Impact of Corporate Venture Capital on sustainability knowledge transfer in the European mobility sector to achieve open innovation

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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).

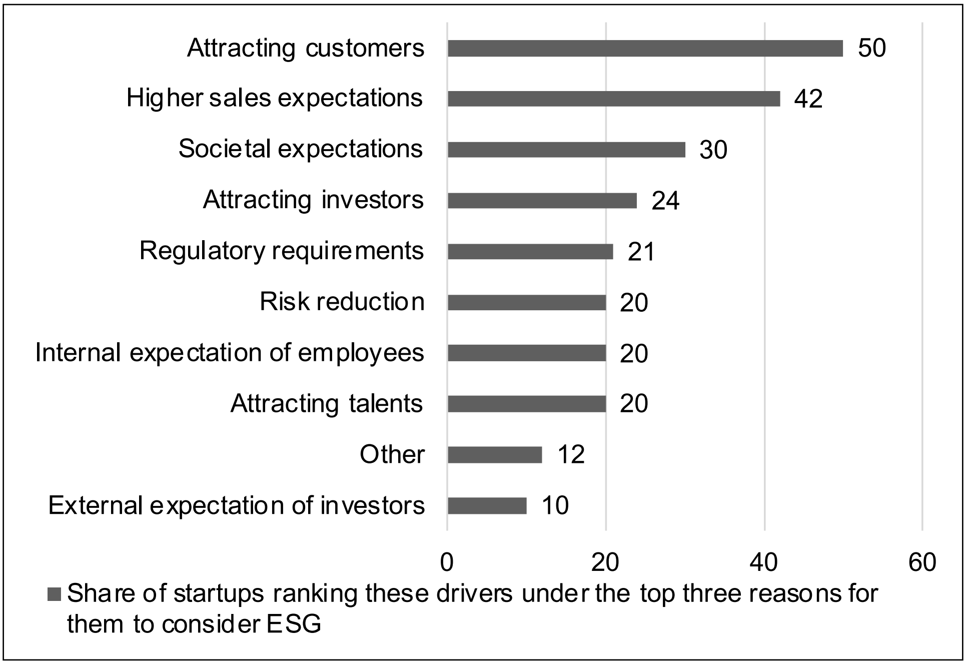
Based on new values, methods like design thinking can be used differently. Value ideation, value opportunity selection, and value proposition prototyping are methods including these values in a different way. These lead to sustainable innovations which can be used in the automotive industry (Geissdoerfer *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)[1].

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).

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)[2].

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.

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 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).

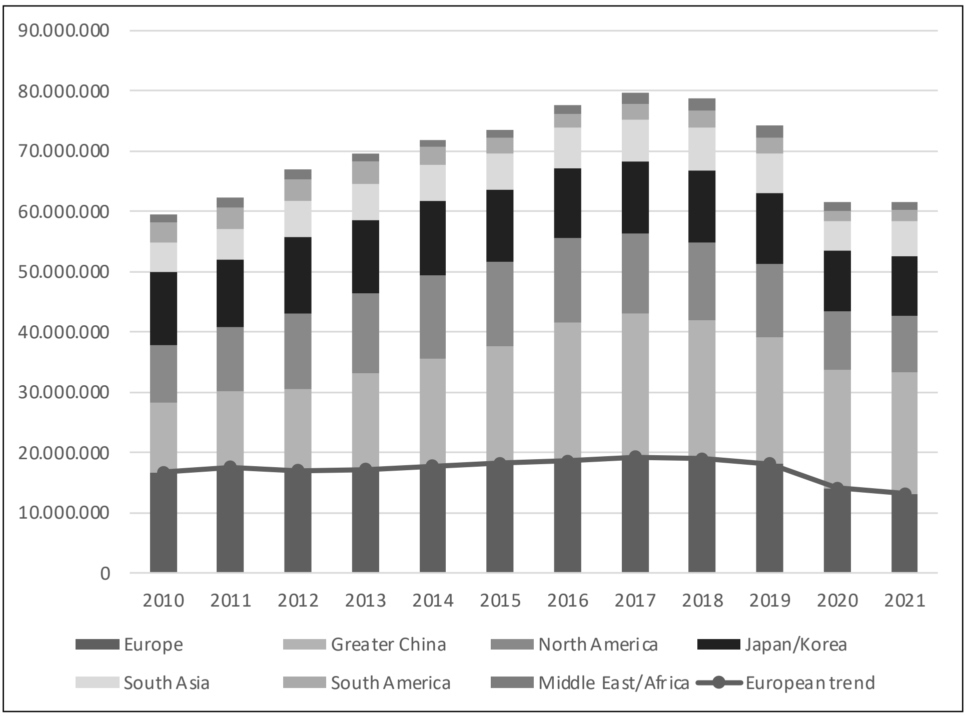
In 2018, motor vehicles worth € 135.9 billion have been exported and € 62.0 billion imported to the EU making a trade surplus of € 73.9 billion. € 60.9 billion have been invested in automotive R&D leading to innovations described in the context of industry development and trend analysis (European Automobile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

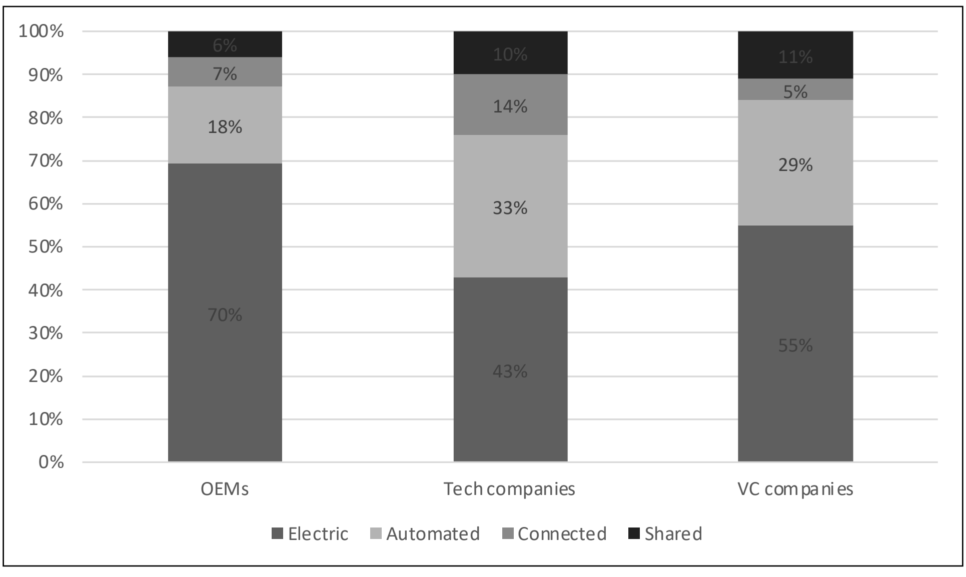
The automotive industry has a high significance of employment in the EU is reasonable considering the number of people working in the manufacturing of motor vehicles. About 14 million people in the EU are employed in the automotive sector representing six percent of EU employment. Nevertheless, the downside 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).

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

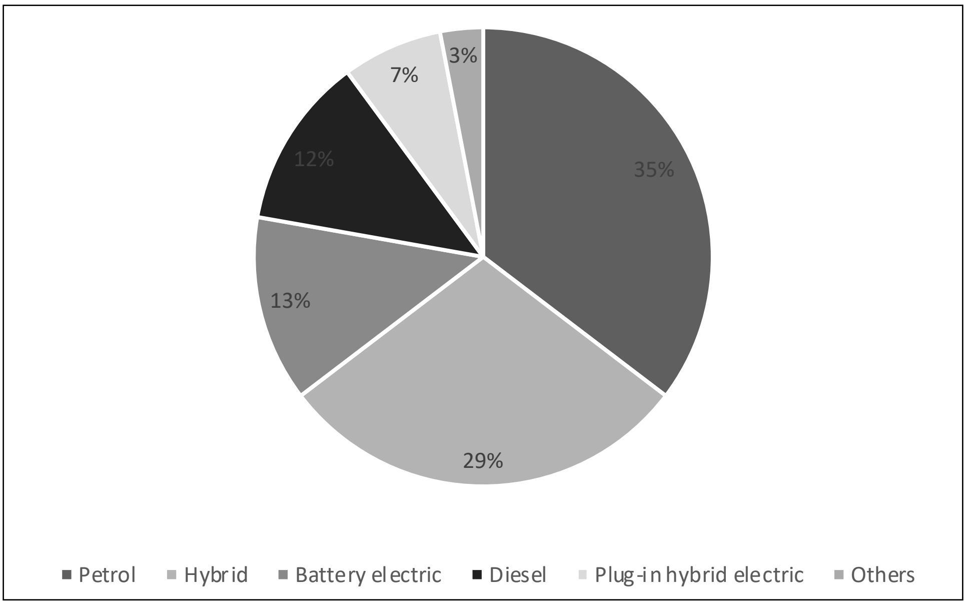


Source: Own elaboration according to Amico *et al.* (2023).

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 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).

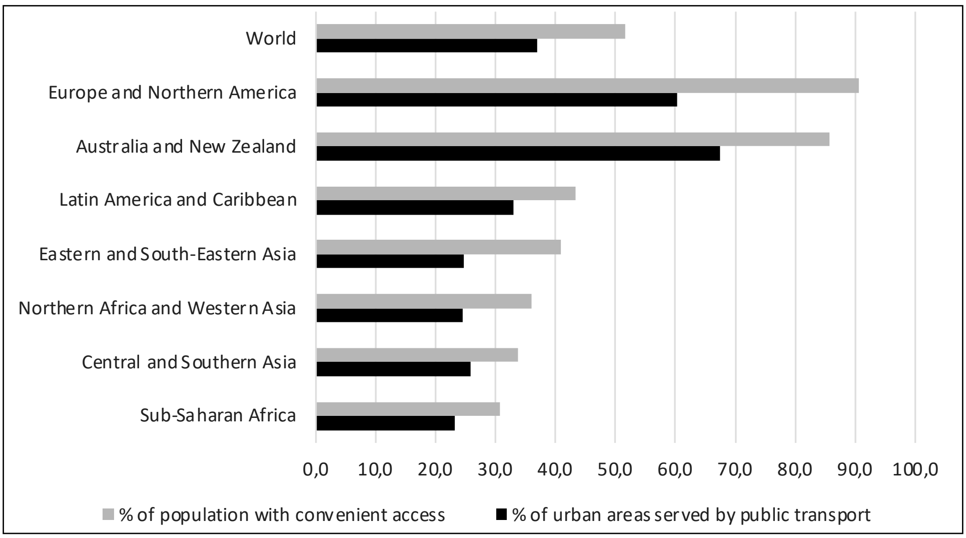
Figure 17. Sustainable solutions for a sharing economy

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)[3].

Figure 18. Public transport accessibility in urban areas in 2020



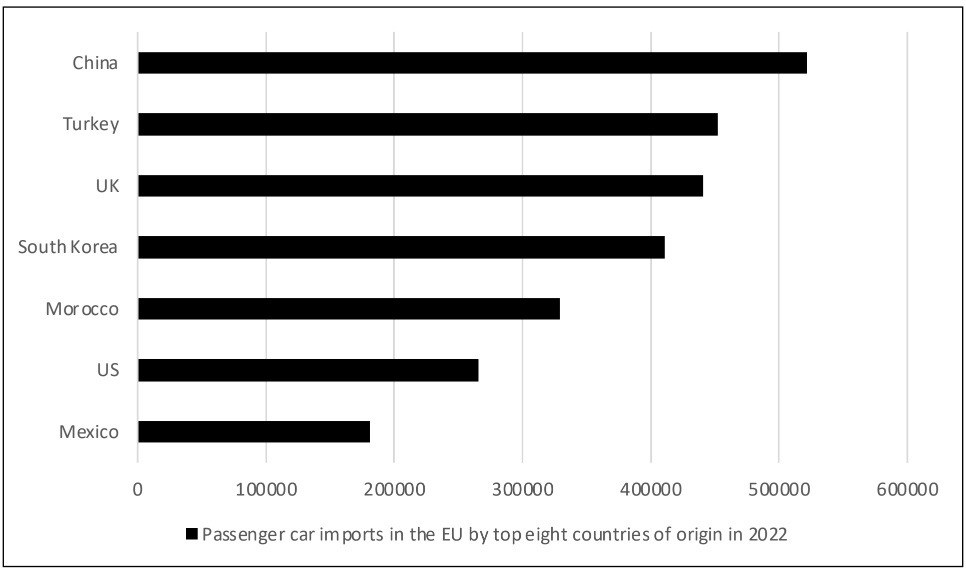
Source: Own elaboration according to United Nations (2022).

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

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 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 vcountries of origin in 2022



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

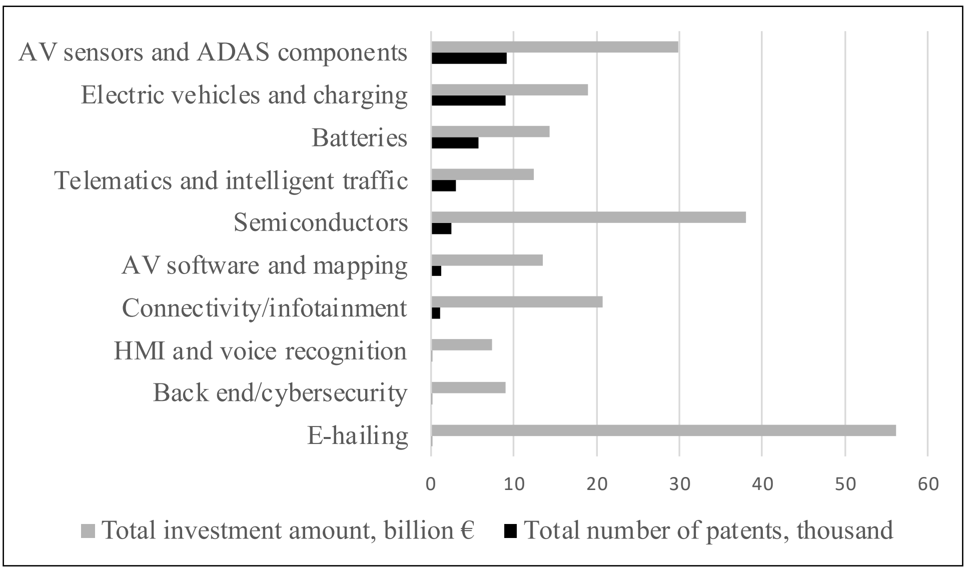
3.3. MOBILITY SECTOR SUSTAINABILITY PROGRESS

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).

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



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

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.

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).

(cont.)

Classification	Autonomous Driving Description
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).

Impact of Corporate Venture Capital on sustainability knowledge transfer in the European mobility sector to achieve open innovation

Esta investigación examina de manera sistemática el impacto del Capital Riesgo Corporativo (CVC) en la transferencia de conocimiento en materia de sostenibilidad dentro del sector europeo de la movilidad. Con un sólido fundamento teórico en la Resource Based View y la Knowledge Based View, la autora aborda un vacío en la literatura mediante un enfoque cuantitativo basado en modelos de regresión binomial negativa, analizando la relación entre inversiones en startups y la producción de patentes de las empresas del índice STOXX Europe 600.

Los resultados confirman que el CVC favorece tanto la transferencia de conocimiento general como la generación de conocimiento verde, validando su papel como instrumento para la innovación abierta y la competitividad del sector. A partir de este análisis empírico, se formulan propuestas para compañías europeas de movilidad y para organismos públicos, contribuyendo al diseño de estrategias que integren capital, innovación y sostenibilidad.

La investigación constituye así una aportación académica pionera que combina teoría, metodología cuantitativa y aplicación práctica, ofreciendo una visión rigurosa y original sobre cómo el CVC puede convertirse en catalizador de la transformación sostenible en Europa.

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