	Quantitative
Jia et al.	2020	Do firms use corporate social responsibility to insure against stock price risk? Evidence from a natural experiment	Strategic Management Journal	Quantitative
Bertrand et al.	2021	Are firms with foreign CEOs better citizens? A study of the impact of CEO foreignness on corporate social performance	Journal of International Business Studies	Quantitative

Source: Own elaboration

4.1.2.23 Risk prevention through environmental activities

Flammer (2013) carry out an event study based on announcement of environment-related corporate news for US publicly traded companies from 1980 to 2009. She finds that stakeholders are sensitive to companies' environmental footprint. In the study, companies which report to behave environmentally responsibly experience a significant stock price increase. Companies which behave irresponsibly experience a significant decrease.

Based on these results, Flammer (2013) research the dependence of the value of environmental CSR on external and internal moderators. She finds an increase of the negative stock market reaction to eco-harmful behavior over time and a decrease of the positive reaction to eco-friendly initiatives. Moreover, the stock market pressure to both eco-friendly and eco-harmful CSR is smaller for companies with higher levels of environmental CSR in general. The journal article is presented in Table 33.

Table 33: Risk prevention through environmental activities research

Author(s)	Year	Title	Journal	Research method
Flammer	2013	Corporate social responsibility and shareholder reaction: The environmental awareness of investors	Academy of Management Journal	Quantitative

Source: Own elaboration

4.1.2.24 Risk prevention through governance activities

Based on the KLD database, F. Gao et al. (2014) find executives of CSR-conscious companies to profit significantly less from insider trades. Furthermore, they are less likely to trade prior to future news than executives of non-CSR-conscious companies. The negative relationship between CSR and insider trading profits is stronger when personal interests of executives are more aligned with the interests of the company.[45]

Flammer and Kacperczyk (2019) take an employee perspective and figure out that CSR can be a tool to avoid knowledge leakage. They find that CSR reduces the willingness of knowledge holding employees to join competitive companies. Moreover, if knowledge holding employees join competitive companies, CSR activities of the previous employer reduce the risk that the knowledge is shared with the new employer. Flammer and Kacperczyk (2019) conclude CSR as reducing the risk that knowledge holding employees “walk” and “talk”.

Table 34 presents the journal articles by F. Gao et al. (2014) and Flammer and Kacperczyk (2019) about risk prevention through governance activities. They apply quantitative research methods.[46]

Table 34: Risk prevention through governance activities research

Author(s)	**Year**	**Title**	**Journal**	**Research method**
F. Gao et al.	2014	Commitment to social good and insider trading	Journal of Accounting and Economics	Quantitative
Flammer and Kacperczyk	2019	Corporate social responsibility as a defense against knowledge spillovers: Evidence from the inevitable disclosure doctrine	Strategic Management Journal	Quantitative

Source: Own elaboration

[45] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.
[46] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

4.1.3 Mobility research

Mobility research is focused on societal habits, products, services, technologies, and innovation. Furthermore, Supply Chain Management and sustainability are investigated in present literature.

4.1.3.1 Societal mobility habits

Ravensbergen et al. (2023) apply an exploratory analysis of mobility of care in Montreal, Canada. Mobility of care is defined to be the daily travel required to complete care labor such as travel to the grocery store or to escort children. They find that mobility of care covers 28 percent of adults' daily mobility. Moreover, they find women to complete more mobility of care than men, especially women from lower-income households and such with children. The presence of children widens the gender gap whereas the number of children present does not alter this gap.

Yu et al. (2023) use a quantitative approach to analyze tourist mobility changes due to public health crises. They analyze mobile phone data from 277 million tourists from 2019 to 2021 in China comparing tourist mobility changes due to two COVID-19 waves. They find an increase in domestic tourism in Beijing after the pandemic compared to the time before. Furthermore, they find that female and elderly groups slowly recovered after the first wave but the opposite after the second wave. Moreover, Yu et al. (2023) find wealthier, larger cities to be weakened more intense. With these findings, they add research the field of tourism management in public health crises and pandemic-related policymaking.

The journal articles published by Ravensbergen et al. (2023) and Yu et al. (2023) are presented in Table 35. The authors apply qualitative and quantitative research to investigate societal mobility habits.

Table 35: Societal mobility habits research

Author(s)	Year	Title	Journal	Research method
Ravensbergen et al.	2023	Exploratory Analysis of Mobility of Care in Montreal, Canada	Transportation Research Record	Qualitative
Yu et al.	2023	Changes in tourist mobility after COVID-19 outbreaks	Annals of Tourism Research	Quantitative

Source: Own elaboration

4.1.3.2 Smart and shared mobility

Savastano et al. (2023) apply a content analysis including more than 1000 reviews published on the official digital platforms of the smart city of Milan, Italy. They apply the Social, Technological, Environmental, Economic, and Political (STEEP) method to take complex perspective concerning the named dimensions' related issues. They combine the STEEP method with a SWOT analysis resulting in comprehensive practical implications to modern municipal smart mobility management systems. Savastano et al. (2023) find a need for suppliers of smart mobility solutions and institutions to understand and communicate digital services implementation knowledge.

Simonofski et al. (2023) apply a qualitative research approach including sixteen interviews and eight documents to investigate smart mobility projects in smart cities. They describe that smart mobility can improve citizens' well-being. Furthermore, cities can reach sustainability objectives by establishing an appropriate mobility system. Simonofski et al. (2023) design and validate a smart mobility framework with seven phases and the corresponding stakeholders. The seven phases are idea, analysis, agenda-setting, preparation, implementation, monitoring, and evaluation. The stakeholders involved are public agents, citizen, companies, and researchers.

Zhu et al. (2023) provide a review of significant elements in sustainable transportation systems with shared mobility. They describe the main subsets of shared mobility to include ridesharing, carsharing, shared micro mobility, on-demand ride services, and shared autonomous vehicles. They find shared mobility to have benefits and improve urban transportation systems, but these benefits vary with travel behavior and company supply. Furthermore, they discuss how government policies regulate travel behavior.

Narayanan and Antoniou (2023) provide a model on shared mobility services. This model allows the choice between bikesharing, carsharing, and ridehailing. The mode choice model defines socio-demographic characteristic, trip-related variables, as well as supply parameter as choice-influencing factors. Furthermore, policy measures are suggested under the categories finance, infrastructure, campaigns, and nudges, as well as service design. Their model closes the research gap of a joint mode choice model for bikesharing, carsharing, and ridehailing services.

Geurs et al. (2023) apply a literature review describing definition, categorization, and guidance for the design of shared mobility hubs. They provide a multidimensional typology for shared mobility hubs with the dimensions physical, digital, and democratic. They find that digital and democratic integration dimensions are usually missing in shared mobility hub concepts, definitions, and planning practice. Furthermore, universal design principles are missing. Geurs et al. (2023) describe that the smarter shared mobility hubs are physically, digitally, and democratically, the more they can potentially create user and societal value.

Smart and shared mobility research is presented in Table 36. This field of research is investigated through quantitative and qualitative research methods as well as a literature review. It should be noted that technical mobility research is different from economic research which is described in the chapters 4.1.1 and 4.1.2. Certain papers are classified as literature reviews as they are based on literature rather than experimental, quantitative, or qualitative research. Such papers classified as literature reviews can be technical, conceptual, and theoretical. As the field of mobility research is more technical than CVC and sustainability research, technical mobility articles are included in this chapter, but differ in the scientific methods.

Table 36: Smart and shared mobility research

Author(s)	Year	Title	Journal	Research method
Savastano et al.	2023	How smart is mobility in smart cities? An analysis of citizens' value perceptions through ICT applications	Cities	Quantitative
Simonofski et al.	2023	Smart mobility projects: Towards the formalization of a policy-making lifecycle	Land Use Policy	Qualitative
Zhu et al.	2023	A comprehensive review of shared mobility for sustainable transportation systems	International Journal of Sustainable Transportation	Literature review
Narayanan and Antoniou	2023	Shared mobility services towards Mobility as a Service (MaaS): What, who and when?	Transportation Research Part A: Policy and Practice	Quantitative
Geurs et al.	2023	The Smarthubs integration ladder: a conceptual model for the categorisation of shared mobility hubs	Transport Reviews	Literature review

Source: Own elaboration

4.1.3.3 Mobility as a Service (MaaS)

Y. Zhang and Kamargianni (2023) present a systematic literature review on key factors influencing adoption and enablers of new mobility technologies and services. In their review, they focus on autonomous vehicles, drones, micro mobility, and MaaS. They find shared, exclusive, opposing, and mixed impacts factors and contribute to policy decisions, especially concerning sequencing of launch and development priorities.[47]

Arias-Molinares and García-Palomares (2020) apply a literature review to 57 MaaS-focused documents from Scopus in January 2019. They answer the following questions. What is MaaS? When and where did the term appear? Who are the main actors in MaaS? How can MaaS be implemented? Why should it be implemented?

They find that there is no standard definition to MaaS. Defining MaaS is a developing process in scientific literature. Even though Sampo Hietanen founded BlaBlaCar in 2006 with the idea of presenting mobility packages, the term MaaS started to be used in 2014. Main actors are transport authorities and transport operators. Arias-Molinares and García-Palomares (2020) recommend collaboration between these actors. Through collaboration, they can achieve forecasted sustainable effects envisioned. Molinares and García-Palomares (2020) also recommend that data on user travel behavior and preferences are collected through MaaS pilots. In this way, transport planners and policy makers are supported evaluating MaaS impacts and feasibility.

The journal articles published by Y. Zhang and Kamargianni (2023) and Arias-Molinares and García-Palomares (2020) are presented in Table 37. These are two of six scientific papers about MaaS. Table 37 and Table 38 are split to reduce the table size to one page and visualize corresponding journal articles close to descriptions.[48]

[47] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

[48] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Table 37: Mobility as a Service (MaaS) research: Part 1

Author(s)	Year	Title	Journal	Research method
Y. Zhang and Kamargianni	2023	A review on the factors influencing the adoption of new mobility technologies and services: autonomous vehicle, drone, micromobility and mobility as a service	Transport Reviews	Literature review
Arias-Molinares and García-Palomares	2020	The Ws of MaaS: Understanding mobility as a service from a literature review	IATSS Research	Literature review

Source: Own elaboration

Schikofsky et al. (2020) conduct a literature review on fundamental characteristics of MaaS. Based on this literature review, they apply qualitative interviews with potential end-users to identify motivational acceptance factors. Based on their inductive findings, they postulate a structural causal equation model to capture motivational mechanisms behind MaaS adoption intention. This model is quantitatively validated with a survey and partial least squares analysis.

Schikofsky et al. (2020) find relevance of psychological needs for acceptance of MaaS. Anticipated advantages of autonomy, competence, and the feeling of being related to a social peer group affect motivation and the expected usefulness of MaaS. Motivation and expected usefulness equally affect behavioral intention.

Furthermore, a theoretical construct is presented by Schikofsky et al. (2020). It describes that cognitive congruency between existing habits and anticipated usage patterns of MaaS significantly affect judgment and behavioral intention.

Butler et al. (2021) apply a systematic literature review and develop a conceptual framework presenting barriers and risks related to MaaS adoption in cities. They present three main findings. The first one is that MaaS is associated with increased trip awareness and improved social equity, but reduced parking, vehicle ownership, and number of vehicle kilometers. The second one refers to MaaS supply side barriers. These include public and private cooperation, business support, service coverage, shared vision, data, and cyber security. The third finding refers to demand side barriers. These are lacking acceptance of older generations, public transport users, and private vehicle users, perceived attractiveness of platforms, and user willingness to pay.

Hensher (2017) refers to hybrid multi-modal MaaS solution presenting positions that could potentially represent future contexts in which bus services might be offered. He finds that a hybrid multi-modal state of affairs possibly will be the most appealing new contract setting. Hybrid multi-modal transports require contract design to enable mode-neutral customer experience and the growing opportunity to focus on MaaS.

Ho et al. (2018) publish a stated choice study about the potential uptake and willingness to pay for MaaS. Their survey is conducted with 252 individuals administered via a face-to-face method in Sydney, Australia. They find that almost half of the sampled respondents would choose MaaS offerings. Potential uptake levels vary significantly across population segments. Infrequent car users are the most likely adopters, and car non-users the least likely adopters. Furthermore, they find that Sydney travelers value one-way car-share more than station-based car-share and are willing to pay € 5.02 for an hour of access to car-share. Sydney travelers willingness to pay for unlimited use of public transport is € 4.62 per day.[49]

Table 38 presents the remaining five of seven journal articles about MaaS. Experimental and quantitative research methods as well as mixed methods and literature reviews are applied in this field of research.

[49] Calculated from USD with the exchange rate (USD 1 = EUR 0.7838) provided by the European Central Bank on average between 09/04/2017 and 23/04/2017 according to the sample timeframe (European Central Bank, 2024).

Table 38: Mobility as a Service (MaaS) research: Part 2

Author(s)	**Year**	**Title**	**Journal**	**Research method**
Schikofsky et al.	2020	Exploring motivational mechanisms behind the intention to adopt mobility as a service (MaaS): Insights from Germany	Transportation Research Part A: Policy and Practice	Mixed methods
Butler et al.	2021	Barriers and risks of Mobility-as-a-Service (MaaS) adoption in cities: A systematic review of the literature	Cities	Experimental
Hensher	2017	Future bus transport contracts under a mobility as a service (MaaS) regime in the digital age: Are they likely to change?	Transportation Research Part A: Policy and Practice	Literature review
Ho et al.	2018	Potential uptake and willingness to pay for Mobility as a Service (MaaS): A stated choice study	Transportation Research Part A: Policy and Practice	Quantitative

Source: Own elaboration

4.1.3.4 Mobility innovation

Strain Modal Testing is an unconventional innovative approach majorly applied in the academic context. Falcetelli et al. (2022) research application opportunities of this approach in the automotive sector. They apply a case study using this approach to evaluate the modal properties of a strengthened composite roof of a racing solar powered automobile. Their research results in an overview of similarities and discrepancies between Strain Modal Testing and conventional approaches.

Referring to appearing technologies, Khan et al. (2022) describe trends upcoming with the automotive industry 5.0. They describe the relevance of 6G communications to provide robust, intelligent, and energy-efficient data sharing. In this context, they refer to two techniques relevant for 6G communication. These are nonorthogonal multiple access and backscatter communications.

Zheng et al. (2023) describe a high research interest on quasi-2D semiconductors due to their unique structural, mechanical, and transport properties. They investigate the relation between electron–phonon coupling and crystal symmetry in quasi-2D system. In this way, they make opportunities to develop high mobility semiconductors for electronic and energy conversion applications transparent.

Birenboim et al. (2023) apply a bottom-up approach as they analyze and characterize 347 tourism mobility apps. They conduct a factor analysis investigate tourist-oriented functionality, orientation and navigation, efficacy, effective mobility, social interaction, and activities. Their research results in a classification into four types of apps. These are mobility, navigation, interaction and experience, and social media apps.

Table 39 presents four journal articles about mobility innovation. The authors apply experimental and quantitative research methods.

Table 39: Mobility innovation research

Author(s)	Year	Title	Journal	Research method
Falcetelli et al.	2022	Strain Modal Testing with Fiber Bragg Gratings for Automotive Applications	Sensors	Experimental
Khan et al.	2022	NOMA-Enabled Backscatter Communications for Green Transportation in Automotive-Industry 5.0	IEEE Transactions on Industrial Informatics	Experimental
Zheng et al.	2023	Symmetry-Guaranteed High Carrier Mobility in Quasi-2D Thermoelectric Semiconductors	Advanced Materials	Experimental
Birenboim et al.	2023	A typology of tourism mobility apps	Tourism Management Perspectives	Quantitative

Source: Own elaboration

4.1.3.5 Innovation through Blockchain

Friedhoff et al. (2023) apply a quantitative research method to analyze the social acceptance for the utilization of Blockchain-based digital identities. They use a questionnaire-based survey with 324 German participants and find the following. Acceptance is significantly influenced by demographics, citizens' experience with Blockchain products, affinity with financial products, and privacy concerns.

Bhawana et al. (2024) propose a Blockchain Enabled Energy Trading framework oriented electric vehicle charging. This is because continuous power grid use causes a significant load on power grids. Bhawana et al. (2024) apply a comparative analysis. This analysis is performed with state-of-the-art works in terms of charging price, revenue, throughput, and latency. They find that their Blockchain Enabled Energy Trading framework outperforms compared to state-of-the-art works to address the renewable energy demand problem to realize E-mobility.

Paiva et al. (2021) apply a review the trends and solutions of smart mobility and corresponding enabling technologies. They provide an overview of how smart mobility fits into smart cities. They describe that Blockchain can provide citizens with a privacy preserved, transparent, and confidential architecture for mobility services. Blockchain-based Internet of Vehicles has different benefits as referred to in chapter 2.3. These are improvement of interaction and communication between vehicles, tracking, and smart city traffic management.

Table 40 lists these papers about Blockchain. The three journal articles include experimental and quantitative research methods as well as a technical literature review.

Table 40: Blockchain research

Author(s)	Year	Title	Journal	Research method
Friedhoff et al.	2023	Analysis of Social Acceptance for the Use of Digital Identities	Computers	Quantitative
Bhawana et al.	2024	BEET: Blockchain Enabled Energy Trading for E-Mobility Oriented Electric Vehicles	IEEE Transactions on Mobile Computing	Experimental
Paiva et al.	2021	Enabling technologies for urban smart mobility: Recent trends, opportunities and challenges	Sensors	Literature review

Source: Own elaboration

4.1.3.6 Innovation through Digital Twins

Piromalis and Kantaros (2022) describe the relevance of Digital Twins for the automotive industry. They find Digital Twins to be relevant from designing vehicles until the construction. Apart from this, Digital Twins can be helpful during the use of a car leading to a more enjoyable, comfortable, and safe experience for drivers. Especially for electric vehicles, Digital Twins are useful.

According to Mukherjee and DebRoy (2019), 3D printing is more relevant to niche markets than broader health care, automotive and aerospace industries. Reasons for this are high product cost and delay in the qualification. Mukherjee and DebRoy (2019) explain Digital Twin of the printing machine usage to reduce the number of trial and error tests. In this way, Digital Twin users can obtain desired product attributes and reduce the time needed for part qualification to make the printed components cost efficient. They conclude that comprehensive Digital Twin of 3D printing can reduce trial and error testing, defects, and shorten time between design and production. Preconditions are that Digital Twins of 3D printing machines consist of mechanistic, control and statistical models of 3D printing, machine learning and big data.

Qi et al. (2018) describe how manufacturing services and Digital Twins are united naming components of Digital Twin-related services which are used by manufacturers. They describe Digital Twins to provide an effective way for the cyber-physical integration of manufacturing. They add that combining smart manufacturing services and Digital Twins changes product design, manufacturing, usage, maintenance, repair, operations, and further processes. This results in more reasonable manufacturing planning and precise production control. As a result, smart manufacturing involves two-way connectivity between the virtual and physical worlds of manufacturing.

Schleich et al. (2017) describe that more realistic virtual models of manufactured products are necessary. Current models leave a gap between design and production and do not mirror the reality correctly in the virtual twins. Schleich et al. (2017) propose a reference model based on the concept of Skin Model Shapes. Skin Model Shapes acts as a Digital Twin of a physical product in design and manufacturing. In their model, they address conceptualization, representation, implementation, and applications along the product life cycle.

Digital Twin research is split to Table 41 and Table 42 to present one table per page and visualize corresponding journal articles close to descriptions. The journal articles presented include technical literature reviews and experimental research methods.

Table 41: Digital Twins research: Part 1

Author(s)	Year	Title	Journal	Research method
Piromalis and Kantaros	2022	Digital Twins in the Automotive Industry: The Road toward Physical-Digital Convergence	Applied System Innovation	Literature review
Mukherjee and DebRoy	2019	A digital twin for rapid qualification of 3D printed metallic components	Applied Materials Today	Experimental
Qi et al.	2018	Digital Twin Service towards Smart Manufacturing	Procedia CIRP	Literature review
Schleich et al.	2017	Shaping the digital twin for design and production engineering	CIRP Annals - Manufacturing Technology	Literature review

Source: Own elaboration

Stark et al. (2019) examine aspects of developing and operating Digital Twins under consideration of eight dimensions. These are integration breadth, connectivity modes, update frequency, Cyber-Physical Systems intelligence, simulation capabilities, digital model richness, human interaction, and product lifecycle. Stark et al. (2019) describe main benefits of Digital Twins to be digital monitoring as well as functional improvement of interconnected products, devices and machines. Moreover, they name advantages of horizontal and vertical manufacturing integration.

Anshari et al. (2022) apply an exploratory study to investigate robo-advisors with Digital Twin capabilities for personal finance. They develop an interactive and interpretive model integrating Digital Twin concepts and applications. Their model analyzes critical variables to the design of a next level financial robo-advisor. During their research process, Anshari et al. (2022) conduct an assessment, review the data, and then propose a model to provide an overview of future research perspectives.

The research conducted by Anshari et al. (2022) results in a concept of Digital Twin as the next frontier of robo-advisor. The objective is to provide intelligent financial advisors in supporting FinTech services and management personalization and customization. They find that robo-advisors enabled with Digital Twins will no longer be ad hoc but comprehensive and dynamic financial advisory services.

Botín-Sanabria et al. (2022) conduct a systematic literature review leading towards a comprehensive view on the Digital Twin technology. The results are Digital Twin implementation challenges, limits, and applications in engineering and other areas. They describe Digital Twins to enable data-driven decision making, complex systems monitoring, product validation, simulation, and object lifecycle management. Digital Twins collect information from the real environment and represent, validate, and simulate present and future behavior.

Martínez-Olvera (2022) applies a literature review about concepts related to the role of Digital Twins in the realization of mass customization in an Industry 4.0 environment. He describes Digital Twins for synchronization of the physical and digital world to enable addressing mass customization. He describes the objective of mass customization to be achieving the highest level of customer satisfaction and optimization of the value creation process. Mass customization in the context of Industry 4.0 is referred to as mass customization 4.0. Mass customization 4.0 success depends on the degree of sustainability.

Qian et al. (2022) describe the Internet of Things to connect smart devices to collect big data, monitor, and control numerous objects in cyber-physical systems. They add the relevance of Digital Twins as digital clones of physical systems due to a risk of manipulating or updating real systems. Qian et al. (2022) name a Digital Twin challenge that it is a complex digital system. Effectively represent a variety of things timely and efficient presents challenges to networking, computing, and data analytics for the Internet of Things. Moreover, design requirements like latency, reliability, safety, scalability, security, and privacy occur to be challenging. To address these challenges, Qian et al.

(2022) review the architectures of Digital Twins, data representation, and communication protocols. Then they review existing efforts on applying Digital Twins into Internet of Things data-driven smart systems. As smart systems, they include smart grid, smart transportation, smart manufacturing, and smart cities. Next, they conclude challenges of cyber-physical systems, data science, optimization, security, and privacy.

Table 42 presents further five journal articles about Digital Twins. They include scholarly and technical literature reviews.

Table 42: Digital Twins research: Part 2

Author(s)	Year	Title	Journal	Research method
Stark et al.	2019	Development and operation of Digital Twins for technical systems and services	CIRP Annals - Manufacturing Technology	Literature review
Anshari et al.	2022	Digital Twin: Financial Technology's Next Frontier of Robo-Advisor	Journal of Risk and Financial Management	Literature review
Botín-Sanabria et al.	2022	Digital Twin Technology Challenges and Applications: A Comprehensive Review	Remote Sensing	Literature review
Martínez-Olvera	2022	Towards the Development of a Digital Twin for a Sustainable Mass Customization 4.0 Environment: A Literature Review of Relevant Concepts	Automation	Literature review
Qian et al.	2022	Digital Twin—Cyber Replica of Physical Things: Architecture, Applications and Future Research Directions	Future Internet	Literature review

Source: Own elaboration

4.1.3.7 Supply Chain Management in the automotive sector

As a response to global supply chain disruptions, Muhammad et al. (2022) apply an interpretive structural modelling approach to discuss the role of additive manufacturing. They refer to additive manufacturing as a method to handle supply chain disruptions and boost resilience in supply chains. In this context, they discuss barriers of additive manufacturing usage and propose suggestions for applying additive manufacturing.

Saha et al. (2023) refer to logistics systems to meet the automotive sector's requirements. These are, for example, just-in-time, lean and agile supply chain operations, productivity, and sustainability. To identify the best warehouse location for the automotive manufacturing company, they define two approaches. They find that energy availability and cost as well as the proximity to port and customs criterion are the most crucial factors.

An overview of these research articles is presented in Table 43. Muhammad et al. (2022) apply a case study and Saha et al. (2023) use a mixed methods approach.

Table 43: Supply Chain Management in the automotive sector research

Author(s)	Year	Title	Journal	Research method
Muhammad et al.	2022	Potential of additive manufacturing for upstream automotive supply chains	Supply Chain Forum	Case study
Saha et al.	2023	Warehouse site selection for the automotive industry using a fermatean fuzzy-based decision-making approach	Expert Systems with Applications	Mixed methods

Source: Own elaboration

4.1.3.8 Relevance of sustainability in the mobility sector

Mathivathanan et al. (2022) apply a Matrix Multiplication Applied to Classification analysis for the Indian automotive industry. This is because they describe a high pressure for the adoption of sustainability in Indian automotive supply chains. They find different influence factors towards pressure for sustainable supply chain management adoption. The main ones are government regulations, benefits of social and environmental certifications, and the interests of the foreign investors in sustainable product development.

Golroudbary et al. (2022) refer to the transportation sector being responsible for the largest share of greenhouse gas emissions in 2019. They investigate the use of magnesium for lightweight vehicle introduction. In this context, they discuss that in comparison to steel and aluminum, the energy consumption and emissions from magnesium primary production are higher. Their research results in a quantification of environmental benefits considering circular economy strategies.

Ketter et al. (2023) develop an information systems research framework for smart sustainable mobility. They describe appearing connected, autonomous, shared, and electric vehicle technology which has created a digital layer in addition to traditional physical mobility system. The layered modular architecture equals other cyber-physical systems, but there are characteristics and challenges which are mobility-specific and require new solution approaches. To meet these challenges, Ketter et al. (2023) recommend information systems research to deliver a smart sustainable mobility ecosystem.

Kakderi et al. (2021) analyze 60 initial policy responses related to urban mobility from cities around the world. They find that emerging strategies are transformational, even though they are mainly temporary. Moreover, they are consistent with the principles of smart growth and sustainable development.

Journal articles referring to the relevance of sustainability in the mobility sector are listed in Table 44. The authors apply quantitative and qualitative research methods and a literature review.

Table 44: Relevance of sustainability in the mobility sector research

Author(s)	Year	Title	Journal	Research method
Mathivathanan et al.	2022	Modeling the pressures for sustainability adoption in the Indian automotive context	Journal of Cleaner Production	Quantitative
Golroudbary et al.	2022	Magnesium Life Cycle in Automotive Industry	Procedia CIRP	Quantitative
Ketter et al.	2023	Information Systems Research for Smart Sustainable Mobility: A Framework and Call for Action	Information Systems Research	Literature review
Kakderi et al.	2021	Smart and resilient urban futures for sustainability in the post covid-19 era: A review of policy responses on urban mobility	Sustainability (Switzerland)	Qualitative

Source: Own elaboration

4.1.3.9 Research gap derived from state of research

It can be concluded that research analyzes CVC, sustainability, and the mobility sector. S. M. Lee et al. (2015) analyze the influence of CVC on knowledge transfer in the US, but do not analyze the correlation in Europe.[50]

Moreover, it is found that CVC can benefit innovation performance leading to an achievement of CSR activities under the condition that the innovations are CSR focused (Bos-Brouwers, 2010; J. J. Li et al., 2021; Wadhwa et al., 2016). But it is not an-

[50] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

alyzed yet if there is a real correlation apart from the possibility of supporting CSR.[51]

The relationship between CSR and financial performance is analyzed in detail in scientific literature. It is found that there is a circular relationship, but the relationship is not understood in detail yet (Awaysheh et al., 2020; T. T. Li et al., 2021; Nirino et al., 2020). An analysis of CVC to create sustainability knowledge in the mobility sector contributes to understand this indirect relationship.[52]

4.2 Sample and research settings

A quantitative approach is applied in the present doctoral dissertation as visualized at the beginning of chapter 4 in Figure 21. The influence of CVC investment on investors' knowledge creation is analyzed with a negative binomial Poisson regression model. Successful patent applications are considered for operationalization of generated knowledge.

After a general analysis of European investors, this investigation is applied to the mobility sector and analyzed with a special focus on sustainable patents. In the following, sample, applied variables, and the applied model are described.

4.2.1 Sample

To ensure the availability and reliability of the database, company data is collected from the capital market. Data sources for include Bloomberg, Refinitiv, Standard & Poor's (S&P) Capital IQ, European Patent Office, LexisNexis, Company Websites, Google, and annual reports.

This analysis is focused on the period from 2000 to 2022 as presented in Figure 25. After investing, invention creation and patent application need time. In this analysis, the five years after an investment are analyzed. Thus, patent application is analyzed during the whole investigation period whereas investments are only analyzed between 2000 and 2017 to leave time until 2022 for patent application. The sample consists of 46

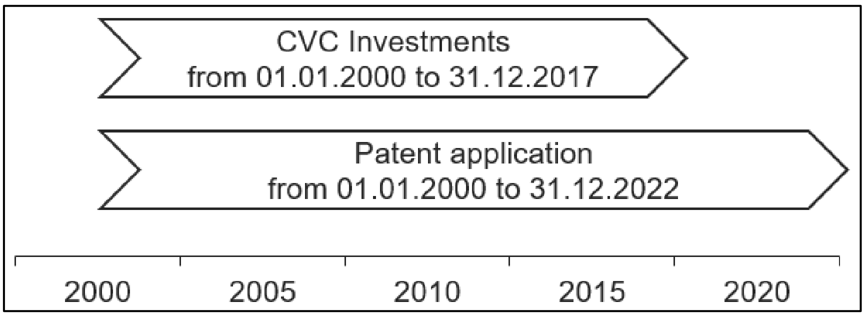
[51] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

[52] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

STOXX Europe 600 indexed companies that invested during this timeframe resulting in 215 firm-year observations (S. M. Lee et al., 2015; Wooldridge, 2019).[53]

The population quantification is limited due to fact that not all CVC investments of European companies are tracked. Thus, STOXX Europe 600 companies are defined as the population which equals the sample. The limitation of the transferability to other European companies is described in chapter 4.5.1.2 (S. M. Lee et al., 2015; Nirino et al., 2022; Wooldridge, 2019).[54]

Figure 25: Data analysis time frames



Source: Own elaboration

The additional analysis of the mobility sector is chosen for different reasons. This industry is relevant to the European economy and transforming due to ecological and social requirements. Moreover, there is a systematical patenting activity in place in case of knowledge creation in the mobility sector to protect intellectual property. Since patenting data is used as the dependent variable in this paper, the mobility sector reflects an industry for which the chosen method is applicable (Blind et al., 2022; European Automobile Manufacturers' Association, 2024; Großmann et al., 2016; Patra & Raju, 2020).

Companies belonging to the mobility sector have been detected through an analysis of the keyword mobil* in their Refinitiv corporate descriptions and on their websites. Past analysis was not possible so that the company description was pulled from Refinitiv on

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[54] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

28.02.2023 and websites were analyzed on 15.04.2023. This approach is limited because not all keywords (e.g., auto*) can be included and mobil* could also relate to other terms (e.g. mobile phone). Thus, an additional manual search of all websites is applied by the author. Based on the number of keyword appearances in corporate descriptions and on investors' websites, companies are classified to belong to the mobility sector. This approach also includes automotive suppliers.

4.2.2 Applied variables

In the following, independent, dependent, and control variables are described. The choice of these variables is oriented towards the study carried out by S. M. Lee et al. (2015) analyzing the influence of CVC on knowledge transfer in the US. To apply the approach to the European market, appropriate databases are chosen and the analysis has been expanded under consideration of further research, e.g., Dushnitsky & Yu (2022), Fels et al. (2021), K. Lee et al. (2023), and Wadhwa & Kotha (2006).[55]

4.2.2.1 Independent variable

An overview of the independent and dependent variables is provided in Table 45. According to S. M. Lee et al. (2015), the number of CVC investments is the number of unique startups invested in by a mobility company. This definition is applied in the methodology of this doctoral dissertation.[56]

If no investment is made during a year, 0 is assigned. This approach is also based on S. M. Lee et al. (2015). Investments are not limited to sustainable investments because non-sustainable investments can result in sustainable solutions (e.g., energy investment can result in sustainable solution development).[57]

The database used for European investments is Refinitiv. Corporate investors can be subsidiaries of STOXX Europe 600 indexed companies. To assign corporate investors

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[56] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.
[57] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

to STOXX Europe 600 indexed companies, the S&P Capital IQ database is used (S&P Global Market Intelligence, 2024).

4.2.2.2 Dependent variable

The knowledge creation rate is operationalized in this doctoral dissertation as the annual count of successful patent applications. Different authors of scientific research apply patent measures as a proxy for the knowledge creation (Ahuja, 2000; K. Lee et al., 2023; S. M. Lee et al., 2015; Wadhwa & Kotha, 2006). In their investigation of the US information and communication technology industry, S. M. Lee et al. (2015) investigate startups' patents cited by the corporate investor. This approach is enlarged in this paper by an additional investigation of successful joint patent applications of the startup and the investor.[58]

The years 2000 to 2022 are analyzed. For consistency, comparability, and reliability reasons, patents granted in the EU are used. The patent data is obtained from Espacenet via the global patent data aggregator IFI CLAIMS Patent Services through Quant IP. Espacenet is the database provided by the European Patent Office. This patent database provides detailed information on patents in the EU. These patents are granted by the European Patent Office (European Patent Office, 2024; Grander et al., 2021; IFI CLAIMS Patent Services, 2023; Kater et al., 2022; Quant IP, 2024).

Patents are aggregated on patent family level according to the European Patent Office identifier. The invention date is defined to be the first publication date of the patent family (European Patent Office, 2017).

The child companies (e.g., R&D unit) belonging to certain corporations are connected using corporate trees from S&P Capital IQ database. In this context, the year of parent company assignment is considered to ensure the corporate family tree was valid in the year of analysis (S&P Global Market Intelligence, 2024) .

The classification of sustainable patents is made according to classification codes of the International Patent Classification Green Inventory. This model is developed by searches for patent information relating to Environmentally Sound Technologies, as

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listed by the United Nations Framework Convention on Climate Change (World Intellectual Property Organization, 2023a).

Table 45: Operationalization of independent and dependent variables

Variable	Description	Abbreviation	Measurement	Database
Independent	# of CVC investments	INV/ MINV	Description	Refinitiv
Dependent (Model A)	Amount of knowledge transferred through the CVC investment	PATJ/ MPATJ/ GPATJ MGPATJ	# of startup (green) patents registered together with the corporate investor from t~t+5	Espacenet
Dependent (Model B)	Amount of knowledge transferred through the CVC investment	PATC/ MPATC/ GPATC/ MGPATC	# of startup patents cited in corporate investor's (green) patents from t~t+5	Espacenet

Source: Own elaboration

4.2.2.3 Control variables

Knowledge Diversity is measured as entropy over class distribution. The International Patent Classification code consists of different levels. The class level consisting of three digits is used to measure this entropy (World Intellectual Property Organization, 2023a, 2023b).

The age of the corporation and of the CVC investing unit can influence intellectual property creation. To calculate the age, the firm investor founded year is deducted from the investment year. The investment dates are extracted from Refinitiv and the investor founded year is extracted from Bloomberg (S. M. Lee et al., 2015). As the databases do not match completely, the calculation result is negative in three percent of the data points. This means that the investment date is before the founding date. Such negative data points are excluded from the analysis.[59]

Company size can influence knowledge creation positively or negatively causing differences in patent creation. The company size of all STOXX Europe 600 companies is operationalized as net sales of the corresponding investment year provided by Bloomberg.

R&D expenses also influence new innovations and intellectual property creation leading to new patents. The R&D expenses of all STOXX Europe 600 companies in the corresponding investment year are provided by Bloomberg.

Knowledge relatedness of a corporate investor and the portfolio company also influence knowledge creation. Sears et al. (2022) find industry relatedness of startup and corporate investor to influence startup concerns towards CVC and therefore knowledge transfer opportunities. To analyze the relatedness, the North American Industry Classification System (NAICS) codes of the corporate investor and the portfolio company are compared. The relatedness is considered in case that the code assignment of CVC investor and startup are matching. Refinitiv is used as database for industry relatedness (Fels et al., 2021; S. M. Lee et al., 2015; Wadhwa & Kotha, 2006).[60]

[59] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.
[60] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Table 46: Operationalization of control variables

Variable	Description	Abbreviation	Measurement	Database
Control	Knowledge diversification	DIV/MDIV	Entropy over class distribution of corporate investor technology t-1~t-4	European Patent Office
Control	Age of corporate investor	AGE/ MAGE	(Year of investment CVC-1)-year founded	Refinitiv
Control	Size of corporate investor	SIZE/ MSIZE	Sales record of corporate investor in t-1	Bloomberg
Control	R&D intensity	RD/MRD	R&D expenditures on sales of corporate investor in t-1	Bloomberg
Control	Relationship to industry	INDC/ MINDC	North American Industry Classification System (NAICS) code equal for investor and investee	Refinitiv

Source: Own elaboration

4.2.2.4 Firm-year observation conclusion

The firm-year observations are concluded on corporate and year level to assign the number of investments per year. To enable this conclusion, the average of investment-specific control variables is built. Investment-specific variables are industry relatedness between investee and investor, investor age on investment date, and investor knowledge diversity (S. M. Lee et al., 2015).[61]

[61] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

An exception is made for the number of patents as it is the dependent variable. The co-published patents and the corporate patents with startup citations are displayed as the sum per number of investments of a corporation per year (S. M. Lee et al., 2015).[62]

4.2.3 Model and estimation

4.2.3.1 Model description

A non-linear binomial Poisson regression model is used according to S. M. Lee et al. (2015) and based on statistical measures described by Wooldridge (2019). The dependent variable is the number of patents registered.[63]

In Model A, the number of startup patents cited by corporate investors is analyzed. The citations from all documents belonging to a patent family are concluded on patent family level. In Model B, the number of startup patents registered together with the corporate investor is analyzed. This approach is repeated in the models C and D for sustainable patents. These four combinations are applied in the models E to H for the mobility sector.

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[63] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Table 47: Regression model differentiation

Model	Hypothesis	Patents registered jointly	Startup cited in Investor's patent	Only investors with mobility focus included	Only green patents included
Model A	H1	Yes	-	-	-
Model B	H2	-	Yes	-	-
Model C	H3	Yes	-	-	Yes
Model D	H4	-	Yes	-	Yes
Model E	H5	Yes	-	Yes	-
Model F	H6	-	Yes	Yes	-
Model G	H7	Yes	-	Yes	Yes
Model H	H8	-	Yes	Yes	Yes

Source: Own elaboration

In accordance with S. M. Lee et al. (2015) and according to the models presented in Table 47, H1 to H8 are formulated.[64] The corresponding hypothesis and null hypothesis of each model are listed in the following:

H1: The number of CVC investments is positively related to the level of knowledge transferred **between** investee and corporate investor.

Model A H1: **PATJ**~INV+DIV+AGE+SIZE+RD+INDC

Model A H0: **PATJ**~DIV+AGE+SIZE+RD+INDC

[64] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

H2: The number of CVC investments is positively related to the level of knowledge transferred **from** the investee to the corporate investor.

Model B H2: **PATC**~INV+DIV+AGE+SIZE+RD+INDC

Model B H0: **PATC**~DIV+AGE+SIZE+RD+INDC

H3: The number of CVC investments is positively related to the level of **green** knowledge transferred **between** investee and corporate investor.

Model C H3: **GPATJ**~INV+DIV+AGE+SIZE+RD+INDC

Model C H0: **GPATJ**~DIV+AGE+SIZE+RD+INDC

H4: The number of CVC investments is positively related to the level of **green** knowledge transferred **from** the investee to the corporate investor.

Model D H4: **GPATC**~INV+DIV+AGE+SIZE+RD+INDC

Model D H0: **GPATC**~DIV+AGE+SIZE+RD+INDC

H5: The number of CVC investments is positively related to the level of knowledge transferred **between** investee and **mobility** corporate investor.

Model E H5: **MPATJ**~INV+DIV+AGE+SIZE+RD+INDC

Model E H0: **MPATJ**~DIV+AGE+SIZE+RD+INDC

H6: The number of CVC investments is positively related to the level of knowledge transferred **from** the investee to the **mobility** corporate investor.

Model F H6: **MPATC**~INV+DIV+AGE+SIZE+RD+INDC

Model F H0: **MPATC**~DIV+AGE+SIZE+RD+INDC

H7: The number of CVC investments is positively related to the level of **green** knowledge transferred **between** investee and **mobility** corporate investor.

Model G H7: **MGPATJ**~INV+DIV+AGE+SIZE+RD+INDC

Model G H0: **MGPATJ**~DIV+AGE+SIZE+RD+INDC

H8: The number of CVC investments is positively related to the level of **green** knowledge transferred **from** the investee to the **mobility** corporate investor.

Model H H8: **MGPATC**~INV+DIV+AGE+SIZE+RD+INDC

Model H H0: **MGPATC**~DIV+AGE+SIZE+RD+INDC

4.2.3.2 Model quality

The analysis has been applied using the software “RStudio”. To improve model quality, certain activities have been applied. As the negative binomial Poisson regression model usually does not provide R-squared output, the McFadden's R-squared calculation has been applied. It is defined as the log-likelihood for the model divided by the log-likelihood with only an intercept as the independent variable (Helbing et al., 2019). The result is usually between 0 and 1 (Ugba & Gertheiss, 2023). Anyway, the application to the models in this doctoral thesis provide results larger than 3 showing that the McFadden's R-squared is not applicable due to data or calculation error, model specifications, or an R software issue (Wooldridge, 2019).

To evaluate the model quality without McFadden's R-squared, the Log-likelihood and Wald test are interpreted. A detailed overview of the Log-likelihood and Wald test results is provided in chapter 4.3.3.4 (Wooldridge, 2019).

Data are plotted to evaluate the model quality. The scatterplots of the fitted values and residuals if provided in Appendix 1 to Appendix 8. Scatter around zero is interpreted as comparably well. It was tested to remove outliers from the model. As this did not improve the model quality, they are kept as part of the model (Wooldridge, 2019).

4.3 Research results and hypotheses

The research results are described in the following referring to correlations, significance based on p-values, coefficients, degrees of freedom, Log-likelihood, and Wald test results. Furthermore, the relation between the independent and dependent variable is plotted to visualize and verify the statistical results.

Descriptive statistics and correlation results as well as negative binomial regression results are split according to the models. First, models A to D are described as cross-industry analyzes with statistical results presented in Table 48 and Table 49. After this, models E to H are described as they refer to the mobility sector and statistical results are presented in Table 50 and Table 51. The description of each model's results is followed by a comparison between the models including a comparison of model quality.

4.3.1 Cross-sector results: Models A to D

Table 48 provides an overview of descriptive statistics including the mean and standard deviation as well as correlations of the models A to D. The first four variables presented in this table are the dependent variables according to the models A to D. The mean shows that there is a higher number of general patents than green patents included in the models. Moreover, a higher standard deviation is visible for general patents than for green patents. It is also visible that there is a higher mean of investor patents with startup citations than patents registered jointly by startup and investor.

Variable 5 is the independent variable with a mean of 4.26 investments per company and per year and a standard deviation of 5.53. The correlation between the independent and dependent variable is described in this chapter referring to each model.

The variables 6 to 10 are moderating and control variables which are also considered in the analysis. It is visible that there is no more than 20 percent correlation with the dependent variables. R&D intensity has a 34 percent correlation with the number of CVC investments, the independent variable. It can be derived that an indirect relationship between the R&D intensity and the dependent variables of the models is possible but showing direct correlations between -2 percent and 13 percent.

Table 48: Model A to D Descriptive statistics and correlations

Variable	Abbre-viation	Mean	SD	1	2	3	4	5	6	7	8	9
1 # of patents registered jointly	PATJ	1,63	11,68									
2 # of investor patents with startup citations	PATC	20,97	126,62	0,97								
3 # of green patents registered jointly	GPATJ	0,53	2,53	0,66	0,50							
4 # of green investor patents with startup citations	GPATC	6,42	23,03	0,87	0,91	0,59						
5 # of CVC investments	INV	4,26	5,53	0,31	0,32	0,41	0,40					
6 Knowledge diversification	DIV	1,01	0,34	-0,06	-0,06	-0,05	-0,05	-0,20				
7 Age of corporate investor	AGE	36,61	44,83	-0,07	-0,12	-0,12	-0,04	-0,19	0,00			
8 Size of corporate investor	SIZE	41683,96	53992,85	-0,02	-0,05	-0,05	0,00	-0,08	0,27	-0,09		
9 R&D intensity	RD	1208,87	2990,20	-0,02	0,02	0,02	0,13	0,34	-0,14	0,19	0,07	
10 Relationship to industry	INDC	0,15	0,27	0,10	0,09	0,20	0,16	0,24	-0,03	-0,08	-0,01	0,26

Source: Own elaboration

For the models A to D, Table 49 shows the negative binomial regression results. It includes coefficients, p-values, the degrees of freedom, log-likelihood, and Wald test of each model. The models have 137 degrees of freedom and a log-likelihood between -168.2810 and -785.7830. A higher log-likelihood is interpreted as better fitting the observed data than a lower log-likelihood (Dörnemann, 2023; Wooldridge, 2019). This indicates that Model C has the highest model quality.

The Wald test is applied to evaluate the significance of the independent variable. The values displayed in Table 49 refer to the null hypothesis. Model A H1 and H0, for example, are the following as described for all models in chapter 4.2.3:

Model A H1: PATJ~INV+DIV+AGE+SIZE+RD+INDC

Model A H0: PATJ~DIV+AGE+SIZE+RD+INDC

The results indicate F-statistics between 19.331 for Model C H0 and 48.779 for Model B H0 indicating the lowest model quality in Model B H0. This corresponds with the log-likelihood results. It is derived that Model B has the highest models quality and the lowest model quality for the null hypothesis. The p-values below 0.001 for the F-statistics of all models are significant. It is derived that there is significant evidence to reject the null hypothesis that the coefficient for "INV" is zero in Models A to D. A general and detailed comparison between the models including model quality is provided in this chapter after separate descriptions of the model results.

Table 49: Model A to D negative binomial regression results

Variables	Abbreviation	Model A	Model B	Model C	Model D
1 # of CVC investments	INV	2.728e-01***	2.248e-01***	2.149e-01***	1.707e-01***
2 Knowledge diversification	DIV	4.767e-01	3.356e+00***	2.418e-01	3.152e+00***
3 Age of corporate investor	AGE	1.327e-02*	1.188e-02***	6.121e-03	1.231e-02*
4 Size of corporate investor	SIZE	-1.123e-05	-7.841e-06**	-6.178e-06	-2.075e-06
5 R&D intensity	RD	-5.490e-05	6.701e-05.	-6.337e-05	7.323e-05
6 Relationship to industry	INDC	1.590e-01	1.168e+00	1.221e+00	1.400e+00
df		137	137	137	137
Log-likelihood		-240.1250	-785.7830	-168.2810	-573.4610
Wald test		31.337***	48.779***	19.331***	20.678***
	Significance codes: ***p<0.001; **p<0.01; *p<0.05; .p<0.1				

Source: Own elaboration

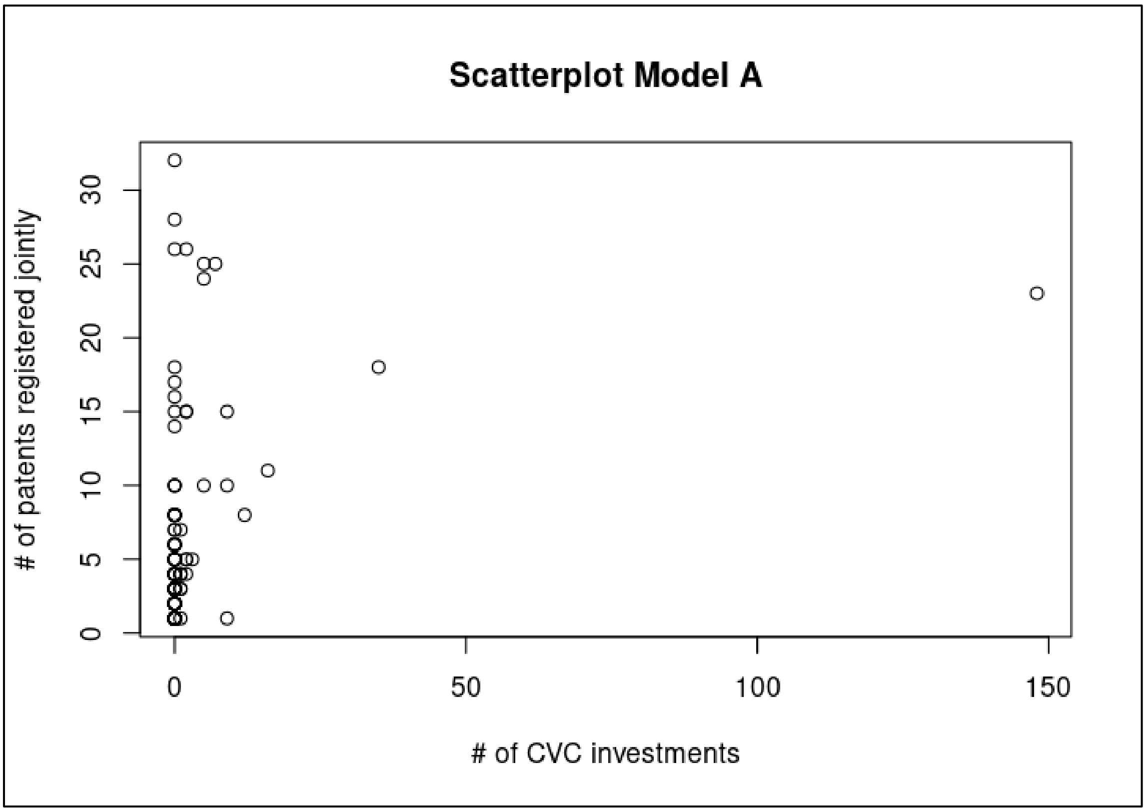
4.3.1.1 Model A descriptive statistics, correlations, and regression results

H1 states that *the number of CVC investments is positively related to the level of knowledge transferred between investee and corporate investor.* Table 48 shows a correlation of 31 percent between the number of CVC investments and the level of knowledge transferred between investee and corporate investor operationalized as the number of patents registered jointly. With a p-value below 0.001 of the independent variable, Table 49 shows a significant influence of the number of CVC investments on the level of knowledge transferred. The coefficient is 2.728e-01.

The relationship between the number of CVC investments and the number of patents registered jointly by the investor and investee company is plotted in Figure 26. The visualization supports the statistic finding that the number of CVC investments and the level of knowledge transferred between investee and corporate investor are positively related. It is visible that knowledge can also be transferred without investments, but there is a tendency towards more jointly registered patents if the number of CVC investments is higher. Most companies considered in this thesis invest up to 20 times per year with exceptions visualized in Figure 26. The exclusion of these exceptions from the model did not improve the model quality.

It can be concluded that H1 is supported. Furthermore, the age of corporate investor is significant with a p-value below 0.05. The variables knowledge diversification, size of corporate investor, R&D intensity, and relationship to industry are not significant in model A. They have been kept in the model because leaving them out did not improve the model quality.

Figure 26: Model A scatterplot of dependent and independent variable



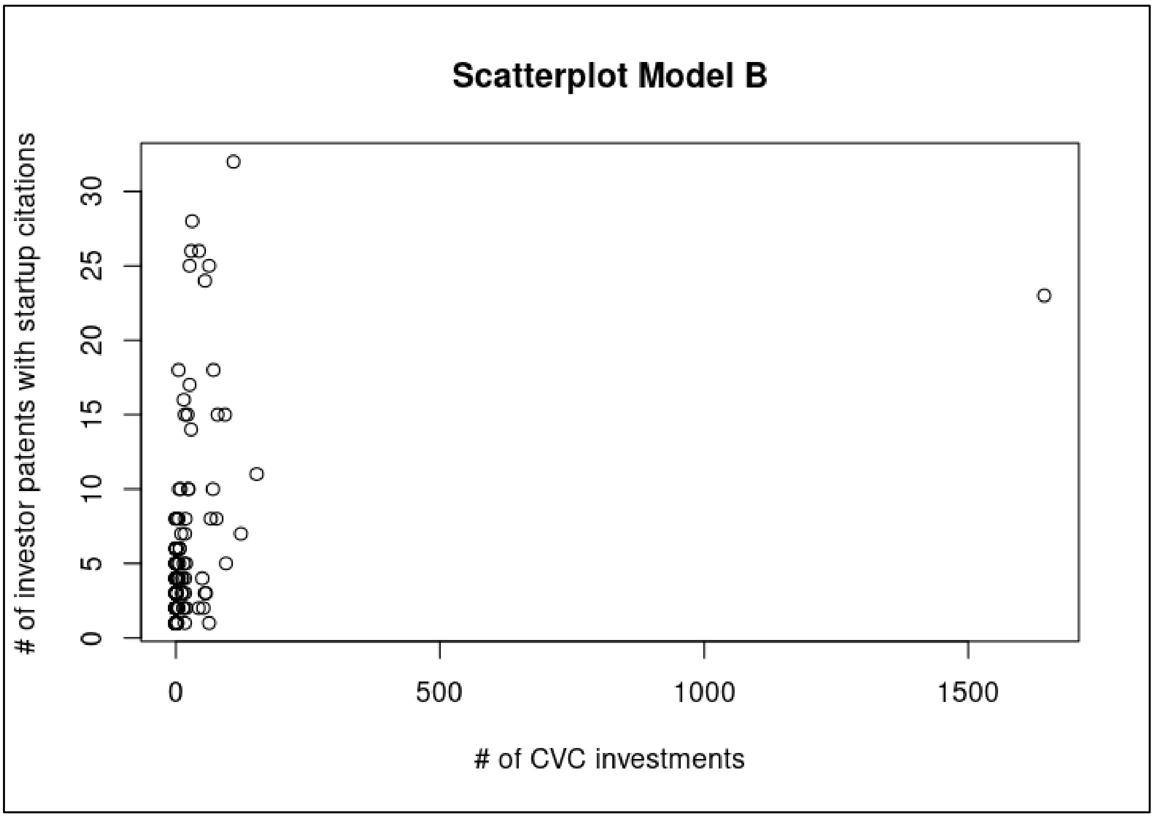
Source: Own elaboration

4.3.1.2 Model B descriptive statistics, correlations, and regression results

According to H2, *the number of CVC investments is positively related to the level of knowledge transferred from the investee to the corporate investor*. As presented in Table 48, a 32 percent correlation exists between the number of CVC investments and the number of investor patents with startup citations. Furthermore Table 49 shows a significant relation between the independent and dependent variable with a p-value below 0.001 with 2.248e-01 as the coefficient. It can be derived that H2 is supported.

Figure 27 visualizes this relationship and underlines the statistical results. Most investors who cited startups in their patents made between 0 and 200 investments and there is a higher number of patents with startups cited by the investor than patents registered jointly. This shows that knowledge transfer is possible to companies with investment units even if they do not invest. Furthermore, a higher number of investments tend to increase the number of investor patents with investee citations. The elimination of one exceptional investor who invested more than 1600 times in one year did not increase the model quality. Thus, this investment is kept as part of Model B. Furthermore, the variables knowledge diversification and age of corporate investor are significant in this model with a p-value below 0.001, the size of corporate investor with a p-value below 0.01 and the R&D intensity with a p-value below 0.1. The relationship to industry is not significant. Removing the relationship to industry from the model did not lead to an improvement of the model quality.

Figure 27: Model B scatterplot of dependent and independent variable



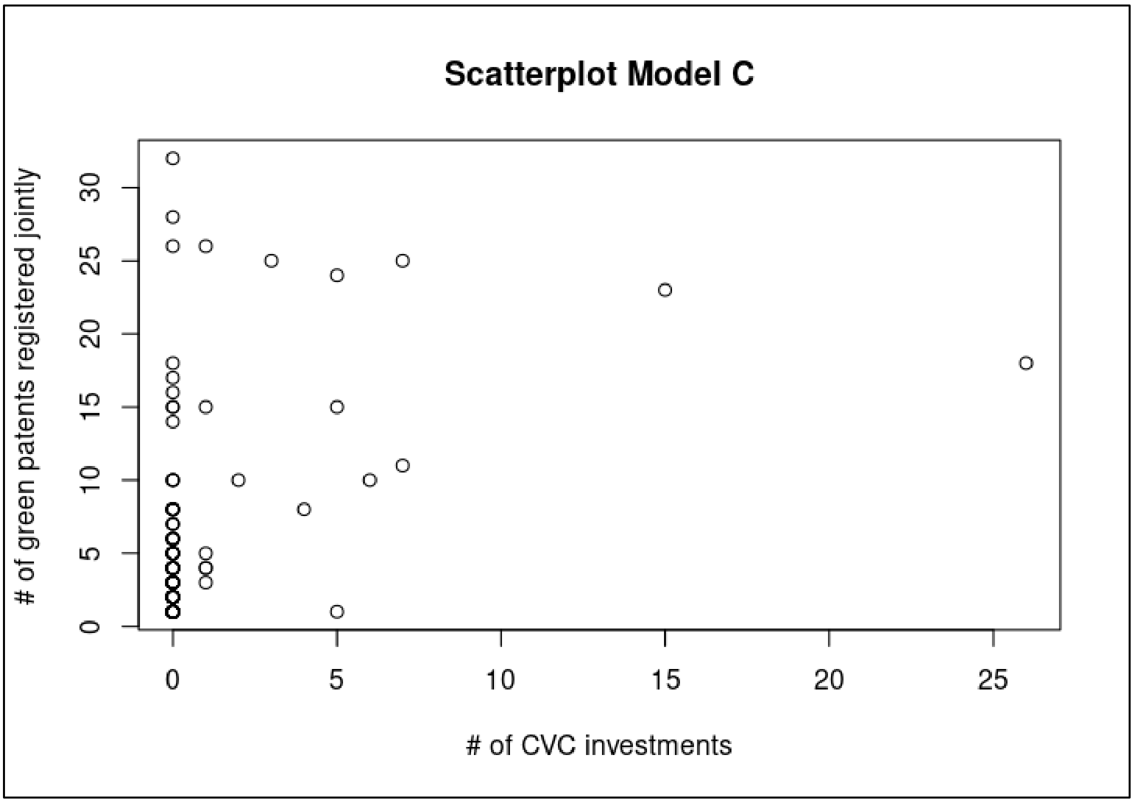
Source: Own elaboration

4.3.1.3 Model C descriptive statistics, correlations, and regression results

H3 states that *the number of CVC investments is positively related to the level of green knowledge transferred between investee and corporate investor.* Table 48 presents a 41 percent correlation between the number of CVC investments and the level of green knowledge transferred between investee and corporate investor operationalized as the number of green patents registered. This correlation is underlined by the negative binomial regression results in Table 49. A p-value below 0.001 shows a significant relation between the independent and dependent variable with 2.149e-01 as the coefficient.

Figure 28 visualizes this relationship and underlines that H3 can be supported. Moreover, it shows that knowledge can be transferred to companies with CVC units even if they do not invest in a certain year. In model C, no variable apart from the independent variable is significant but removing other variables did not increase the model quality.

Figure 28: Model C scatterplot of dependent and independent variable



Source: Own elaboration

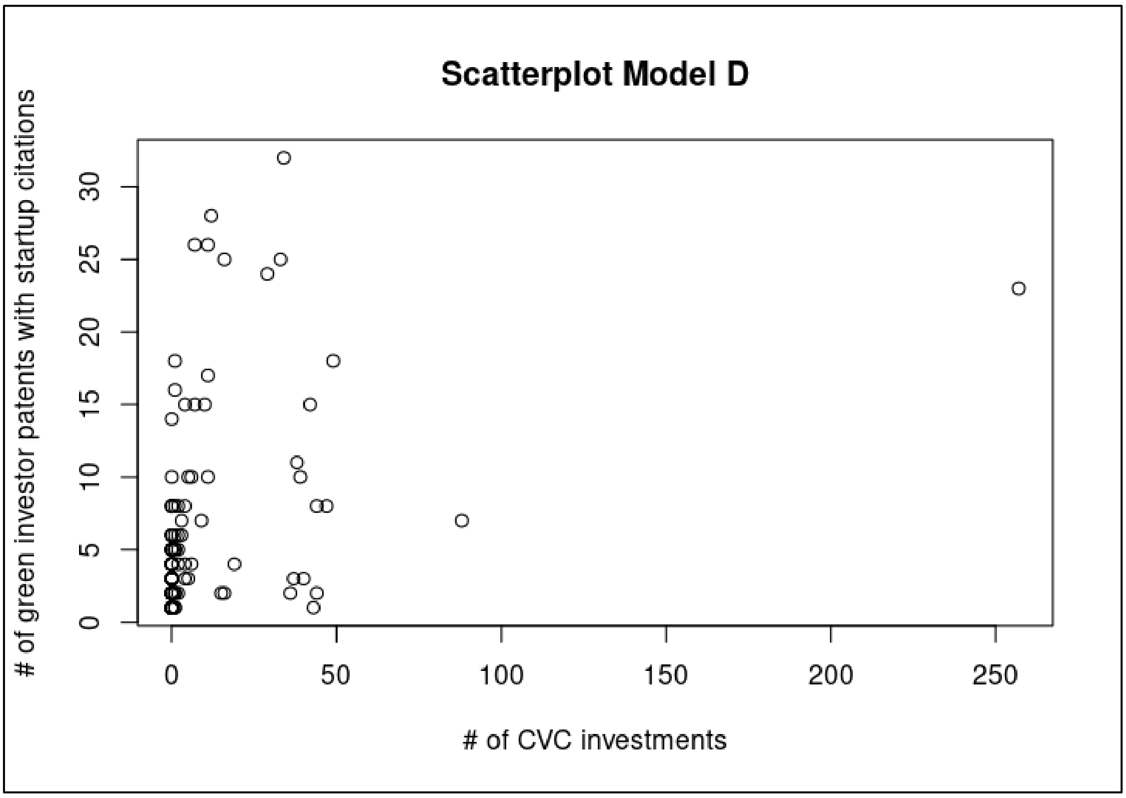
4.3.1.4 Model D descriptive statistics, correlations, and regression results

Model D is applied to analyze H4, if *the number of CVC investments is positively related to the level of green knowledge transferred from the investee to the corporate inves-*

tor. Table 48 shows a 40 percent correlation between the number of CVC investments and the number of green investor patents with startup citations. A p-value below 0.001 shows a significant relation between the independent and dependent variable with 1.707e-01 as the coefficient as presented in Table 49.

Figure 29 visualizes that a part of the number of green investor patents with startup citations can be explained by the number of CVC investments and emphasizes that according to the statistical results, H4 can be supported. Apart from the number of CVC investments, the knowledge diversification is significant with a p-value below 0.001 and the age of the corporate investor is significant with a p-value below 0.05. Investor size, R&D intensity, and industry relatedness are not significant. They have been kept as part of Model D because a removal did not increase the model quality.

Figure 29: Model D scatterplot of dependent and independent variable



Source: Own elaboration

4.3.2 Mobility sector results: Models E to H

An overview of descriptive statistics including the mean and standard deviation as well as correlations for the models E to H is provided in Table 50. Variables 1 to 4 are the dependent variables according to the models E to H. Like the models A to D, the mean and standard deviation are higher for the number of general patents than green patents included in the models. A higher mean of investor patents with startup citations than patents registered jointly by startup and investor is also visible similar to the models A to D.

The number of mobility company CVC investments is the independent variable shows a mean of 2.46 investments per mobility company and per year and a standard deviation of 2.01. Correlations are described in detail this thesis referring to each model.

The variables moderating and control variables 6 to 10 have a maximum correlation of 17 percent with the dependent variable in the models E to G. In model H, the independent variable indicates a 21 percent correlation with the dependent variable whereas the variable knowledge diversification indicates the same degree of correlation with 21 percent. The R&D intensity correlates with the number of green investor patents with startup citations in the mobility sector by 46 percent. The impact of this correlation on the model is discussed during this doctoral thesis.

Table 50: Model E to H Descriptive statistics and correlations

Variable	Abbre-viation	Mean	SD	1	2	3	4	5	6	7	8	9
1 # of patents registered jointly	MPATJ	0,27	1,83									
2 # of investor patents with startup citations	MPATC	7,17	22,82	0,74								
3 # of green patents registered jointly	MGPATJ	0,13	0,81	0,99	0,75							
4 # of green investor patents with startup citations	MGPATC	3,01	9,62	0,43	0,74	0,46						
5 # of CVC investments	MINV	2,46	2,01	0,47	0,41	0,46	0,21					
6 Knowledge diversification	MDIV	1,12	0,38	0,05	0,16	0,06	0,21	-0,19				
7 Age of corporate investor	MAGE	13,01	26,60	-0,05	-0,08	-0,05	-0,05	-0,28	0,46			
8 Size of corporate investor	MSIZE	56978,47	71998,15	-0,03	-0,07	-0,03	-0,02	-0,19	0,32	0,35		
9 R&D intensity	MRD	312,58	609,62	-0,06	0,17	-0,03	0,46	-0,10	0,23	-0,11	-0,14	
10 Relationship to industry	MINDC	0,13	0,25	0,08	0,14	0,07	0,11	0,18	0,04	-0,16	-0,19	0,07

Source: Own elaboration

Table 51 indicates the negative binomial regression results of the models E to H. It shows the coefficient, p-values, the degrees of freedom, log-likelihood, and Wald test of the models E to G. Model H could not be calculated by the statistical software R due to correlations not fitting the negative binomial regression model. Details are described and discussed in the context of the detailed result description of model H. The models E to G have 54 degrees of freedom and a log-likelihood between -168.2810 and -28.446. A higher log-likelihood indicates that Model G has the highest model quality. The Wald test results displayed in Table 51 refer to the null hypothesis. The regression hypotheses for Model E, for example, are concluded the following way:

Model E H5: MPATJ~MINV+MDIV+MAGE+MSIZE+MRD+MINDC

Model E H0: MPATJ~MDIV+MAGE+MSIZE+MRD+MINDC

The results indicate F-statistics between 6.8954 for Model E H0 and 23.478 for Model F H0 indicating the lowest model quality in Model E H0 with a significance derived from a p-value below 0.05. Model F is significant with a p-value below 0.001 for the F-statistics and Model G with a p-value below 0.01. It is derived that there is significant evidence to reject the null hypothesis that the coefficient for "INV" is zero in the mobility sector Models E to G. A detailed model quality comparison is provided in this chapter after descriptions of the model results.

Table 51: Model E to H negative binomial regression results

Variables	Abbreviation	Model E	Model F	Model G	Model H
1 # of mobility company CVC investments	MINV	1.014e+00**	5.655e-01***	1.107e+00**	Not possible to calculate due to missing applicability of the negative binomial regression model
2 Knowledge diversification	MDIV	-9.516e-01	5.749e+00**	3.464e+00**	
3 Age of corporate investor	MAGE	2.484e-02	-4.508e-02	3.321e-02	
4 Size of corporate investor	MSIZE	-1.536e-05	-7.762e-06	-3.512e-05	
5 R&D intensity	MRD	1.826e-03	1.330e-03***	1.892e-03.	
6 Relationship to industry	MINDC	-6.365e+00	2.486e+00*	-9.744e+00	
df		54	54	54	
Log-likelihood		-34.909	-240.4610	-28.446	
Wald test		6.8954*	23.478***	10.01**	
	Significance codes: ***p<0.001; **p<0.01; *p<0.05; .p<0.1				

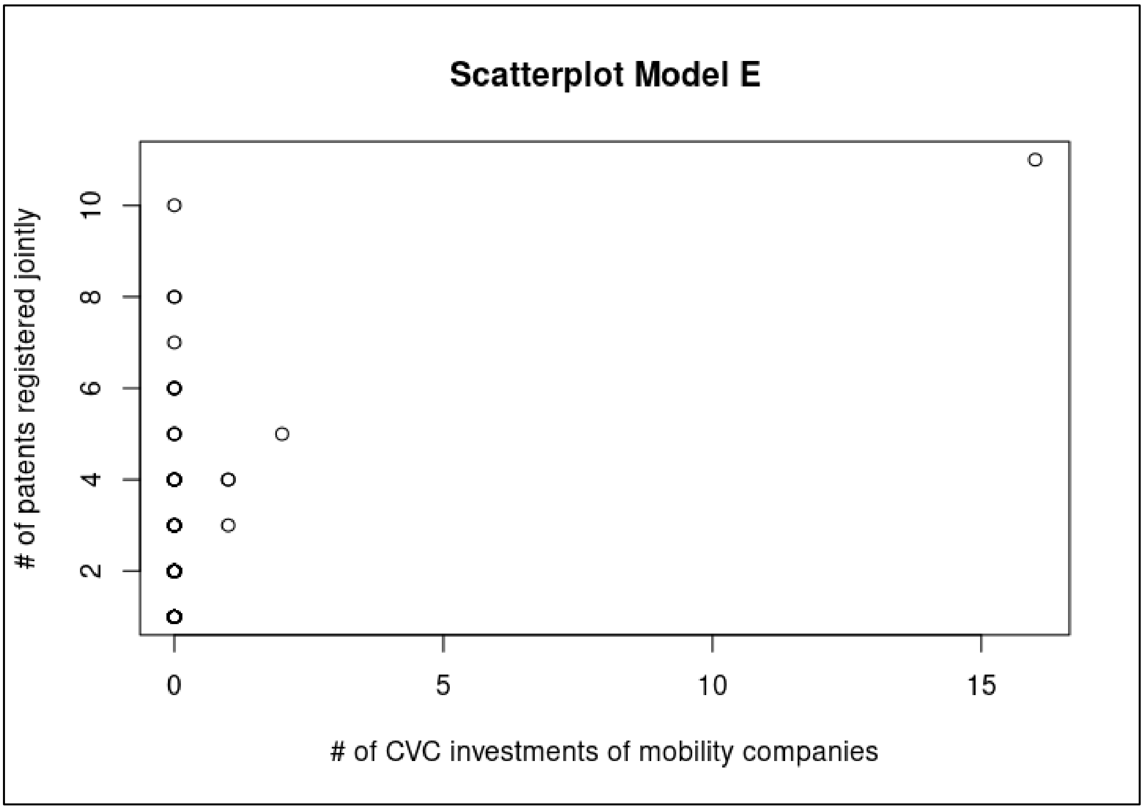
Source: Own elaboration

4.3.2.1 Model E descriptive statistics, correlations, and regression results

In the following, the results concerning Model E and H5, if *the number of CVC investments is positively related to the level of knowledge transferred between investee and mobility corporate investor*, are presented. Table 50 shows a correlation of 47 percent between the number of CVC investments and the level of knowledge transferred between investee and corporate investor in the mobility sector. A p-value below 0.01 of the independent variable in Table 51 shows a significant influence of the number of CVC investments on the level of knowledge transferred in the mobility sector. The coefficient is 1.014e+00. The relation between the number of CVC investments and the number of patents registered jointly by the investor and investee company in the mobility sector is plotted in Figure 30. The illustration shows that only four investments lead to patents registered jointly.

It can be derived that H5 is supported statistically but limited to a small sample due to more investor patents with startup citations than patents jointly registered as Model F includes a larger sample. Table 51 shows that no further variables from the model are significant. Removing them did not lead to an improvement of the model quality so they have been kept as part of the model.

Figure 30: Model E scatterplot of dependent and independent variable



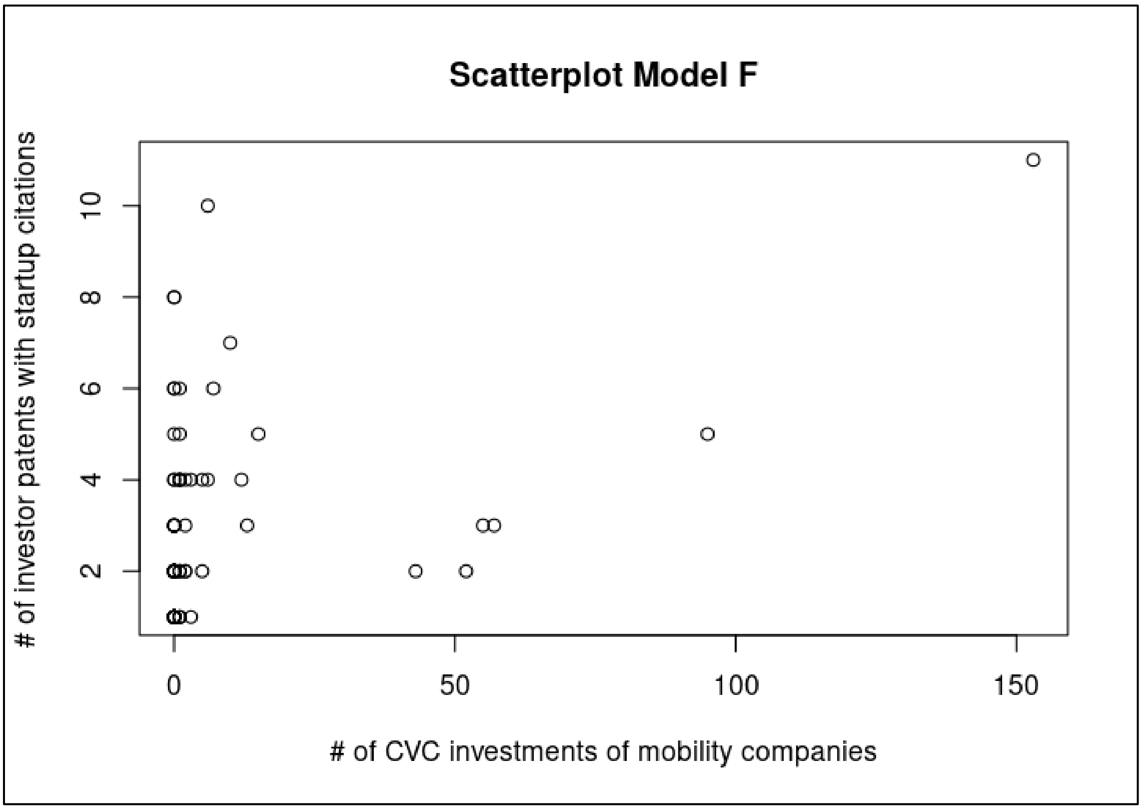
Source: Own elaboration

4.3.2.2 Model F descriptive statistics, correlations, and regression results

To examine H6, if *the number of CVC investments is positively related to the level of knowledge transferred from the investee to the mobility corporate investor*, Model E was analyzed. As displayed in Table 50, the number of CVC investments conducted by mobility companies and the number of investor patents with startup citations correlate with 41 percent. Table 51 demonstrates a significant relation between the independent and dependent variable with a p-value below 0.001 and 5.655e-01 as the coefficient.

It is derived that H2 is supported. Figure 31 illustrates this relation and underlines the statistical results. Most mobility company investors who cited startups in their patents made between 0 and 20 investments. Especially investors that invested more than 40 times per year appear almost linear in the tendency towards a higher patent number with a higher investment number. Figure 31 also shows that knowledge transfer is possible to companies in the mobility sector with investment units even if they do not invest. Table 51 shows that apart from the independent variable, R&D intensity is significant with a p-value lower than 0.001. Knowledge diversification is significant with a p-value below 0.01 and the industry relatedness with a p-value under 0.05. Age and size of corporate investors in the mobility industry are not significant in Model F. Removing further variables did improve the model quality so they remain in model F.

Figure 31: Model F scatterplot of dependent and independent variable



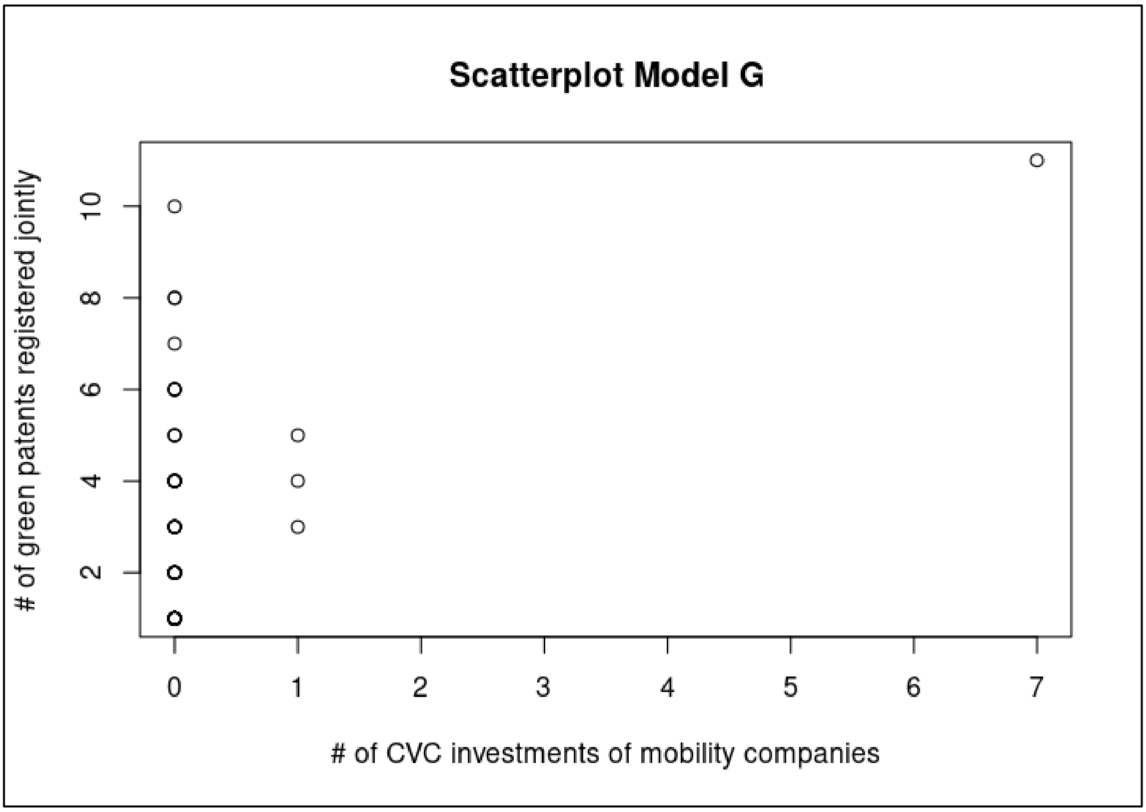
Source: Own elaboration

4.3.2.3 Model G descriptive statistics, correlations, and regression results

H7 states that *the number of CVC investments is positively related to the level of green knowledge transferred between investee and mobility corporate investor*. Table 50 shows a 46 percent correlation between the number of mobility sector CVC investments and the level of green knowledge transferred between investee and corporate investor. A p-value below 0.01 illustrated in Table 51 shows a significant relation between the independent and dependent variable with 1.107e+00 as the coefficient.

It is derived that H3 is supported. Figure 32 visualizes the relationship and shows that knowledge can be transferred to companies with CVC units even if they do not invest in a certain year. Furthermore, it shows that only four times, investments led to joint green patent registration. It can be derived that there is a relation, but this relation is not applicable to a high number of investments. Figure 32 also shows the possibility that a higher number of green patents can be registered jointly without any investment as there are further impact factors influencing patent registration. With a p-value below 0.01, knowledge diversification is also significant in Model G. Furthermore, R&D intensity is significant with a p-value under 0.1. No other variables from Model G are significant, but removing these variables did not improve the model quality so they have been kept as part of the model.

Figure 32: Model G scatterplot of dependent and independent variable



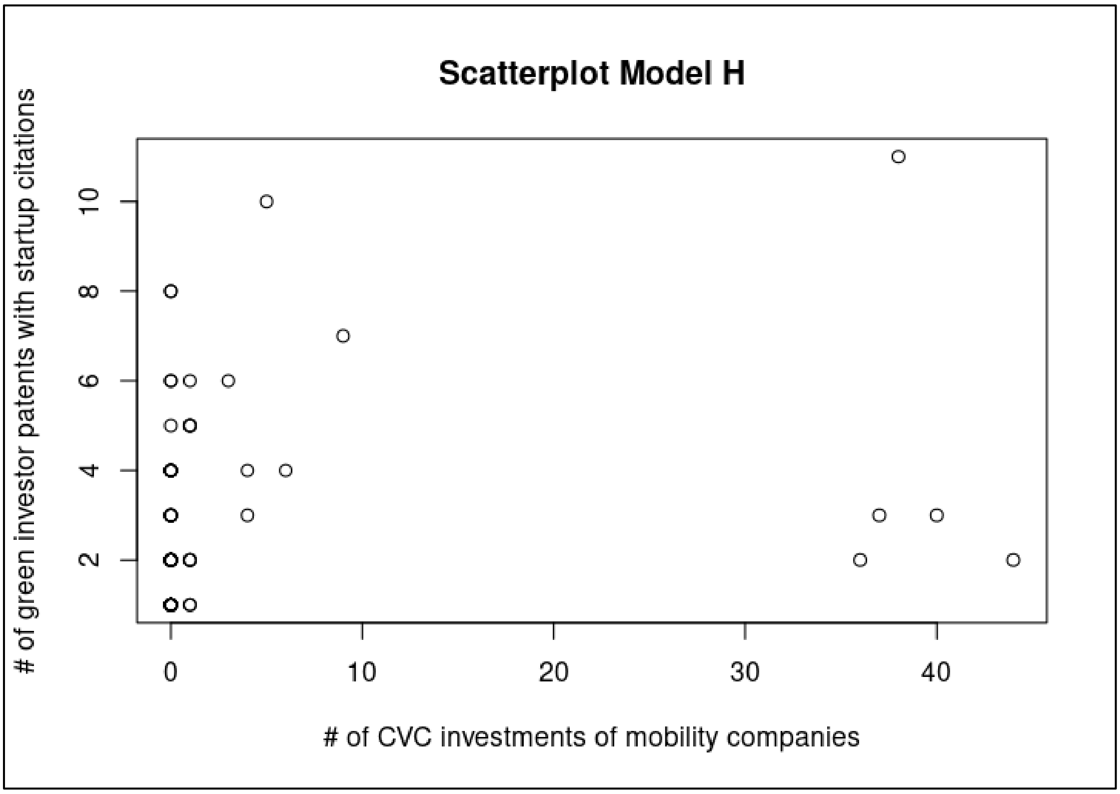
Source: Own elaboration

4.3.2.4 Model H descriptive statistics, correlations, and regression results

With Model H, it is analyzed if H8, *the number of CVC investments is positively related to the level of green knowledge transferred from the investee to the mobility corporate investor*, can be supported. Table 50 shows a 21 percent correlation between the number of mobility CVC investments and the number of green investor patents with startup citations. Figure 33 visualizes that a part of the number of green investor patents with startup citations can be explained by the number of CVC investments in the mobility sector. On the other hand, there are companies with between 35 and 45 investments showing a low amount of knowledge transferred.

Due to this unclear relationship, the negative binomial regression model could not be applied to model H in the statistical software R as presented in Table 51. H4 cannot be supported. Furthermore, Table 50 shows a 21 percent correlation of the dependent variable with the level of knowledge diversification and a 46 percent relationship with the R&D intensity.

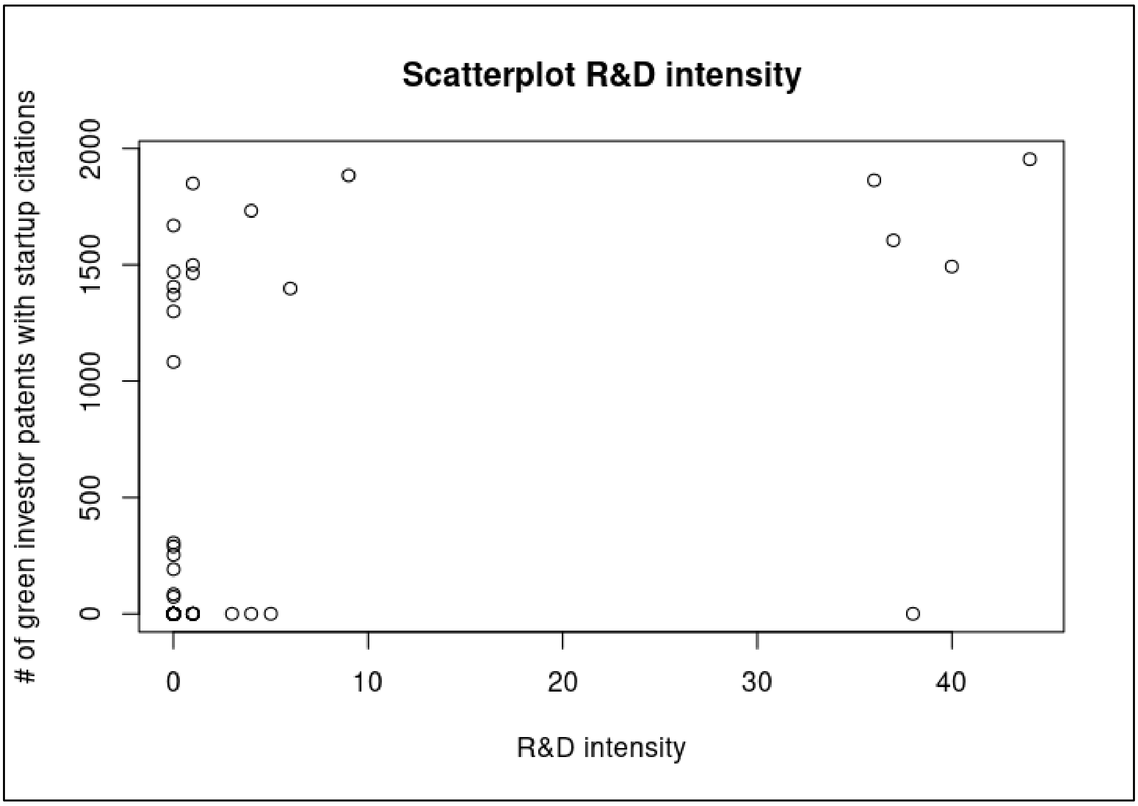
Figure 33: Model H scatterplot of dependent and independent variable



Source: Own elaboration

Figure 34 illustrates the relationship between dependent variable, the number of green investor patents with startup citations, and the R&D intensity. It is visible that the 46 percent correlation between these variables is higher than the 21 percent correlation between the dependent variable and the number of CVC investments of mobility companies.

Figure 34: Scatterplot of dependent variable and R&D intensity



Source: Own elaboration

It can be concluded that H8 can neither be supported nor rejected as the negative binomial regression model is not applicable and other regression models are not applicable either. It is derived that further research is necessary on the relation between the number of green investor patents with startup citations, the number of CVC investments of mobility companies, knowledge diversification, and R&D intensity.

Combining the statistical and scatterplot visualization results, it can be concluded that positive relations between the independent and dependent variables exist. Furthermore, the scatterplots show that knowledge can be transferred from startups to investors without or a low number of investments analyzing the knowledge transferred with zero investments.

4.3.3 Model comparison

4.3.3.1 Comparison between the results of models A to D

All four models are significant with a p-value below 0.001 as presented in Table 49. A difference between correlations is visible in Table 52. Correlations of 0.41 of Model C and 0.40 of Model D are higher than 0.31 for Model A and 0.32 for Model B. It is derived that there is a higher correlation between patent rates and CVC investments for green patent registration than for patent registration in general.

Table 52: Model A to D correlation comparison

Model: Hypothesis	A: H1	B: H2	C: H3	D: H4
Variable	# of patents registered jointly	# of investor patents with startup citations	# of green patents registered jointly	# of green investor patents with startup citations
Abbreviation	PATJ	PATC	GPATJ	GPATC
# of CVC investments INV	0.31	0.32	0.41	0.40

Source: Own elaboration

4.3.3.2 Comparison between the results of models E to H

As described previously, Model F is significant with a p-value below 0.001 as presented in Table 51. Models E and G are significant with a p-value below 0.01 and the negative binomial regression model is not applicable to Model H as described previously. Thus, only the regression results of the models E to G are compared.

A difference between correlations is visible in Table 53. With 0.47, Model E shows a higher correlation between the dependent and independent variable than Model F with 0.41. This shows that in the mobility sector, CVC investments correlate more with patents registered jointly than with patents registered by investors with startup citations.

Table 53 shows that with 0.46, there is a higher correlation between the dependent and independent variable in Model G than in Model H with 0.21. It is derived that in the mobility sector, CVC investment correlates more with joint green patent registration than with green investor patent registration with startup citation. A regression comparison between Model G and Model H is not possible due to Model H missing applicability of the negative binomial regression model.

With 0.47, the correlation between the dependent and independent variable of Model E is higher than the correlation of Model G with 0.46. Furthermore. With 0.41, Model F shows a higher correlation than Model H with 0.21. It is derived that there is a stronger correlation in the mobility sector between CVC investment and general knowledge transfer than green knowledge transfer. The regression results are less obvious as Models E and G both show a p-value below 0.01. Models F and H are not comparable due to missing applicability of the negative binomial regression model to Model H.

Table 53: Model E to H correlation comparison

Model: Hypothesis	E: H5	F: H6	G: H7	H: H8
Variable	# of patents registered jointly	# of investor patents with startup citations	# of green patents registered jointly	# of green investor patents with startup citations
Abbreviation	MPATJ	MPATC	MGPATJ	MGPATC
# of mobility company CVC investments MINV	0.47	0.41	0.46	0.21

Source: Own elaboration

4.3.3.3 Comparison between the cross-sector and mobility sector results

As visualized in Table 54, correlations between mobility CVC investment and general patent registration are higher than between general CVC investment and general patent registration. It can be derived that without a special focus on sustainability, the mobility sector has a knowledge transfer after CVC investment above the average of industries in STOXX Europe 600.

The regression results presented in Table 55 show the opposite. The CVC investments and joint patent registration show a higher significance in a cross-sector analysis than in the mobility industry. The significance results for investor patents with startup citations are similar in the mobility sector and cross-industry analysis. Reasons for these opposed findings can be a stronger linear relation forcing higher correlation results, significance, samples size dependencies as well as context matters. As the focus of this doctoral dissertation is to find the impact of CVC on knowledge transfer and not on the comparison between the findings, further test are not applied. Future investigation is necessary to analyze the interdependencies in detail (Wooldridge, 2019).

With a focus on green patents, there is a higher correlation between CVC investment and joint patent registration in the mobility sector than in the cross-sector analysis. According to the regression results presented in Table 55, the cross-sector relation is more significant than the mobility sector significance.

The correlation between the number of green investor patents with startup citations and cross-sector CVC investments is higher than in the mobility sector. A regression comparison cannot be conducted due to missing applicability of the regression analysis to Model H.

Table 54: Cross-sector and mobility sector correlation comparison

Variable	# of patents registered jointly	# of investor patents with startup citations	# of green patents registered jointly	# of green investor patents with startup citations
Abbreviation	PATJ/MPATJ	PATC/MPATC	GPATJ/MGPATJ	GPATC/MGPATC
# of CVC investments INV	0.31	0.32	0.41	0.40
# of mobility company CVC investments MINV	0.47	0.41	0.46	0.21

Source: Own elaboration

Table 55: Cross-sector and mobility sector regression comparison

Variable	# of patents registered jointly	# of investor patents with startup citations	# of green patents registered jointly	# of green investor patents with startup citations
Abbreviation	PATJ/MPATJ	PATC/MPATC	GPATJ/MGPATJ	GPATC/MGPATC
# of CVC investments INV	2.728e-01***	2.248e-01***	2.149e-01***	1.707e-01***
# of mobility company CVC investments MINV	1.014e+00**	5.655e-01***	1.107e+00**	Not applicable

Source: Own elaboration

4.3.3.4 Model quality comparison

To measure the model quality, degrees of freedom, log-likelihood, F-statistics, and the p-value of F-statistics are displayed in Table 56 and Table 57. Models A to D include 137 degrees of freedom. Models E to G include 54 degrees of freedom. Model H is excluded due to missing applicability as described previously. According to the log-likelihood of -28.446, model G has the best model quality (Wooldridge, 2019).

The Wald test refers to testing the null hypothesis of each model. The p-value indicates the significance with which the null hypothesis can be rejected. The null hypotheses of the models A to D and F can be rejected with a p-value below 0.001. The null hypothesis of the model G can be rejected with a p-value below 0.01, and the model E null hypothesis can be rejected with a p-value below 0.05. It is concluded that the null hypotheses of the models A to G are rejected and derived that the number of CVC investments has a significant impact on knowledge transfer. These results count for the mobility sector and cross-sectoral in Europe, and for green knowledge transfer as well as general knowledge transfer (Liu et al., 2023; Wooldridge, 2019).

Table 56: Model A to D cross-sector quality measures

Measure	Model A	Model B	Model C	Model D
df	137	137	137	137
Log-likelihood	-240.1250	-785.7830	-168.2810	-573.4610
Wald test	31.337***	48.779***	19.331***	20.678***
Significance codes: ***p<0.001; **p<0.01; *p<0.05; .p<0.1				

Source: Own elaboration

Table 57: Model E to H mobility sector quality measures

Variables	Model E	Model F	Model G	Model H
df	54	54	54	Not applicable
Log-likelihood	-34.909	-240.4610	-28.446	
Wald test	6.8954*	23.478***	10.01**	
Significance codes: ***p<0.001; **p<0.01; *p<0.05; .p<0.1				

Source: Own elaboration

4.4 Critical appraisal and proposals for action

In the critical appraisal, the research results are discussed critically in the context of existing literature to derive proposals for action. The structure of this chapter is related to chapter 4.1, the state of research. Methodologies applied by the authors of scientific literature are not described again.

4.4.1 Corporate Venture Capital (CVC) discussion

This chapter is focused on the critical discussion of CVC. As the number of CVC investments is the independent variable in all models, this chapter refers to all models described in chapter 4.2.3.

4.4.1.1 Corporate Venture Capital (CVC) antecedents

Turetta and Junior (2022) find CVC investment barriers to be risk aversion, anxiety for financial return and different vocabulary between startup and investor to be barriers to an effective adhesion to CVC. With the startup instead of corporate perspective, Sears et al. (2022) examine startup concerns towards intellectual property misappropriation of CVC investors. According to Sears et al. (2022), credibility is related to prior investment quantity and continuity depending on industry relatedness of investor and startup as included in all applied models of this research.

This doctoral thesis shows that besides barriers, CVC is used by European investors to generate knowledge including industry relatedness as a control variable. As presented in Table 58, two proposals result from this doctoral thesis in the context of research from Turetta and Junior (2022) and Sears et al. (2022). The first one is that companies should invest CVC despite in-vestment barriers as advantages like knowledge transfer predominate. The second one is that CVC investors should achieve sufficient investment quantity and continuity depending on industry relatedness to be perceived as trustworthy by startups.

Table 58: Proposals: Corporate Venture Capital (CVC) antecedents

Research result	Proposal for action
Besides CVC investment barriers like risk aversion, anxiety for financial return and different vocabulary between startup and investor, CVC is used by European investors to generate knowledge.	Companies should invest CVC despite investment barriers as advantages like knowledge transfer predominate.
Startups consider credibility to be related to prior investment quantity and continuity depending on industry relatedness of investor and startup.	CVC investors should achieve sufficient investment quantity and continuity depending on industry relatedness of investor and startup to be considered being trustworthy by startups.

Source: Own elaboration

4.4.1.2 Corporate Venture Capital (CVC) performance influence factors

According to Fels et al. (2021), CVC performance is influenced by portfolio composition, corporate knowledge, organizational relationship, managerial influence and focus. Adding more details, Bugl et al. (2022) refer to different strategic agendas. They find mission, backing, organization, financing, autonomy, involvement, resources, and attractiveness impacting value creation.

Brinkmann and Kanbach (2022) find 41 factors influencing VC performance clustered into the four dimensions “decisions about strategies”, “exploitation of venture capital resources and characteristics”, “active involvement in the venture capital environment”, and “limited underlying room for maneuvering”. Especially investment objectives, organizational autonomy, and structure, interorganizational relationships, commitment of corporate parent, and parent company size influence CVC lifespan. As opposed to general corporate performance, Bendig et al. (2024) find that CVC and alliance activity effect product safety explaining an indirect influence on corporate performance.

It is derived that different factors influence CVC performance, and it should be considered that CVC performance is not generally defined. For example, performance can be split into financial and strategic performance. The research approach applied in this paper adds the number of CVC investments to impact knowledge creation indirectly influencing financial performance in Europe.

CVC conflicts are researched by Anokhin et al. (2022) as well as Jeon and Maula (2022). Anokhin et al. (2022) find reputation for experience, active involvement in the investee, and misconduct positively associated with the CVC ability to attract investments. Reputation for misconduct does not frighten startups if the investor is known for experience. In case of investor reputation for active involvement, misconducts lead to a loss of investees.

Jeon and Maula (2022) find three central conflicts in CVC as named in chapter 4.1.1. The first is championing of CVC-based exploration versus core business-focused exploitation. The second is that CVC programs simultaneously belong to the corporate parent versus the startup or VC ecosystem. The third is that startups and VCs view CVC programs as a threat rather than an opportunity. This doctoral thesis finds that despite these conflicts, CVC investments are made cross-sectorial as well as in the mobility sector and lead to general including green knowledge creation.

Rossi et al. (2022) find CVC to positively impact regional and international innovation eco flows in the US, Asia, and Europe. The finding that CVC positively impacts eco flows in Europe can possibly be explained by this paper as knowledge creation can impact the eco flow. The relation between knowledge creation and eco flows is not focus of this research. Accordingly, this possible explanation should be subject of future research applying a quantitative research approach as referred to in chapter 4.5.

As opposed to this doctoral thesis which is focused on CVC rather than institutional VC, Wang et al. (2023) compare independent VC and CVC. They discover independent VC to be more favorable to enhance the internal corporate reputation and to be more beneficial to promoting the evolution of self-centered technological innovation networks. CVC is more favorable to consolidate external reputation of companies and promote the holistic technological innovation networks evolution. That CVC promotes holistic technological innovation networks evolution corresponds with the presented research results considering knowledge creation as driver for innovation. Future research in this field should compare knowledge creation through CVC and institutional VC as this is not covered in this paper.

Table 59 presents three recommendations for action based on the results related to CVC performance influence factors. The first one is that CVC investors should consider and balance a variety of performance influencing factors. In this way, they can indirectly achieve financial performance through knowledge transfer.

The second proposal is that CVC investors, startups and VCs should be aware of possible conflicts and reduce them according to their capabilities. In case that elimination and reduction are not possible, CVC should be invested despite these conflicts.

The third proposal is that CVC should be invested by companies and supported by the government. This is how they can positively impact eco flows and promote holistic technological innovation networks.

Table 59: Proposals: performance influence factors

<table>
<tr><th>Research result</th><th>Proposal for action</th></tr>
<tr><td>CVC performance is influenced by a number of factors. These can impact knowledge creation and indirectly impact financial performance.</td><td>CVC investors should consider and balance a variety of performance influencing factors to indirectly achieve financial performance through knowledge transfer.</td></tr>
<tr><td>Despite conflicts, CVC investments are made in general as well as in the mobility sector and lead to general including green knowledge creation.</td><td>CVC investors, startups and VCs should be aware of possible conflicts and reduce them according to their capabilities. If elimination and reduction are not possible, CVC should be invested despite these conflicts.</td></tr>
<tr><td>CVC positively impacts eco flows in Europe through knowledge creation.</td><td rowspan="2">CVC should be invested by companies and supported by the government to positively impact eco flows and promote holistic technological innovation networks.</td></tr>
<tr><td>CVC promotes holistic technological innovation networks evolution through knowledge transfer.</td></tr>
</table>

Source: Own elaboration

4.4.1.3 Corporate Venture Capital (CVC) strategic and financial objectives

Pinkow and Iversen (2020) present a framework about strategic CVC objectives. These are strengthening the core business, leveraging the ecosystem, and exploring new markets and technologies. That these objectives can be achieved is proven by Haslanger et al. (2022). They find a positive impact of CVC on strategic outcomes of startups and investors but no significant relationship between CVC and financial outcomes. Different opinions exist whether CVC is used to pursue financial objectives. This can be explained by different causes for companies to invest CVC and the indirect influence of strategic performance on financial performance.

Focusing on financial objectives, Tawiah and O'Connor Keefe (2022) compare CVC investors and non-VC investing companies. They find that CVC investing companies hold less debt and more cash and that such companies with growth or investment opportunities maintain financial flexibility. It is derived that even though literature is focused on strategic objectives, CVC can be applied to pursue financial objectives. With a focus on knowledge transfer through CVC, the present paper is focused on strategic objectives indirectly influencing financial goals.

Ladnar et al. (2023) find that after CVC units collaborate with corporate open innovation units, CVC activities are integrated into decentralized open innovation activities. To achieve digital open innovation, a dedicated team in a CVC unit can be responsible for open innovation and Venture Client-based open innovation. It is derived that CVC investment enables open innovation through the knowledge transfer found in this doctoral dissertation. General and green knowledge can be applied cross-sectorial and in the mobility industry to innovate.

Another finding presented by Ladnar et al. (2023) is that CVC supports digital business transformation at organizational, social, and technical levels. It is derived that transferred green and general knowledge can be applied by corporate investors on organizational, social, and technical levels.

An overview of proposals for action related to strategic and financial objectives is provided in Table 60. This table concludes four proposals for action based on the according research results.

The first proposal is that companies should invest CVC if they pursue financial objectives. Based on this, the second proposal refers to decision-making processes of CVC investors and their stakeholders. They should understand that even though direct financial results can be below certain targets, financial performance can be impacted indirectly through knowledge transfer.

The third proposal is that to achieve open innovation, companies should invest CVC in corresponding fields and generate knowledge in these fields. To distribute knowledge to the right levels of a company, CVC investors should consider organizational, social, and technical investment benefits. They should distribute knowledge on organizational, social, and technical levels.

Table 60: Proposals: strategic and financial objectives

Research result	**Proposal for action**
CVC can be applied to pursue financial objectives.	Companies should invest CVC if they pursue financial objectives.
Financial performance is indirectly influenced by CVC-caused knowledge transfer.	In decision-making processes, CVC investors and their stakeholders should understand that even though direct financial results can be below certain targets, financial performance can be impacted indirectly through knowledge transfer.
CVC investment enables open innovation through knowledge transfer.	To achieve open innovation, companies should invest CVC in corresponding fields.
Green and general knowledge transferred can be applied by corporate investors on organizational, social, and technical levels.	CVC investors should consider investment benefits and distribute knowledge on organizational, social, and technical levels.

Source: Own elaboration

4.4.1.4 Corporate Venture Capital (CVC) ambidexterity research

Ladnar et al. (2023) find that CVC is used to pursue ambidexterity, digital exploration, and exploitation. It is derived that the knowledge transferred to CVC investors can be applied to explore, exploit, and pursue ambidexterity.

Rossi et al. (2020) develop a theoretical model for CVCs and institutional VCs with the three dimensions knowledge to explore, exploit, and cumulate. Weiss and Kanbach (2022) add four different types of corporate venturing setups based on abilities and approaches which enable organizational ambidexterity. The corporate venturing setups are differentiated by the ambidexterity on system, unit, and function level and dynamic capabilities in structure and processes or behavior and routines. Scientific research is consistent in the fact that CVC can be applied to lead exploration, exploitation, and ambidexterity.

Anokhin and Morgan (2023) find that CEO duality affects the adoption of goal ambidexterity in CVC. Furthermore, they observe CEO tenure to negatively influence the likelihood of goal ambidexterity adoption. It is derived that CEO characteristics influence CVC objectives and the degree of goal ambidexterity. Knowledge transfer is relevant for CVC to be considered as a tool to lead goal ambidextrous organizations. The present research enhances the current state of research finding that knowledge transfer to lead goal ambidextrous organizations can be pursued and achieved.

In 2023, Weiss et al. enhance scientific research on this field with an exploratory model about strategic corporate venturing. Their model includes organizational antecedents for strategic corporate venturing, enablers, and mediators. The key enablers they find are process activities, relational mechanisms, and dynamic capabilities. Furthermore, Weiss et al. (2023) find ambidextrous orientation to be a mediator. The research results of this doctoral thesis present that knowledge is transferred through CVC from startups to corporate investors. It is not specified whether this knowledge is classified as exploration, exploitation, or ambidexterity. As CVC can be applied for those three, none of these is excluded from the methodology applied in this research paper. If one of the three dimensions is especially pursued and achieved can be researched in the future.

Table 61 presents four proposals for action related to ambidexterity. The first proposal is that companies should invest CVC accordingly if they pursue to explore, exploit, or ambidexterity.

The second and third finding refer to CEO characteristics. CEOs should use CVC to pursue their objectives and the according degree of ambidexterity. In case that CEOs are chosen by certain authorities, these should consider CEO characteristics based on their own CVC objectives and pursued degree of ambidexterity.

The fourth finding refers to strategic corporate orientation towards ambidexterity. Especially companies which pursue ambidexterity should invest CVC to achieve their objectives.

Table 61: Proposals: Corporate Venture Capital (CVC) and ambidexterity

Research result	**Proposal for action**
Knowledge transferred to CVC investors can be applied to explore, exploit, and pursue ambidexterity.	If companies pursue to explore, exploit, or ambidexterity, they should invest CVC accordingly.
CEO characteristics influence CVC objectives and the degree of ambidexterity.	CEOs should use CVC to pursue their objectives and the according degree of ambidexterity.
	If CEOs are chosen by certain authorities, they should consider CEO characteristics based on their own CVC objectives and pursued degree of ambidexterity.
The need of ambidexterity enhances the need for CVC investment for corporations.	Especially companies which pursue ambidexterity should invest CVC to achieve their objectives.

Source: Own elaboration

4.4.1.5 Corporate Venture Capital (CVC) patent research

The method applied in this paper is related to the analysis applied by S. M. Lee et al. (2015) on the US information and communication technology industry. They find a U-shaped relationship between CVC and knowledge transfer moderated by the level of knowledge diversification. In contrast to S. M. Lee et al. (2015), this doctoral thesis does not describe the characteristics of the relationship, but analyzes if a significant relation exists. The research applied by S. M. Lee et al. (2015) is enhanced through the present doctoral dissertation finding that a significant relation also exists in Europe.[65]

Shuwaikh and Dubocage (2022) find that CVC-backed companies have a higher innovation output compared to institutional VC-backed companies. This can be explained by the knowledge transfer measured as joint patent creation found for Europe. With the present research, not only the investee firm innovation outcome, but also the investor benefit is underlined. It can be derived that both investee and investor benefit from CVC investments.

K. Lee et al. (2023) observe that CVC-backed firms are more innovative than non-CVC-backed firms. This corresponds with the research results showing that startups and CVC investors jointly register patents due to knowledge transfer through CVC investment.[66]

Table 62 presents that companies in the US and in Europe should invest CVC to achieve knowledge transfer. Furthermore, it is recommended that companies should pursue to be CVC-backed rather than VC-backed or non-CVC-backed. As a result, companies can achieve a competitive advantage due to a higher innovation output.

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[65] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

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Table 62: Proposals: Corporate Venture Capital (CVC) and patents

Research result	Proposal for action
CVC influences knowledge transfer from startups to investors in the US and in Europe.	To achieve knowledge transfer, companies in the US and in Europe should invest CVC.
CVC-backed companies have a higher innovation output compared to institutional VC-backed companies due to transferred knowledge.	To achieve a competitive advantage due to a higher innovation output, companies should pursue to be CVC-backed rather than VC-backed or non-CVC-backed.

Source: Own elaboration

4.4.1.6 Corporate Venture Capital (CVC) sustainability research

Battisti et al. (2022) find that CVC positively influences investors' environmental and social performance. With a qualitative research approach, Schönwalder and Weber (2023) find that companies with dedicated units for entrepreneurship are more likely to have a stronger sustainable corporate entrepreneurship focus. The present paper supports research by Battisti et al. (2022) as well as Schönwalder and Weber (2023) stating that CVC leads to green knowledge transfer.

It is derived that knowledge transfer can be an enabler to let CVC positively influence investors' environmental and social performance. Constant knowledge transfer can be a reason why companies with dedicated CVC units are more likely to have a stronger sustainable corporate entrepreneurship focus.

Proposals for action based on the critical discussion analyzing CVC in the context of sustainability are presented in Table 63. It is recommended that companies invest CVC to enable generate knowledge and environmental and social performance enhancement. Furthermore, companies should invest CVC and generate knowledge to achieve a stronger sustainable corporate entrepreneurship focus.

Table 63: Proposals: Corporate Venture Capital (CVC) and sustainability

Research result	Proposal for action
Knowledge transfer can be an enabler to let CVC positively influence investors' environmental and social performance.	Companies should invest CVC to enable generate knowledge and environmental and social performance enhancement.
Knowledge transfer can be a reason why companies with dedicated CVC units are more likely to have a stronger sustainable corporate entrepreneurship focus.	To achieve a stronger sustainable corporate entrepreneurship focus, companies should invest CVC and generate knowledge.

Source: Own elaboration

4.4.2 Sustainability discussion

In this chapter, scientific literature on sustainability is discussed in the context of research results of this doctoral thesis. The models C, D, G, and H as described in chapter 4.2.3 refer to green knowledge transfer. Thus, this discussion refers to the results of the models C, D, G, and H of the present doctoral thesis.

4.4.2.1 Environmental, Social, Governance (ESG) research

This doctoral thesis enlarges the systematic ESG literature review provided by T. T. Li et al. (2021). ESG ratings refer to companies rather than patents. Thus, green patents are analyzed in a different way and under different criteria than the ones provided by ESG ratings. Future research can analyze if ESG ratings moderate green patent registration of investors. This analysis is not included in the scope of this thesis.[67]

Based on the fact that patents are not rated according to ESG criteria, Table 64 presents the proposal for action derived. This proposal is that ESG rating agencies should enlarge their scope to rate companies as well as specific patents to enable proper patent analyses.

[67] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Table 64: Proposals: Environmental, Social, Governance (ESG)

Research result	Proposal for action
Companies are ESG-rated, but single patents are not. The only related operationalization of patents possible is a categorization of green patents.	ESG rating agencies should enlarge their scope to rate companies as well as specific patents to enable proper patent analyses.

Source: Own elaboration

4.4.2.2 Environmental, Social, Governance (ESG) measurement

S. Kim et al. (2021) find CSR to be associated with low implied volatility. In contrast, Chatterji et al. (2016) suggested caution when relying on CSR ratings due to a lack of agreement across the ratings. The analysis applied in this doctoral thesis proofs green knowledge transfer impact through CVC isolating the number of investments as independent variable. Due to the lack of agreement, neither CSR ratings nor ESG ratings are included in the models.[68]

Table 65 presents the resulting proposals for action. First, companies should invest CVC and focus on green knowledge transfer to achieve low implied volatility. Second, CSR and ESG ratings should be standardized by rating agencies under governmental support to achieve comparability. Without such a standardization, CVC investors cannot rely on CSR and ESG ratings when evaluating potential investee companies.

[68] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Table 65: Proposals: Evaluation and measurement

Research result	Proposal for action
CSR is associated with low implied volatility.	Companies should invest CVC and focus on green knowledge transfer to achieve low implied volatility.
There is a missing reliability of CSR ratings due to a lack of agreement across the ratings.	CSR and ESG ratings should be standardized by rating agencies under governmental support to achieve comparability.
	CVC investors should not rely on CSR and ESG ratings when evaluating potential investee companies.

Source: Own elaboration

4.4.2.3 Measurement based on Kinder, Lydenberg, and Domini (KLD)

The KLD database is referred to by different authors over time such as Deckop et al. (2006), F. Gao et al. (2014), Godfrey et al. (2009), Ioannou and Serafeim (2015), King and Lenox (2002), T. T. Li et al. (2021), Russo and Fouts (1997), Shiu and Yang (2017), and Waddock and Graves (1997b). KLD-based CSR-related studies are related to ESG, CSR, companies' commitment to social good and insider trading, CSR performance, and research on the impact to financial performance. In the present paper, sustainability references are taken from patent classification rather than KLD patents are not ESG rated. KLD sustainability measures can be subject of studies in the context of CVC evaluating the investors rather than patents.[69]

KLD advantages are named by Godfrey et al. (2009) and Shiu and Yang (2017). These are that KLD is an independent rating agency suggesting independent results and that all S&P 500 companies are rated on several attributes relevant to corporate social performance. Further advantages are an exhibit robust construct validity, availability of the

[69] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

KLD database over a long time and permanent development.

Disadvantages are named by Entine (2003), Mattingly and Berman (2006), and Shiu and Yang (2017). For example, the rating might not be permanent over time leading to a score in different years which may represent different levels of CSR engagement. Furthermore, KLD scores are individually constructed, and some CSR key components are missing. Johnson-Cramer (2004), Mattingly and Berman (2006), and Kacperczyk (2009) describe that the KLD's strengths and concerns lack convergent validity. Chatterji et al. (2016) describe that the KLD index can be used for simple CSR assessment and as a comprehensive index for the assessment of the degree of CSR effort.

It is derived that there are advantages and disadvantages to set up analyses based on the KLD score. The main advantage is the number of companies and data availability over time. The main disadvantage is a lack of data reliability. Shiu and Yang (2017) recommend that the KLD score should be adjusted. Not only the KLD score is not standardized. As described previously, ESG score standardization is developing. Current ratings lead to a bias in measurement. This is one reason why ESG ratings are not included in the analysis of this paper.

Table 66 concludes four proposals for action referring to the KLD database. CVC investors should use KLD sustainability measures for startup evaluation. CVC investors using the KLD database should take advantage of independence, validity, availability over a long time, and permanent development. At the same time, they should consider a bias in their measurement.

The last proposal refers to KLD use cases. Especially when pursuing simple CSR assessment and a comprehensive index for the assessment of the degree of CSR effort, KLD usage is recommended.

Table 66: Proposals: Kinder, Lydenberg, and Domini (KLD) database

Research result	Proposal for action
KLD sustainability measures can be subject of studies in the context of CVC evaluating the investors rather than patents.	CVC investors should use KLD sustainability measures for startup evaluation.
KLD advantages are independence, validity, availability over a long time, and permanent development.	CVC investors using the KLD database should take advantage of independence, validity, availability over a long time, and permanent development.
A KLD disadvantage is that rating might not be permanent over time leading to a score in different years which may represent different levels of CSR engagement. A second one is that KLD scores are individually constructed, and some CSR key components are missing.	CVC investors using the KLD database should consider a bias in their measurement.
KLD index can be used for simple CSR assessment and as a comprehensive index for the assessment of the degree of CSR effort.	Especially when pursuing simple CSR assessment and a comprehensive index for the assessment of the degree of CSR effort, KLD utilization is recommended.

Source: Own elaboration

4.4.2.4 Measurement based on Thomson Reuters ASSET4 database

T. T. Li et al. (2021) refer to scientific ESG literature based on the Thomson Reuters ASSET4 database which includes CSR data from companies in the Russell 1000 since 2002 with 900 evaluation criteria. For example, Chatterji et al. (2009), Ioannou and Serafeim (2012), and Cheng et al. (2014), S, Kim et al. (2021) use the three ESG pillars from this database. Cheng et al. (2014) and Surroca et al. (2020) equally weight the three ESG dimension scores whereas Lys et al. (2015) and S. Kim et al. (2021) limit their research to certain of these dimensions. This doctoral thesis applies patent analysis referring to green patents. With this classification, the environmental dimension is a focus of this dissertation.[70]

Table 67 presents the proposal for action that CVC investors should use ASSET4 database ESG measures for startup evaluation. This does not contradict the proposal that KLD is also recommended as both databases can be used.

Table 67: Proposals: Thomson Reuters ASSET4 database

Research result	Proposal for action
The Thomson Reuters ASSET4 database is used for CVC analyses as it includes CSR data from companies in the Russell 1000 since 2002 with 900 evaluation criteria.	CVC investors should use ASSET4 database ESG measures for startup evaluation.

Source: Own elaboration

4.4.2.5 Environmental, Social, Governance (ESG) theories

Main ESG theories referred to in scientific literature are the institutional theory and the stakeholder theory. Thus, these theories are described in chapter 2.2 and repetitively referred to in this research paper.

[70] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

4.4.2.6 Sustainability research related to institutional theory

Jayachandran et al. (2013) find that the information on corporate social performance provided to stakeholders varies. They figure out that the positive impact of product social performance on corporate performance is stronger than the impact of environmental social performance. Environmental social performance refers to companies ensuring that environmental concerns that arise either out of its business operations or otherwise are addressed. Koh et al. (2014) support the statement of social performance enhancing company value. Focusing on patents, this doctoral thesis analyzes products rather than other corporate environmental activities as the objective is to investigate knowledge transfer to innovate. This thesis expands the state of research by investigating environmental performance rather than social performance.

Flammer et al. (2019) refer to the institutional theory indicating a positive influence of ESG focus in management on company performance. They find that integrating CSR into executive contracting increases long-term orientation, company value, social and environmental initiatives, green innovation and reduces emissions. This doctoral thesis adds the influence of CVC on green innovation through knowledge transfer in addition to executive contracting.

Table 68 concludes proposals for actions related to the institutional theory based on the abovementioned results. First, CVC investors should use independent measures when evaluating startups to avoid corporate social performance-related information asymmetries.

Second, when pursuing corporate performance, CVC investors should focus on enhancing product social performance instead of environmental social performance. Third, CVC investors should follow corporate social performance enhancing activities and investment to enhance their company value.

Table 68: Proposals: Institutional theory

Research result	**Proposal for action**
The information on corporate social performance provided to stakeholders varies.	CVC investors should use independent measures when evaluating startups to avoid corporate social performance-related information asymmetries.
The positive impact of product social performance on corporate performance is stronger than the impact of environmental social performance.	When pursuing corporate performance, CVC investors should focus on enhancing product social performance instead of environmental social performance.
Corporate social performance enhances company value.	To enhance their company value, CVC investors should follow corporate social performance enhancing activities and investments.

Source: Own elaboration

4.4.2.7 Sustainability research related to stakeholder theory

Referring to the stakeholder theory, Kölbel et al. (2017) find a relation between corporate social irresponsibility and financial risk. To operate in a socially responsible manner, CSR knowledge in companies is necessary. It is derived that with green knowledge creation through CVC, financial risk can be reduced. In this context, analyses of other ESG pillars than the environmental one can enhance the state of research.

Surroca et al. (2010) find no direct, but an indirect relationship between financial performance and corporate responsibility due to mediating effect of a company's intangible resources. Between CVC investment and innovation, there is also no direct relationship. Knowledge transfer is necessary to achieve open innovation through CVC investment. CVC impacts green knowledge transfer. This green knowledge transfer enables green innovation and an increase of corporate responsibility. Combining this finding with the results found by Surroca et al. (2010), it is derived that CVC indirectly impacts financial performance through corporate responsibility.

T. T. Li et al. (2021) refer to the stakeholder theory suggesting that companies responding to stakeholders' ESG requirements perform better than irresponsible companies. Through CVC leading to green knowledge transfer, CSR can be strengthened supporting a better response of CVC investors to stakeholders' ESG requirements. In this way, CVC can enhance corporate performance. Consideration should, however, be given to the fact that other factors also influence corporate performance.[71]

Muller and Kräussl (2011) find that in crises, reputation for social irresponsibility leads to the greatest drop in stock prices and the greatest likelihood of making a subsequent charitable donation in response to crisis. It is derived that CVC can be used to create knowledge and develop a company towards CSR. In this way, CVC can indirectly strengthen investors in crises.

Flammer and Kacperczyk (2019) find that CSR is perceived to mitigate a threat of knowledge leakage. CVC enhances the level of knowledge of an investor and can be used to improve CSR. In this way, CVC does not only lead to knowledge transfer. It is derived that it reduces the threat of knowledge leakage.

The proposals for actions derived from these research results are presented in Table 69. First, to reduce financial risk, companies should pursue green knowledge transfer through CVC. However, the financial risk of each investment should be considered despite the advantage of green knowledge transfer.

Second, companies should invest CVC to achieve three advantages. These are an increase in corporate financial performance through corporate responsibility, green transfer of knowledge, and responding to stakeholders' ESG requirements.

Third, to become more resistant to crises, CVC should be invested and knowledge creation to develop a company towards CSR should be leveraged. Fourth, corporations should invest CVC to reduce the thread of knowledge leakage.

[71] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Table 69: Proposals: Stakeholder theory

Research result	**Proposal for action**
With green knowledge creation through CVC, financial risk can be reduced.	To reduce financial risk, companies should pursue green knowledge transfer through CVC under consideration of financial investment risk.
CVC indirectly impacts financial performance through corporate responsibility.	To increase their corporate financial performance through corporate responsibility, green knowledge transfer, and responding to stakeholders' ESG requirements, companies should invest CVC.
CVC indirectly impacts corporate performance as it responds to stakeholders' ESG requirements through green knowledge transfer.	
CVC can be used to create knowledge and develop a company towards CSR. In this way, CVC can indirectly strengthen investors in crises.	To become more resistant to crises, CVC should be invested and knowledge creation to develop a company towards CSR should be leveraged.
CVC reduces the treat of knowledge leakage.	To reduce the thread of knowledge leakage, corporations should invest CVC.

Source: Own elaboration

4.4.2.8 Environmental, Social, Governance (ESG) dimensions relation

T. T. Li et al. (2021) refer to different papers analyzing the interaction between the three ESG dimensions. This interaction is taken into consideration as this doctoral thesis is focused on green patents. With this focus, the environmental dimension of investors is analyzed partly. An analysis of the interactions between different ESG dimensions enables deriving indirect results on the social and governance dimension.[72]

Based on the fact that different ESG dimensions impact each other, Table 70 presents a proposal for CVC investors. The influence on other dimensions should be considered by investors when focusing on certain ESG dimensions to achieve knowledge transfer through CVC.

Table 70: Proposals: Dimensions relations

Research result	Proposal for action
Different ESG dimensions impact each other.	When focusing on certain ESG dimensions to achieve knowledge transfer through CVC, the influence on other dimensions should be considered.

Source: Own elaboration

4.4.2.9 Environmental dimension interaction research

T. T. Li et al. (2021) describe that the interaction between the environmental and governance dimensions is a hot spot of ESG research referring to Flammer et al. (2019). As CVC positively impacts green knowledge transfer, it is derived that green innovation can improve the governance ESG dimension as described by Flammer et al. (2019).[73]

Davidson et al. (2019) find companies led by materialistic executives to have lower CSR scores, less strengths, and more weaknesses. CVC can be a tool to balance this

[72] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.
[73] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

through CSR support. As opposed to this, executives can determine CVC investment focus. If executives decide to place financial objectives over strategic ones, an investment focus can be on other than green innovation.

Cheng et al. (2014) find that access to finance can be improved through CSR strategies and this relationship is supported by environmental and social ESG dimensions. CVC can be an integral part of a CSR strategy building a circle by improving access to finance and use the resources for further investment. Especially green knowledge transfer supports this finding.

T. T. Li et al. (2021) name few research on the relationship between the environmental and social dimension as the environmental is usually considered as part of the social dimension. As this paper majorly refers to the environmental dimension, the above-mentioned results can partly be considered as results for the social dimension as well.[74]

Table 71 presents proposals for action based on environmental dimension interaction research. First, if companies pursue an improvement of the governance ESG dimension, they should invest CVC to achieve green knowledge transfer and enhance green innovation.

Second, if a company has materialistic executives, authorities are recommended to promote CSR enhancement through CVC. In this way, they can balance CEO-caused lower CSR scores, less strengths, and more weak-nesses. Third, if the CEOs focuses on financial rather than strategic CVC investments, they are open to set another investment focus than green knowledge transfer. At the same time, they should consider the indirect impact of CVC on financial performance.

Fourth, companies should consider CVC as an integral part of CSR strategies. CVC should already be integrated during the CSR strategy definition process.

Findings for the social dimension cannot generally be applied to the environmental dimension. Thus, it is recommended to organizations and individuals including researchers to differentiate between these dimensions.

[74] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Table 71: Proposals: Environmental dimension interaction

Research result	**Proposal for action**
CVC-caused green knowledge transfer can enhance green innovation and thus, indirectly improve the governance ESG dimension.	If they pursue an improvement of the governance ESG dimension, companies should invest CVC to achieve green knowledge transfer and enhance green innovation.
CVC can be a tool to balance the fact that materialistic executives have lower CSR scores, less strengths, and more weaknesses.	In case that a company has materialistic executives, authorities are recommended promote CSR enhancement through CVC to balance CEO-caused lower CSR scores, less strengths, and more weaknesses.
If executives decide to place financial objectives over strategic ones, an investment focus can be on other than green innovation.	If the CEOs focus is on financial rather than strategic CVC investments, they are open to set another investment focus than green knowledge transfer but should consider the indirect impact on financial performance.
CVC can be an integral part of a CSR strategy building a circle by improving access to finance and use the resources for further investment.	When setting up a CSR strategy, companies should consider CVC as an integral part.
The environmental ESG dimension is usually considered as part of the social dimension.	It is recommended to organizations and individuals including researchers to differentiate between the environmental and social ESG dimensions.

Source: Own elaboration

4.4.2.10 Interaction research of the social and governance dimensions

T. T. Li et al. (2021) find the interaction between the social and governance dimensions to be highly researched. Scientific research is focused on the relation between the social dimension, executive factors, and stakeholders. The results are discussed in the following.[75]

It is derived from T. T. Li et al. (2021) that the interaction between the social and governance dimensions is also relevant to practice. Table 72 adds the proposal to managers that they should consider the interaction between the social and governance dimensions in decision-making processes.[76]

Table 72: Proposals: Social and governance dimensions interaction

Research result	Proposal for action
The interaction between the social and governance dimensions is relevant to practice.	Managers should consider the interaction between the social and governance dimensions when making decisions.

Source: Own elaboration

4.4.2.11 Relationship between the social dimension and executive factors

Y. Kim et al. (2012) find that socially responsible companies are less likely to manage earnings through discretionary accruals, manipulate real operating activities. Furthermore, such companies are less likely to be the subject of US SEC investigations. As named by T. T. Li et al. (2021), the environmental is usually considered as part of the social dimension. It is derived that CVC can be utilized as a vehicle to develop a company towards acting socially responsible. Thus, CVC can indirectly reduce management of earnings through discretionary accruals, manipulation of real operating activi-

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[76] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

ties and the probability that investors become subject to US SEC investigations.[77]

As described in chapter 4.1.2, F. Gao et al. (2014) find executives of CSR-conscious companies to profit less from insider trades. Furthermore, they are less likely to trade prior to future news compared to non-CSR-conscious companies. Alignment of executives' personal objectives with the company objective support this relation. As found in this doctoral thesis, CVC can be used to transfer green knowledge from startups to investors. With this generated knowledge, companies can improve their CSR-consciousness. In this way, CVC investors can indirectly reduce the risk that executives profit from insider trade and trade prior to future news.[78]

Hubbard et al. (2017) find that in case of a poor financial performance, the likelihood of CEO dismissal increases with past investments in CSR. Opposed, in case of good financial performance, the likelihood of CEO dismissal decreases with past investments in CSR. In the context of CVC investment, it is derived that CEOs should take financial performance into consideration when investing CVC to generate green knowledge. Financial and strategic objectives should be balanced. In case of financial success, CVC investment to pursue CSR decreases the likelihood of CEO dismissal. In case that CVC investment leads to poor financial performance, the likelihood of CEO dismissal is increased.

Fu et al. (2020) find that the presence of a CSO increases CSR and decreases socially irresponsible activities. This effect is strengthened in case that a company has a sustainability committee. The fact that the corporate organization influences CSR is supported by the research results of this doctoral thesis. CVC can be utilized by CSOs to generate green knowledge to act socially responsible.

Tang et al. (2015) find a positive relation between CEO arrogance and socially irresponsible activities. Moreover, they find a negative one between CEO arrogance and socially responsible activities. This relation is supported if companies rely less on resources from stakeholders and markets are more certain and less competitive. With CVC, startups become corporate stakeholders. It is derived that investment in CVC weakens the positive relationship between CEO arrogance and socially irresponsible

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[78] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

activities. Furthermore, CVC weakens the negative relationship between CEO arrogance and socially responsible activities.

Petrenko et al. (2016) find a positive relation between CEO narcissism and CSR activity. Furthermore, they find a negative relation between CEO narcissism and the effect of CSR on corporate performance due to personal objectives pursued with CSR. The reason they describe is that CSR activities can be performed due to CEOs' needs for attention and reinforcement of image. This threat should be considered in the context of CVC investment. Investments in startups which are classified as CSR activity should pursue corporate objectives rather than personal CEO objectives.

Tang et al. (2018) find that narcissistic CEOs care more about CSR than hubristic CEOs and discover a dependency on peer companies' behavior. Furthermore, they find that narcissistic CEOs tend to engage in CSR in the opposite manner as peer companies after joining them as described in chapter 4.1.2. It is derived that a CEO change can lead to a change in CVC sustainability direction. For example, a CEO taking over a company that did not engage in CSR much can be led into a direction engaging more in CSR and the other way around.

Another executive factor according to Davidson et al. (2019) is CEO materialism. They add that materialistic CEOs tend to have lower CSR scores. CVC can be applied to balance such low CSR scores and achieve CSR score improvement through investment. In this context it should be noted that CEOs also determine the direction of a CVC unit. A possible threat is that materialistic CEOs lead CVC units into a direction which is less focused on CSR.

Table 73 and Table 74 present seven proposals for action. These are derived from the described research results on the relationship between the social dimension and executive factors.

First, companies should invest CVC to indirectly achieve four benefits. These are to reduce management of earnings through discretionary accruals, manipulation of real operating activities, the probability that investors become subject to US SEC investigations, and the risk that executives profit from insider trade and trade prior to future news.

Second, CEOs should take financial performance into consideration when investing

CVC to generate green knowledge. Third, management is recommended to balance financial and strategic objectives. Fourth, to generate green knowledge to act socially responsible, CSOs are recommended to foster CVC.

Table 73: Proposals: Social dimension and executive factors: Part 1

<table>
<tr><th>Research result</th><th>Proposal for action</th></tr>
<tr><td>CVC can indirectly reduce management of earnings through discretionary accruals, manipulation of real operating activities and the probability that investors become subject to US SEC investigations.</td><td rowspan="2">Companies should invest CVC to indirectly reduce management of earnings through discretionary accruals, manipulation of real operating activities, the probability that investors become subject to US SEC investigations, and the risk that executives profit from insider trade and trade prior to future news.</td></tr>
<tr><td>CVC investors can indirectly reduce the risk that executives profit from insider trade and trade prior to future news.</td></tr>
<tr><td rowspan="2">In case of financial success, CVC investment to pursue CSR decreases the likelihood of CEO dismissal. In case that CVC investment leads to poor financial performance, the likelihood of CEO dismissal is increased.</td><td>CEOs should take financial performance into consideration when investing CVC to generate green knowledge.</td></tr>
<tr><td>Financial and strategic objectives should be balanced.</td></tr>
<tr><td>CVC can be utilized by CSOs to generate green knowledge to act socially responsible.</td><td>To generate green knowledge to act socially responsible, CSOs are recommended to foster CVC.</td></tr>
</table>

Source: Own elaboration

Fifth, CVC is recommended to be invested to balance the negative influence of CEO arrogance on socially irresponsible activities. Sixth, investments in startups which are classified as CSR activity should pursue corporate objectives rather than personal CEO objectives.

Seventh, CEO change can lead to changes for CVC stakeholders. Thus, CVC stakeholders should consider the dependency of CEOs and the CVC sustainability direction and CSR focus in decision-making processes.

Table 74: Proposals: Social dimension and executive factors: Part 2

Research result	**Proposal for action**
CVC weakens the influence of CEO arrogance on socially irresponsible activities.	CVC should be invested to balance the negative influence of CEO arrogance on socially irresponsible activities.
CSR activities can be performed due to CEOs' needs for attention and reinforcement of image.	Investments in startups which are classified as CSR activity should pursue corporate objectives rather than personal CEO objectives.
CEO change can lead to a change in CVC sustainability direction.	CVC stakeholders should consider the dependency of CEOs and the CVC sustainability direction and CSR focus in decision-making processes as CEO change can lead to changes for CVC stakeholders.
CEOs determine the direction of a CVC unit. A possible threat is that materialistic CEOs lead CVC units into a direction which is less focused on CSR.	

Source: Own elaboration

4.4.2.12 Chief Executive Officers' (CEOs') beliefs and sustainability

Hafenbradl and Waeger (2017) state that managers believing in a business case for CSR do not engage more in CSR than managers not believing in the business case. The described reason why they believe in a business case is that they follow a fair market ideology tending to justify and idealize the market economy system. On the other hand, a reason for less CSR engagement is that such managers feel weaker moral emotions when being confronted with ethical problems. It is derived that management CSR believes do not necessarily go along with CSR engagement. Selecting managers, this fact should be considered in a hiring process and affects CVC in a way that a manager believing in CSR does not necessarily need to lead a CVC unit towards green investment. Thus, measurements such as the ones executed in this doctoral thesis should be applied to determine CVC outcome in terms of CSR.

Researching CEOs' political ideology, Chin et al. (2013) find that compared to conservative CEOs, liberal CEOs emphasize CSR more. With a CEO's relative power, this relation is strengthened. It is derived that leading CVC units, liberal managing directors emphasize CSR more which can lead to a higher focus on CSR in knowledge transfer between startups and investors. Chin et al. (2013) add that conservative CEOs pursue CSR as financial performance allows whereas liberal CEOs also pursue CSR in financially weak times. It is deducted that liberal managing directors leading CVC units can strengthen the units' persistence in financially weak times.

As opposed to Chin et al. (2013) researching CEOs' political ideology, Gupta et al. (2017) research companies' political ideology. They find that companies which tend to be liberal engage more in CSR than companies which tend to be conservative. Accordingly, their result corresponds to that of Chin et al. (2013) considering CEO ideology influence on company ideology. Gupta et al. (2017) add that this effect is stronger in companies with long organizational tenure of the CEO. This is explained by an increasing influence of CEO ideology on the company ideology over time. Since CVC ideology is connected to company ideology, it is derived that with a long organizational tenure of a liberal CEO, CVC activities are focused more on CSR. Gupta et al. (2017) describe that the influence of companies' political ideology on CSR engagement is stronger in industries in which peers have weaker CSR records and in HR intense industries. It is deducted that companies' political ideology influences CVC focus on CSR stronger in industries in which peers have weaker CSR records and in HR intense industries.

Gupta et al. (2019) differentiate the two strategies CSR and workforce downsizing. They discover that liberal oriented CEOs tend to apply a CSR strategy to lead companies. Conservatively oriented CEOs tend to lead companies with a workforce downsizing strategy. These findings also correspond to the results described by Chin et al. (2013) that compared to conservative CEOs, liberal CEOs emphasize CSR more. The same results can be transferred to CVC investments. CEOs lead a company with a CVC strategy focused on CSR to a certain degree according to their political orientation.

The relations found by Gupta et al. (2019) are strengthened by extraversion of CEOs. Narcissism enhances the effect that liberal oriented CEOs tend to lead companies with a CSR strategy. In contrast, narcissism does not significantly influence conservative CEOs in downsizing. It is derived that CEO extraversion can also influence CEO political orientation effects on CSR focus in CVC leadership. CEO narcissism can enhance the effect of liberal CEOs choosing a CSR strategy. Furthermore, the results found for CEOs can be transferred to CVC unit leaders. As CVC units are usually own legal units with a managing director, the results for CEOs can be transferred to managing directors of CVC units. It should be considered that CVC unit managing directors are influenced by the CEO of the parent company. Thus, further research is necessary to verify this relation.

Two years later, Gupta et al. (2021) find that CEOs' political orientation impacts the likelihood of peer companies to imitate the setup of CSR executive position. If a conservative CEO implements a CSR executive position, peers are more likely to do the same than if the implementation is applied by a liberal CEO. As CVC sustainability focus is supported by CSR executives, it is derived that CEOs' political orientation impacts peer likelihood for CVC focus on sustainability. Compared to a liberal CEO, if a conservative CEO implements a CSR executive position, peers are more likely to do the same and increase CVC focus on sustainability. In this way, CEO political orientation effects the degree of green knowledge transferred between startups and investors.

Table 75 presents five proposals for action related to CEOs' beliefs and sustainability. These are based on the results derived during the critical discussion and described in the following.

First, the difference between CSR believes and engagement should be considered in a hiring process of CVC managers. Second, to achieve a higher focus on CSR in knowledge transfer and strengthen the units' persistence in financially weak times, liberal managing directors should be chosen for CVC units.

Third, to achieve a higher focus on CSR in CVC activities, CEOs and managing directors should be incentivized for long organizational tenure. Fourth, to develop companies towards CSR, managers should consider the company's political ideology, strength of CSR records, and industry in strategizing.

Fifth, when choosing CEOs and managing directors, recruiters are recommended to consider applicants' political orientation and orientation towards narcissism. Moreover, shareholders and stakeholders should consider a CEO's political orientation and orientation towards narcissism in their decision-making processes.

Table 75: Proposals: Chief Executive Officers' (CEOs') beliefs

Research result	Proposal for action
A manager believing in CSR does not necessarily need to lead a CVC unit towards green investment.	The difference between CSR believes and engagement should be considered in a hiring process of CVC managers.
Leading CVC units, liberal managing directors emphasize CSR more. This can lead to a higher CSR focus in knowledge transfer between startups and investors and can strengthen the units' persistence in financially weak times.	To achieve a higher focus on CSR in knowledge transfer between startups and investors and strengthen the units' persistence in financially weak times, liberal managing directors should be chosen for CVC units.
With a long organizational tenure of a liberal CEO or managing director, CVC activities are focused more on CSR.	To achieve a higher focus on CSR in CVC activities, CEOs and managing directors should be incentivized for long organizational tenure.
Companies' political ideology influences CVC focus on CSR stronger in industries in which peers have weaker CSR records and in HR intense industries .	To develop companies towards CSR, managers should consider the company's political ideology, strength of CSR records, and industry in strategizing.
CEOs lead a company with a CVC strategy focused on CSR to a certain degree according to their political orientation. This effect is moderated by CEO narcissism. These results can also be applied to CVC unit managing directors.	When choosing CEOs and managing directors, recruiters are recommended to consider applicants' political orientation and orientation towards narcissism. Furthermore, shareholders and stakeholders should consider these characteristics in their decision-making processes.
CEOs' political orientation impacts peer likelihood for CVC focus on sustainability and green knowledge transfer.	

Source: Own elaboration

4.4.2.13 Chief Executive Officers' (CEOs') demographics

Kang (2016) finds a negative impact of CEOs' nearing retirement on company commitment to CSR. It is derived for CVC that CEOs' nearing retirement decreases the investor's commitment to CSR-focused investments. Thus, CSR-focused knowledge transfer between startups and investors is negatively influenced by CEOs' nearing retirement. According to Kang (2016), this effect is weakened in case that CEOs are relatively older and in case that they remain part of the board of directors of their own companies. There results can also be transferred to CVC. The negative impact of CEOs' nearing retirement on CSR-focused knowledge transfer is weakened if CEOs are relatively older and if they remain part of the board of directors.

Han et al. (2019) find that compared to local executives, executives who previously spent time abroad tend to lead companies with a higher level of CSR. Luo et al. (2021) also find that executives who spent time abroad participate more, especially by making corporate donations. It is derived that executives' experience abroad can also influence CVC engagement in CSR. Compared to local executives, executives who previously spent time abroad can impact the level of CSR knowledge transferred between startups and investors through CVC more. It should be considered that this assumption is made based on the transfer of the research results described in this doctoral thesis, Han et al. (2019), and Luo et al. (2021). Further research is necessary for justification.

Lai et al. (2020) observe that CEOs working near their childhood homes have a stronger focus on CSR reflected by making decision with a long-term growth focus. They find that there are less information asymmetries with local CEOs in labor markets leading to less pressure to deliver short-term results and enable a long-term orientation. It is derived that companies with local CEOs can lead CVC to invest with a long-term growth focus. This long-term growth focus enables CSR-focused knowledge transfer between investors and startups. According to Lai et al. (2020), this effect is stronger in companies with embedded business interests and general strength of local social bonds. It is deducted that the difference between local CEOs and non-local CEOs in their effect on CVC focus depends on the same parameters. It is assumed that in companies with embedded business interests and general strength of local social bonds, CVC investments are more focused on CSR.

Whereas from Lai et al. (2020) analyze CSR in general, Bertrand et al. (2021) investigate corporate social performance. Bertrand et al. (2021) argue that foreign CEOs in local companies are confronted with a higher need to build trustworthiness and legitimacy. Thus, Bertrand et al. (2021) describe that foreign CEOs need to achieve a higher level of corporate social performance than local CEOs. As described in this doctoral thesis, foreign CEOs can apply CVC investment to achieve sustainable knowledge transfer and increase corporate social performance.

Church et al. (2019) find that nonfinancial measures lead to higher attention to the society and to higher CSR investment than financial measures in a decision-making process. These results are relevant for decision-making processes in CVC. Setting up CVC decision-making processes based on nonfinancial measures can impact the degree of investment focus on CSR. In this context, financial and strategic objectives of CVC need to be considered in a holistic framework. Different objectives should be balanced and to achieve other, especially financial objectives, financial measures are necessary.

S. Li and Lu (2020) find that the likelihood of companies to take more CSR actions as a response to governmental CSR activities increases with the CEO interest in legitimacy. Especially under social pressure of building credibility, CEOs respond with CSR when CEOs need to deliver results in the short-term. It is derived that CVC investment with CSR focus can be an executive response to governmental CSR activities. This effect more likely if CEOs are under social pressure of building credibility and need to deliver results in the short-term.[79]

Five proposals for action derived from the main research results of this critical discussion are concluded in Table 76. First, shareholders, recruiters, and further stakeholders should consider CEOs' and CVC managing directors' nearing retirement and experience abroad. They are recommended to include these criteria in their decision-making processes to achieve a CSR focus and engagement.

Second, shareholders, recruiters, and other stakeholders should consider CEOs' and CVC managing directors' childhood homes. In this way, they can achieve long-term growth and CSR-focused knowledge transfer through correct decision criteria. Third, if they pursue building trustworthiness, foreign CEOs are recommended to invest CVC to

[79] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

transfer green knowledge and increase corporate social performance. Fourth, financial and strategic objectives of CVC are recommended to be balanced and considered in a holistic framework with financial and nonfinancial measures. Fifth, politicians should use governmental CSR activities to support CVC investment with CSR focus.

Table 76: Proposals: Chief Executive Officers' (CEOs') demographics

Research result	Proposal for action
CEOs' nearing retirement decreases the investor's commitment to CSR-focused investments.	Shareholders, recruiters, and further stakeholders should consider CEOs' and CVC managing directors' nearing retirement and experience abroad in their decision-making processes to achieve a CSR focus and engagement.
Executives' experience abroad can influence CVC engagement in CSR.	
Companies with local CEOs can lead CVC to invest with a long-term growth focus. This long-term growth focus enables CSR-focused knowledge transfer between investors and startups.	Shareholders, recruiters, and other stakeholders should consider CEOs' and CVC managing directors' childhood home as decision criterium for long-term growth and CSR-focused knowledge transfer.
To build trustworthiness, foreign CEOs can apply CVC investment, achieve sustainable knowledge transfer, and increase corporate social performance.	If they pursue building trustworthiness, foreign CEOs are recommended to invest CVC to transfer green knowledge and increase corporate social performance.
Setting up CVC decision-making processes based on nonfinancial measures can impact the degree of investment focus on CSR.	Financial and strategic objectives of CVC are recommended to be balanced and considered in a holistic framework with financial and nonfinancial measures.
CVC investment with CSR focus can be an executive response to governmental CSR activities.	Politicians should use governmental CSR activities to support CVC investment with CSR focus.

Source: Own elaboration

4.4.2.14 Social dimension and stakeholder factors relation

According to the stakeholder theory, CSR impacts the corporate financial performance because stakeholders reward certain CSR types. Madsen and Rodgers (2015) investigate antecedents and consequences of stakeholder attention to corporate disaster relief CSR. They find that stakeholder attention is driven by the legitimacy, urgency, and enactment of disaster relief CSR initiatives. It is derived that stakeholders reward certain CVC investments focused on CSR and support CVC-related CSR activities especially driven by legitimacy, urgency, and enactment. For CVC units which are in the need of support with their CSR activities, it is recommended to make legitimacy, urgency, and enactment transparent to stakeholders.

Balakrishnan et al. (2011) discover a significant increase of employee motivation through corporate giving activities resulting in a possible engagement increase. As with CVC, a return is usually expected, CVC investments cannot directly be considered as corporate giving activities. The finding described by Balakrishnan et al. (2011) refers to employee commitment to corporate activities. CVC investment with ESG objectives can increase employee commitment as well and improve sustainable knowledge transfer. In this way, CVC investment can also be applied to increase employee motivation. Referring to a focus on strategic rather than financial objectives pursued with CVC, indirect return should be considered by investors. When achieving an increase in employee motivation, an engagement increase can result in higher financial performance even though direct return is considered low. Thus, a CVC investor is recommended to invest although direct return is not expected to be sufficient in case that an indirect return is expected. In this doctoral thesis, different drivers of an indirect return are named such as the engagement increase named in this paragraph or reputation improvement.

Focusing on employee retention, Carnahan et al. (2017) support the findings described by Balakrishnan et al. (2011). Carnahan et al. (2017) find that employees with a focus on meaningful work are more motivated than others. This subjective level of meaningfulness can be increase with CSR activities. This underlines a possible increase of motivation through CVC investment with a focus on CSR knowledge transfer.

Farooq et al. (2017) find differences between internal and external stakeholder orientation concerning organizational identification of employees. There is a stronger impact of internal stakeholder orientation on employee behavior. Moreover, there are different degrees of impact due to social and cultural factors. Especially CSR activities focusing on employee welfare increases the organizational identification of employees. It is derived that an investment focus of CVC on employee welfare can increase organizational identification of employees. Furthermore, social and cultural factors should be considered.

Muller et al. (2014) find that employees have an impact on charitable efforts of enterprises under the condition that corporate decision is based on psychological factors like compassion. CVC cannot be equated with charitable efforts of enterprises as most investments pursue other financial or strategic objectives. On the other hand, certain CVC investments can be made although they do not directly, but indirectly lead to financial or strategic goal achievement. Such investments can, but do not necessarily need to be CSR-focused and based on psychological factors like compassion.

Flammer and Luo (2017) discover that CSR can be used as an employee governance tool improving employee engagement. Furthermore, they find that companies react with CSR to increased risk of adverse behavior. The finding described by Flammer and Luo (2017) demonstrates the relevance of CSR for employee engagement. CVC can be a vehicle for CSR knowledge transfer between startups and investors as described in chapter 4.3. In this way, CVC focused on CSR can increase employee engagement under the condition that it is CSR-focused.

Mun and Jung (2018) find an influence of institutional investors and local CSR managers on workplace gender diversity. A positive relation with the number of women in board or management positions is described. Contrary, institutional investors and local CSR managers do not significantly influence the number of non-managerial or entry level positions. This is caused by board or management positions being more visible than non-managerial or entry level positions to HR managers and investors. CVC units employ management positions as well as non-managerial and entry level positions. In a CVC organization, influence of institutional investors and local CSR managers on workplace gender diversity should be considered on the different levels. It is not analyzed yet whether CVC investors and local CSR managers influence founder gender diversity. If there is a significant influence on the number of women in board or management positions of investee companies can be subject of future research.

Elliott et al. (2014) compare unintended and explicit CSR assessment. They find that investors who are exposed to, but do not explicitly assess, CSR performance derive higher fundamental value estimates in response to positive CSR performance. Furthermore, they find that investors who are exposed to, but do not explicitly assess, CSR performance derive lower fundamental value estimates in response to negative CSR performance. This bias should be considered in the CVC investment process. CSR measures should be used. In an exit process, the finding described by Elliott et al. (2014) can support CVCs to better understand the buyer behavior concerning CSR performance measures and valuation.

Naughton et al. (2019) find that companies' CSR activity announcement leads to a positive abnormal return if investors place a valuation premium on CSR. Furthermore, companies respond to investor sentiment with CSR. This effect is strengthened if companies face investor valuation uncertainty. These results should be considered in the CVC valuation process to avoid overvaluation. CVC investors can take advantage of the findings described by Naughton et al. (2019) during the exit process. CVC investors can utilize investee CSR activity announcement encouraging a positive abnormal return if the new investors place a valuation premium on CSR.

Table 77 provides six proposals for action referring to the relationship between the social dimension and stakeholder factors. These are derived from the results of the critical discussion. First, CVC units which are in the need of support with their CSR activities, should make legitimacy, urgency, and enactment transparent to stakeholders.

Second, a CVC investor is recommended to invest although direct return is not expected to be sufficient in case that an indirect return is expected. Indirect return should be pursued through achievement of strategic objectives, employee commitment, identification, motivation, and engagement. Third, in a CVC organization, influence of institutional investors and local CSR managers on workplace gender diversity should be controlled to enable gender diversity.

Fourth, the valuation dependency on CSR performance and activity announcement should be considered in the CVC valuation process to avoid overvaluation of startups. Moreover, CVC investors should utilize investee CSR performance and activity announcement encouraging a positive abnormal return. This is recommended if the new investors place a valuation premium on CSR.

Table 77: Proposals: Social dimension and stakeholder factors relation

<table>
<tr><th>Research result</th><th>Proposal for action</th></tr>
<tr><td>Stakeholders reward CVC investments focused on CSR and support CVC-related CSR activities especially driven by legitimacy, urgency, and enactment.</td><td>CVC units which are in the need of support with their CSR activities, should make legitimacy, urgency, and enactment transparent to stakeholders.</td></tr>
<tr><td>CVC investment can be applied to increase employee motivation.</td><td rowspan="4">A CVC investor is recommended to invest although direct return is not expected to be sufficient in case that an indirect return is expected. Indirect return should be pursued though achievement of strategic objectives, employee commitment, identification, motivation, and engagement.</td></tr>
<tr><td>CVC focused on CSR can increase employee engagement under the condition that it is CSR-focused.</td></tr>
<tr><td>An investment focus of CVC on employee welfare can increase organizational identification of employees.</td></tr>
<tr><td>CVC investments can be made although they do not directly, but indirectly lead to financial or strategic goal achievement.</td></tr>
<tr><td>There is an influence of institutional investors and local CSR managers on workplace gender diversity.</td><td>In a CVC organization, influence of institutional investors and local CSR managers on workplace gender diversity should be controlled to enable gender diversity.</td></tr>
<tr><td>CSR performance assessment influences corporate value estimates.</td><td rowspan="2">The valuation dependency from CSR performance and activity announcement should be considered in the CVC valuation process to avoid overvaluation of startups. Furthermore, CVC investors should utilize investee CSR performance and activity announcement encouraging a positive abnormal return.</td></tr>
<tr><td>Companies’ CSR activity announcement leads to a positive abnormal return if investors place a valuation premium on CSR.</td></tr>
</table>

Source: Own elaboration

4.4.2.15 Environmental, Social, Governance (ESG) influencing economics

T. T. Li et al. (2021) find a literature focus and high attention on financial performance, company performance and company value. This thesis adds information to this research field because of an indirect influence of knowledge transfer on financial performance, company performance and company value. It is described previously that CVC significantly impacts green knowledge transfer between investors and investees. This knowledge transfer is operationalized as the number of patents registered by investors referring to investees or by both jointly. In certain industries, patents reflect innovation impacting on financial performance, company performance and company value.[80]

Khan et al. (2016) find companies with good ratings on material sustainability issues to significantly outperform companies with poor ratings on material sustainability. Contrary, companies with good ratings on immaterial sustainability issues do not significantly outperform companies with poor ratings on immaterial sustainability. This thesis analyzes material sustainability issues as well as immaterial sustainability issues and finds green knowledge transfer to investors to be enabled through CVC. It is derived that CVC can indirectly influence if CVC investors outperform peers or not as CVC impacts investors' material sustainability issues.

Awaysheh et al. (2020) find that for best-in-class CSR companies within certain industries, investors place higher valuations. To improve corporate CSR, CVC can be applied to generate green knowledge as described in the present paper. In this way, CVC can indirectly improve corporate valuation.

Kölbel et al. (2017) find that corporate social irresponsibility significantly increases credit risks of companies and financial risks. Corporate social irresponsibility can be avoided through CVC investment enhancing CSR knowledge of investors. In this way, consciousness can be built in a corporate decision-making process to avoid corporate social irresponsibility and therefore decrease credit risks and financial risks.

Table 78 concludes four proposals for action derived. First, patent rates should be used by CVC investors as a success measure which indirectly impacts financial and company performance, and company value. Second, to outperform peers through an impact on material sustainability issues, companies should invest CVC.

[80] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Third, to improve corporate valuation through CSR resulting from green knowledge transfer, companies are recommended to invest CVC. Fourth, companies should enhance their CSR knowledge through CSR-focused CVC investment. In this way, they can avoid corporate social irresponsibility, decrease credit and financial risks, and build consciousness in decision-making processes.

Table 78: Proposals: Influence on economics

Research result	Proposal for action
In certain industries, patents reflect innovation impacting financial performance, company performance and company value.	Patent rates should be used by CVC investors as a success measure which indirectly impacts financial and company performance, and company value.
CVC can indirectly influence if CVC investors outperform peers or not as CVC impacts investors' material sustainability issues.	To achieve a competitive advantage through an impact on material sustainability issues, companies should invest CVC.
To improve corporate CSR, CVC can be applied to generate green knowledge as described in the present paper. In this way, CVC can indirectly improve corporate valuation.	To improve corporate valuation through CSR resulting from green knowledge transfer, companies are recommended to invest CVC.
Corporate social irresponsibility can be avoided through CVC investment enhancing CSR knowledge of investors. In this way, consciousness can be built in a corporate decision-making process to avoid corporate social irresponsibility and therefore decrease credit risks and financial risks.	To avoid corporate social irresponsibility, decrease credit risks and financial risks, and build consciousness in a corporate decision-making process, companies should enhance their CSR knowledge through CSR-focused CVC investment.

Source: Own elaboration

4.4.2.16 Types of relationships in sustainability research

As described in chapter 4.1.2, T. T. Li et al. (2021), split ESG research into four types of relationships. These relationship types are positive correlation, negative correlation, non-linear relationship, and indirect relationship. The present research describes a positive correlation between CVC investment and knowledge transfer. Thus, it is classified and adds findings to the field of positive correlations in scientific research. It should be considered that ESG ratings are not subject of the methodology applied in this paper. Anyway, green knowledge transfer especially refers to the environmental dimension of ESG.[81]

Table 79 concludes the research result that the named four relationship types are present and the derived proposal for action. Different types of ESG relationships are recommended to be considered in management and investment decision-making processes including indirect relations. Indirect relations are mentioned explicitly as they are not obvious.

Table 79: Proposals: Environmental, Social, Governance (ESG) relations

Research result	**Proposal for action**
The four types of ESG relations are positive correlation, negative correlation, non-linear relationship, and indirect relationship.	Different types of ESG relationships are recommended to be considered in management and investment decision-making processes including indirect relations.

Source: Own elaboration

[81] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

4.4.2.17 Positive correlations

Mackey et al. (2007) find a positive correlation between ESG activities and corporate market values. With CVC enhancing green knowledge transfer between investees and investors, CVC can support corporate ESG activities. In this way, CVC can indirectly increase corporate value as discussed previously referring to Awaysheh et al. (2020). As opposed to market value, Mackey et al. (2007) do not find a significant impact on maximization of the present value of company's future cash flows. Mackey et al. (2007) find that management decisions in publicly traded companies fund CSR activities that do not maximize the present value of company's future cash flows. It is derived that CVC indirectly supports maximizing the market value of a firm but not the present value of company's future cash flows.

Jayachandran et al. (2013) find a positive relation between corporate social performance and corporate performance. They add that compared to the environmental ESG dimension, the social dimension has a stronger positive impact on corporate performance. As CVC can support the social performance of an investor, it is derived that CVC indirectly supports corporate performance. Current patent measures allow the analysis of green knowledge transfer rather than social ESG dimension focused knowledge transfer. Operationalizing social knowledge transfer can allow future comparison between the environmental and social dimension and indirect CVC impact on corporate performance. This doctoral thesis is limited to the environmental ESG dimension.

Barnett and Salomon (2006) find a curvilinear relation between number of social screens used by an socially responsible investing fund and financial returns. First, financial returns decline, but then rebound as the number of screens is maximized. Barnett and Salomon (2006) add the finding that financial performance varies with the types of social screens used. Community relations screening increases financial performance. Environmental and labor relations screening decreases financial performance. It is derived that the relationship between CSR and corporate performance described by other authors should not be considered in isolation. The number of social screens used by a socially responsible investing fund is not analyzed in the methodology of this thesis as the focus is not on financial performance. When interpreting the indirect CVC impact on financial performance, Barnett and Salomon (2006) demonstrate that social screens also impact the outcome.

As named to in the context of institutional theory and environmental ESG dimension interaction, Flammer et al. (2019) research CSR contracting. They find a positive impact of executive CSR contracting on company value. This positive relation can be added to the variables explaining the indirect impact of CVC on financial performance and company value.

Matsumura et al. (2014) find that company value significantly decreases with every additional thousand metric tons of carbon emissions. Furthermore, they find the median value of companies that disclose their carbon emissions to be significantly higher than that of comparable non-disclosing companies. As named in chapter 4.1.2, lower carbon emissions and higher transparency on this topic are favorable to company value. To reduce corporate carbon emissions, knowledge is necessary. The results presented in this doctoral thesis show that CVC can be invested to generate green knowledge operationalized as green patents.

Godfrey (2005) describe a positive relationship between corporate philanthropy and positive moral capital among communities and stakeholders. Moral capital can function as insurance-like protection for a company's relationship-based intangible assets. This protection contributes to shareholder wealth. Through CVC investment, knowledge transfer can be achieved to improve corporate philanthropy. In this way, CVC can indirectly increase moral capital among communities and stakeholders.

Wang and Qian (2011) add a finding of positive correlation between corporate philanthropy and corporate financial performance. It is derived that CVC can indirectly increase moral capital among communities and stakeholders as well as financial performance.

The effect described by Wang and Qian (2011) is enhanced by two factors. These are greater public visibility and better performance in the past. It is also found that companies which are not government-owned or politically well-connected tend to benefit more from philanthropy. It is derived that apart from CVC, public visibility and performance in the past influence financial performance. Furthermore, the relationship between depends on governmental and political relations. Such governmental and political relations can be influenced as investments can be publicly funded and supported by governmental financial programs. CVC increases the connectivity of an investor improving the explanation why CVC indirectly influences financial performance.

Kaul and Luo (2018) find that the financial and social benefits of CSR activities depend on the relation to the core business and to other non-profit organizations. CSR activities should be related to the core business or should not overlap with activities of non-profit organizations to realize financial benefit. To realize social benefit, both criteria should be fulfilled as described in chapter 4.1.2.

Proposals for actions are derived from these research results as presented in Table 80 and Table 81. These proposals relate to positive ESG relations.

Companies should invest CVC if they pursue to support corporate ESG activities through green knowledge transfer, improve corporate value, and performance. Furthermore, CVC should be invested if companies pursue to improve financial performance through social screens and increase company value through carbon emissions reduction. Additionally, CVC should be invested to increase financial performance and moral capital among communities and stakeholders.

Furthermore, managers should consider that CVC can support maximizing market value even though it does not present future cash flow value. They should not rely on CVC to be the only impact factor on financial performance and company value. Apart from CVC investment, CSR contracting should be considered.

Table 80: Proposals: Positive correlations: Part 1

Research result	Proposal for action
With CVC enhancing green knowledge transfer, CVC can support corporate ESG activities.	To support corporate ESG activities through green knowledge transfer, companies should invest CVC.
CVC can indirectly increase corporate value and performance.	To improve corporate value and performance, companies should invest CVC.
CVC supports maximizing the market value of a firm but not the present value of company's future cash flows.	Managers should consider that CVC supports maximizing market value but not present future cash flow value.

Source: Own elaboration

CVC should not be considered as the only factor influencing financial performance. Especially business performance and public visibility should be considered. Another proposal is that to achieve financial performance objectives, corporate processes should be implemented to strengthen the CVC influence on connectivity. Last, CSR activities should be related to the core business or should not overlap with activities of non-profit organizations to realize financial benefit.

Table 81: Proposals: Positive correlations: Part 2

Research result	**Proposal for action**
The CVC impact on financial performance is impacted by social screens.	To improve performance through social screens, companies should invest CVC.
Executive CSR contracting helps to explain the indirect CVC impact on financial performance and company value.	Managers should consider CSR contracting impacting financial performance and company value.
CVC-caused knowledge transfer can lead to carbon emissions reduction which is favorable to company value.	To increase company value through carbon emissions reduction, companies should invest CVC.
CVC can indirectly increase moral capital among communities and stakeholders as well as financial performance.	To increase financial performance and moral capital of communities and stakeholders, companies should invest CVC.
Apart from CVC, public visibility and performance in the past influence financial performance.	Apart from CVC, business performance and public visibility should be considered influencing financial performance.
CVC increases the connectivity of an investor.	Corporate processes should strengthen the CVC influence on connectivity.
The benefits of CSR activities depend on the relation to the core business and to other non-profit organizations.	CSR activities should be related to the core business or not overlap with activities of non-profit organizations.

Source: Own elaboration

4.4.2.18 Negative correlations

Manchiraju and Rajgopal (2017) find that forcing companies to spend on CSR is likely to negatively impact shareholder value. Applying an event study, they discover a drop of stock prices of companies forced to spend money on CSR. The study refers to an Indian law introduction naming that companies which fulfill certain profitability, net worth, and size thresholds need to spend at least two percent of their net income on CSR. Manchiraju and Rajgopal (2017) recommend that companies voluntarily spend on CSR to maximize shareholder value. By already investing in CVC for CSR, companies can be prepared for such a law change and avoid being forced to spend more on CSR.

Chen et al. (2018) focus on CSR reporting rather than CSR spendings. They find that mandatory CSR reporting negatively influences profitability. It is concluded that mandatory CSR reporting generates positive externalities like industrial wastewater and SO_2 emission reduction at the expense of shareholders. A decrease of shareholder value named by Manchiraju and Rajgopal (2017) as well as Chen et al. (2018) also influences corporate decisions on CVC investments. CVC investments are dependent on investors' financial resources and shareholder value. Thus, CVC management should consider the relevance of CSR legal requirements on their business. The exact relation between CSR legal requirements, shareholder value, and CVC investment should be investigated in future research.

It is derived that corporate CVC and legal units are recommended to collaborate. In this way, they should make sure CVC is prepared for future legal requirements and legal requirements do not constrain CVC activities. This proposal is presented in Table 82.

Table 82: Proposals: Negative correlations

Research result	Proposal for action
By already investing in CVC for CSR, companies can be prepared for a law change and avoid being forced to spend more on CSR.	Corporate CVC and legal units should collaborate to make sure CVC is prepared for future legal requirements and legal requirements do not constrain CVC activities.
CVC investments are dependent on investors' financial resources and shareholder value.	

Source: Own elaboration

4.4.2.19 Non-linear relationships

Barnett and Salomon (2006) research socially responsible investing funds. They find that with a higher social screening intensity, financial returns decline at first and then increase again as the screen intensity reaches its maximum. As described previously, these results can be applied to CVC funds. It is assumed that a U-shaped relationship between social screening intensity and financial returns is present for CVC as well. This relationship can be used to explain financial returns achieved through CVC. Especially in the case of lower financial performance, CVC units need to justify themselves. Not considering this U-shaped relation could lead to the wrong assumption that social screening decreases financial returns linearly. It should be considered that moving on and increasing the number of social screens can be of advantage and improve financial returns in CVC investment processes.

Barnett and Salomon (2012) describe further U-shaped relationships with the previously described KLD score as independent variable. They find that the KLD score has an impact on return on assets and net income. Return on assets and net income both decline at first and after a turning point, they increase as illustrated previously in Figure 23 and Figure 24 in chapter 4.1.2. This finding demonstrates the relevance of sustainability for return on assets and net income. CVC can be invested to generate corporate green knowledge. With this knowledge, companies can improve their sustainability ratings. It is derived from the findings presented by Barnett and Salomon (2012) that CVC can indirectly impact return on assets and net income.

Waddock and Graves (1997a) find that corporate social performance is positively associated with prior and future financial performance. This finding is rejected by Zhao and Murrell (2016) describing a complex relationship between corporate social and financial performance. The critical discussion of this paper supports the complex relationship described by Zhao and Murrell (2016) as it refers to a number of indirect relationships and variables.

Three proposals are concluded in Table 83. First, managers should consider that moving on and increasing the number of social screens can be of advantage and improve financial returns. This is the case in CVC investment processes even if financial returns decline at first.

Second, to improve their sustainability ratings through green knowledge transfer, companies should invest CVC. Third, managers should consider a variety of direct and indirect relations analyzing the relationship between corporate social and financial performance in their companies. They should be aware of the complexity and not judge based on single factors.

Table 83: Proposals: Non-linear relationships

Research result	Proposal for action
A U-shaped relationship between social screening intensity and financial returns is present for CVC.	Managers should consider that moving on and increasing the number of social screens can be of advantage and improve financial returns in CVC investment processes even if they decline at first.
With CVC-caused green knowledge, companies can improve their sustainability ratings.	To improve their sustainability ratings through green knowledge transfer, companies should invest CVC.
There is a complex relationship between corporate social and financial performance due to indirect relations.	Managers should consider a variety of direct and indirect relations analyzing the relationship between corporate social and financial performance in their companies.

Source: Own elaboration

4.4.2.20 Indirect relationships

Surroca et al. (2010) find an indirect relationship between corporate responsibility and financial performance. They describe mediating effects through intangible resources. As CVC indirectly impacts corporate responsibility, this underlines the indirectness of the effect CVC has on financial performance through sustainable knowledge transfer. Apart from this strategic focus, the direct influence of CVC on financial performance through exits should be considered.

Hull and Rothenberg (2008) describe an indirect impact of corporate social performance on financial performance. They find two moderating factors to be related to company differentiation influencing financial performance. These are the level of differentiation in the industry and innovation. Through knowledge transfer, CVC can influence both differentiation and innovation. In this way, CVC can be invested to indirectly support financial performance.

Ramchander et al. (2012) research the relationship between corporate social responsibility and financial performance as well. They find that additions and deletions to the Domini Social 400 index change share price. A high degree of information asymmetries impact index additions to raise share prices and negative reactions by competitive companies. In case of company removals, the share price drops. The results presented by Ramchander et al. (2012) demonstrate the impact of information asymmetries on shareholder value. Knowledge transfer through CVC reduces information asymmetries across the companies in certain industries. In this way, CVC can reduce investors' risk of share price drops as an answer to additions to the social indices.

Hawn and Ioannou (2016) find that due to increased intangible resources, internal and external CSR jointly support an association of better market value. This finding underlines the results described previously. With CVC, investors can generate additional CSR-related knowledge. In this way, they can increase their intangible resources and thus, association of better market value.

Lys et al. (2015) find that CSR expenditure does not directly lead to financial performance. They argue that these expenditures are undertaken in a certain period when companies expect stronger financial performance in the future. This research result should be considered in CVC context. It is derived that investors tend to invest in CSR during financially strong periods. CSR expenditure for sustainable investee startups do not directly lead to financial performance as well.

Surroca et al. (2020) study the impact of the simultaneous adoption of managerial entrenchment provisions and CSR on financial performance. In liberal market economies, they find a positive impact as the adoption of managerial entrenchment provisions and CSR create shareholder value. This effect is enhanced if CSR projects are international. In coordinated market economies, they find the adoption of managerial entrenchment provisions and CSR destroying shareholder value. This impact in coordinated market economies is supported if CSR is external. To conclude, Surroca et al. (2020) describe that CSR impact on financial performance depends on market economies. It is derived that CVC indirect impact on financial performance also depends on the type of market economy. It is expected that green knowledge transfer through CVC indirectly supports shareholder value in liberal market economies. In coordinated market economies, green knowledge transfer through CVC is expected to destroy shareholder value.

Six proposals for action are derived from these results. These are presented in Table 84. The first three proposals relate to antecedents for CVC investments as CVC investment relevance is derived from corporate objectives.

The first proposal is that companies are recommended to invest CVC if they pursue to increase their financial performance through intangible resources. This can be achieved through sustainable knowledge transfer.

The second proposal is that companies should invest CVC if they pursue to reduce investors' risk of share price drops as an answer to additions to the social indices. This goal can be achieved through knowledge-caused information asymmetry reduction.

The third proposal is that companies should invest CVC if they pursue to increase their intangible resources and thus, association of better market value. Additional CSR-knowledge causes this indirect relationship.

The next two proposals relate to corporate decision-making processes. Managers need to understand CSR and CVC relations to make decisions accordingly.

The fourth proposal is that in decision-making processes, available resources should be considered for CSR-focused CVC investment. Without existing resources, CVC should not be invested.

The fifth proposal is that managers should consider the circle that CVC can influence financial performance and that CVC is invested due to existing financial performance. This is of special relevance if managers measure CVC success of their companies.

The last proposal derived from the indirect ESG relation discussion related to the type of market economy. CSR-related knowledge transfer should be pursued to enhance shareholder value in liberal market economies but not in coordinated market economies.

Table 84: Proposals: Indirect relationships

Research result	Proposal for action
CVC indirectly impacts financial performance through intangible resources and sustainable knowledge transfer. Through knowledge transfer, CVC can influence both differentiation and innovation and thus, indirectly support financial performance.	If companies pursue to increase their financial performance through intangible resources, sustainable knowledge transfer, differentiation, and innovation, they should invest CVC.
Through information asymmetry reduction, CVC can reduce investors' risk of share price drops as an answer to additions to the social indices.	If companies pursue to reduce investors' risk of share price drops as an answer to additions to the social indices through information asymmetry reduction, they should invest CVC.
Through additional CSR-knowledge, CVC investors can increase their intangible resources and thus, association of better market value.	If companies pursue to increase their intangible resources and thus, association of better market value through additional CSR-knowledge, they should invest CVC.
Investors tend to invest in CSR during financially strong periods. CSR expenditure for sustainable investee startups do not directly lead to financial performance as well.	In decision-making processes, available resources should be considered for CSR-focused CVC investment. Managers should consider the circle that CVC can influence financial performance and that CVC is invested due to existing financial performance.
CVC indirect impact on financial performance also depends on the type of market economy.	CSR-related knowledge transfer should be pursued to enhance shareholder value in liberal market economies but not in coordinated market economies.

Source: Own elaboration

4.4.2.21 Risk prevention through sustainability

T. T. Li et al. (2021) find a research focus on risk prevention role of ESG in business activities. According to the structure in chapter 4.1.2, the results are split according to the dimension focus and discussed critically in the context of the research results of the present doctoral thesis.[82]

As presented in Table 85, the relation between ESG and risk prevention can be applied to CVC. To pursue a risk prevention role, CVC resulting in ESG activities is recommended.

Table 85: Proposals: Risk prevention

Research result	**Proposal for action**
ESG activities have a risk prevention role for companies.	To pursue a risk prevention role, CVC resulting in ESG activities is recommended.

Source: Own elaboration

4.4.2.22 Risk prevention through social activities

Koh et al. (2014) find that the corporate social performance depends on the question if a company gained pragmatic or moral legitimacy as defined in chapter 4.1.2. Pragmatic legitimacy adds two to four percent to company value and serves as an ex-ante insurance mechanism. CSR activities less likely create value in case of moral legitimacy in socially contested industries or if the company is in financial distress. Even though the focus of this chapter is on the influence of performance enhancement through CSR, moral legitimacy is not the only factor influencing corporate social performance. Pragmatic legitimacy has a stronger impact on company value. It is derived that in CVC investment decision-making, CSR is one factor to consider apart from other ones like pragmatic legitimacy.

[82] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Mithani (2017) finds that multinational companies can contribute to recovery and relief efforts after local disasters. In this way, multinational companies can strengthen their position in the local community and mitigate liability of foreignness. Mithani (2017) add that the post-disaster philanthropy for multinational companies is stronger than for domestic companies. It is derived from the research results presented by Mithani (2017) that contribution to recovery and relief efforts after local disasters can mitigate liability of foreignness. If this is applicable to CVC investment should be subject to future research and is not analyzed in this doctoral thesis. It should be noted that even though a focus can be on sustainable strategy objectives, CVC investment cannot be equated with recovery and relief efforts after local disasters.

Zhou and Wang (2020) research the liability of foreignness in a different context than Mithani (2017). Zhou and Wang (2020) research the relation between parent companies and subsidiaries in relation to risk and CSR. Subsidiaries apply CSR for spillover reduction. This is done due to high visibility of multinational parent companies, the control of parent companies over subsidiaries and liability of foreignness. As most CVC units are organized as subsidiaries of their parent companies, the results described apply to CVC units. It is derived that CVC investment in CSR can be utilized for spillover reduction. Investing CVC in CSR can reduce risks due to high visibility of multinational parent companies, the control of parent companies over CVC units, and liability of foreignness.

Zhou and Wang (2020) add the finding of a positive relation between parent company reputation risk and foreign subsidiary CSR activities. This positive relation is supported if foreign subsidiaries do not directly report to the parent company. It is derived that there can be a relation between parent company reputation risk and foreign CVC unit CSR activities. Moreover, it is assumed that this relation is positively supported if foreign CVC units do not directly report to the parent company. In this context, it should be considered that usually, CVC units do directly report to the parent company. Thus, the relation between parent company reputation risk and foreign CVC unit CSR activities is not often supported by this factor.

Zhou and Wang (2020) add another factor influencing the relation between parent company reputation risk and foreign subsidiary CSR activities. The named relation is supported in case of shorter operations in the host country and a smaller distance between home and host countries. It is derived that distance between parent and CVC unit can influence the relation between parent company reputation risk and foreign subsidiary CSR activities. Furthermore, shorter operations in the host country influence the relation. Some CVC units are located in startup ecosystem hubs (e.g., Silicon Valley). Especially in such cases, this relation should be considered.

Shiu and Yang (2017) find that a long-term engagement in CSR can be beneficial as an insurance-like effect, but only for one negative event. The insurance-like effect disappears after a second negative event. It is derived that long-term focus of CSR in CVC investment can be beneficial as an insurance-like effect for a limited amount of events. It should be subject to future research to what extent this insurance-like effect can be achieved through CVC.

Jia et al. (2020) find that companies facing stock price risks increased their CSR activities. It is derived that that companies facing stock price risks can invest CVC with a focus on CSR as part of their CSR activities.

Bertrand et al. (2021) research the need of corporate social performance to enable CEOs achieving legitimacy and trustworthiness. Local companies with foreign CEOs need to achieve a higher corporate social performance level than local companies with local CEOs. It is derived that the need to obtain CSR knowledge from CVC investment is higher if foreign CEOs lead local companies.

Bertrand et al. (2021) add that the difference between local and foreign CEOs of local companies is stronger for more authentic and trust-increasing CSR activities. Transferring this information to a CVC investment with the objective of corporate social performance, this impact factor should be considered. Not only the CEO characteristics are relevant, but also the characteristics of CSR activities like authenticity and trust promotion.

In addition, Bertrand et al. (2021) find that the difference between local and foreign CEOs is stronger where the need to build trustworthiness with locals is higher. Apart from CEO characteristics and characteristics of CSR, the need to build trustworthiness has to be considered in CVC investment. The three factors named influence the need of corporate social performance to enable CEOs achieving legitimacy and trustworthiness which can be pursued through CVC.

Table 86 presents proposals for action derived from these discussion results. The six proposals are described in the following.

First, CVC managers should include CSR and pragmatic legitimacy in their decision-making criteria. Second, if recovery and relief efforts after local disasters are required, managers should not compensate these with CVC.

Third, four objectives are identified which are recommended to be supported through CSR-focused CVC. These are spillover reduction, risk reduction due to high visibility of multinational parent companies, the control of parent companies over CVC units, and liability of foreignness. Fourth, to achieve an insurance-like effect for a limited number of events, companies should invest CVC with a long-term rather than short-term focus on CSR.

Fifth, to reduce stock price risks, companies should invest CVC with a focus on CSR as part of their CSR activities. Sixth, especially if foreign CEOs lead local companies, companies should invest CVC to obtain CSR knowledge.

Table 86: Proposals: Risk prevention through social activities

Research result	Proposal for action
In CVC investment decision-making, CSR is one factor to consider apart from other ones like pragmatic legitimacy.	CVC managers should include CSR and pragmatic legitimacy in their decision-making criteria.
CVC investment cannot be equated with recovery and relief efforts after local disasters.	If recovery and relief efforts after local disasters are required, managers should not compensate these with CVC.
CVC investment in CSR can be utilized for spillover reduction, to reduce risks due to high visibility of multinational parent companies, the control of parent companies over CVC units, and liability of foreignness.	If companies pursue spillover reduction, to reduce risks due to high visibility of multinational parent companies, the control of parent companies over CVC units, and liability of foreignness, they should apply CSR-focused CVC.
Long-term focus of CSR in CVC investment can be beneficial as an insurance-like effect for a limited number of events.	To achieve an insurance-like effect for a limited number of events, companies should invest CVC with a long-term rather than short-term focus on CSR.
Companies facing stock price risks can invest CVC with a focus on CSR as part of their CSR activities.	To reduce stock price risks, companies should invest CVC with a focus on CSR as part of their CSR activities
The need to obtain CSR knowledge from CVC investment is higher if foreign CEOs lead local companies.	Especially if foreign CEOs lead local companies, companies should invest CVC to obtain CSR knowledge.

Source: Own elaboration

4.4.2.23 Risk prevention through environmental activities

Flammer (2013) finds that companies which report to behave environmentally responsibly experience a significant stock price increase. Companies which report to behave irresponsibly experience a significant stock price decrease. Flammer's (2013) finding is relevant to CVC investment decisions. It is derived that irresponsible investment decisions can lead to a decrease in stock prices. Responsible CVC investment decisions can positively influence stock prices. This doctoral thesis is focused on knowledge transfer through CVC. It does not categorize investments themselves, but the green knowledge transfer outcome. Future research can analyze the investments themselves categorizing them as responsible or irresponsible to verify if the relation found by Flammer (2013) also applies to responsible or irresponsible CVC investment.

Flammer (2013) adds the finding of a negative stock market reaction increase to eco-harmful behavior over time and a decrease of the positive reaction to eco-friendly initiatives. It is derived that in the long term, companies need more eco-friendly initiative effort to achieve positive results and more effort to compensate for negative effects. In this context, CVC with a focus on green investment can be utilized to standardize execution of eco-friendly initiatives.

Another moderating factor found by Flammer (2013) is that stock market pressure to eco-friendly and -harmful CSR is smaller for firms with higher environmental CSR levels. It is derived that the general environmental CSR level influences stock market pressure. CVC can be invested to pursue a higher environmental CSR level. As this doctoral thesis presents, CVC significantly impacts green knowledge transfer. Thus, knowledge can be transferred to an organization, support green innovations and consciousness for the environmental CSR dimension. In this way, CVC can lead to an increase of the environmental CSR level.

Table 87 concludes three proposals for action related to risk prevention through environmental activities. These are derived from the critical discussion.

The first proposal is that CVC investors should invest responsibly to positively support stock price levels. The second one is that companies are recommended to invest CVC with a focus on green investment if they pursue to standardize execution of eco-friendly initiatives. The third proposal is that companies should invest green knowledge transfer-focused CVC if they pursue to increase their environmental CSR level.

Table 87: Proposals: Risk prevention through environmental activities

Research result	Proposal for action
Irresponsible investment decisions can lead to a decrease in stock prices. Responsible CVC investment decisions can positively influence stock prices.	CVC investors should invest responsibly to positively support stock price levels.
CVC with a focus on green investment can be utilized to standardize execution of eco-friendly initiatives.	If companies pursue to standardize execution of eco-friendly initiatives, they are recommended to invest CVC with a focus on green investment.
CVC can lead to an increase of the environmental CSR level.	If companies pursue to increase their environmental CSR level, they should invest green knowledge transfer-focused CVC.

Source: Own elaboration

4.4.2.24 Risk prevention through governance activities

F. Gao et al. (2014) find executives of CSR-conscious companies to profit significantly less from insider trades. CVC can be invested to transfer CSR-related knowledge to investing organizations. Through this knowledge transfer, CSR consciousness can be increased. Thus, CVC can indirectly lead companies to profit less from insider trades.[83]

They add that executives of CSR-conscious companies are less likely to trade prior to future news than executives of non-CSR-conscious companies. Due to the same reasons described in the last paragraph, CVC can indirectly reduce the risk that executives trade prior to future news.

F. Gao et al. (2014) add the moderating of personal interests of executives being aligned with the interests of the company. The negative relation between CSR and insider trading profits is stronger if personal interests of executives are more aligned with

[83] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

the interests of the company. It is derived that the need of CSR-consciousness is stronger if personal interests of executives are less aligned with the interests of the company. In such cases, companies can even more profit from the positive effects of CVC on CSR consciousness.[84]

Flammer and Kacperczyk (2019) find that CSR can avoid knowledge leakage as it reduces the willingness of knowledge holding employees to join competitive companies. The present doctoral thesis shows that CVC impacts green knowledge transfer between startup and investor. As described previously, CVC can indirectly improve investor CSR and reduce the risk of knowledge leakage. To conclude, CVC with a focus on CSR can support investors obtaining CSR knowledge and holding this knowledge within the company.

Flammer and Kacperczyk (2019) add research to shared knowledge if knowledge holding employees join competitive companies. They find that CSR of the previous employer reduces the risk that the knowledge is shared with the new employer. It is derived that CSR-focused CVC supports that knowledge of employees joining competitive companies is not shared with the new employer.

As named in chapter 4.1.2, Flammer and Kacperczyk (2019) conclude that CSR reduces the risk that knowledge holding employees “walk” and “talk”. The present research adds to this conclusion that CVC with a focus on CSR has three advantages. These are that it leads investors to generate knowledge, holding this knowledge within the company, and avoid that knowledge is shared with competitors.

Table 88 concludes three proposals related to risk prevention through governance activities. First, if companies pursue that employees profit less from insider trades and reduce the risk that executives trade prior to future news, they should invest CVC.

Second, companies with an executive risk of interests being less aligned with the interests of the company and a higher need of CSR-consciousness should invest CVC. Third, should invest CVC with a focus on CSR to achieve three benefits. These are that it leads investors to generate knowledge, holding this knowledge within the company, and avoid that knowledge is shared with competitors.

[84] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Table 88: Proposals: Risk prevention through governance activities

Research result	Proposal for action
CVC can indirectly lead companies to profit less from insider trades.	If companies pursue that employees profit less from insider trades and reduce the risk that executives trade prior to future news, they should invest CVC.
CVC can indirectly reduce the risk that executives trade prior to future news.	
If personal interests of executives are less aligned with the interests of the company, the need of CSR-consciousness is stronger, and companies can even more profit from the positive effects of CVC on CSR consciousness.	Especially companies with an executive risk of interests being less aligned with the interests of the company and a higher need of CSR-consciousness should invest CVC to achieve CSR consciousness.
CVC with a focus on CSR has three advantages. These are that it leads investors to generate knowledge, holding this knowledge within the company, and avoid that knowledge is shared with competitors.	If companies pursue to obtain CSR knowledge, holding this knowledge within the company, and that knowledge of employees joining competitive companies is not shared with the new employer, they should invest CVC with a focus on CSR.

Source: Own elaboration

4.4.3 Mobility discussion

Similar to chapter 4.1.3, this chapter is split into habits, products, services, technologies and appearing innovation, Supply Chain Management, and sustainability. Research results are discussed in the context of the findings of this doctoral thesis.

As described in chapter 4.2.3, the models E to H are focused on the mobility sector. Thus, this chapter refers to the findings of the models E to H. As this chapter is focused on technologies, a focus in the proposals for action is on use cases for CVC.

4.4.3.1 Societal mobility habits

Ravensbergen et al. (2023) find that mobility of care covers 28 percent of adults' daily mobility and women to complete more mobility of care than men. This gender gap is strengthened if women belong to lower-income households and have children. It is derived for mobility companies that customer mobility behavior depends on household income and the presence of children. According to these factors, the need of mobility solutions can vary. As found in this doctoral dissertation, mobility companies can achieve knowledge transfer through CVC investment. CVC can be used to achieve knowledge transfer according to the abovementioned needs.

Yu et al. (2023) find an increase in domestic tourism in Beijing after the COVID-19 pandemic compared to the time before. Furthermore, they find individual tourism behavior recovery to be dependent on age and gender and city recovery to be dependent on welfare. With these findings, they enhance tourism management understanding during public health crises. Additionally, they provide insights into policymaking during post-pandemic recovery and for future outbreaks. It is derived that public health crises can influence mobility behavior. Companies need to adapt to changing consumer behavior and offer suitable solutions to customers. To meet these changing requirements, companies can invest CVC and pursue knowledge transfer. This knowledge can be utilized to find solutions and meet consumer needs.

The proposals for action derived from the critical discussion of research results from Ravensbergen et al. (2023) and Yu et al. (2023) are presented in Table 89. The proposals relate to CVC antecedents.

Companies should invest CVC and pursue knowledge transfer if one of the following objectives are present. The first one is that they pursue to offer solutions according to gender- and income-based mobility needs. The second one is that they face changing mobility requirements due to public health crises and pursue to meet consumer needs.

Table 89: Proposals: Societal mobility habits

Research result	Proposal for action
CVC can be used to achieve knowledge transfer necessary to offer solutions according to gender- and income-based mobility needs.	If companies pursue knowledge generation to offer solutions according to gender- and income-based mobility needs, they should invest CVC.
Public health crises can influence mobility behavior and change requirements. Companies can invest CVC and pursue knowledge transfer to find solutions and meet consumer needs.	If companies face changing mobility requirements due to public health crises, they should invest CVC and pursue knowledge transfer to find solutions and meet consumer needs.

Source: Own elaboration

4.4.3.2 Smart and shared mobility

Savastano (2023) find a need for suppliers of smart mobility solutions and institutions to understand and communicate digital services implementation knowledge. CVC can be invested to support mobility suppliers understand more about of smart mobility solutions. This can happen during the whole investment process resulting in transferred knowledge as it was found in this doctoral dissertation. Furthermore. CVC can support investors who pursue understanding and communicating digital services implementation know-how.

Simonofski et al. (2023) define a smart mobility framework. This framework includes the phases idea, analysis, agenda-setting, preparation, implementation, monitoring, and evaluation. Furthermore, the smart mobility framework names stakeholders involved to be public agents, citizen, companies, and researchers. Simonofski et al. (2023) describe the relevance of smart mobility for citizens' well-being and pursuing sustainability objectives. This dissertation finds that general and green knowledge can be transferred through CVC investment. Investors can conduct CVC investment to obtain knowledge during the smart mobility phases which Simonofski et al. (2023) name in their framework. It is derived that CVC can indirectly support investors to support citizens’ well-being and pursuing sustainability objectives through knowledge transfer.

Zhu et al. (2023) describe the main subsets of shared mobility to include ridesharing, carsharing, shared micro mobility, on-demand ride services, and shared autonomous vehicles. They describe shared mobility benefits and improvement of urban transportation systems in relation to company supply and discuss government policies. The present doctoral dissertation describes how knowledge can be transferred to CVC investors in the mobility sector. In this way, CVC can support corporate activities related to ridesharing, carsharing, shared micro mobility, on-demand ride services, and shared autonomous vehicles.

As described in chapter 4.1.3, Narayanan and Antoniou (2023) provide a model allowing the choice between bikesharing, carsharing and ridehailing. The model variables are socio-demographic characteristic, trip-related variables, and supply parameters. Moreover, finance, infrastructure, campaigns, and nudges, as well as service design are defined as policy-measures. CVC can be invested to obtain knowledge about bikesharing, carsharing, and ridehailing. With the abovementioned factors, mobility corporations can understand consumer behavior better and decide which services to focus on. Consequently, they can invest CVC according to the variables found by Narayanan and Antoniou (2023) and obtain the corresponding knowledge to offer relevant solutions.

Geurs et al. (2023) find universal design principles, digital and democratic integration dimensions to be missing in shared mobility hub concepts, definitions, and planning. The smarter shared mobility hubs are physically, digitally, and democratically, the more user and societal value can they create. CVC can be invested to generate knowledge on shared mobility hubs. Investors can focus on physical, digital, and democratic dimensions to create smart shared mobility hubs and create societal value.

Table 90 provides an overview of four antecedents leading to advice when CVC investments are recommended. These are based on the abovementioned results. First, if companies pursue to generate knowledge about smart mobility, understand and communicate digital services implementation they are recommended to invest CVC. Second, they should invest CVC if companies pursue knowledge transfer to support citizens’ well-being and sustainability objectives.

Third, if companies pursue to generate knowledge and offer solutions referring to the following products and services, they should invest CVC. The products and services are ridesharing, ridehailing carsharing, bikesharing shared micro mobility, on-demand ride services, and shared autonomous vehicles. Fourth, companies are recommended to invest CVC with a focus on physical, digital, and democratic dimensions. The antecedents for this are that they pursue to generate knowledge, build shared mobility hubs, and create societal value.

Table 90: Proposals: Smart and shared mobility

Research result	**Proposal for action**
CVC can be invested to understand smart mobility and support investors understanding and communicating digital services implementation know-how.	If companies pursue to generate knowledge about smart mobility, understand and communicate digital services implementation they should invest CVC.
CVC can indirectly support investors to support citizens' well-being and pursuing sustainability objectives through knowledge transfer.	If companies pursue knowledge transfer to support citizens' well-being and sustainability objectives, they should invest CVC.
CVC can support corporate activities related to ridesharing, carsharing, shared micro mobility, on-demand ride services, and shared autonomous vehicles.	If companies pursue to generate knowledge and offer solutions referring to the following products and services, they should invest CVC. The products and services are ridesharing, ridehailing carsharing, bikesharing shared micro mobility, on-demand ride services, and shared autonomous vehicles.
CVC can be invested to obtain knowledge about bikesharing, carsharing, and ridehailing.	
CVC can be invested to generate knowledge on shared mobility hubs and create societal value. Investors can focus on physical, digital, and democratic dimensions.	If companies pursue to generate knowledge, build shared mobility hubs, and create societal value, they should invest CVC with a focus on physical, digital, and democratic dimensions.

Source: Own elaboration

4.4.3.3 Mobility as a Service (MaaS)

Y. Zhang and Kamargianni (2023) find factors influencing new mobility technologies and services adoption and enablers. They focus on autonomous vehicles, drones, micro mobility, and MaaS. Key factor types are socio-demographic, mobility and travel related patterns, geography, build environment, weather and environment, personal traits, attitudes, technologies, and acceptance theories related factors. According to the key factors found by Y. Zhang and Kamargianni (2023), mobility companies can analyze customer needs. Based on these needs, they can invest CVC to generate knowledge in the corresponding field. For example, they can invest in drones if they find a target group interest in drones.[85]

Arias-Molinares and García-Palomares (2020) find main MaaS actors to be transport authorities and transport operators and recommend collaboration between them. Furthermore, they recommend using MaaS pilots to collect data on user travel behavior and preferences. The results can support transport planners and policy makers to evaluate MaaS impacts and feasibility. The results found by Arias-Molinares and García-Palomares (2020) are support CVC investment processes of companies that pursue to learn about MaaS. These can be companies that already offer MaaS solution or such that pursue to do so. CVC can be invested in startups focused on developing MaaS pilots to collect data on user travel behavior and preferences. In this way, investors can learn to set up such pilots themselves and about the data content. Therefore, they can evaluate MaaS impacts and feasibility and develop MaaS solutions according to uses' needs.

Schikofsky et al. (2020) find psychological needs to be relevant for MaaS acceptance. Motivation and expected usefulness of MaaS are influenced by anticipated advantages of autonomy, competence, and the feeling of being related to a social peer group. Through motivation and expected usefulness, behavioral intention triggered. Furthermore, they find that cognitive congruency between existing habits and anticipated usage patterns of MaaS significantly affect judgment and behavioral intention. The findings presented by Schikofsky et al. (2020) help MaaS providers to better understand their customers. Furthermore, companies focused on supplying vehicles can analyze their customers and decide if it makes sense to expand offering MaaS solutions. If cus-

[85] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

tomers are, for example, anticipating advantages of autonomy, competence, and the feeling of being related to a social peer group, they can also be a MaaS target group. To meet these target group's needs, companies can invest CVC to generate MaaS knowledge and offer corresponding services.

Butler et al. (2021) present a conceptual framework with outcomes, barriers and risks related to MaaS adoption in cities. The first finding refers to positive outcomes associated with MaaS. MaaS is associated with increased trip awareness and improved social equity, but reduced parking, vehicle ownership, and number of vehicle kilometers. It is derived that the same factors can be antecedents for CVC investment in MaaS-focused startups to generate MaaS-related knowledge. Increased trip awareness and improved social equity, reduced parking, vehicle ownership, and number of vehicle kilometers can be arguments for MaaS investments. These arguments can be applied within CVC investing organizations and communicated to the outside.

Further findings by Butler et al. (2021) refer to MaaS supply and demand side barriers. Supply side barriers include public and private cooperation, business support, service coverage, shared vision, data, and cyber security. Demand side barriers are lacking acceptance of older generations, public transport users, and private vehicle users, perceived attractiveness of platforms, and user willing-ness-to-pay. These barriers should be considered by CVC decision-makers when investing to pursue MaaS-based knowledge transfer. On the other hand, CVC investments can be applied to overcome the abovementioned barriers. For example, MaaS providers can invest in startups focused on user experience and design to overcome the barrier of perceived attractiveness of platforms.

Hensher (2017) find that hybrid multi-modal requires new contract setting. New contracts should enable mode-neutral customer experience and the opportunity to focus on MaaS. With contract setting, Hensher (2017) describe one example of what CVC investors can learn from MaaS-focused startups. In the next step, they can apply this transferred knowledge to their own contract setting for MaaS solutions.

As described in chapter 4.1.3, Ho et al. (2018) find that almost half of Sydney, Australia travelers would choose MaaS offerings. Potential uptake levels vary significantly across population segments. Infrequent car users are the most likely adopters, and car non-users the least likely adopters. It is derived that automotive suppliers can classify their customers' likelihood of car sharing adoption based on car usage frequency. With this analysis and under consideration of further variables, they can estimate the relevance of MaaS to these customers. If they find a high relevance of MaaS for these customers, they can apply CVC investment to transfer knowledge and offer solutions in the field of MaaS. If they do not pursue to offer MaaS themselves, they can present startup MaaS to their customers to enhance the investee scaling process and achieve a financially successful exit. Furthermore, investors' reputation can benefit indirectly from such investments as they can be associated with innovative and digital technologies and solutions.

Ho et al. (2018) also find that Sydney travelers are willing to pay € 5.02 for an hour of access to carshare. Sydney travelers willingness to pay for unlimited use of public transport is € 4.62 per day. To meet these requirements, suppliers need to minimize costs. To minimize costs, CVC can be invested in startups which offer cheap solutions. In this way, MaaS suppliers in general, car sharing suppliers, and public transport suppliers can offer lower prices due to lower cost. Therefore, they can meet travelers' willing to pay.[86]

Eight proposals for action in the field of MaaS are presented in Table 91 and Table 92. First, companies should invest CVC, generate knowledge, and offer autonomous vehicles, drones, micro mobility, and MaaS solutions. This proposal should be applied if the target group meets the abovementioned criteria found by Y. Zhang and Kamargianni (2023).[87]

Second, if companies pursue to evaluate MaaS impacts and feasibility and develop MaaS solutions according to uses' needs, they should invest CVC. Third, to meet target group's needs, companies are recommended to invest CVC to generate MaaS knowledge and offer corresponding services.

Fourth, if managers seek for MaaS-related CVC investment arguments internally and externally, they should name the following benefits. These benefits are increased trip awareness, improved social equity, reduced parking, vehicle ownership, and number of vehicle kilometers.

[86] Calculated from USD with the exchange rate (USD 1 = EUR 0.7838) provided by the European Central Bank on average between 09/04/2017 and 23/04/2017 according to the sample timeframe (European Central Bank, 2024).

[87] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

Table 91: Proposals: Mobility as a Service (MaaS): Part 1

Research result	Proposal for action
Autonomous vehicles, drones, micro mobility, and MaaS adoption are influenced by patterns, geography, build environment, weather, environment, personal traits, attitudes, technologies, and acceptance theories related factors.	If companies have a target group meeting criteria found by Y. Zhang and Kamargianni (2023), they should invest CVC, generate knowledge, and offer autonomous vehicles, drones, micro mobility, and MaaS solutions.
CVC can be invested in startups focused on developing MaaS pilots to collect data on user travel behavior and preferences to learn about the data content and set up such pilots themselves.	If companies pursue to evaluate MaaS impacts and feasibility and develop MaaS solutions according to uses' needs, they should invest CVC.
Motivation and expected usefulness of MaaS are influenced by anticipated advantages of autonomy, competence, and a feeling of relatedness.	To meet target group's needs, companies are recommended to invest CVC to generate MaaS knowledge and offer corresponding services.
Increased trip awareness and improved social equity, reduced parking, vehicle ownership, and the number of vehicle kilometers can be arguments for MaaS investments.	If managers seek for MaaS-related CVC investment arguments internally and externally, they should name benefits like increased trip awareness, improved social equity, reduced parking, vehicle ownership, and the number of vehicle kilometers.

Source: Own elaboration

Fifth, MaaS supply and demand side barriers should be considered by CVC decision-makers when investing to pursue MaaS-based knowledge transfer. Furthermore, CVC investments should be applied to overcome these barriers. Sixth, CVC investors should invest in and learn from MaaS-focused startups. In the next step, they should apply this transferred knowledge to their own contract setting for MaaS solutions.

Seventh, if automotive suppliers find a high relevance of MaaS for customers, they should apply CVC investment for three purposes. The first one is to transfer knowledge and offer solutions in the field of MaaS. The second one is to present startup MaaS to their customers to achieve a financially successful exit. The third one is for an indirect investors' reputation benefit.

Eighth, if companies pursue to meet travelers' willingness to pay, they should invest CVC in startups which offer cheap carsharing solutions. In this way, they can offer lower prices due to lower cost.

Table 92: Proposals: Mobility as a Service (MaaS): Part 2

Research result	**Proposal for action**
Supply and demand side barriers are present for MaaS.	MaaS supply and demand side barriers should be considered by CVC decision-makers when investing to pursue MaaS-based knowledge transfer. Furthermore, CVC investments should be applied to overcome these barriers.
Hybrid multi-modal requires new contract setting.	CVC investors should invest in and learn from MaaS-focused startups and apply this transferred knowledge to their own contracts for MaaS solutions.
Automotive suppliers can classify their customers' likelihood of car sharing adoption based on car usage frequency.	If automotive suppliers find a high relevance of MaaS for customers, they should apply CVC investment.
CVC can be invested in startups which offer cheap carsharing solutions to offer lower prices due to lower cost and meet travelers' willingness to pay.	If companies pursue to meet travelers' willingness to pay, they should invest CVC in startups which offer cheap carsharing solutions.

Source: Own elaboration

4.4.3.4 Mobility innovation

As referred to in chapter 4.1.3, Falcetelli et al. (2022) research application opportunities of Strain Modal Testing in the automotive sector. They provide an overview of similarities and discrepancies between Strain Modal Testing and conventional Experimental Modal Analysis approaches. Falcetelli et al. (2022) describe that Strain Modal Testing is mainly restricted to academics and requires additional research for a successful industry transition. Startups tend to be more flexible and have less risk applying academic approaches which are not already industry proven. Investing CVC can pursue a window on technology as referred to by Dushnitsky and Yu (2022). In this way, investors can learn about Strain Modal Testing to stay competitive as soon as it is established in the industry.

Khan et al. (2022) describe the relevance of 6G communications to provide robust, intelligent, and energy-efficient data sharing. They name nonorthogonal multiple access and backscatter communications as techniques relevant for 6G communication. CVC investment screening processes help investors to stay up to date on upcoming technologies. Investment focused on 6G communications, especially nonorthogonal multiple access and backscatter communications support investors obtaining knowledge. This know-how transferred from startups to investors as found for the mobility sector in this thesis supports investors to innovate.

Birenboim et al. (2023) classify tourism mobility apps into four types of apps. These four types of apps are mobility, navigation, interaction and experience, and social media apps. It is derived that corporations can invest CVC in tourism mobility apps. With such investments, they can obtain knowledge about mobility, navigation, interact and experience, and social media.

Table 93 presents an overview of mobility innovation-related proposals for action derived from these results. Mobility companies are recommended to invest CVC in corresponding startups if they pursue the following objectives.

The first one is a window on technology and learn about Strain Modal Testing to stay competitive as soon as it is established in the industry. The second one is to innovate in the field of 6G communications, especially nonorthogonal multiple access and backscatter communications. The third is to obtain knowledge about mobility, navigation, interaction and experience, and social media in the field of tourism mobility apps.

Table 93: Proposals: Mobility innovation

Research result	Proposal for action
Investing CVC can pursue a window on technology. In this way, investors can learn about Strain Modal Testing to stay competitive as soon as it is established in the industry.	If mobility companies pursue a window on technology and learn about Strain Modal Testing to stay competitive as soon as it is established in the industry, they should invest CVC in corresponding startups.
Investment focused on 6G communications, especially nonorthogonal multiple access and backscatter communications support investors obtaining knowledge. This know-how supports investors to innovate.	If mobility companies pursue to innovate in the field of 6G communications, especially nonorthogonal multiple access and backscatter communications, they should invest CVC in corresponding startups.
Corporations can invest CVC in tourism mobility apps. With such investments, they can obtain knowledge about mobility, navigation, interaction and experience, and social media.	If mobility companies pursue to obtain knowledge about mobility, navigation, interaction and experience, and social media in the field of tourism mobility apps, they should invest CVC in corresponding startups.

Source: Own elaboration

4.4.3.5 Blockchain innovation focus

Friedhoff et al. (2023) find that social acceptance for the utilization of Blockchain-based digital identities is significantly influenced by four factors. These are demographics, citizens' experience with Blockchain products, affinity with financial products and privacy concerns. It is derived that CVC can be invested in Blockchain-focused startups. Especially if mobility companies identify their target group to be open for Blockchain according to the factors described by Friedhoff et al. (2023), they can use CVC. Acquired knowledge through can be used to offer additional Blockchain-based solutions.

Bhawana et al. (2024) find an Blockchain Enabled Energy Trading framework to outperform compared to state-of-the-art works. Their analysis is based on addressing the renewable energy demand problem to realize E-mobility. It is derived that mobility companies can invest in startups focused on Blockchain Enabled Energy Trading to generate knowledge and offer corresponding solutions.

Paiva et al. (2021) describe that Blockchain can provide citizens with a privacy preserved, transparent, and confidential architecture for mobility services. They name Blockchain-based Internet of Vehicles to have three benefits. These benefits are improvement of interaction and communication between vehicles, tracking, and smart city traffic management.

It is derived from Paiva et al. (2021) that mobility companies can invest CVC in Blockchain-focused startups if they pursue improvement of interaction and communication between vehicles, tracking, and smart city traffic management. They can learn about Blockchain and achieve these benefits.

Furthermore, the benefits named by Paiva et al. (2021) can be pursued by governmental organizations. If they pursue to achieve these benefits, they can incentivize and support CVC with a focus on Blockchain. Furthermore, they can support startups directly.

Four proposals for action are derived from these results as presented in Table 94. First, mobility companies should invest in Blockchain-focused startups if they identify their target group to be open for blockchain according to four factors. These are demographics, citizens' experience with Blockchain products, affinity with financial products and privacy concerns.

Second, mobility companies should invest CVC in startups focused on Blockchain Enabled Energy Trading if they pursue to generate knowledge and offer corresponding solutions. Third, mobility companies should invest CVC in Blockchain-focused startups if they pursue three benefits. These are improvement of interaction and communication between vehicles, tracking, and smart city traffic management.

Fourth, governmental organizations should incentivize and support Blockchain-focused CVC. This is the case especially if they pursue improvement of interaction and communication between vehicles, tracking, and smart city traffic management. Furthermore, they should support startups directly. This can be done through subventions, for example for R&D.

Table 94: Proposals: Blockchain

Research result	Proposal for action
CVC can be invested in Blockchain-focused startups if mobility companies identify their target group to be open for blockchain according to the factors described by Friedhoff et al. (2023).	Mobility companies should invest in Blockchain-focused startups if they identify their target group to be open for blockchain according to the factors described by Friedhoff et al. (2023).
Mobility companies can invest in startups focused on Blockchain Enabled Energy Trading to generate knowledge and offer corresponding solutions.	Mobility companies should invest CVC in startups focused on Blockchain Enabled Energy Trading if they pursue to generate knowledge and offer corresponding solutions.
Mobility companies can invest CVC in Blockchain-focused startups if they pursue improvement of interaction and communication between vehicles, tracking, and smart city traffic management.	Mobility companies should invest CVC in Blockchain-focused startups if they pursue improvement of interaction and communication between vehicles, tracking, and smart city traffic management
Governmental organizations can incentivize support Blockchain-focused CVC if they pursue improvement of interaction and communication between vehicles, tracking, and smart city traffic management. Furthermore, they can support startups directly.	Governmental organizations should incentivize and support Blockchain-focused CVC if they pursue improvement of interaction and communication between vehicles, tracking, and smart city traffic management. Furthermore, they should support startups directly.

Source: Own elaboration

4.4.3.6 Digital Twins innovation focus

Piromalis and Kantaros (2022) find Digital Twins to be relevant from designing vehicles until the construction, especially for electric vehicles. CVC can be invested in Digital Twin technology. As this doctoral thesis demonstrates, knowledge can be transferred from the startup to the investor. This new knowledge can then be applied to design until construction processes. In this way, CVC can support a more enjoyable, comfortable, and safe experience for drivers as these advantages are named by Piromalis and Kantaros (2022).

Mukherjee and DebRoy (2019), find that Digital Twins of 3D printing machines reduce the number of trial and error tests in 3D printing, defects, and save time. They name the preconditions that Digital Twins of 3D printing machines consist of mechanistic, control and statistical models of 3D printing, machine learning and big data. CVC can be invested by mobility companies to learn about Digital Twins. In detail, they can generate knowledge about mechanistic, control and statistical models of 3D printing, machine learning and big data. This knowledge can be used to reduce the number of trial-and-error tests in 3D printing, defects, and save time. Accordingly, CVC investors can reduce their costs, their prices and strengthen their market positions.

Qi et al. (2018) describe how manufacturing services and Digital Twins are united naming components of Digital Twin-related services which are used by manufacturers. Combined smart manufacturing services and Digital Twins change product design, manufacturing, usage, maintenance, repair, operations, and further processes. It is derived that smart manufacturing service providers can invest CVC to generate knowledge about Digital Twins. They can use this knowledge to enlarge their offer and change product design, manufacturing, usage, maintenance, repair, operations, and further processes.

Schleich et al. (2017) describe that more realistic virtual models of manufactured products are necessary to mirror the reality correctly in the Digital Twins. As described in chapter 4.1.3, they propose a reference model which addresses conceptualization, representation, implementation, and applications along the product life cycle. Startups are more flexible in their operations and in certain cases, innovate faster than corporations. It is derived from the results described by Schleich et al. (2017) that CVC can be invested in startups which are working or offering more realistic virtual models.

Knowledge transfer about such more realistic virtual models can support investors to offer or use these virtual twins themselves to make profit and reduce costs.

In their scientific and application oriented analysis, Stark et al. (2019) examine aspects of developing and operating Digital Twins considering eight dimensions. The dimensions are integration breadth, connectivity modes, update frequency, Cyber-Physical Systems intelligence, simulation capabilities, digital model richness, human interaction, and product lifecycle. It is derived that mobility companies can invest CVC and generate knowledge about developing and operating Digital Twins. This knowledge can be subdivided into the eight abovementioned dimensions. Hence, CVC mobility investors can improve their offered and used Digital Twins. Benefits can be digital monitoring and functional improvement of interconnected products, devices, and machines. Furthermore, investors can take advantage of horizontal and vertical integration in manufacturing.

Anshari et al. (2022) develop an interactive and interpretive model which integrating Digital Twin concepts and applications. They find robo-advisors enabled with Digital Twins no longer to be ad hoc but comprehensive and dynamic financial advisory services. Two results are derived from the findings presented by Anshari et al. (2022). The first one is addressed to the CVC evaluation process and the second one to mobility service providers.

According to the results found by Anshari et al. (2022), robo-advisors enabled with Digital Twins can support financial advisory services. These can be applied by CVC investors across industries including the mobility sector. Investments can result in enhanced knowledge transfer under the condition that robo-advisors enabled with Digital Twins consider knowledge transfer when advising.

Transferring the results presented by Anshari et al. (2022) to the mobility sector, it can be derived that Digital Twins can be applied to enhance services. Mobility companies can use CVC to invest in Digital Twins and achieve knowledge transfer through CVC. With this newly generated knowledge, they can offer new or improved services.

Botín-Sanabria et al. (2022) describe Digital Twins to enable data-driven decision making, complex systems monitoring, product validation, simulation, and object lifecycle management. They add that Digital Twins collect information from the real environment and represent, validate, and simulate present and future behavior. It is derived that mobility companies can invest CVC in Digital Twins to obtain related knowledge. This knowledge can result in data-driven decision making, complex systems monitoring, product validation, simulation, and object lifecycle management. Furthermore, investors can apply the knowledge to represent, validate, and simulate present and future behavior of a physical environment through Digital Twins.

Martínez-Olvera (2022) describes the objective of mass customization to be achieving the highest level of customer satisfaction and optimization of the value creation process. Furthermore, he describes mass customization 4.0 success to depend on the degree/level of sustainability and names concepts related to the role of Digital Twins. It is derived that CVC can be invested into mass customization directly and into Digital Twins. As this doctoral thesis finds that CVC enables general and green knowledge transfer in the mobility sector, these investments can be carried out by mobility companies. In this way, they can generate knowledge about mass customization, Digital Twins, and offer new or developed solutions supporting sustainability.

Qian et al. (2022) name the relevance of Digital Twins as digital clones of physical systems due to a risk of manipulating or updating real systems. It is derived that mobility CVC investors can invest in startup focused on Digital Twins to learn about and achieve risk mitigation of manipulating or updating real systems.

Qian et al. (2022) name Digital Twin challenges to be networking, computing, and data analytics for the Internet of Things as well as complexity. They add design requirements like latency, reliability, safety, scalability, security, and privacy occur to be challenging. Startups tend to be more flexible than established companies to work on technological and market challenges such as the abovementioned. By investing CVC in startups, investors can learn about solutions to use Digital Twins with eliminated or reduced challenges.

Smart systems which are used as described by Qian et al. (2022) include smart grid, smart transportation, smart manufacturing, and smart cities. The target group for the risk mitigation as well as challenge elimination and reduction is derived from these finding. Risk mitigation, challenge elimination and reduction can be applied by investors focused on smart grid, smart transportation, smart manufacturing, and smart cities.

Eight proposals derived from the critical discussion about Digital Twins are derived and concluded in Table 95 and Table 96. These proposals for action relate to CVC antecedents and describe in which cases CVC investment is recommended. First, if companies pursue to offer a more enjoyable, comfortable, and safe experience for drivers, they should invest CVC. In this way, they are recommended to generate knowledge and apply this from design until construction processes.

Second and third, companies should invest CVC and generate knowledge accordingly if they pursue the following objectives. The objectives are cost and price reduction, strengthening of market positions through reduction of trial-and-error tests in 3D printing, defects, and saved time. Pursuable objectives for smart manufacturing service providers are enlarging their offer and change product design, manufacturing, usage, maintenance, repair, operations, and further processes.

Table 95: Proposals: Digital Twins: Part 1

Research result	Proposal for action
CVC be invested in Digital Twin-focused startups to generate knowledge and be applied from design until construction processes. In this way, CVC can support a more enjoyable, comfortable, and safe experience for drivers.	If companies pursue to offer a more enjoyable, comfortable, and safe experience for drivers, they should invest CVC to generate knowledge and apply this from design until construction processes.
CVC can be invested by mobility companies to learn and use this knowledge to reduce the number of trial-and-error tests in 3D printing, defects, and save time. Accordingly, CVC investors can reduce their costs, prices and strengthen their market positions.	If companies pursue to reduce their costs, prices and strengthen their market positions through reduction of trial-and-error tests in 3D printing, defects, and save time, they should invest CVC and generate knowledge accordingly.
Smart manufacturing service providers can invest CVC to generate knowledge about Digital Twins to enlarge their offer and change product design, manufacturing, usage, maintenance, repair, operations, and further processes.	If smart manufacturing service providers pursue to enlarge their offer and change product design, manufacturing, usage, maintenance, repair, operations, and further processes, they should invest CVC to generate knowledge about Digital Twins.

Source: Own elaboration

Fourth, if companies pursue to offer or use virtual twins to make profit and reduce costs, they should invest CVC. They are recommended to invest in startups working with or offering more realistic virtual models.

Fifth, if mobility companies pursue digital monitoring and functional improvement of inter-connected products, devices, and machines, they should invest CVC. Furthermore, they should invest to achieve horizontal and vertical integration in manufacturing and learn about Digital Twins.

Sixth, if mobility companies pursue to offer new or developed solutions supporting sustainability, they should invest CVC into mass customization and Digital Twins. Seventh, if mobility companies pursue to mitigate risk of manipulating or updating real systems, they should invest CVC in Digital Twin-related startups. Eighth, if mobility companies pursue to use Digital Twins with eliminated or reduced challenges, they are recommended to invest CVC in corresponding startups.

Table 96: Proposals: Digital Twins: Part 2

Research result	**Proposal for action**
CVC can be invested in startups which are working or offering more realistic virtual models. Knowledge transfer can support investors to offer or use these virtual twins themselves to make profit and reduce costs.	If companies pursue to offer or use virtual twins to make profit and reduce costs, they should invest CVC in startups which are working with or offering more realistic virtual models.
Mobility companies can invest CVC and generate knowledge about Digital Twins. Potentials are digital monitoring, functional improvement of interconnected products, devices, and machines, besides horizontal and vertical integration in manufacturing.	If mobility companies pursue digital monitoring and functional improvement of interconnected products, devices, and machines, as well as horizontal and vertical integration in manufacturing, they should invest CVC and learn about Digital Twins.
CVC can be invested by mobility companies into mass customization and Digital Twins. In this way, they can generate corresponding knowledge and offer new or developed solutions supporting sustainability.	If mobility companies pursue to offer new or developed solutions supporting sustainability, they should invest CVC into mass customization and Digital Twins.
Mobility CVC investors can invest in startup focused on Digital Twins to learn about and achieve risk mitigation of manipulating or updating real systems.	If mobility companies pursue to mitigate risk of manipulating or updating real systems, they should invest CVC in Digital Twin-related startups.
By investing CVC in startups, investors can learn about solutions to use Digital Twins with eliminated or reduced challenges.	If mobility companies pursue to use Digital Twins with eliminated or reduced challenges, they are recommended to invest CVC in corresponding startups.

Source: Own elaboration

4.4.3.7 Supply Chain Management in the automotive sector

Muhammad et al. (2022) describe additive manufacturing as a method to handle supply chain disruptions and boost resilience in supply chains. CVC can be invested in startups focused on additive manufacturing and other supply chain management supporting production processes. The results of analyzing models E and F show that CVC leads to joint knowledge creation with the startup as well as knowledge transfer from the startup to the investor. In this way, investors can acquire knowledge and thus, handle supply chain disruptions and boost resilience in supply chains.

Saha et al. (2023) describe just-in-time, lean and agile supply chain operations, productivity, and sustainability to meet the automotive sector's requirements. This doctoral thesis extends the research results found by Saha et al. (2023). It is found that CVC enables knowledge transfer between startups and investors in the mobility industry. Models E and F refer to general knowledge transfer which can include just-in-time, lean and agile supply chain operations, productivity, and sustainability. Models G and H are focused on green knowledge transfer emphasizing the opportunity of generating knowledge on sustainability. It is derived that CVC can support meeting the automotive sector's requirements.

Saha et al. (2023) add key criteria to identify the best warehouse location for the automotive manufacturing company. These are energy availability and cost as well as the proximity to port and customs. CVC can be applied to extend the location opportunities of a plant. Enabling ambidexterity, the core business can be focused on criteria such as energy availability and cost as well as the proximity to port and customs. Another part of the company which pursues to explore and innovate rather than exploit can be located in entrepreneurship hubs. Referring to the findings of this doctoral dissertation, knowledge can be gained by investors to explore and exploit at the same time. To enable this ambidexterity, different location criteria can be chosen for the core business and a CVC unit.

Zheng et al. (2023) find opportunities to develop high mobility semiconductors for electronic and energy conversion applications. Mobility companies can invest CVC in quasi-2D semiconductors and related technologies to keep window on technology and learn from startups. In this way, established corporations can stay competitive even if disruptive technologies arise. Another advantage for European investors is that they can invest in startups in other regions (e.g., Asia) and pursue knowledge transfer. This would not only be an advantage for single companies but enlarge competitive and economic strength of the European region.

Table 97 presents six Supply Chain Management-related proposals for action. First, if companies pursue to handle supply chain disruptions and boost resilience in supply chains, they are recommended to invest CVC. They should invest in startups focused on additive manufacturing and other supply chain management supporting production processes to obtain corresponding knowledge.

Second, governmental organizations should incentivize CVC to support meeting the automotive sector's requirements. These requirements include just-in-time, lean and agile supply chain operations, productivity, and sustainability. Third, companies should invest to meet their own objectives aligned with the same requirements.

The fourth proposal considers an extension of location opportunities and ambidexterity as CVC antecedents. If companies pursue to extend the location opportunities of a plant and enable ambidexterity, they should invest CVC.

Fifth, European governmental organizations should incentivize CVC to let European companies generate knowledge and enlarge competitive and economic strength. This proposal should consider that in this setup, CVC can also strengthen startups in competitive geographic areas. The sixth proposal is that European companies should invest inter-regional CVC to learn and use own quasi-2D semiconductor solutions.

Table 97: Proposals: Supply Chain Management

Research result	Proposal for action
CVC can be invested in startups focused on additive manufacturing and other supply chain management supporting production processes. In this way, investors can acquire knowledge and thus, handle supply chain disruptions and boost resilience in supply chains.	If companies pursue to handle supply chain disruptions and boost resilience in supply chains, they should invest CVC in startups focused on additive manufacturing and other supply chain management supporting production processes to obtain corresponding knowledge.
CVC enables knowledge transfer between startups and investors in the mobility industry which can include just-in-time, lean and agile supply chain operations, productivity, and sustainability. Thus, CVC can support meeting the automotive sector's requirements.	Governmental organizations should incentivize CVC to support meeting the automotive sector's requirements including just-in-time, lean and agile supply chain operations, productivity, and sustainability.
	Companies should invest to meet their own objectives aligned with the automotive sector's requirements.
CVC can be applied to extend the location opportunities of a plant and enable ambidexterity.	If companies pursue to extend the location opportunities of a plant and enable ambidexterity, they should invest CVC.
Mobility companies can invest CVC in quasi-2D semiconductors and related technologies to keep window on technology and learn from startups. An advantage for European investors is that they can invest in startups in other regions (e.g., Asia) and pursue knowledge transfer.	European governmental organizations should incentivize CVC to let European companies generate knowledge and enlarge competitive and economic strength.
	European companies should invest interregional CVC to learn and use own quasi-2D semiconductor solutions.

Source: Own elaboration

4.4.3.8 Relevance of sustainability in the mobility sector

Mathivathanan et al. (2022) find different influence factors towards pressure for sustainable supply chain management adoption. The key influence factors are government regulations, benefits of social and environmental certifications, and interests of the foreign investors in sustainable product development. CVC can support investors developing towards sustainable supply chain management. This need is increased by government regulations, benefits of social and environmental certifications, and interests of the foreign investors in sustainable product development. It is derived that the CVC benefit increases if the abovementioned influence factors are present.

Golroudbary et al. (2022) name the transportation sector being responsible for the largest share of greenhouse gas emissions in 2019. Thus, they describe the relevance of moving the mobility sector towards sustainability. This thesis describes with the analysis of the models G and H how moving the mobility sector towards sustainability is possible through CVC.

Golroudbary et al. (2022) analyze the use of magnesium for lightweight vehicle introduction. As described in chapter 4.1.3, their research results in a quantification of environmental benefits considering circular economy strategies. CVC can be invested to generate knowledge about the use of magnesium or lightweight vehicle introduction in general. To generate such knowledge, CVC investors invest in startups with this focus and explore new technologies. That knowledge is transferred in the mobility sector is presented in chapter 4.3 referring to the models E to H.

Ketter et al. (2023) argue that connected, autonomous, shared, and electric vehicle technology has created a digital layer added to traditional physical mobility system. This additional layer and its corresponding characteristics and challenges need to be met by mobility companies. To learn more about connected, autonomous, shared, and electric vehicle technology, companies can invest CVC into startups focused on these technologies. With this opportunity, also traditional automotive companies can meet needs required by the digital layer.

Kakderi et al. (2021) find emerging urban mobility strategies to be transformational, even though they are mainly temporary. They also find emerging urban mobility strategies to be consistent with the principles of smart growth and sustainable development. To support emerging urban mobility strategies, mobility technologies and solutions as well as knowledge on these fields is relevant. As found in this doctoral dissertation, CVC can be invested to transfer general and green knowledge in the mobility sector. With such knowledge, solutions can be offered to meet emerging urban mobility strategies' requirements.

Table 98 provides an overview of four proposals for action related to the relevance of sustainability in the mobility sector. First, government regulations, benefits of social and environmental certifications, and interests of the foreign investors in sustainable product development are CVC antecedents. If these are present, companies should invest CVC to support investors developing towards sustainable supply chain management. Second, to move the mobility sector towards sustainability, governmental organizations should incentivize CVC investment.

Third, if companies should invest CVC in corresponding startups if they pursue to generate knowledge in the following fields. These knowledge fields are the use of magnesium or lightweight vehicle introduction, connected, autonomous, shared, and electric vehicle technology. Fourth, if companies pursue to meet emerging urban mobility strategies' requirements, they should invest CVC in related startups and obtain general and green knowledge.

Table 98: Proposals: Relevance of sustainability in the mobility sector

Research result	Proposal for action
CVC can support investors developing towards sustainable supply chain management. This need is increased by government regulations, benefits of social and environmental certifications, and interests of the foreign investors in sustainable product development.	Especially if government regulations, benefits of social and environmental certifications, and interests of the foreign investors in sustainable product development are present, companies should invest CVC to support investors developing towards sustainable supply chain management.
Moving the mobility sector towards sustainability is possible through CVC.	To move the mobility sector towards sustainability, governmental organizations should incentivize CVC investment.
CVC can be invested to generate knowledge about the use of magnesium or lightweight vehicle introduction.	If companies pursue to generate knowledge about the use of magnesium or lightweight vehicle introduction, connected, autonomous, shared, and electric vehicle technology, they should invest CVC in related startups.
To learn more about connected, autonomous, shared, and electric vehicle technology, companies can invest CVC into startups focused on these technologies.	
CVC can be invested to transfer general and green knowledge in the mobility sector. With such knowledge, solutions can be offered to meet emerging urban mobility strategies' requirements.	If companies pursue to meet emerging urban mobility strategies' requirements, they should invest CVC in related startups and obtain general and green knowledge.

Source: Own elaboration

4.5 Research limitations

This doctoral dissertation finds that CVC impacts general and green knowledge transfer cross-sectorial and in the mobility sector. To apply this analysis including eight models in the scope of this doctoral dissertation, limitations are considered. These limitations refer to the state of research, the applied methodology and derived from the critical discussion of the research results. Thus, this chapter is subdivided to limitations of the state of research, the applied methodology and the critical discussion.

4.5.1 Limitations of the state of research and methodology

4.5.1.1 State of research limitations

English literature is analyzed in this doctoral thesis and literature in other languages is not considered in this doctoral dissertation. Furthermore, literature analyzed includes the years 1970 to 2024 with a focus on literature published between 2015 and 2024.

Mobility research is more technical than CVC and sustainability research. Thus, other research methods are applied as described in chapter 4.1.3. Furthermore, less economic literature is available than about CVC and sustainability. Thus, also literature from lower-ranked journals is included in the state of research and critical discussion about mobility.

Another impact of unequal availability of current literature of CVC, sustainability, and mobility is that state of research and critical discussion sub-chapters differ in their length. The state of research and critical discussion about sustainability is longer than the sub-chapters about mobility. Furthermore, the sub-chapters about mobility in chapter 4 are longer than the ones about CVC.

4.5.1.2 Methodological limitations

Patent analysis is applied in this doctoral dissertation to measure knowledge transfer in order to achieve open innovation through CVC. Measuring innovation through patent analysis is limited and further innovation measures exist. For example, innovation activity, output, and expenditure are differentiated and can be measured with different methods. As this dissertation is focused on knowledge transfer, patent analysis is applied (S. M. Lee et al., 2015; L. Wang et al., 2023).[88]

A confident approach to identify green patents does not exist. As described in chapter 4.2, the classification of sustainable patents is made according to classification codes of the International Patent Classification Green Inventory. If an invention is marked as green according to this definition, this does not mean with certainty that this invention is green. Conversely, if an invention is marked as non-green, it can be stated that the invention is not green (World Intellectual Property Organization, 2023). For reasons of replicability and objectivity, remaining patents were not examined individually.

Due to limited data availability, the size and R&D intensity of the corporation listed at Bloomberg instead of the dedicated investment unit are analyzed. Future research should analyze size and R&D intensity on investment unit level.

Due to the patent timeframe of 5 years after an investment, only investments until 2016 can be considered analyzing patents created until 2022. During this time, other technologies have been relevant and the focus on sustainability was lower. Thus, it can be assumed that the relation intensified since then. Furthermore, the analysis was applied in the year 2023. The process of discussing the results took from end of 2023 until April 2024. To enable this process, data from 2023 needed to be excluded as the year was not finished at the time the analysis was applied.

American NAICS codes are used rather than European company classification systems. The reason is that the is standardized in international patent research and practice (Anokhin & Morgan, 2023; Dushnitsky & Yu, 2022).

There is no clear demarcation of mobility companies from other companies. For example, an IT company can build software for autonomous driving, but NAICS industry is not directly classified as mobility. Thus, a keyword analysis is applied. In this context, keywords in business descriptions and on websites are analyzed and double-checked by the author to avoid wrong interpretation of keyword usage.

Within the scope of this doctoral thesis, 8 models have been analyzed to figure out whether a positive relationship between the number of CVC investments and

[88] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

knowledge transfer exists. For the US and without a special focus on the mobility industry and sustainability, S. M. Lee et al. (2015) find a curvilinear relationship between the number of CVC investments and knowledge transfer. Based on this thesis, future research can apply the same methodology and figure out if the relation is also curvilinear in Europe focusing on the mobility industry and sustainability.[89]

Due to the sample size, a general negative binomial Poisson regression model is applied rather than a panel analysis. Future research can apply an analysis to further companies than the STOXX Europe 600 to enable a panel analysis.

As described in chapter 4.2.1, the population quantification is limited. The reason for this is that not all CVC investments of European companies are tracked. STOXX Europe 600 companies are defined as the population which equals the sample. Therefore, the transferability to other European companies than STOXX Europe 600 companies is limited (Nirino et al., 2022; Wooldridge, 2019).

Correlations between mobility CVC investment and general patent registration are higher than between general CVC investment and general patent registration. The regression results show the opposite with a higher significance in a cross-sector analysis than in the mobility industry. As described in chapter 4.3.3.3, reasons for these opposed findings can be a stronger linear relation forcing higher correlation results, significance, samples size dependencies as well as context matters. Further research is necessary to analyze the interdependencies in detail (Wooldridge, 2019).

The Log-likelihood for the models A to G is between -785.7830 and -28.446 and the Wald test results are between 6.8954* and 48.779***. The model quality can be improved with further variables relevant for the regression model. These could not all be considered in the scope of this dissertation but leading to knowledge creation. Such variables can be prior joint ventures, alliances, and M&A deals. Moreover, sustainability measures such as ESG ratings are not considered. To choose the most relevant variables, an analysis of previous literature is applied. The five control variables with the highest significance levels are applied. Excluded variables are described in the following (Wooldridge, 2019).

[89] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

4.5.1.3 Variables not considered in the analyzed models

Due to the scope of this dissertation, a decision is made by the author which variables are included in the model and which ones are not. Certain variables are excluded if they are identified to have a comparably low or no influence on the dependent variable of the corresponding model. Variables excluded are described in the following.

The maturity of a portfolio company can influence the knowledge creation of the investor. To operationalize the maturity, the round number can be used in future research. Startups pass due diligence checks before an investor decides to invest. Thus, the number of investors can be considered as a proxy for the quality of a portfolio company (Wadhwa & Kotha, 2006).

Investment strength can be operationalized by the number or value of prior joint ventures, alliances, and M&A deals. Future research can apply Refinitiv as a data source for this variable (Wadhwa & Kotha, 2006).

CVC investors can invest directly or indirectly. In case that the investor invests directly, the investment is assigned 1 as strong tie according to S. M. Lee et al. (2015). Investments assigned 0 for weak tie are wholly owned subsidiaries, dedicated funds or limited partnerships. The tie strength variable is a binary variable which is not applicable to the negative binomial Poisson regression model due to the number of zeros. A zero-inflated model has been applied instead but was not applicable to the other variables. After the zero-inflated model has been applied only to the variable tie strength and did not have a significative impact on the dependent variable, it has been excluded from the model (Dushnitsky & Yu, 2022; Röhm, 2018; Q. Zhang & Yi, 2023).[90]

On average, there are different numbers of patents registered in different industries. To ensure that the model is not biased due to different standard patent registration frequency, the average patent application rate can be considered as a control variable. It can be measured in future research as the number of patents registered by a company in the four years before a corporate investment is made (European Patent Office, 2024).

The CVC investment quantity of an investor can be measured to consider investment experience. It is assumed that regular investments enlarge the relevance of clearly de-

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fined corporate processes and responsibilities to leverage knowledge transfer potential (K. Lee et al., 2023; S. M. Lee et al., 2015; Shuwaikh & Dubocage, 2022).[91]

Economic cycles consist of the phases expansion, peak, depression, and trough (Tüzen et al., 2022). A dummy variable is defined for economic cycles especially due to particularly high mortality due to downturns (Asel et al., 2015). The dummy variable is not included in this model as they are not the focus of this doctoral dissertation. Furthermore, the years need to be specified depending on different factors. Future research can set 0 for expansion and peak and 1 during the contraction phases. (S. M. Lee et al., 2015; Wilson & Silva, 2013).[92]

4.5.2 Limitations of the critical discussion and limitations conclusion

During the critical discussion in chapter 4.4, research limitations are identified. An overview of these limitations is provided in the following.

4.5.2.1 Critical discussion imitations on Corporate Venture Capital (CVC)

Rossi et al. (2022) find CVC to positively impact regional and international innovation eco flows in the US, Asia, and Europe. The present doctoral thesis adds that knowledge transfer is possible in Europe and S. M. Lee et al. (2015) found a similar relation in the US. If CVC impacts knowledge transfer in Asia is not investigated yet. Furthermore, the clear relationship between CVC-based knowledge transfer and eco flows is not subject to the methodology applied in this thesis. The relationship between CVC-based knowledge transfer and eco flows can be subject to future research.[93]

Wang et al. (2023) compare independent VC and CVC. They find independent VC to be useful to enhance the internal corporate reputation and promoting the evolution of self-centered technological innovation networks. CVC is more suitable to consolidate external reputation of companies and promote the holistic technological innovation

[91] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.
[92] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.
[93] Please note that the first name abbreviation is displayed because two authors with the same surname are cited in this doctoral dissertation.

networks evolution. Future research should compare knowledge transfer between independent VC and CVC. Especially as main objectives of independent VC tend to be financial and main objectives of CVC tend to be strategic, a difference in knowledge transfer is assumed. Independent VCs also need knowledge during investment processes. This knowledge is assumed not to be necessary for innovation, but for the different investment phases such as screening and due diligence. Hence, knowledge transfer in independent VC might not be reflected in patent rates, but in internal knowledge measures. Such knowledge measurements can also be applied to CVC units independent from the parent company.

During the critical discussion of this doctoral dissertation, the following results are derived from Ladnar et al. (2023). CVC investment enables open innovation through the general and green knowledge transfer cross-sectorial and in the mobility industry found in this doctoral dissertation. This result derived should be validated in future research. It is found that CVC enables open innovation, and that CVC enables knowledge transfer. The research gap of a relation description between knowledge transfer and open innovation remains open.

Two further results derived from Ladnar et al. (2023) are limited. The first one is that the knowledge transferred to CVC investors can be applied to explore, exploit, and pursue ambidexterity. The second one is that transferred green and general knowledge can be applied by corporate investors on organizational, social, and technical levels. These findings should also be validated with future research.

Weiss et al. (2023) find ambidextrous orientation to be a mediator for strategic corporate venturing. The present doctoral thesis is focused on CVC but not on other corporate venturing activities (e.g., internal corporate venturing). Knowledge transferred in other types of corporate venturing is not analyzed yet and builds a research limitation.

Furthermore, this doctoral does not specify whether knowledge transferred is classified as exploration, exploitation, or ambidexterity. Future research can support companies to decide if CVC can generate the knowledge needed depending on whether they pursue exploration, exploitation, or ambidexterity (Weiss et al., 2023).

4.5.2.2 Limitations of the sustainability-related critical discussion

T. T. Li et al. (2021) present the results of a systematic ESG literature review. ESG ratings are not subject to the methodology applied in this paper even though they can impact green knowledge transfer. Future research should investigate if ESG ratings moderate green patent registration of investors. Such research can support investors to decide whether CVC investment supports knowledge creation according to their corporate characteristics such as ESG ratings.[94]

Gupta et al. (2019) research the relation between CEO political orientation and leadership of companies with a CSR strategy. Furthermore, they research the impact on narcissism on this relation. If this relation can be applied to managing directors of CVC units should be subject of further investigation. Learning about the characteristics of leaders can influence the CVC focus and improve aligning recruiting and CVC corporate objectives. Furthermore, the influence of parent CEO characteristics on CVC leadership with a CSR strategy can be a focus of future research. The present research is limited as these relations are not explored yet. Results of such studies can also enhance the model analyzed in this doctoral thesis if further variables are found to be considered.

Han et al. (2019) describe that executives who previously spent time abroad tend to lead companies with a higher level of CSR compared to local executives. Luo et al. (2021) add that executives who spent time abroad make more corporate donations. Han et al. (2019) and Luo et al. (2021) describe executive experience influencing corporate CSR. In addition to the limitations derived from Gupta et al. (2019) referring to CEO characteristics, a research gap on executive experience abroad is present. From this, two research questions are derived. The first one is if CVC unit executive experience abroad influences the CVC unit level of CSR. The second research question is if parent company executive experience abroad influences the CVC unit level of CSR.

Mun and Jung (2018) find an influence of institutional investors and local CSR managers on the number of women in board or management positions. The influence on the number of non-managerial or entry level positions is not significant. A research gap is identified to be whether CVC investors and local CSR managers influence founder gender diversity. This analysis should be applied to startup board or management posi-

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tions as well as non-managerial or entry level positions. Furthermore, it should be analyzed if CVC influences gender diversity of parent companies. This investigation should also be carried out for board or management positions as well as non-managerial or entry level positions.

Chen et al. (2018) find that mandatory CSR reporting negatively influences profitability. The influence of legal requirements on CVC is not researched in detail yet. Especially the influence of CSR-related legal requirements on CVC should be investigated in future research. Also, the influence of legal requirements on CVC-based knowledge transfer is not yet analyzed. Due to this research gap, results described by Chen et al. (2018) are discussed in this dissertation even though legal requirements are not part of the applied methodology. Future research on legal requirements influencing CVC and knowledge transfer can allow managers to adapt according to the dependencies.

Mithani (2017) state that multinational companies can contribute to recovery and relief efforts after local disasters to strengthen their position in the local community and mitigate liability of foreignness. It is not analyzed yet whether the same relation is applicable to CSR-related CVC. A research question can be if multinational companies invest CSR-related CVC to strengthen their position in the local community and mitigate liability of foreignness.

This doctoral thesis describes the influence of CVC on knowledge transfer leading to a second research question. This research question is if multinational companies use CSR-related knowledge transferred through CVC to strengthen their position in the local community and mitigate liability of foreignness. Research on the utilization of knowledge can allow executives to lead a company towards profitability through an enhanced market position. Therefore, research on the utilization of knowledge would enhance the research field of this doctoral thesis by improving the understanding of CVC-linked relations.

As described in chapter 4.4.2, Shiu and Yang (2017) find that a long-term engagement in CSR can be beneficial as an insurance-like effect for one negative event. This insurance-like effect disappears after a second negative event. It is not researched yet if this insurance-like effect also applies to CSR-related CVC investment. If a relation is significant, it should be investigated for how many negative events this relation applies. Furthermore, it should be investigated if a relation between CSR-related CVC investment and an insurance-like effect is direct or indirect. As described previously, this doctoral thesis improves scientific research on the influence of CVC on green knowledge transfer. It should be researched if newly generated knowledge can be applied in other corporate activities to enhance the insurance-like effect. Furthermore, different ESG dimensions should be considered to enhance the detailed understanding of CVC and insurance-like effect dimensions.

4.5.2.3 Limitations of the critical discussion on mobility

Ravensbergen et al. (2023) describe a gender gap in mobility of care execution to depend on the presence of children and household income. CVC investors in the mobility sector invest to meet customer needs. If these needs vary through the presence of children and household income, these variables can influence the relationship between CVC investments and knowledge transfer. The reason is that an investment focus on knowledge transfer focused on mobility of care can differ from green knowledge transfer which is the focus of this dissertation. Future research should investigate if these variables influence the relationship between CVC investments and knowledge transfer.

Yu et al. (2023) find changes in domestic tourism after the COVID-19 pandemic, individual recovery to be dependent on age and gender and city recovery to be dependent of welfare. The influence of public health crises on CVC investment is not fully investigated yet. Furthermore, CVC recovery after pandemics and moderating factors build a research gap. This research gap is present for the mobility sector and cross-sectorial. Moreover, the influence of global pandemics on CVC-caused knowledge transfer is not analyzed yet. This doctoral dissertation analyzes investments prior to COVID-19 as patent registration after investments can be delayed by five years.

Simonofski et al. (2023) define a smart mobility framework including the phases idea, analysis, agenda-setting, preparation, implementation, monitoring, and evaluation. Furthermore, the smart mobility framework defines public agents, citizens, companies, and researchers as stakeholders. This doctoral dissertation closes the research gap if general and green knowledge is transferred through CVC in the mobility sector.

What is still open to future research is in which smart mobility phases this knowledge can be applied. Thus, future research can classify newly created knowledge into idea, analysis, agenda-setting, preparation, implementation, monitoring, and evaluation.

Furthermore, the stakeholders of this newly transferred knowledge should be defined. The investor perspective is the focus of this doctoral thesis, but public agents, citizens, other companies, and researchers can be impacted through CVC indirectly. This indirect relation should be validated in future research.

Zhu et al. (2023) describe the subsets of shared mobility. Moreover, they discuss how government policies and company supply regulate travel behavior. Three research gaps resulting in three research questions are derived from this research. The first one refers to investor, investment, and patent classification. Future research should investigate the differences between ridesharing, carsharing, shared micro mobility, on-demand ride services, and shared autonomous vehicles. The second research gap is the influence of government policies on knowledge transfer. The third research gap leads to the research question is if CVC investment influences shared mobility company supply.

Narayanan and Antoniou (2023) describe a model allowing the choice between bikesharing, carsharing and ridehailing according to variables described in the chapters 4.1.3 and 4.4.3. This doctoral dissertation finds that knowledge transfer can be achieved through CVC. Anyway, the required knowledge to meet consumer needs for bikesharing, carsharing, and ridehailing is not defined in scientific research yet. Closing this research gap can allow CVC investment-decisions to be more target- and customer-oriented.

Geurs et al. (2023) describe universal design principles, digital and democratic integration dimensions to be missing in shared mobility hub concepts, definitions, and planning. This doctoral thesis investigates CVC impact on knowledge transfer of single investments and closes the corresponding research gap. A research gap which is open is the influence of CVC on mobility sector ecosystems, for example, the shared mobility hub. It should be investigated in future research if CVC influences mobility sector ecosystems rather than single companies in certain dimensions like knowledge transfer.

Y. Zhang and Kamargianni (2023) find factors influencing new mobility technologies and services adoption and enablers. It is not researched yet how these factors influence CVC investments of investors if they pursue knowledge transfer. This research gap should be closed in future research. In the critical discussion of this doctoral dissertation, the assumption is made that companies can invest CVC according to the influencing factors named by Y. Zhang and Kamargianni (2023).[95]

Arias-Molinares and García-Palomares (2020) recommend using MaaS pilots to collect data on user travel behavior and preferences. It is derived in the critical discussion that through CVC, investors can learn to set up such pilots themselves and about the data content. Comparing the value of learning about (1) setting up pilots themselves and (2) about the data content is an open research gap. Comparing the value can support investors learning about what to focus on in a knowledge transfer process.

Schikofsky et al. (2020) find psychological needs to be relevant for MaaS acceptance. Examples are influenced by anticipated advantages of autonomy, competence, and the feeling of being related to a social peer group. The indirect influence of customer psychological needs on CVC investment focus on MaaS is not yet researched. Furthermore, MaaS knowledge transfer through CVC builds a research gap. To handle this limitation, the assumption is made in the critical discussion that CVC can be applied to learn about MaaS.

Butler et al. (2021) present a conceptual framework with outcomes, barriers and risks related to MaaS adoption in cities. It is derived during the critical discussion that outcomes can be communicated by managers as positive arguments for CVC investments on MaaS. Nevertheless, barriers and risks should be considered in the decision-making process. Furthermore, CVC can be invested to overcome barriers of MaaS adoption. The quantification of the arguments presented by Butler et al. (2021) is a research gap which should be closed to enable decision-making based on numbers. For example, a weighted decision matrix can be applied to quantify the relevance of outcomes, barriers, and risks. Furthermore, it should be investigated if CVC investment is a suitable solution to overcome MaaS barriers.

Hensher (2017) describe that hybrid multi-modal requires new contract setting. It is derived in the critical discussion of this doctoral dissertation that CVC investors can learn about contract design from MaaS-focused startups. This dissertation is focused on knowledge transfer resulting in patents whereas knowledge transfer resulting in contracts is not covered. This type of knowledge transfer should be validated in future re-

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search to validate if CVC is a suitable solution for knowledge transfer related to contracting.

During the critical discussion of the findings found by Ho et al. (2018), three results in the context of CVC are derived. Ho et al. (2018) find that infrequent car users are the most likely adopters of MaaS and car non-users the least likely adopters. First, automotive suppliers can classify their customers' likelihood of car sharing adoption based on car usage frequency and estimate the relevance of MaaS to these customers. If they find relevance of MaaS for these customers, they can invest CVC to transfer knowledge and offer solutions in the field of MaaS. This result refers to the result of this doctoral dissertation. Future research should validate if specific MaaS knowledge is transferred through CVC and if this knowledge can be transferred to new and developed product and service offers.

Second, it is derived from findings of Ho et al. (2018) that if automotive suppliers do not pursue to offer MaaS themselves, they can present startup MaaS to their customers. Accordingly, they can enhance the investee scaling process and achieve a financially successful exit. Third, it is derived that investors' reputation can benefit from MaaS investments as they can be associated with innovative and digital technologies and solutions. If the effect of the second and third results derived is present should be validated. Furthermore, the influence of these benefits on corporate performance should be compared to support managers defining investment objectives.

Ho et al. (2018) present another finding. This is that Sydney travelers are willing to pay € 5.02 for an hour of access to car-share and € 4.62 per day for public transport.[96] It is derived in this dissertation's critical discussion that CVC can be invested in startups which offer cheap solutions. If the resulting knowledge transfer is enough to offer solutions meeting the customers' willingness to pay is an open research gap.

Mukherjee and DebRoy (2019), find that Digital Twins of 3D printing machines reduce the number of trial and error tests in 3D printing, defects, and save time. Preconditions are that Digital Twins of 3D printing machines consist of mechanistic, control and statistical models of 3D printing, machine learning, and big data. It is derived and assumed in the critical discussion that CVC can be invested by mobility companies to learn about

[96] Calculated from USD with the exchange rate (USD 1 = EUR 0.7838) provided by the European Central Bank on average between 09/04/2017 and 23/04/2017 according to the sample timeframe (European Central Bank, 2024).

Digital Twins. Specific knowledge can be transferred from the startup to the investor about mechanistic, control and statistical models of 3D printing, machine learning, and big data. This doctoral dissertation finds that general and green knowledge is transferred from startups to investors due to CVC investment. It should be validated in future research if knowledge is transferred about Digital Twins, mechanistic, control and statistical models of 3D printing, machine learning, and big data. This validation should be applied with a quantitative research approach. Furthermore, an open research gap to be closed includes the research question if transferred knowledge in the abovementioned fields indirectly leads to cost saving.

Qi et al. (2018) describe how manufacturing services and Digital Twins are united naming components of Digital Twin-related services which are used by manufacturers. It is derived that smart manufacturing service providers can invest CVC to generate knowledge about Digital Twins. This doctoral thesis finds general and green knowledge transfer to be possible through CVC. If Digital Twin knowledge transfer is possible through CVC should be validated in future research.

Qi et al. (2018) add that combined smart manufacturing services and Digital Twins change product design, manufacturing, usage, maintenance, repair, operations, and further processes. It is derived in the critical discussion that CVC can indirectly support these changes. This assumption should also be validated in future research.

Chapter 4.4.3 discusses Digital Twin virtual models described by Schleich et al. (2017). It is derived that CVC can be invested in startups which are working or offering more realistic virtual models to enable knowledge transfer. If startups focus on realistic virtual models and if knowledge transfer about such realistic virtual models is possible should be validated in future research. Furthermore, it should be investigated if newly generated knowledge on realistic virtual models indirectly increases profit and reduces costs.

In chapter 4.4.3, the results found by Stark et al. (2019) are discussed in the context of knowledge transfer and CVC. It is derived that CVC can be invested to generate knowledge about developing and operating Digital Twins. This assumption should be validated in future research. In a quantitative study, Digital Twin-related knowledge transfer can be subdivided into the dimensions named by Stark et al. (2019). These are integration breadth, connectivity modes, update frequency, Cyber-Physical Systems intelligence, simulation capabilities, digital model richness, human interaction, and product lifecycle. Furthermore, it should be validated if obtained knowledge through CVC can be transferred into operative benefits. These are digital monitoring and functional improvement of interconnected products, devices and machines, horizontal and vertical integration in manufacturing.

It is derived from Anshari et al. (2022) that robo-advisors enabled with Digital Twins can support CVC investment evaluation across industries including the mobility sector. This relation should be validated in future research as Anshari et al. (2022) refer to personal finance advisory instead of CVC advisory. Such an analysis should answer the question if robo-advisors enabled with Digital Twins can consider strategic objectives as pursued with CVC.

The second result derived from Anshari et al. (2022) is that Digital Twins can be applied to enhance mobility services. It should be validated if CVC investment in Digital Twins leads to Digital Twin knowledge transfer. Moreover, the research gap if such knowledge results in new or enhances services should be closed.

During the critical discussion, it has been derived from Botín-Sanabria et al. (2022) that mobility companies can invest CVC in Digital Twins to obtain related knowledge. This knowledge is derived to result in data-driven decision making, complex systems monitoring, product validation, simulation, and object lifecycle management. Also derived is that investors can apply the knowledge to represent, validate, and simulate present and future behavior of a physical environment through Digital Twins. These results should be validated in future quantitative research to enhance CVC investors' decision-making processes.

It is derived from the results presented by Martínez-Olvera (2022) that CVC can be invested into startups focused on mass customization and Digital Twins. It is assumed in the critical discussion that this way, mobility companies can generate knowledge about mass customization and Digital Twins. This assumption should be validated in future research. The present doctoral dissertation finds that general and green knowledge can be transferred to mobility companies. A quantitative methodology to analyze if specific knowledge about mass customization and Digital Twins can be transferred should be applied.

Based on newly generated knowledge, it is derived in the critical discussion that mobility companies can offer new or developed solutions supporting sustainability. This result derived from Martínez-Olvera (2022) should also be validated in future research. Quantitative research should be applied to find if obtained knowledge leads to new or developed solutions supporting sustainability.

The first of three results derived in the critical discussion from Qian et al. (2022) is that CVC investors can invest in startups focused on Digital Twins. In this way, they can learn about and achieve risk mitigation of manipulating or updating real systems. This result derived should be validated in quantitative future research. It should be analyzed if learning from Digital Twin-focused investments is possible and if it mitigates the risk of manipulating or updating real systems.

A second result derived from Qian et al. (2022) during the critical discussion is that CVC can be applied to reduce and eliminate challenges and meet requirements. The Digital Twin challenges named are networking, computing, and data analytics for the Internet of Things as well as complexity. Design requirements are latency, reliability, safety, scalability, security, and privacy. A research gap to validate the occurrence of these reduced challenges, eliminated challenges, and met requirements should be closed with quantitative research.

Third, it is derived from Qian et al. (2022) that risk mitigation, challenge elimination and reduction can be applied by investors focused on smart grid, smart transportation, smart manufacturing, and smart cities. It should be analyzed in future research if the named advantages apply to investors focused on smart grid, smart transportation, smart manufacturing, and smart cities.

Birenboim et al. (2023) classify tourism mobility apps into mobility, navigation, interaction and experience, and social media apps. Future research should analyze about which of these app types investors can learn about through CVC investment. Furthermore, the research gap if knowledge transfer impacts successful app innovation in the fields of mobility, navigation, interaction and experience, and social media should be closed.

Ketter et al. (2023) find that connected, autonomous, shared, and electric vehicle technology adds a digital layer to traditional physical mobility systems. It is derived that, to learn more about such technologies, companies can invest CVC into startups focused on these technologies. This doctoral dissertation closes the research gap of the influence of CVC investment on general and green knowledge transfer cross-sectorial and in the mobility sector. What is not analyzed is what CVC focus areas lead to knowledge transfer. For example, a research question can be if CVC investment in green startup leads to more green knowledge transfer than general CVC investment.

Kakderi et al. (2021) find emerging urban mobility strategies to be transformational and consistent with the principles of smart growth and sustainable development. It is derived that CVC can be invested to transfer knowledge to investors which can offer solutions to meet according requirements. An open research gap is to validate if solutions offered by companies are suitable to meet emerging urban mobility strategies' requirements. Furthermore, it should be researched if a knowledge transfer from companies to urban mobility strategies' decision-makers is possible and occuring.

4.5.2.4 Limitations of proposals for action

The proposals for action derived in the present doctoral dissertation are limited to STOXX Europe 600 companies. They cannot be generalized and applied to all European companies.

For example, proposals for action to invest CVC are not applicable to Small and Medium-Sized Enterprises (SMEs) which miss necessary capital and investment capability. Furthermore, exceptions exist due to companies and industries which are less sensitive to innovation and knowledge-based competitive advantage.

It is derived during the critical discussion that companies can invest in startups focused on certain technology, products, and services. From this, the proposal is derived that they should invest if they pursue to learn about and offer solutions in these fields. These results and proposals are limited in the investment opportunities. Startups which are open for CVC investments are not continuously available. Furthermore, a limitation to further parameters influencing an investment decision are present.

4.5.3 Summary of research limitations

It is found with this doctoral dissertation that CVC impacts general and green knowledge transfer cross-sectorial and in the mobility sector. Nevertheless, research gaps in the context of CVC, sustainability, and mobility research remain open. These limitations refer to the state of research of this thesis, the applied methodology, and the critical discussion.

As this doctoral dissertation is restricted in its scope, it is limited to English research of the years 1970 to 2024. In chapter 4.4, the research results are discussed in the context of the state of research. Thus, the limitation of the state of research also impacts the limitation of the critical discussion.

Main limitations of the methodology relate to definition inaccuracies, especially of mobility companies and green patents. This definition bias negatively impacts the model validity. Another limitation is that model H cannot be analyzed with the negative binomial Poisson regression model. Further research is necessary to analyze the corresponding hypothesis, especially in relation to the influence of R&D on knowledge transfer as described in chapter 4.3.2.

The critical discussion of this thesis suggests relations which are not in the scope of this doctoral dissertation. Relations are derived from scientific research in the context of this doctoral thesis, but not validated. Such validation should be applied in future quantitative research.

5 Conclusions

5.1 Conclusions of research results

To answer the research question if CVC investment impacts open innovation through sustainability knowledge transfer in the European mobility sector, the following hypotheses are tested. A significant cross-sectoral positive influence of CVC on general and green knowledge transfer in Europe is found. H1 to H4 as described in the following are supported:

H1: The number of CVC investments is positively related to the level of knowledge transferred **between** investee and corporate investor.

H2: The number of CVC investments is positively related to the level of knowledge transferred **from** the investee to the corporate investor.

H3: The number of CVC investments is positively related to the level of **green** knowledge transferred **between** investee and corporate investor.

H4: The number of CVC investments is positively related to the level of **green** knowledge transferred **from** the investee to the corporate investor.

Furthermore, a significant positive influence of CVC in the mobility sector on general and green knowledge transfer is found. H5 to H7 are supported whereas the analysis of H8 is not possible with the applied negative binomial Poisson regression model and should be subject to future research:

H5: The number of CVC investments is positively related to the level of knowledge transferred **between** investee and **mobility** corporate investor.

H6: The number of CVC investments is positively related to the level of knowledge transferred **from** the investee to the **mobility** corporate investor.

H7: The number of CVC investments is positively related to the level of **green** knowledge transferred **between** investee and **mobility** corporate investor.

H8: The number of CVC investments is positively related to the level of **green** knowledge transferred **from** the investee to the **mobility** corporate investor.

It is derived that CVC investment impacts open innovation through sustainability knowledge transfer in the European mobility sector. With this finding, the objective of this doctoral dissertation to answer the research question is achieved.

5.2 Practical implications and proposals for action

Legal and societal requirements towards sustainable corporate orientation generate competitive pressure. This pressure to develop companies toward sustainability is present in the mobility sector, but also cross-sectorial.

The findings of this doctoral thesis support managers to understand that CVC can be applied to generate green knowledge resulting in green patent registration. Such patents reflect innovation and the intellectual property of a company. It is derived that executives and managers can lead CVC activities towards green knowledge transfer objectives and indirectly improve competitiveness of CVC investors.

In the following, a conclusion of the proposals for action which are derived during the critical discussion is provided. Proposals addressed to European companies in general, European mobility companies and European governmental organizations are concluded.

5.2.1 Proposals for European companies

Figure 35 concludes proposals for action for European companies without a sectorial limitation. These are split by proposals for CVC units and to achieve sustainability objectives. It should be noted that certain of these proposals apply to both CVC units and achieving sustainability objectives. In such cases, they are grouped by the category which applies more.

Eight proposals for CVC units of European companies are concluded. These are that companies should (1) invest despite barriers and conflicts if advantages predominate and (2) achieve sufficient investment quantity and continuity. Furthermore, they should (3) consider and balance a variety of performance influencing factors and (4) pursue knowledge transfer and open innovation to achieve strategic and financial objectives including corporate performance and value. It is also proposed that (5) CVC units balance strategic and financial objectives and (6) use CVC explore, exploit, or pursue both with ambidexterity. CVC units should (7) make CVC advantages in comparison to disadvantages transparent, consider direct and indirect relationships, and include these criteria in decision-making processes. Last, CVC units should (8) invest to achieve a competitive advantage.

With a focus on sustainability, this doctoral dissertation describes proposals to achieve sustainability objectives. The eight main ones are described in the following. European companies should (1) invest CVC if they pursue to (a) achieve knowledge transfer and (b) enhance environmental and social performance. Furthermore, they should invest CVC if they pursue to (c) achieve a stronger sustainable corporate entrepreneurship focus, (d) achieve low implied volatility, and (e) reduce risks.

Further proposals for European companies to achieve ESG objectives are to (2) consider CSR and ESG ratings bias and (3) use KLD, Thomson Reuters ASSET4 or other independent sustainability measures for startup evaluation. Moreover, they should (4) follow corporate social performance enhancing activities and investments and (5) consider interdependencies between ESG dimensions. (6) Shareholders, recruiters, and other stakeholders should consider CEOs', further executives', and managers' characteristics. Further proposals are that (7) CVC and CSR strategy should be aligned and (8) CVC and legal units should collaborate to make sure CVC is prepared for future legal requirements and legal requirements do not constrain CVC activities.

Figure 35: Proposals for action for European companies

Proposals for action for **European** companies	
For CVC units	To achieve ESG objectives
1. Invest despite barriers and conflicts if advantages predominate 2. Achieve sufficient investment quantity and continuity 3. Consider and balance a variety of performance influencing factors 4. Pursue knowledge transfer and open innovation to achieve strategic and financial objectives including corporate performance and value 5. Balance strategic and financial objectives 6. Use CVC explore, exploit or pursue both with ambidexterity 7. Make CVC advantages in comparison to disadvantages transparent, consider direct and indirect relationships, and include these criteria in decision-making processes 8. Invest to achieve a competitive advantage	1. Invest CVC to a) Achieve green knowledge transfer and open innovation b) Enhance environmental and social performance c) Achieve a stronger sustainable corporate entrepreneurship focus d) Achieve low implied volatility e) Reduce risks 2. Consider CSR and ESG ratings bias 3. Use KLD, Thomson Reuters ASSET4 or other independent sustainability measures for startup evaluation 4. Follow corporate social performance enhancing activities and investments 5. Consider interdependencies between ESG dimensions 6. Shareholders, recruiters, and other stakeholders should consider CEOs', further executives' and managers' characteristics 7. CVC and CSR strategy should be aligned 8. CVC and legal units should collaborate to make sure CVC is prepared for future legal requirements and legal requirements do not constrain CVC activities

Source: Own elaboration

5.2.2 Propositions for established European mobility companies

Figure 36 illustrates proposals for European mobility companies. These are split according to pursued objectives. Proposals supporting technical objectives and further objectives are differentiated.

European mobility companies are proposed to invest CVC to learn and offer corresponding solutions in different fields. These are (1) smart mobility, smart mobility hubs, digital services, (2) autonomous vehicles, drones, micro mobility, and MaaS solutions. Moreover, they are recommended to invest in startups related to (3) ridesharing, ridehailing carsharing, bikesharing, shared micro mobility, on-demand ride services, and shared autonomous vehicles. Further recommended investment fields are (4) Blockchain including Blockchain Enabled Energy Trading, (5) Digital Twins, additive manufacturing, and smart manufacturing. Furthermore, the fields of (6) 6G communications, (7) Tourism mobility apps, (8) semiconductors, and (9) magnesium or lightweight vehicles, connected, shared, and electric vehicle technology are proposed.

Further proposals are more related to customer needs and processes. European mobility companies are recommended to invest CVC to learn and offer corresponding solutions to achieve nine advantages. These are to (1) meet market needs and changing mobility requirements, (2) support citizens' well-being and sustainability objectives, and (3) create societal value. Furthermore, CVC is recommended to (4) increase trip awareness, improved social equity, reduced parking, vehicle ownership, and number of vehicle kilometers. Further conditions under which European mobility companies should invest CVC are that they pursue to (5) meet travelers' willing to pay and (6) handle supply chain disruptions and boost resilience in supply chains. CVC is also recommended to (7) extend the location opportunities of a plant and enable ambidexterity and (8) develop towards sustainable supply chain management. Finally, European mobility companies are recommended to invest CVC to (9) meet emerging urban mobility strategies' requirements.

Figure 36: Proposals for action for European mobility companies

Proposals for action for European **mobility** companies	
Technical CVC objectives	Futher CVC objectives
Invest CVC to learn and offer corresponding solutions in the following fields: 1. Smart mobility (hubs) and digital services 2. Autonomous vehicles, drones, micro mobility, and MaaS solutions 3. Ridesharing, ridehailing carsharing, bikesharing, shared micro mobility, on-demand ride services, and shared autonomous vehicles 4. Blockchain including Blockchain Enabled Energy Trading 5. Digital Twins, additive manufacturing, smart manufacturing 6. 6G communications 7. Tourism mobility apps 8. Semiconductors 9. Magnesium or lightweight vehicles, connected, shared, and electric vehicle technology	Invest CVC to learn and offer corresponding solutions in order to: 1. Meet market needs and changing mobility requirements 2. Support citizens' well-being and sustainability objectives 3. Create societal value 4. Increase trip awareness, improved social equity, reduced parking, vehicle ownership, and number of vehicle kilometers 5. Meet travelers' willing to pay 6. Handle supply chain disruptions and boost resilience in supply chains 7. Extend the location opportunities of a plant and enable ambidexterity 8. Develop towards sustainable supply chain management 9. Meet emerging urban mobility strategies' requirements

Source: Own elaboration

5.2.3 Suggestions for European governmental organizations

While the previously described proposals are addressed to companies, Figure 37 illustrates proposals for action for governmental organizations. These are differentiated by proposals to support startups, such to support established companies and such ones to meet sustainability-related objectives. Again, there are interdependencies between these categories and a classification is applied to meet to most suitable category.

Governmental organizations are recommended to support Blockchain-focused startups. Therefore, they can improve interaction and communication between vehicles, tracking, and smart city traffic management.

To support established companies, five proposals are concluded. Governmental organizations should (1) support CVC to positively impact eco flows and promote holistic technological innovation networks.

Further proposals suggest incentives. Governmental organizations should (2) incentivize and support Blockchain-focused CVC. This is the case if they pursue improvement of interaction and communication between vehicles, tracking, and smart city traffic management. Moreover, they should (3) incentivize CVC to support meeting the automotive sector's requirements including just-in-time, lean and agile supply chain operations, productivity, and sustainability. (4) CVC should also be incentivized to let European companies generate knowledge and enlarge competitive and economic strength and (5) to move the mobility sector towards sustainability.

The last two proposals concluded are related to sustainability objectives. (1) CSR and ESG ratings should be standardized by rating agencies under governmental support to achieve comparability. (2) Governmental organizations are recommended to apply CSR activities themselves to support CVC investment with CSR focus.

Figure 37: Proposals for action for European governmental organizations

Proposals for action for **governmental** organizations		
Startup support	Support established companies	ESG objectives
Directly support Blockchain-focused startups to improve interaction and communication between vehicles, tracking, and smart city traffic management	1. Support CVC to positively impact eco flows and promote holistic technological innovation networks 2. Incentivize and support Blockchain-focused CVC if they pursue improvement of interaction and communication between vehicles, tracking, and smart city traffic management 3. Incentivize CVC to support meeting the automotive sector's requirements including just-in-time, lean and agile supply chain operations, productivity, and sustainability 4. Incentivize CVC to let European companies generate knowledge and enlarge competitive and economic strength 5. Incentivize CVC to move the mobility sector towards sustainability	1. CSR and ESG ratings should be standardized by rating agencies under governmental support to achieve comparability 2. Use governmental CSR activities to support CVC investment with CSR focus

Source: Own elaboration

5.3 Implications for scientific research and outlook

Different CVC relationships are investigated in scientific research. This thesis enhances the understanding of CVC research by describing a significant influence of CVC on (green) knowledge transfer in Europe.

Due to the relevance of sustainability research, literature is available on ESG and CSR. Various relations are found by authors over time investigating antecedents for ESG and CSR and the influence of ESG and CSR on other aspects. The findings of this doctoral thesis enhance research in the fields of RBV, KBV, shareholder theory, stakeholder theory, and institutional theory in the context of CSR research. It adds that CVC can be used to transfer green knowledge. In the next step, this green knowledge can be utilized by organizations to develop further towards sustainable processes, technology, products, and services.

Mobility sector research is focused on innovation. This doctoral thesis fills the research gap of describing how CVC can be used to generate knowledge as an antecedent for innovation strength in the mobility sector.

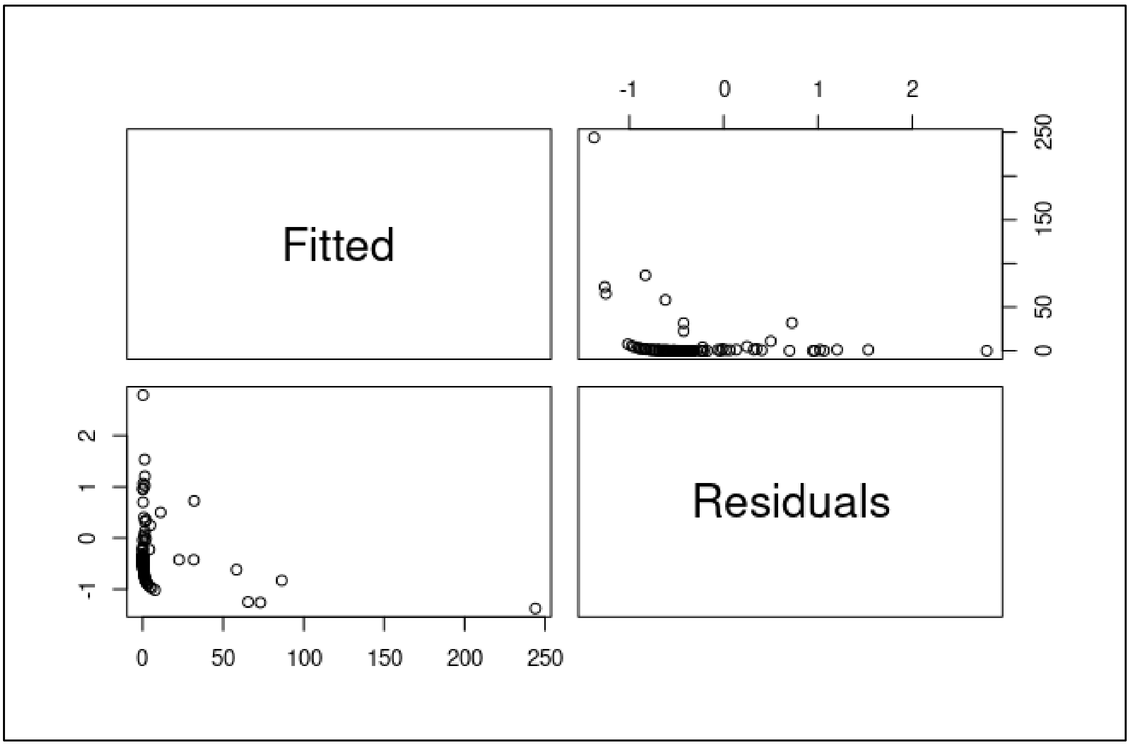
Research gaps are identified in CVC research, sustainability research, and mobility research. In these three research fields, different factors influence each other. This complexity results in a need of analyzing different relations and variables. Especially the relationship between CVC and the three ESG dimensions is not analyzed yet.

This doctoral dissertation is focused on green knowledge transfer. It analyzes the influence of unspecified investments on general and green knowledge transfer. Future research should analyze the characteristics of investments which lead to green knowledge transfer. Findings in this research field can improve CVC management investment decision-making.

Furthermore, a research gap is present for CVC in the mobility sector. Technical innovations are described and discussed in detail, but research on factors influencing the innovation strength of mobility companies is limited.

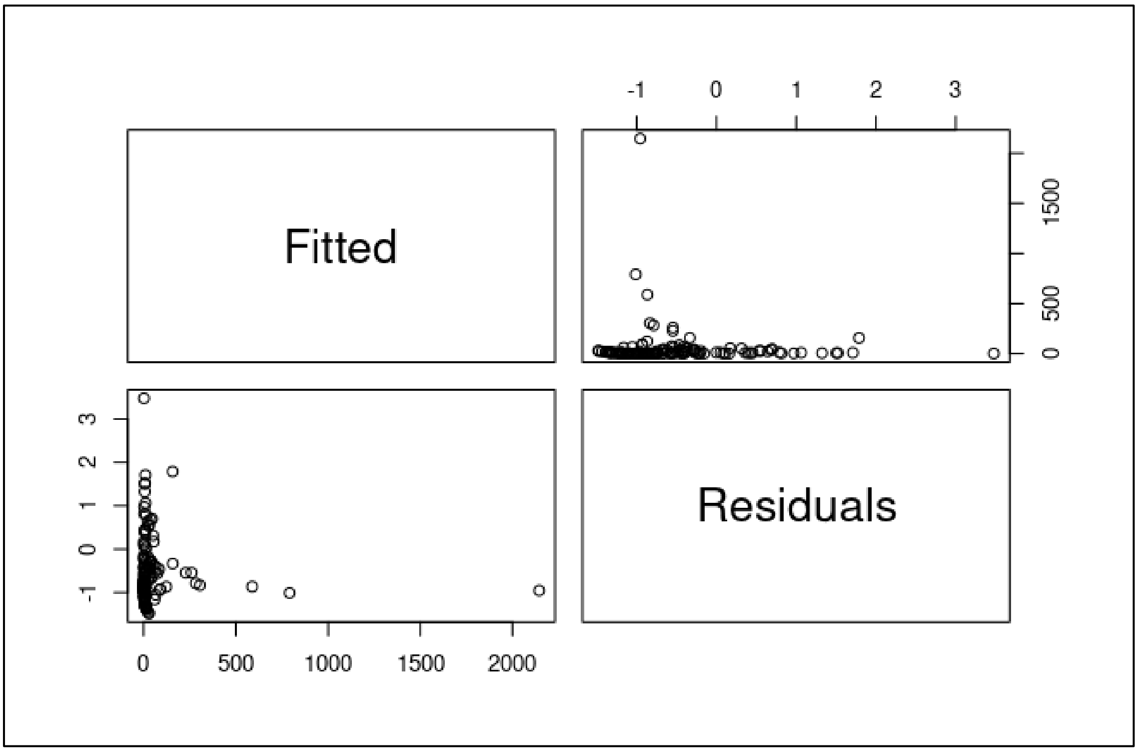
Appendix

Appendix 1: Model A scatterplot of the fitted values and residuals



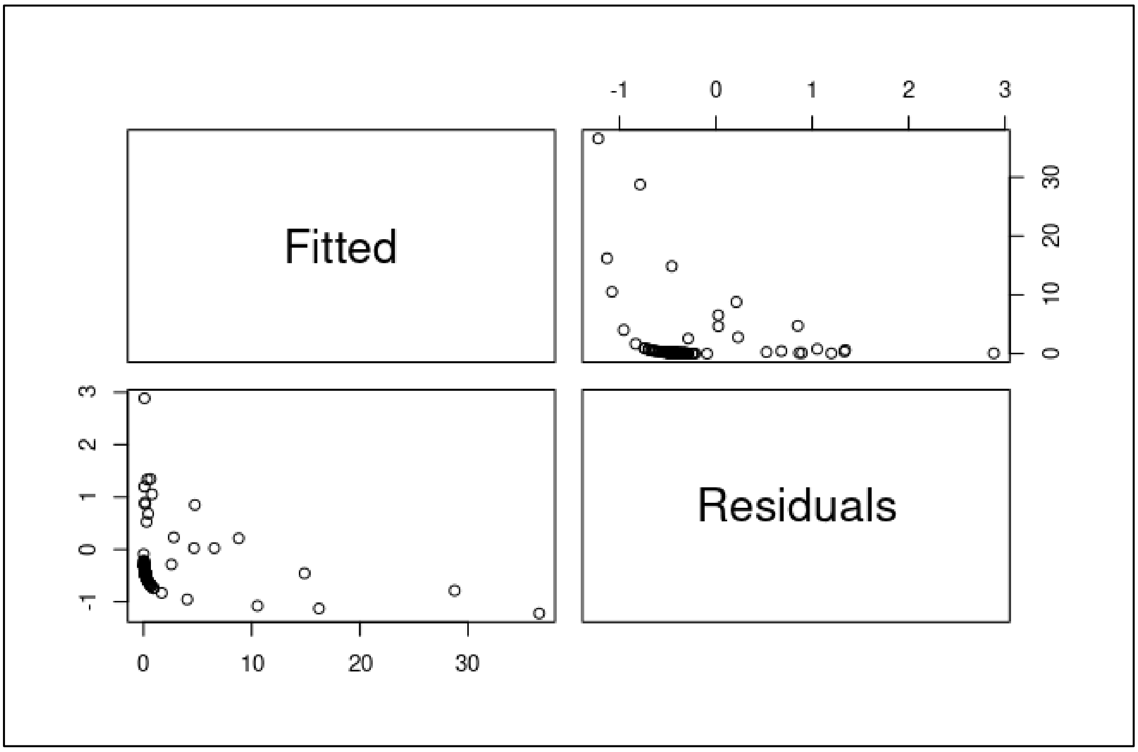
Source: Own elaboration

Appendix 2: Model B scatterplot of the fitted values and residuals



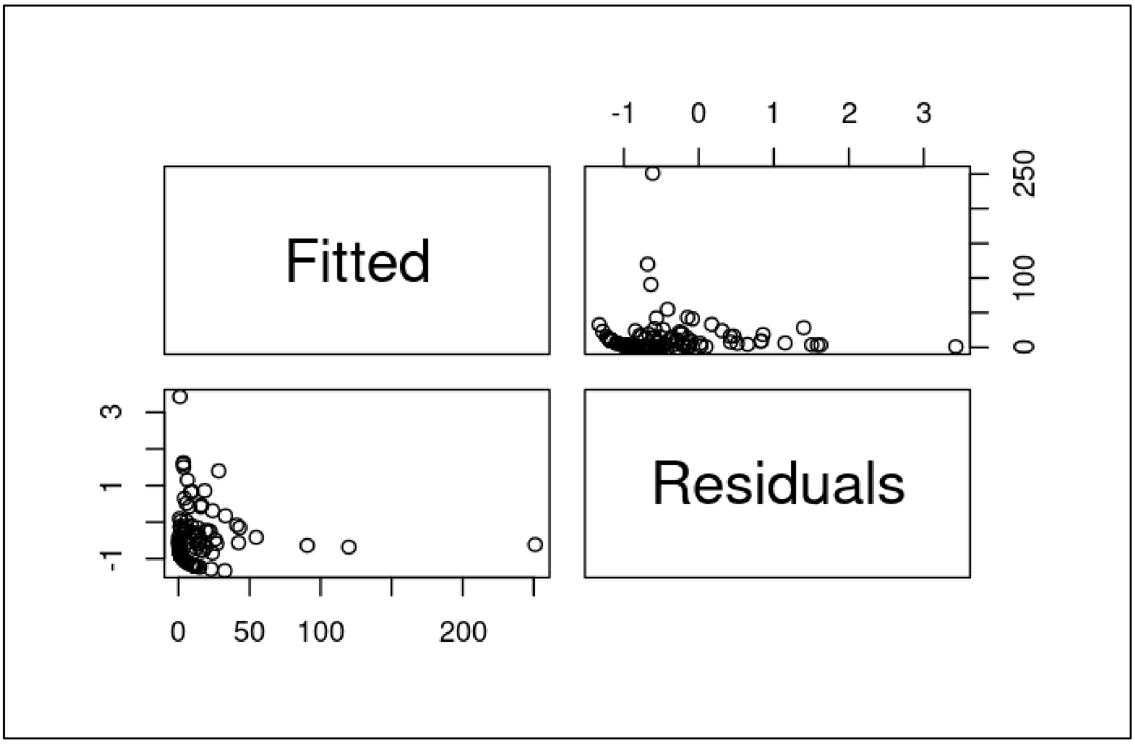
Source: Own elaboration

Appendix 3: Model C scatterplot of the fitted values and residuals



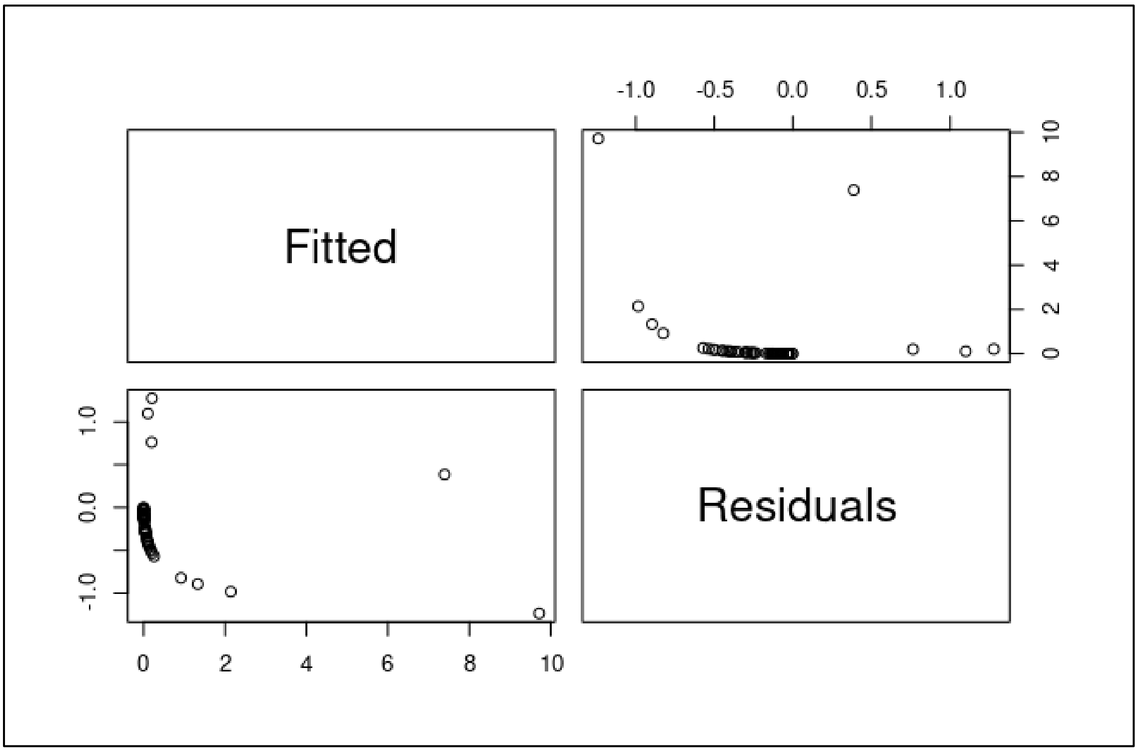
Source: Own elaboration

Appendix 4: Model D scatterplot of the fitted values and residuals



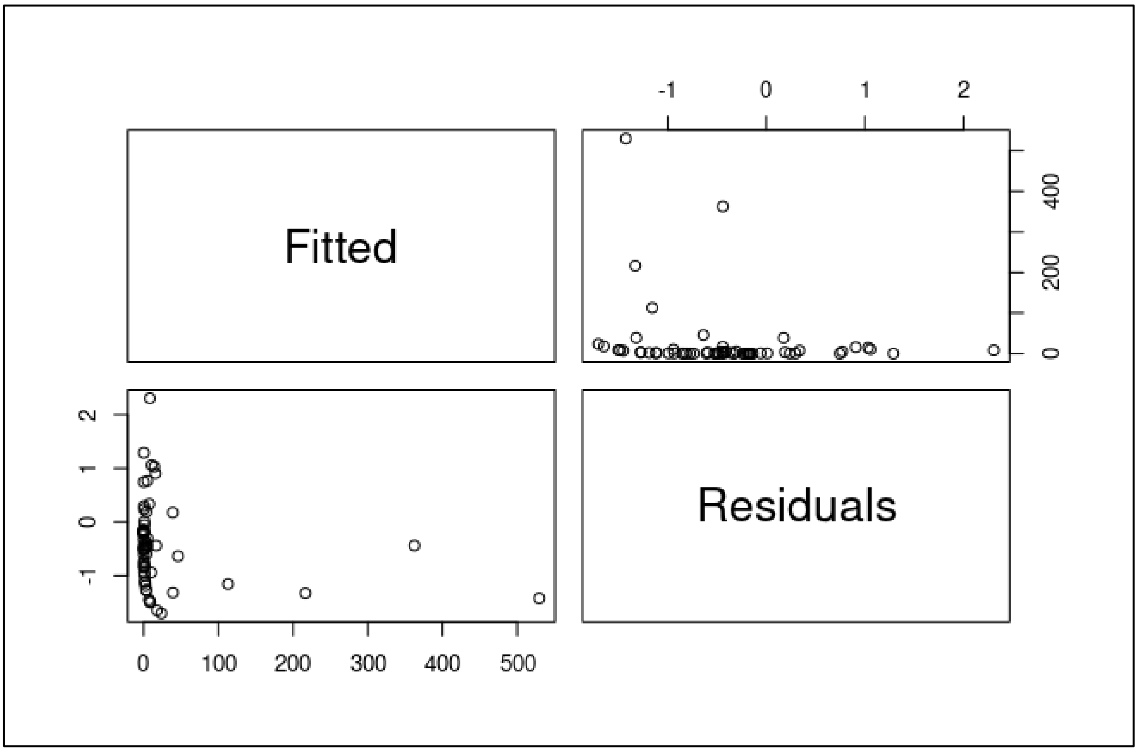
Source: Own elaboration

Appendix 5: Model E scatterplot of the fitted values and residuals



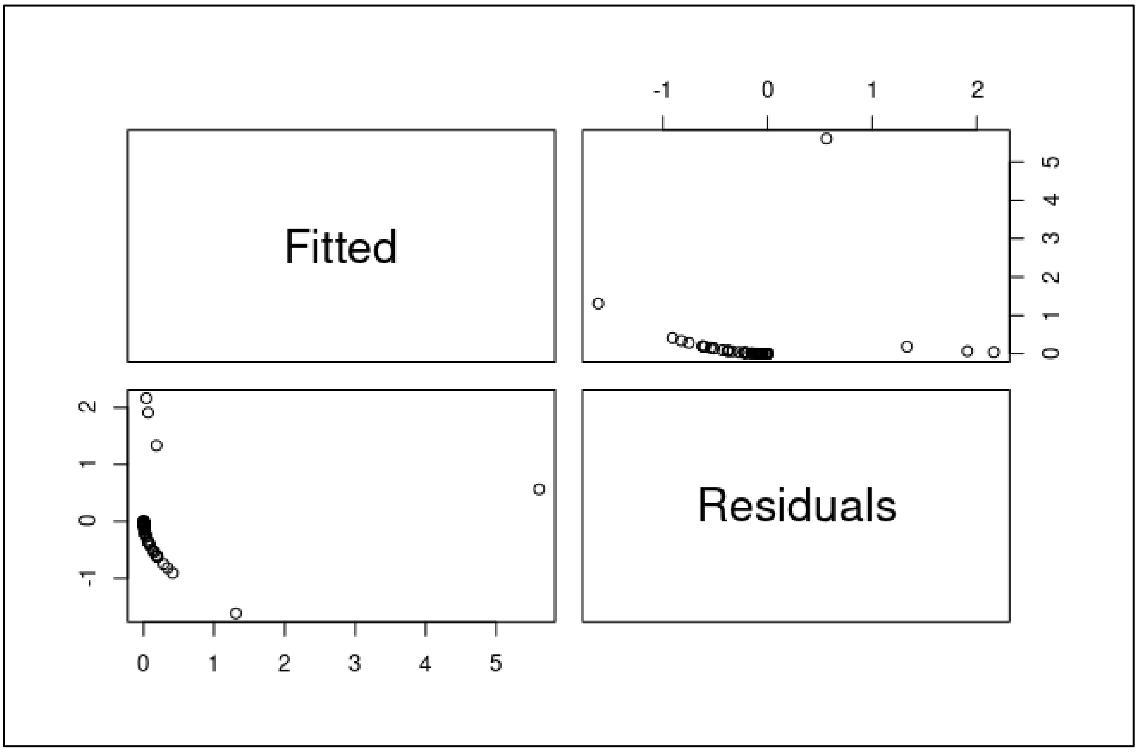
Source: Own elaboration

Appendix 6: Model F scatterplot of the fitted values and residuals



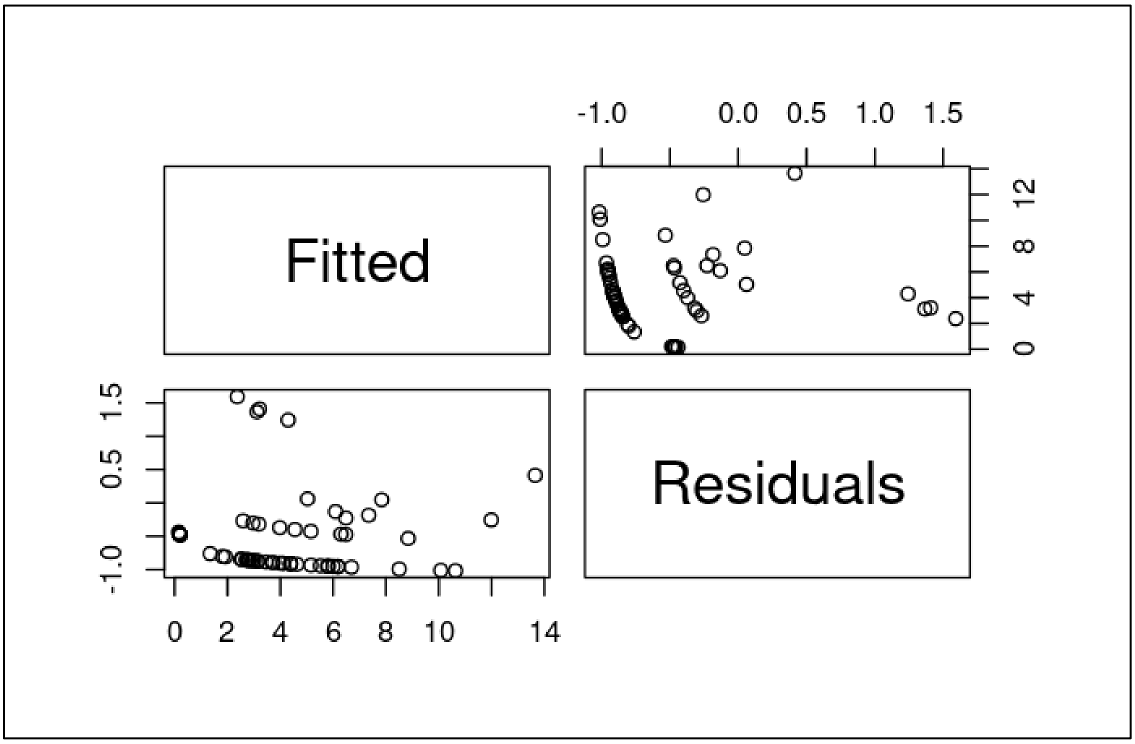
Source: Own elaboration

Appendix 7: Model G scatterplot of the fitted values and residuals



Source: Own elaboration

Appendix 8: Model H scatterplot of the fitted values and residuals



Source: Own elaboration

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