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Analysis of the impact of green innovation on environmental indicators and the CO2 footprint - Europe's way forward

A Master's Thesis submitted for the degree of
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Affidavit

I, **IRIS ZERLAUTH, BSC (WU)**, hereby declare

1. that I am the sole author of the present Master's Thesis, "ANALYSIS OF THE IMPACT OF GREEN INNOVATION ON ENVIRONMENTAL INDICATORS AND THE CO2 FOOTPRINT - EUROPE'S WAY FORWARD", 96 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
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Abstract

Climate change, and especially the unprecedented speed at which it is currently progressing, requires a fundamental change, transition and accelerated action on all levels and from all shareholders. In order to slow the climate crisis, vast CO_2 reductions are necessary combined with clear policy and behavioral changes. The CO_2 footprint counts among the most commonly known environmental indicators, aiding policy makers to evaluate and analyze progress and giving a clear and understandable indication of the CO_2 developments and trends.

This thesis aims to analyze and draw conclusions from climate- and CO_2 relevant policies of the USA and China, in order to understand which learnings can be applied to Europe. Policies impacting green innovation will be looked upon in detail, analyzing three drivers in both countries. The innovation criteria focused on were examined from a corporate and governmental perspective and centered around the country's (a) Legal and Regulatory Framework, (b) its Entrepreneurial Conditions and Requirements for Competitiveness and (c) its Financial and Tax System.

Knowing the drivers and (past) impacts, it is the goal of this thesis to analyze their previous contributions, possibly re-evaluate the criteria and effectiveness before questioning ways for the European Union to use these learnings to foster green innovation within the EU in the next years. Although policy approaches cannot be implemented 1:1 in another country, it has been found that the hypotheses H1-H3 could be validated in the case of the US and China. Amongst others, stricter environmental laws and regulations do generate the push-pull effect and are therefore beneficial for corporate as well as governmental targets (H1). Strong, independent patents are seen as key regarding entrepreneurial conditions, as they foster green innovation (H2), aid transparent communication and reduce inefficiency. Nonetheless, financial help (e.g. tax credit, ease of the investment landscape) needs to be given to SMEs and larger business (H3) in order to lift the potential additional financial burden coming with green adjustments. Partnerships between the public and private sector are essential to bridge possible investment gaps and build a stronger civil society involvement. As there is no time to waste, hopefully these policy examples and learnings can help multiple countries and especially the EU to implement and act faster, more efficiently and environmentally KPI-driven.

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List of Abbreviations

COI= Clusters of Innovation

EEA= European Environment Agency

EPI= Environmental Performance Index

GII= Global Innovation Index

KPI= Key Performance Indicator

NDCs= Nationally Determined Contributions

SME= Small and Medium-sized Enterprises

VC= Venture Capital

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1. Introduction

As climate change is currently one of the most severe challenges we are facing, with the continuous warming of the planet, limited resources, and the need to use them the best way possible, every aspect has to be examined for improvement and change - from company and corporate processes to governmental ones. Indicators have been developed, measuring the depletion of certain substances (e.g. ODS - Ozone Depleting Substances in the atmosphere, CO_2 and greenhouse gas emissions), their current utilization intensities or energy usage. Even though there is no global understanding of neither a definition nor a common methodology in terms of environmental footprints (Matuštík & Kočí, 2021), the OECD is among the leading platforms for accessing data on environmental issues and addressing sustainable development (OECD, 2021). The carbon footprint or ecological footprint enqueue amongst the water footprint and carbon demand on land footprint amongst the rather well-known ones. However, the question arises, as to how well those footprints capture the planetary boundaries and depleting resources, and how much action is actually taken after seeing alarming KPIs, footprints and indicators.

Over the past two years, digitalization and innovative digital solutions got an incredible boost due to the Covid-19 pandemic (OECD, 2020a), as did green innovation. With more digitalization and higher data usage, the CO_2 footprint does generally increase rather than decrease, the possibilities and potentials of leveraging data, using new synergies, improved innovative processes and therefore benefitting the environmental footprint, cannot be forgotten. Climate change mitigation strategies therefore have to take digitalization and its direct and indirect effects into consideration, including certain societal aspects. It is important to see if the beneficial, innovative effects from, for example, Big Data, Industry 4.0, machine learning and efficiency gains can outweigh the higher energy consumption, CO_2 emissions and global warming impact (Santarius, Pohl, & Lange, 2020) to an overall positive contribution to the environmental footprint.

On a microeconomic level - that means, that in order to stay competitive and profit from the positive correlation between green process innovation and a company's corporate advantage, a shift in many companies occurred in specific areas of their business. For example, the implementation of a greener supply chain, investments in greener

technology or equipment (Tseng, Huang, & Chiu, 2012) increased in various fields and hence possibilities have been shown to reduce environmental KPIs and footprints. There is an especially high potential of better analysis due to more precise data, those synergies and improvements can be further implemented and fostered. When not motivated through increased outputs and competitiveness, firms adopt alternatively, due to the legislative necessities and changes. Therefore, it can be assumed that as important as corporate players are in that environmental and change-debate, governmental ones are as well, which is why both paths are heavily interconnected: "(…) Comparing the mitigating and the aggravating impacts of digitalization, (…) a more active political and societal shaping of the process of digitalization is needed (…) for global environmental sustainability" (Santarius et al., 2020, p. 1).

Although a positive importance of both digitalization and its direct effects on green innovation can be seen, only a few studies can be found in literature focusing on the actual drivers of *green* innovation and the environmental effects of digitalization. Knowing the drivers and impacts, it is the aim of this master thesis to analyze their potential contributions and, re-evaluate the criteria and effectiveness before coming up with ways for the European Union to foster and actively use the digitalization push and promotion of green innovation in the next years.

As best practice examples, two selected countries are examined more specifically: Firstly, China has been chosen, as over the last three years its digital competitiveness continuously increased and the country has been dominantly holding and defending its global first place as Digital Riser (European Center for Digital Competitiveness2021) & (Meissner, 2021). Furthermore, China has proposed to explore various options at the First China Digital Carbon Neutrality Summit to green its economy through digitalization benefits and innovative technologies such as cloud computing, AI, blockchain and big data (Global Times 2021). China is furthermore a good example, as a lot of actions, investments and efforts will be required from the country to reach its set goal of carbon neutrality until 2060 (McGrath, 2020).

The second country chosen is based on a different index - the Global Innovation Index (GII), where after Switzerland and Sweden, the United States is holding spot number three (EuropeanCommission, 2020) & (WIPO, 2021). The first two countries have not been chosen based on their small size and rather specialized innovation fields, whereas in

the United States multiple sectors can be seen as innovation pioneers. The size of the country is relevant with regard to investment volumes, innovation funds and grant volumes, which is why next to China, the US is more suitable than Switzerland and Sweden. Based on the two selected countries, strategies for green innovative advancement for the European Union will be derived.

1.1. Introduction to KPIs and environmental footprints

Before starting with this thesis and exploring green innovation, it is important to clearly define the relevance of the topic as well as to provide a more general introduction (1.2.). A definition is given, followed by an explanation on why footprints and environmental KPIs are relevant for policy makers, as well as the distinction between boundaries and footprints with regard to the policy context (1.3.). A SWOT analysis of the carbon footprint should give more clarity (1.4.), while actions taken based on elevated footprints (1.5.) and takeaways from chapter 1 (1.6.) round the introduction off.

1.1. General Introduction to the topic and relevance today

Climate change, and especially the unprecedented speed at which it is currently progressing, requires a fundamental change, transition and accelerated action on all levels. In order to slow down and limit climate change, it is undisputed that vast CO_2 reductions are necessary. Although other greenhouse gases and pollutants affect climate change, "(…) the evidence is clear that carbon dioxide (CO_2) is the main driver" (IPCC, 2021, p. 15). Depending on the reduced amount, the IPCC has calculated different scenarios and models. Action is required now, as the majority of scenarios that scrape the curve below 2°C or higher, count on immediate action and change. Debra Roberts (Co-Chair of the IPCC Working Group 2) outlined that "(…) The decisions we make today are critical in ensuring a safe and sustainable world for everyone, both now and in the future (…)" (IPCC, 2018, p. 14).

In order to limit overall global warming to 1,5°C and reach net zero by 2050, anthropogenic CO_2 emissions need to be cut by 45% by 2030 compared to the 2010 level. The difference between a 1,5°C warming compared to a 2°C warming would result already by 2100 in life different to the one we know: This 0,5°C difference makes extreme

heat exposure every 5 years 2,6x worse, makes the difference between losing 70% of coral reefs compared to 99-100% or makes the difference between losing arctic ice in summer every 100 vs. every 10 years (Lieberman, 2021). The frequency and intensity of already experienced and observed changes in temperature extremes, precipitation and flooding events and patterns, sea level rises as well as permafrost and glacier melting, to just name a few, will continue to increase. The effectiveness of natural carbon sinks such as the ocean and land will decrease, allowing for an even higher accumulation of CO_2 and GHGs in the atmosphere. Experts further warn about food shortages, water availability and droughts. Those changes and experienced events will continue to globally enlarge as the warming continues - changes and impacts, that are unalterable and irreparable for 100-1000 years (Masson- Delmotte, 2021). Debra Roberts further points out that "(…) the next few years are probably the most important in our history" (Matthew, 2018, p. 5).

In order to understand the relevance, one option is to further examine the IPCC Report for policy makers, outlining for example that "(…) (i)n 2019, atmospheric CO_2 concentrations were higher than at any time in at least 2 million years (….) and concentrations of CH_4 and N_2O were higher than at any time in at least 800.000 years" (IPCC Report, 2021, p. 8). Environmental KPIs such as the ones mentioned above (e.g. CO_2, N_2O concentrations) play an essential role not only to outline the current status, show progress, but also demonstrate the need to act.

1.2. Definition of environmental footprints & relevance for policy making

As an overall introduction, it can be pointed out that footprints and KPIs are an inevitable measurement system to show the ecological current standing as well as its development (Vanham et al., 2019). As pointed out, various different footprints and KPIs exist, although the focus will be on the CO_2 footprint and implication for this thesis.

In order to provide an answer for the question above, it is important to differentiate and understand two similar, yet not synonymous concepts: planetary boundaries and environmental footprints.

As both are used as an environmental KPI, the connection between planetary boundaries, often referred to and regarded complementary as "(…) carrying capacity - the maximum persistently supportable load that the environment can offer without impairing the functional integrity of ecosystems" (K. Fang, Heijungs, Duan, & De Snoo, 2015, p. 218) and human demand, planetary and ecological footprints have been introduced. They are used in order to stipulate and better communicate the pressures exerted onto our habitat and environmental conditions. The list of specific footprints is extensive, the most popular and well-known including the water, biodiversity, carbon, phosphorus and nitrogen footprint. On everyone's lips is once a year also the ecological footprint, by the latest when "Earth Overshoot Day" and the campaigns centered around it mark the day when more of nature has been used by mankind than is possible to regenerate in that year. Those ecological limits have been moving from late September around the 2000s to late July by 2022, outlining that our behavior is pushing the earth's natural limits more and more and action is required sooner rather than later (Global Footprint Network, 2022).

When examining this list of footprints and indicators in more detail, one needs to mention the partial similarity between environmental footprints and the framework planetary boundaries. Those are "(…) (b)y its definition, capacity thresholds for a broad range of environmental issues at the global scale are explicitly identified, including climate change, rate of biodiversity loss, interference with the nitrogen and phosphorus cycles, stratospheric ozone depletion, ocean acidification, global freshwater use, change in land use, chemical pollution, and atmospheric aerosol loading" (K. Fang, Heijungs, Duan, et al., 2015, p. 218).

Footprints are often observed individually, although their connection should not be underestimated. It is important to look at the holistic perspectives, interconnections and implications. This can be done through footprint families, for example (K. Fang, Heijungs, & De Snoo, 2015). Due to the scope of this thesis, footprint families cannot be included, nonetheless are an important issue for further scholarly research.

However, what has been seen as essential for this work is to briefly discuss the footprint vs. boundary – theme. In order to illustrate the difference between footprints and planetary boundaries, table 1 outlines it on the example of the CO_2 footprint:

Table 1: Carbon Footprint vs. Planetary Boundary on the example of Carbon

carbon footprint vs. boundary	footprint	boundary
Definition	"carbon footprint: a measure of the total amount of greenhouse gas emissions that are directly and indirectly caused by an activity or are accumulated over the life cycle of a product" (K. Fang, Heijungs, & De Snoo, 2015, p. 220) & (Hoekstra & Wiedmann, 2014)	"carbon boundary: a measure of the maximum sustainable carbon footprint level at the global scale. Carbon deficit: equal to subtracting carbon boundary from carbon footprint." (K. Fang, Heijungs, & De Snoo, 2015, p. 220) & Hoekstra & Wiedmann, 2014)
Target	„ (…) (T)he footprint metric serves as a counterpart to the boundary metric by offering background values for environmental issues and thereby helping to better understand the concept of environmental sustainability." (K. Fang, Heijungs, & De Snoo, 2015, p. 221)	"(…) quantifying the regenerative and absorptive capacity (…) (with) numerical results for capacity thresholds at the global scale"(K. Fang, Heijungs, & De Snoo, 2015, p. 221)
Advantages (+) and disadvantages (-)	+ Contextualization of the footprint allows, contrary to planetary boundaries, to measure and adapt on a microscopic/local/small level. - Need to establish "footprint families" and put footprints into context for a more holistic assessment (K. Fang, Heijungs, & De Snoo, 2015)	+ The carbon boundary can be applied more generally as it is less dependent on local preconditions (compared to the water or land boundary) - Boundaries were designed to be applied on a large scale, rather than on a national or smaller level, making it more difficult to be used directly in a policy

		context. As downscaling is however extremely challenging, it makes the overall framework more complex. -The currently applicable top-down approach is lacking the bottom-up stream (Steffen et al., 2015) & (K. Fang, Heijungs, & De Snoo, 2015) -Boundaries are not the same as tipping points or thresholds, which they are often mistaken and confused with. Contrary to footprints, boundaries are set before thresholds, still allowing a time-zone to operate and act before reaching critical points (Steffen et al., 2015) -Translation of boundaries into quantities is required to present the data first, adding complexity (Steffen et al., 2015)
Connection and interaction:	When deducting the carbon boundary from the carbon footprint, one derives at the carbon deficit (K. Fang, Heijungs, & De Snoo, 2015) & (Hoekstra & Wiedmann, 2014)	

The question arises why footprints are still more commonly used instead of the planetary boundary framework, even though criticism has been voiced.

Firstly, it has been shown that environmental footprints are firmly linked to planetary boundaries and outline the amount within the planetary boundary that is already used up (Hoekstra & Wiedmann, 2014). Secondly, the communication using footprints is very effective and widely used and picked up by the media (Hoekstra & Wiedmann, 2014). It is popularly known, that with continuing our current lifestyle, two planets would be

needed by 2030, while specific countries top and peak even this number. (e.g. if everyone were to live a similar lifestyle than the US, 4,5 Earths would merely be enough to meet our needs while 0,4 Earths would suffice with a lifestyle comparable with the one from people living in India) (Global Footprint Network, 2022). Similar examples could be brought up with regards to the water/nitrogen/carbon footprints. Especially in the field of sustainable consumption, a shift with a wider audience of consumers can be observed, as more information is given while consumers drive an overall change in the area due to their every-day choices (Glen P. Peters, 2010).

Thirdly, and when going into more detail with the latter one, its importance on a microscopic as well as macroscopic level to understand the communicational importance and added level of simplicity an indicator provides. On a product level, the carbon footprint can be calculated for certain products with a Life Cycle Analysis. On a slightly bigger level, carbon footprinting can be further calculated for companies, which includes not only their on- and offsite emissions but also their supply chain. This aspect can potentially become especially relevant when concepts such as carbon pricing and taxation models are implemented. The carbon footprint of countries is especially of interest on a macroscopic and policy level, as bigger amounts of carbon can be saved, and primary concerns addressed by policy efforts (Glen P. Peters, 2010).
Not only nationally, but also internationally "(…) issues such as carbon leakage, competitiveness concerns, border-tax adjustments, and the distribution of emissions between countries are receiving increased interest" (Glen P. Peters, 2010, p. 248) in the sustainability and footprint debate.

The increased relevance is shown as footprint analysis and discussions find their way more and more often into policy documents (e.g. "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the Sustainable Consumption and Production and Sustainable Industrial Action Plan"). There, they especially identify the "(…) need to move towards sustainable patterns of consumption and production (…) (as) more pressing than ever" (Commission of the European Union2008, p. 3).

Therefore, the question above can be answered proving that the concept of footprints, and more particularly, the carbon footprint, is useful as communication tool as well as closely

linked to carbon emission drivers and policy efforts (Glen P. Peters, 2010). Dialogues and the inclusion in various official policy documents outline the ability and role which (carbon) footprints do play already and will fulfill in the future.

It has been suggested in literature that a combination of footprints and planetary boundaries should be used, in order to provide an improved image of the environmental status quo and way forward (K. Fang, Heijungs, & De Snoo, 2015). This approach is able to provide a more holistic overview, and as mentioned above, the scope of this paper focuses on footprints only in order to provide depth and more information.

1.3. SWOT Analysis of the carbon footprint

In order to get an overview and deeper understanding of the carbon footprint, a SWOT Analysis has been conducted on the carbon footprint itself, outlining not only its positive aspects and possibilities, but also possible struggles and weaknesses on why the indicator per se might not be an ideal tool for the evaluation and way forward. It is especially the Weaknesses (W) and Threads (T) within the SWOT Analysis that require particular consideration and mitigation, if the footprint is challenged or doubted in a policy making environment. Therefore, and due to the potential seen in positively affecting climate change and the surrounding policy debate, possible solutions on strengthening the footprint (by mitigating Weaknesses (W) and Threads (T)) have been included after the presentation of the analysis. It needs to be pointed out that these options are merely the start of that debate, they, however, provide first arguments to counter critical views.

Strengths:

High level of data accuracy and scaling possibilities (nations to households)

The carbon footprint can be derived from various different levels (predominantly from national accounts from statistics offices, trade statistics as well as environmental statements) ranging from a nation's carbon footprint to a household, and therefore offers a wide range of information that can further be used for targeted policy changes to national ones. To illustrate its versatility: from specific products to businesses, to sectors and populations in certain areas. Compared to other indicators and footprints, a breakdown is easily possible and therefore a true strength is the ability with that level of

accuracy and various scales allowing to target, and more importantly, measure the impact of policies (Knoblauch, 2010).

Easy integration in footprint families and contextualization

Furthermore, the carbon footprint can easily be integrated in what is referred to as footprint families (Galli et al., 2012). In order to provide more context and paint a more holistic picture of the current situation and impact anthropocentric factors have, the Water Footprint (WF) as well as the Environmental Footprint (EF) are often considered as triplet together with the Carbon Footprint (CF) (Knoblauch 2010).

High reliability of data and close link with academia

Data reliability is given, as outlined, due to their credible sources from national or statistical institutions. Furthermore, yet another strength of the carbon footprint is the high evaluation and analysis scholarly, in peer-reviewed papers and journals. An active dialogue and scholarly discourse in academia about the data, input variables and overall conceptual approach is aiding the process and analytical credibility and discourse (Knoblauch, 2010).

Easily understandable and communicable strategies

Due to a very high presence in the mass media and daily use, a broad understanding, connection and applicability of the indicator is given. The majority of people know what the indicator is about and the fact that the lion share amount (75%) of GHG emissions is linked to them as consumers, making it further effective to start further communication and reduction strategies there. Once a strong voice from consumers gets louder, the supply chain beforehand needs to adapt, resulting in a multiplier-effect that brings high potential and leverage for change (Alvarez, Carballo-Penela, Mateo-Mantecón, & Rubio, 2016).

Weaknesses:

Data is an accounting, not a forecasting tool

The data from which the carbon footprint is calculated sums up the CO_2 directly and indirectly emitted for various production stages/companies/nations. One weakness, however, is that the data acts as an accounting tool not a forecasting tool, making it

unhandy to use, as data need to be exported and forecasting is a whole next, separate step. This step per se might be a great forecasting tool, if simulated correctly, however, it is predominantly a reporting and data base (Alvarez et al., 2016).

Lacking comprehensiveness and contextualization and need for analysis

Although scholarly papers argue that it is the footprint's simplicity and usability, others question its ability to represent and possibly neglect other hazards and risks. Therefore, footprint families are of relevance, as the CF indicator alone cannot depict climate change as a unique and holistic indicator. The indicator itself has its limits and does not without contextualization depict the current sustainability assessment. Decisions and strategies built solely on the carbon footprint will likely not be successful, as not just a part of the picture can be looked at (Galli et al., 2012) & (Alvarez et al., 2016).

Trade related export and import of emissions - lack of responsibility and possibility of embellishment

When looking at indicators, and the CF in particular, the trade problematic and emissions trading needs to be looked at. If not looked precisely at variations in the indicator as well as the entirety of the supply chain (including by-products,), it could fall short with regards to emission trading and outsourcing high CO_2- products or by-products. The above-mentioned contextualization is therefore relevant to not have a shifted image of certain processes/supply chains (Alvarez et al., 2016) & (Glen P. Peters & Hertwich, 2008).

Local/national uniqueness and variableness in processes (e.g. supply chain)

Various non-standardized dealings with the carbon footprint (e.g. what is still considered a relevant emission; lacking standardized labeling of CO_2 -intense products; assignment and inclusion of co-products or dealings with possible carbon storage) makes the carbon footprint subject national uniqueness, increasing complexity and variations (Alvarez et al., 2016).

Opportunity:

Broad applicability and use for various strategies

This opportunity builds on the good understanding and wide usage of the indicator. Due to the two prior strengths, the footprint is broadly applicable and therefore can be used

for various strategies in the most diverse industries and areas. It can be used to analyze small units including certain products or organizations, or entire nations. This is seen as valuable opportunity as emissions on every stage of the supply chain could be analyzed and therefore strategies and first actions prioritized (Alvarez et al., 2016).

Sustainability Strategies attract corporate investment - CF as potential driver for climate change action

Investors are more likely to invest into companies with strong sustainability strategies, as is outlined by the CDP Report. The CF could act therefore as strong potential driver for change and a stronger emphasis on climate action (CDP, 2013) & (Alvarez et al., 2016).

Accessibility predominantly free of charge

Multiple organizations and governments offer, on the one hand, CF databases, but also tools, predominantly free of charge, ensuring accessibility. This is seen as a unique opportunity, as the financial constraint and limited access to data and instruments is lifted (Alvarez et al., 2016).

Stronger consumer focus could result in shift

Although difficult to anticipate, strong consumer feedback and a change in consumer demand could create the necessary pressure to adapt decision-making supply chains. The CO_2 footprint could provide an easy and helpful tool in order to spark and fuel the transition on the consumer side, creating enough market pressure for change (Alvarez et al., 2016).

Threats:

Compatibility with carbon budget and policy communication:

Although the carbon footprint is only that - a footprint- and not a threshold, it can easily be used as indicator in combination with a pre-defined threshold. That is and should be given in climate policies and by the goal defined by the Paris Agreement in 2015 where 2 Degrees, ideally 1,5 Degrees, is the limit for global warming compared to preindustrial times (IPCC, n.d.). Therefore, indirectly, a threshold is given as along with the temperature goal a carbon budget follows: "(…) every ton of CO_2 emitted contributes to that, no matter where and when emitted; and as a consequence, global emissions thus

need to be near zero at some point to halt further warming." (Knutti, Rogelj, Sedláček, & Fischer, 2016, p. 5). An opportunity is seen, as the carbon footprint is not only an essential indicator, but also very compatible with the commonly used principle of the Carbon Budget, and hence policy communication and evaluation.

Data quality difficulties due to streamlining and compatibility and partly lacking submissions from countries

Data limitations are related to the submission of data on a voluntary basis, as well as on its actuality and streamlining. Firstly, data often comes directly from statistical or national institutes, making the source as well as quality arguably very reliable (Knoblauch, 2010). Naturally, data have to be adapted and possibly adjusted for comparability reasons. Authors including (G. P. Peters, Weber, Guan, & Hubacek, 2007) pointed out the lack of transparency during those internal adjustments and corrections.

Data difficulties due to complex supply chains and cut-offs

System barriers further count amongst the most significant threats of carbon indicators due to the complexity of supply chains, international life cycles, data ambiguity and access. Depending on who assesses certain indicators, cut-offs might be placed differently while data from countries abroad are partially not accessible at all. Simulations or indirect data-determination contains a high level of uncertainty and inaccuracy (Alvarez et al., 2016).

Added complexity due to high, not streamlined eco-labels

Although the communication and recognizability is listed amongst the strengths and opportunities of the indicator, the derivation still has improvement potential. The list of indicators derived from carbon data or sustainability indices is, with over 450 eco-labels, beyond extensive (Ecolabel Index, 2015). The simplicity advocated by those indicators is partially removed by the considerable, inscrutable derivation (Alvarez et al., 2016).

A learning, possibly also EU-relevant, would be to ensure that the weaknesses are balanced and threats addressed. This is especially relevant to not give critics a too strong stage. One policy approach would be to ensure that data have to be submitted not on a voluntary, but on a compulsory basis. For this to happen, an international organization would need a mechanism to ensure this submission after its approval. It could be added

to the submitted NDC-data for example, as it would be in the greater interest that reliable, continuously accessible, free data can be accessed and used by member states as well as companies. The EU could submit this proposal, led by example or start the initiative on an international scale.

1.4. Actions taken based on elevated footprints

Some of the essential documents including the UNFCCC, the Kyoto Protocol or later around the 2000s the European Climate Change Protocol (ECCP) introducing Emissions Trading System (ETS) opened dialogues, set first targets and aimed and streamlined efforts to decrease GHGs on an international level (Knoblauch2010). More specific documents and declarations (e.g. The "Community Strategy to Limit Carbon Dioxide Emissions and to Improve Efficiency" from 1991, however only ratified by 2002) later put a stronger emphasis on carbon dioxide. Although it is not this thesis's main aim to provide an overview of existing efforts and directives, it is essential to mention some of the more current ones, to understand the developments and trends. Amongst the important policy papers are the "EU Sustainable Development Strategy", more specific ones such as the "Strategy on the Sustainable Use of Natural Resources", or long-term ones including the "2050 long-term strategy" focusing on net-0 GHG emissions by 2050, the upcoming transition and way there. More recently and as way to come strengthened out of the pandemic, the EU invests 806,9 billion Euros within the "NextGenerationEU" in order to make Europe "(…) greener, more digital and more resilient"(European Comission, n.d., p. 1). This is also the latest policy effort seen most relevant for this thesis, as firstly a focus on green and innovative development has been set, and secondly the question arises how the money is spent and if the EU's policy focus could be ameliorated with the learnings from abroad.

While those directives and strategic policy efforts are a first and essential step towards reducing big drivers and having an environmental impact, more critical analyses of the EU's policy efforts outline that no more than modest to negligible action could be recorded (Galli et al., 2012). Partly responsible for the lack of success is the vague formulation and default to formulate concrete and tangible goals, that nations can be accounted for. Despite the fact that outlining and declaring one's/ a nation's intent is still the right path, without action following up and being backed by substantial action, those

promises are empty ones by now. This shortcoming therefore can also be seen as learning though for the development and formulation of the upcoming policy papers and mitigation strategies. Especially on EU level, footprints and environmental KPIs could provide exactly the lacking accountability and tracking of goals and progress.

Footprints are an essential block of communication and possibility to increase accountability, and hence find their way more and more into the policy and decision-making process. Nevertheless, it has been very complex to assess their impact up until now and even more difficult as little effort has been made. Although international externalization (=shift of environmental burdens abroad; consumption and production are geographically different due to international trade) can be seen when comparing national (carbon) footprints and consumption, little policy effort has been focused on reducing the trade-and resource dependent issue, backed with concrete data and implacable measures. Local and international dependencies on resource intense or low-labor cost countries build and deepen further while sustainable production is in direct conflict with high export earning potential (Hoekstra & Wiedmann, 2014). One approach to address this (social and environmental) inequality through a policy angle failed and turned out very ineffectively, as during the Kyoto Protocol a reduction of emissions and trading did not occur, but rather a shift of emissions to countries outside the Protocol's jurisdiction (Hoekstra & Wiedmann, 2014). This example proves yet once again, that sustainability and long-term change is not a top-priority, but short-term reliance on resources and political "comfortable" short term decisions are.

It needs to be added that it is not only the production side, which needs to be regulated, but also the consumption side needs a shift towards more sustainability. Policy actions therefore need to focus not only on efficiency, which can largely be driven by innovation as well as new strategies and approach (Henderson, 2017), but also on consumption dimensions. As this thesis focuses more on finding ways to promote innovation, a deep dive on efficiency as driver will follow.

1.5. Takeaways from chapter 1

The key takeaways from this chapter for the thesis are therefore additional to the definitions and differentiations as well as the close interlinkages from planetary

boundaries and footprints, the role they play in (policy) decision making, boundary assessment as well as communication. Furthermore, too little action has been taken up to now on an international policy level, and if action has been taken, it was predominantly the intent versus the actual setting of concrete goals and tangible, quantifiable and accountable roadmaps and action plans. Moreover, the EU has published numerous directives, regulations and strategy papers.

2. Methodology

2.1. Sources

Scholarly papers have been the primary resource used in order to derive the extensive literature. Google Scholar as well as the databases from TU build the academic structure. Priority has been given to peer-reviewed papers and in order to ensure the relevance, papers from 2015 onwards have been preferred. When looking through the literature, it has been found that 2015 is especially relevant in the sustainability and policy field (and hence also in the scholarly publications in that area), as the Sustainable Development Goals (SDGs) were adopted in September 2015, and officially came into action with the 1st of January 2016 (U.N., n.d.). Therefore, a great number of analyses and publications center around that period of time. A second peak and important time period, where numerous of the found papers have been published circles around 2020. It not only marks 10 years until the 17 defined SDGs should be achieved by 2030, but also provided unexpected and unforeseen learnings in the sustainability discussion due to the Covid-19 pandemic. The pandemic did not only outline the interplay and dependance of the human well-being and that of the environment, but also, for a short time, showed the effect certain measures (e.g. travel restrictions, restricted supply chains, closed boarders) have on the environment and recovery thereof (EEA, 2022). It provided essential lessons in tackling climate change and consequently has been especially important for policy making and this thesis.

Additional to scholarly papers, to include a partially more critical view and analysis, papers, progress analyses and reports from universities, consultancies and experts have been included as well. Institutions along with focused and specialized networks such as, amongst others, One Planet Economy Network or the European Environment Agency (EEA), have been further contained. Thirdly, official governmental and non-governmental published documents and treaties (e.g. Kyoto Protocol, EU Publications) are seen as important reference and literature building block.

As fourth, however, not as recurrent source, credible websites and magazines have been added as means to supplement more contemporary angles, which are either not found in scholarly research yet, or include a different field and area of expertise. Forbes Magazine,

The New York Times or similar quality papers would be examples, due to their focus in business innovation and management or their factual, current reporting. Overall, over 200+ sources have been read and approximately 115+ included in this thesis. Endnote has been used as citation program to manage literature resources best. For each country, the US and China, an introduction to the country overall is given (5.1.), followed by an introduction to the policy landscape of the specific country (5.2.).

2.2. Structure

The structure of this paper is centered around four main thematic blocks. Chapter number one (1) includes the Introduction with a general introduction, the overall relevance as well as the relevance of environmental footprints. Chapter two (2) outlines the methodology of this paper with (2.1.) focusing on sources, (2.2.) the thesis's structure, (2.3.) on data and methodology specifically linked to the analysis and (2.4.) on the relevance and scholarly gap found identified in the literature. Chapter three (3) focuses thematically on the Literature Review and Analysis. Here, factors overall promoting innovation (3.1.) with definitions (3.1.1.), drivers (3.1.2.) as well as the thereof deducted drivers of green innovation (3.1.3.) and the hypothesis (3.1.4.) are in the center. An introduction (5.1. China /6.1. US) to China (chapter 5) and the US (chapter 6) will allow a practical deep-dive and better understanding, followed by an explanation of the current situation in each country (5.2. China /6.2. US) and link and address identified problems and challenges. Each country will be first shortly presented (5.2. China / 6.2.US) before a focus on relevant policies is set (5.3 China / 6.3. US). Further detail and the analysis are provided, following the same structure for each country during the analysis part. First, the Legal and Regulatory Framework is analyzed, followed by the Entrepreneurial Conditions and Requirements for Competitiveness, ending with the Financial and Tax System. Learnings as from China and the US are on the one hand summarized in the tables of the specific factors, but selected ones also depicted also at the end of each chapter.

2.3. Data, categories and methodology for analysis

In order to best evaluate, on the one hand, the country's overall situation and, on the other hand, the learnings, relevant indicators have been analyzed. Those included a wide range

from economic ones to environmental and emission-based indices up to innovation benchmarks and scales. Data from 2015, 2018 and 2020 have been taken, as well as more recent data from 2021-22 added in categories where it was available and seen as necessary. The years have been chosen based due to their relevance for the climate discussions. 2015 marks an essential year, as the SDGs were adapted then and it is often used as reference point in analysis. Furthermore, the five year steps until 2020/25 and 2030 when progress reports are published and until the SDGs end (2030). However, the year 2020 marks a crucial point, next to the SDG Update Report, as Covid-19 and its impact were globally disrupting existing systems and altering indicators. Due to that reason, 2018 has been added as year for the evaluation in order to best see trends before numbers and indicators are falsified due to lockdowns and the pandemic. Furthermore, 2016 has been the start of a new Five Year Plan, the Thirteenth, which brought along essential changes in China. Wherever applicable, available and in certain relevant categories, data from the past two years have been included. It has to be noted though, that a recovery period after Covid may influence those values. The analysis of all values chosen can be found in the Appendix. The values identified as relevant for the subsections and this paper are summarized in the analysis of each country. Trends will be identified based on data and supplemented by research in order to find out which policies and actions were responsible for positive trends, and which efforts are to be avoided for negative ones. It is noted, that this research is not complete, and that only exemplary factors have been selected for this Master Thesis in order to stay within the scope and focus of this work.

The Categories include predominantly a) Economic and Macroeconomic Indicators (e.g. Trade, GDP, Productivity Data, Consumption and Household Data) as well as b) Entrepreneurial, Governance and Business Indicators (e.g. interest payments, days to start a company (bureaucratic hurdle), Innovation index, R&D investments, ease of doing Business Score)

With regards to data, the World Bank Database has been used, as well as supplementary diverse datasets. Often, even extremely comprehensive and extensive datasets (such as for example the World Bank Data Set on Development Indicators) have gaps and no information from certain countries or time periods. It has been challenging to find comparable and reliable data for China, the US as well as Europe. However, a lot of effort

has been invested in order to find the same data from the same source within one Indicator/Category for all three geographical areas in order to avoid data distortion and falsification. It is beyond the scope of this Master Thesis to debate or question if access to certain data is withheld due to political or other motives, however it cannot be eliminated.

2.4. Relevance and gap in current literature

That the topic overall has utmost importance has been outlined in chapter 1.1 already. This chapter as an addition, however, focuses on the gap that has been identified in the scholarly literature:

This thesis aims to present findings and key take-aways for policy and decision makers based on only one specific indicator, the CO_2 footprint. The currently existing gap and lack of scholarly literature, links, policy recommendations and critical assessments in this area however, cannot be filled by one thesis or paper, but rather by a more focused scholarly approach combined with practical examples and strategic collaborations between politics, expert groups and academia on both, a national and international level. During the writing process of this thesis, the author has, due to the role footprints play in communication and perception, briefly also incorporated current best practice approaches on how experts and scholar findings are communicated to central turntables and multipliers such as decision makers or the media. In that area as well, more research is necessary and then in a further step (policy and best-practice and learning focus) needs to be applied to communicate more effectively as well. Attention and learnings from the Covid-19 pandemic globally could provide useful insights in the interplay of scientific and scholarly information, communication to policy and decision makers as well as to the public (Saitz & Schwitzer, 2020). Especially due to the incredibly high urgency to put policies and restrictions into place and the role clear communication played, the pandemic is a relevant comparison and place for learning. Furthermore, high policy acceptance found during Covid could be interesting in the climate crisis as well, as urgency and acceptance or the lack thereof, are crucial drivers. This however, could be a thesis of its own. It is important to outline illustratively that more research is needed in the area of

effective communication, policy assessment and learnings as well as international collaboration and effective measures to combat the climate crisis.

2.5. Focus and writer's comments

One more relevant comment concerns several points on why China and the USA have been chosen. In order to illustrate the difference best, it has been summarized in a table (Table 2):

Table 2: Differentiation of chosen countries- writers note

Relevance & importance of countries	China	USA
State of development *)	Developing country → essential as it could prove the way forward	Developed county
Critical development point **)	Weaker development not built on CO_2 in past; change now and until CO_2 peak	Strongly built on CO_2
Time of CO_2 Peak	CO_2 Emission peak still ahead	CO_2 Emission peak in past (2005)
System	Authoritarian System → changes possibly quicker applicable	Democratic System

*) There exists a U-shaped relationship between economic growth and pollution (Aslan, Destek, & Okumus, 2018), which also impacts different development stages, different income levels/investments/R&D spendings,, meaning that different development levels have possibly a different stage and relationship towards pollutions, and hence possibly different policies to learn from.

**) with regards to the critical development point, one comment is needed that explains certain frictions and lacking understanding: the USA, similar to the majority of countries in Europe, have built up their industries and economies with CO_2 in the past. It can be

hoped, that successor countries now, or countries currently transitioning and developing do this, without such a strong reliance on CO_2. This opens the discussion on fairness, distribution and equal opportunities.

3. Literature review and analysis

Chapter 3 will focus on the literature review and provide relevant scholarly input for the analysis that will follow.

3.1. General: Analysis of factors measuring and promoting innovation and digitalization

The aim of the first part of chapter 3 is to provide a clear understanding of green innovation (3.1.1.), followed by demonstrating the drivers of green innovation (3.1.2.). Only when having a general understanding, knowing the levers for change, and identifying the most relevant ones for this thesis, the three innovation criteria can be presented (3.1.3.) together with the derived hypotheses (3.1.4.).

3.1.1. Definition of green innovation

On a scholarly level, a clear definition of "green innovation" is still lacking, although the role and importance of green innovation is increasing (B. Yuan, Li, Yin, & Zeng, 2022). Overall, the variants of definition alter only minimally and to an extent that can be neglected for this thesis. As a start, one could say that, "Eco-innovation, often used interchangeably with environmental innovation, can be viewed as the production, application, or exploitation of a product, service, production process, organizational structure, or management or business method that is novel to the firm or user, and which results in a reduction of environmental risk, pollution, and the negative impact of resource use" (Ullah, Agyei-Boapeah, Kim, & Nasim, 2022, p. 2) & (Horbach, Rammer, & Rennings, 2012). In short, green innovation is the " innovation processes toward sustainable development (eco-innovations) (…) (through) : technological, social and institutional innovation"(Rennings & Rammer, 2011, p. 319).

The uniqueness of green innovation compared to innovation in the classical and previously common use therefore can be summarized in 2 points:

a) "(…) innovation that reflects the concept's explicit emphasis on a reduction of environmental impact" (OECD, 2009, p. 13)
b) "(…) not limited to innovation in products, processes, marketing methods and organizational methods, but also includes innovation in social and institutional structures" (OECD, 2009, p. 13)

Even though there is still some unclarity on the definition, as one clear and uniform definition would aid tremendously, it is undisputed that green innovation, also often referred to as eco-innovation, is essential for long-term, stable economic development. It is further proven that eco-innovation acts as ease and is essential for the decoupling between environmental management and economic growth (J. Chen, Cheng, & Dai, 2017). Furthermore, eco-innovation is essential for the long-term aspect as well, ensuring stable economic development and ease and decoupling between environmental management and economic growth (J. Chen et al., 2017). So far, it has been found in several countries, that energy efficiency successfully reduces CO_2 emissions, so does innovation, proving the coupling between green innovation and CO_2 emission reductions (Y.-J. Zhang, Peng, Ma, & Shen, 2017).

With this definition of eco-innovation, its particularities should further be presented: While social and institutional innovation is rather present, the double externality as well as regulatory push and pull effect is comparatively not as well known (Rennings, 2000). This will change during the thesis, as the double externality effect is explained in further detail. With regards to achieving better policies, all three aspects need to be understood and taken into consideration, which explains why they reappear in Table 1 in the Innovation Criteria.

3.1.2. Drivers promoting green innovation on a corporate and governmental level

Innovation and the better understanding of its drivers have become more and more important considering that through innovation, a) environmental growing burdens as well

as b) costs can be reduced while increasing, amongst others, corporate and governmental competitiveness and sustainable growth (Rennings & Rammer, 2011).

On a *corporate level,* organizations are trying to balance and incorporate ecological conservation through, for example, low emissions, changes in the production cycle or recycling. While these changes are often driven and motivated by external factors such as legal alterations and the regulatory changing landscape, green innovation is also driven by internal factors including higher competitiveness through possible efficiency gains as well as the targeting of new customer segments (eco-friendly, environmentally motivated consumers) (Y. Zhang, Sun, Yang, & Wang, 2020). Three aspects have been identified assessing "(…) green innovation readiness: technology readiness, organization readiness, and environment readiness" (Y. Zhang et al., 2020, p. 2). While organizational and technology readiness are internal factors, environmental readiness is strongly influenced by the framework and setting laid out by the government - so set externally. "Moreover, product eco-innovation, process eco-innovation, organizational eco-innovation, and environmental R&D investments seem to be driven by common drivers, such as regulations, market pull factors, EMS, and cost savings" (Hojnik & Ruzzier, 2016, p. 1). The question therefore arises, which structure and pull factors the government can provide, and which framework criteria might need adaption for macroeconomic pull and push factors to provide enough incentives on a micro-level. As it has been proven to be internal as well as external pressures pushing a firm to green innovation (Dayong Zhang, Rong, & Ji, 2019), which ones are key for environmental effectiveness on a corporate level?

On a *governmental* level, not only the regulatory landscape must be provided, but also shaped and adapted in a way that allows for innovation to grow, and for a transition to green innovation to happen. Studies have found that in certain fields, the application of a strict environmental policy line has positive implications for investments, technological progress and therefore cooperative innovation and success (Testa, Iraldo, & Frey, 2011). Regulatory pressure has proven to advance green responses and positively correlate to green innovation performance and training, while pressure exerted from consumers results in a stronger R&D focus and investment (Huang, Hu, Liu, Yu, & Yu, 2016). Do stricter legal and regulatory regulations promote green innovation? Which other adaptations and changes need to be made in order to promote not only green innovation,

but sustainable growth and development? Are further governmental incentives needed in order to balance out possible stricter regulations?

Based on the questions as well as separating between the corporate and the governmental level, three key green innovation criteria have been identified. Those will be presented in chapter 4.1.3. Additionally, the separation undertaken in this chapter between a Corporate and Governmental level will be kept in chapter 4.1.3.

3.1.3. Presentation of key 3 green innovation criteria & structure for thesis

Based on the questions above as well as research conducted, three key areas in the field of green innovation have been identified as especially relevant:

1) Legal and regulatory framework
2) Entrepreneurial conditions and requirements for competitiveness
3) Financial and tax system

Those three defined categories will be the basis according to which China, the US and Europe will be evaluated. Furthermore, they provide a guiding structure for this paper. Therefore, a more elaborate explanation for each will be given (table 3) before country specific details will be added.

As mentioned in chapter 4.1.2., the differentiation between the corporate and governmental level will be kept to better understand and visualize stakeholder interests. Although the corporate and governmental level affect each other strongly, stakeholder interests as well as objectives differ greatly. It is especially the government whose policy effects are aiding and moving micro-level players towards change (Push and Pull Effect). For policies to be successful, it has been found that both stakeholder-views need to be looked at and identified, explaining the separation between B and C in table 3:

Table 3: Innovation Criteria and Structure of Paper

	Innovation Criteria	Corporate	Governmental
1	Legal and regulatory Framework	• Stricter regulations put a strain on companies to adapt • However, promote innovation and create possible competitive advantages for companies	• Stricter regulations aid the government to achieve environmental targets & its responsibility • Providing the legal landscape acts as driver for change and has Push- and Pull Effect
2	Entrepreneurial Conditions & requirements for Competitive-ness	• entrepreneurial conditions need to be given to allow innovation within existing & new companies. • companies can profit from Double externality effects	• Having strong entre-preneurial ecosystems, however, benefits the country as it, among other things, increases FDI, attractiveness, GDP, and ensures long term growth.
3	Financial and Tax System	• An adaption and/or reform of financial existing systems would aid the existing corporate financial burden	• Financial Change & incentives needed to counteract and balance (stricter) environmental laws

In order to add more background knowledge to each innovation criterion in Table 3, a short explanation is given for the criteria:

Ad 1: Legal and regulatory framework

Although it is often argued that stricter regulations put a stronger strain on companies and make the country unattractive for business, it is also environmental laws and stricter regulations that have a positive effect on green innovation and a country's transformation. Porter in his hypotheses elaborated that "(…) strict but appropriate environmental

regulations can promote innovation to a certain extent, and the benefits that are generated can be sufficient to offset the costs incurred by enterprises, thereby allowing them to gain a competitive advantage.“ (Yang & Wang, 2021, p. 1435) & (Porter & Van der Linde, 1995). Scholarly assumed and empirically proven is that companies do not, without the regulatory pressure to act, adopt in an environmentally friendly and CO_2 reducing way. Companies can register higher sales or profits through green innovation (Dayong Zhang et al., 2019). Therefore, this “push” needs to be given by the governments.

Ad 2: Entrepreneurial conditions and requirements for competitiveness

However, regulatory pressure alone does not do the trick either. Other factors, such as R&D funding and investment are essential in the mix. Few studies focused on the relationship between the effect of regulations on green innovation (L. Li et al., 2020). It can be argued, if due to the public nature of green innovation (social benefit > individual benefit) compensational incentives are needed in order to bridge the gap to a higher financial strain on companies or not (Lv, Shao, & Lee, 2021). That compensation could have many shapes and forms starting from an improvement of R&D protection, a possible tax relief or ending at an easier access to financial means overall.

Next to the legal possibilities, it is often scholarly argued, that the government has the possibility to support in areas, where firms lack investments and focus. This is especially relevant in R&D investments. However, the exact role and involvement of the government in corporate R&D is unclear, as a possible “crowding effect” could have the opposite, negative impacts on corporate R&D effort (L. Li et al., 2020). Therefore, R&D is limited to projects outside the company’s R&D funds in this thesis.

Apart from R&D, the country’s general entrepreneurial setting will be examined. While competitiveness can be an essential motivation for a company, it can also be so with regards to the attractiveness of the country. While companies, which are at the forefront obtain higher profits, can meet the customer’s needs, they possibly even enlarge their customers through addressing and serving new, green customer segments. The country attracts not only FDI and other firms with good entrepreneurial conditions, but actively influences GDP and sustainable growth. It has been noted, that countries set different foci on entrepreneurship and innovation. Therefore, a table with a short analysis has been researched (including various factors ranging from “time to start a business” to patent applications to the number of unicorns). This table can identify not only how attractive it is for a company, but also how attractive the entire entrepreneurial landscape is for the

country concerned. Specific sub-points will be taken out based on the analysis and policies presented.

Ad 3: Financial and tax system:

The financial system is an important category, as with a lot financial efficiency, increased capital turnover and with it, the access and solving of often high financial constraints for companies are lower (Lv et al., 2021). Innovation, and especially green innovation is often hindered or considerably slowed down with inefficient financial access and capital, inhibiting firms and innovation. Vice versa, an uplift can be seen in financial systems, given by environmental regulations and the effects thereof, as with new/stricter/adapted regulatory changes, financial capital needs to be risen from either the banking or financial sector (Lv et al., 2021). If that sector transforms as well and adapts, companies entering the market needs, from the beginning onwards to build greener and more innovate processes, and existing ones require to modify and transform. Therefore, with the introduction of regulations and the change of and in the financial system, green innovation is promoted (Lv et al., 2021).

3.1.4. Leading questions and hypotheses H1-3:

Resulting from the Table 1 and the information provided above, the leading three Hypothesis can be summarized:

H1: Stricter legal and regulatory regulations promote green innovation

H2: Favorable innovative and entrepreneurial pre-conditions need to be given in order to foster green innovation

H3: An adapted financial system is necessary to aid green innovation and incentivize cooperation to change

Those will be verified or falsified. Based on H1-H3, leading sub-questions have been added to the table, providing the guiding structure for the paper. It has been noted that the criteria and sub-criteria might alter slightly depending on the country (China vs. US vs. Europe). Therefore, the leading questions as well as the criteria have been defined in a

broader way (e.g. Entrepreneurial Conditions and requirements for competitiveness). This ensures, that both stakeholder views (corporate and governmental) can be taken into consideration, as well as the foci of each country. As this paper aims to provide specific policy learnings, the space should and needs to be given for these foci and relevant country specific (sub)-points.

The mentioned sub-questions have been added to table 4, which have been, together with column B and C, used as basis to derive the hypotheses afterwards:

Table 4: Innovation Criteria, Hypotheses and Guiding Questions for this Thesis

	A	B	C	D
	Innovation Criteria	Corporate	Governmental	Guiding Questions
1	Legal and regulatory Framework	• Stricter regulations put a strain on companies to adapt • However, promote innovation and create possible competitive advantages for companies	• Stricter regulations aid the government to achieve environmental targets & its responsibility • Providing the legal landscape acts as driver for change and has a Push-and-Pull Effect	• Do stricter regulatory requirements promote green innovation? • Is the current situation supporting the green transition, or do loopholes/bottle necks exist?
2	Entre-preneurial Conditions & require-ments for Competi-tiveness	• entrepreneurial conditions need to be given to allow innovation within existing & new companies. • companies can profit from Double externality effects	• Having strong entrepreneurial ecosystems however benefits the country as it, among other things increases FDI, attractiveness, GDP,	• Where does the country stand currently with regards to innovation and entrepreneur-ship?

			ensures long term growth	• Which other factors are relevant and a potential lever?
3	Financial and Tax System	• An adaption and/or reform of financial existing systems would aid the existing corporate financial burden	• Financial Change & incentives needed to counteract and balance (stricter) environmental laws	• Does the current financial system aid green innovation?

4. Pioneer case studies – China & US

As described earlier, both countries- China and the US will be analyzed separately, before their learnings are applied to Europe.

5. Country 1: China

Before China [1]is evaluated against the three pre-defined Innovation Criteria outlined in Table 4, it is important to understand the current situation in the country (chapter 5.1.) This includes a peak into the country's macroeconomic, political and environmental trends (5.2.). Chapter (5.3.) will give a brief introduction and elaborate on the relevance eco-innovation and environmental degradation plays in China.

Therefore, it can be summarized that chapters 5.1.- 5.3. provide the background information before chapter 5.4. onwards deep dives into policies relevant for green innovation.

5.1. . Introduction and relevance of China

While building up China's economy, and attaining a GDP ranked second after the United States (TheWorldBank_China, 2022) the country's Environmental Performance Index

[1] When referred to China in this thesis, the author is referring to the People's Republic of China. The Republic of China is not referred to, and Taiwan not included within this thesis. This is due to a simplicity found in the already existing statistics and numbers, as well as yet very different pre-conditions and levels of development in Taiwan in comparison to China. This should in no way be seen as judgment of any form – adding yet another country and dimension would go beyond the scope of this thesis.

(EPI) outlines the price for the steep economic growth: Ranked on place 120 out of 180 with an EPI score of 37,7 (comparison: Lead: Denmark: 82,5; US: Rank: 24, EPI score: 69,3), the environmental performance in comparison to other countries is seen as poor (Yale Center for Environmental, Policy, & Center for International Earth Science Information Network, 2020). Data will show later (see subchapter with analysis) as well, that on a CO_2 emission level, China's trend upwards is what is worrying. While the CO_2 metric tons per capita emissions are on an alarmingly high level with the US (15,2t per capita in 2018), and a lower level with EU countries (Germany: 8,6t per capita in 2018; France 4,6t per capita in 2018), the trends are falling, while China's trend (7,4t per capita in 2018) is rising (ClimateWatch, 2020).

The trend continues when looking at more recent data, and although the Covid-19 pandemic has slowed CO_2 emissions down on a global level, the quick rebound and peak of emissions can be, to a lion's share, accounted to China's economic recovery. "The emissions increase in those two years (referring to 2020-21) in China more than offset the aggregate decline in the rest of the world over the same period. In 2021, China's CO_2 emissions rose above 11.9 billion tones, accounting for 33% of the global total." (IEA, 2022)

Environmentally, China is and has been struggling with air pollution, CO_2 levels as well as water issues. Studies find, that more than 90% of the carbon as well as water footprint are enclosed in trade. This means, that especially developed countries have managed to reduce their own CO_2 emissions by relocating them to China (Wang & Ge, 2020). Although the division between CO_2 consumption and production (where consumption lays in the case of China mostly in Europe and the United States) accounts for part of the high CO_2 emissions, however it has also been, amongst other factors, the rapid urbanization process, intensive industry, construction and agriculture as well as reliance on coal (Wang & Jiang, 2019) & (W. Wu, Sheng, Tang, Zhang, & Liu, 2021).

5.2. Analysis of the current situation and trends in China

The country's historic industry and export dominated structure as well as investment and urbanization intense growth has been questioned and also recognized as problematic (Grubb et al., 2015) & "(…) aggravated environmental pollution, excess industrial

capacity, and a widening regional development gap, which have long been (amongst other problems) in the making by extensive economic growth“ (Jin, Peng, & Song, 2019, pp. 1-2). Current trends center around the shift from a high speed- to a qualitative growth. This movement is achieved through financial and fiscal as well as tax reforms promoting a more efficient and inclusive growth. Furthermore, the country struggles highly with regional differences and thereof resulting inequalities. The Gini Index around 38,5 in 2018 outlines numerically the serious struggles China is facing currently. The presented inequality should be evened out through a social security reform and externality costs aim to pass on the burden extensive resource use is creating. Furthermore, higher prices as well as resource taxes are in discussion to re-distribute and address inequality. Scholarly papers and scenario analysis found, that in the case of China with current policy efforts (and the assumption that coal reaches its peak around 2020 and CO_2 emissions do so around 2030), economic growth is continuing and the goal of “well off society by 2050” met (X. Zhang, Karplus, Qi, Zhang, & He, 2016).

Independent of the label and category China is currently aiming for, economic dominance is partly responsible for the ongoing tense Sino-US relations (Chong & Li, 2019). Global rivalry and the far-reaching trade dispute with the US add to uncertainty and losses (e.g. in GDP, employment). Uncertainty and trade limitations are not surprisingly also unattractive for investments. It is, however, also scholarly proven, that higher levels of uncertainty have the adverse, hence a positive effect on innovation in China, especially on strategic and (green) technological innovation (Jin et al., 2019). The question raises if China benefits and sees green innovation also as a “race” against the US for global domination, or not.

Xi Jinping has elaborated on multiple conferences (e.g. National Conference on Eco-Environmental Protection in 2018, COP 26, 18th National Congress of the Communist Party of China) the necessity of green development and its importance for stability, solving pollution and China’s future (Jia-Lin & Yi-Fei, 2018). The political will is clearly given, also through “(…) incorporate(ing) ecological civilization into the institutionalized and legalized track” (Jia-Lin & Yi-Fei, 2018, p. 223). According to Xi Jinping, the green transition needs to be speeded up through “harness(ing) innovations in science and technology to transform and upgrade our energy and resources sectors (…), industrial structure and consumption pattern, promote a greener economy and society, and explore

a new pathway forward that coordinates development with conservation." (Embassy of the People's Republic of China2021).

China's steep economic growth and the consequently high energy consumption is heavily fueled by fossil, coal and GHG-emission relevant combustibles. As mentioned previously, their rapid growth has been predominantly (around 70%) carried through coal (Riti, Song, Shu, & Kamah, 2017). Together with poor energy utility and rapid urbanization, CO_2 levels kicked the USA off the podium for the largest CO_2 emitter globally in 2006. China still holds the position as biggest emitter of CO_2 (IEA, 2021). Riti et al. (2017) looked at the environmental Kuznets Curve and decoupled economic growth and CO_2 emissions to find out that waiting for the inflexion point is not an option as CO_2 emissions rise with GDP/capita in all calculations in the short run, however acting and actively following and shaping energy policies would be (Riti et al., 2017). The country has realized its urge to act and countered with several policies. One strong focus has been put on renewable energies, where subsidized production as well as the renewable Energy Law in 2006 set the focus on wind, solar and biomass (Y. Fang, 2011). Especially in that field, policy shortcomings and learnings from China can be observed, as lacking coordination and missing consistency have been outlined. It has further been critiqued that not all areas are covered by subsidies, and if, those financial contributions are not big enough. Lastly critique has been voiced regarding the existing incomplete financial- and investment system (Y. Fang, 2011). It remains to be seen throughout this paper if China has learned from its former policy mistakes.

It would be desirable considering China's potential. On the one hand, China can outline and be an example for developing countries for a transition and development with renewables, technology and innovation. On the other hand, China has shown during the pandemic that CO_2 reductions are possible with a change/reduction in energy production, fewer industrial activity and a change in behavior (working style, less commuting) (Han et al., 2021). During the first quarter of 2020, 11% of CO_2 were less emitted compared to the same period in the previous year- those were 257,7Mt of CO_2 in 4 months alone (Han et al., 2021).

5.3. Policies for green innovation found in China

5.3.1. Introduction to the Chinese policy landscape and role of pressures

Corporates have especially been driven by pressures as well the drastic environmental issues to act. China's growth, where on the one side industrial production added 36,6% of value to the country's GDP since 2011, it is also that sector that causes 73% of China's total carbon emissions (in 2019), experts see a big need to act coming from the private and industrial sector (Yang & Wang, 2021). In order to reach the carbon-neutrality as well as environmentally set goals (e.g. China's carbon neutrality by 2060), managers and board members of cooperation as well as startups are not only affected by change, but need to foster it. A link between green innovation and business sustainability has been found in Chinese energy-intense manufacturing firms (L. Li et al., 2020). Therefore, the implementation of policies needs to target energy-intensive industries first, as effective change in those areas not only cuts carbon emissions dramatically, but can serve as example of this energy transition and the potential of green innovation. This can start with implementing circular business models and greener supply- and industrial chains and end at using technological advancements to building low-carbon constructions and housing. In order to target policies correctly, green innovation efficiency, originating from technological efficiency measuring the "(…) degree of greenness of technological innovation efficiency" (L. Li et al., 2020, p. 1434), has become an attractive measurement tool. It should not be an *either* technological progress *or* environmental protection, but a technological progress *and/with/due to.* environmental protection and vice versa (L. Li et al., 2020), as environmental innovation positively affects environmental and economic performance in China (Long et al., 2017).

Empirical evidence from China underlines the importance and roles of pressures: pressure from stakeholder groups including regulators as well as company-specific (e.g. suppliers) positively correlate with green innovation (Cai & Li, 2018). Not surprisingly, so does the relationship between customers and green innovation, however, only with regards to product innovation Cai & Li, 2018).

Both, "(…) coercive and normative pressures have positive and significant effects on a firms' green innovation" (X. Chen, Yi, Zhang, & Li, 2018, p. 304). Institutional pressure has even been identified as essential driver for green innovation (Porter & Van der Linde, 1995), (X. Chen et al., 2018) & (Cai & Li, 2018). Therefore, China proves the often public and general view wrong that pressure and institutional driven change and regulations are "bad for business". It must be conceded, that the different pressures have different effects on innovation though: Coercive pressure has a stronger beneficial effect compared to

normative pressure in companies with organizational slack, as non-compliance results in expensive, stronger impacts including possible fees, operational halts or sanctions. Normative pressure in comparison is less effective and often elapses within the structures of companies (Cai & Li, 2018). Other pressures which are considered relevant are those exerted from the market and consumers. Especially with regards to green product innovation, consumers excerpt relevant pressure aiding green innovation (Yang & Wang, 2021). Problematic and challenging with pressure coming from consumers is that an active demand and change in consumer habits needs to be given, which is more complex to control and influence. Lastly, suppliers, often neglected as stakeholders, have a positive non-neglectable influence on green innovation as well, especially on process innovation. Suppliers exert a push effect and can positively shift towards green innovation through supplying already environmentally friendly products and therefore greening the supply chain and having possible spill-over effects.

Table 5: China - the role of pressures

CHINA	Pressure from institutions	Pressure from consumers/market demand	Pressure from suppliers	Conclusion
Type of pressure	Coercive & normative pressure (Porter & Van der Linde, 1995) (Cai & Li, 2018)	Market demand & market competition (X. Chen et al., 2018) &(Yang & Wang, 2021)	Supplier pressure / push effect (Lin, Zeng, Ma, Qi, & Tam, 2014)	Within different stakeholders need to be considered with varying expectations, needs and pressures
Effect on green innovation?	Yes (positive)	Mixed (negative/not significant/ positive)	Yes (positive)	All three pressures affect green innovation and are therefore

	Process innovation: positive (& stronger) Product innovation: positive (Yang & Wang, 2021)	Process innovation: negative-not significant from consumers Product innovation: positive (& stronger) (Yang & Wang, 2021) & (Lin et al., 2014),	Process innovation: Product innovation: (Lin et al., 2014)	considered relevant.

As demonstrated in Table 5, various factors influence and play together in order to affect green innovation. No weighing has been conducted, as additional to outside factors, pressures and legal frameworks, technological and organizational readiness need to be given for a company to internally change and allow green innovation in the first place. Management, (financial) resources are key in internal processes, however, also highly sector- and company-policy driven - therefore not discussed further in this paper. To conclude, it can be summarized that stakeholder pressure positively affects environmental innovation and therefore has a non-neglectable impact on the private sector and the company's performances in China. This has been proven in Table 5 as well as scholarly (Guo & Wang, 2022).

5.3.2. Analysis China: Legal and regulatory framework

The first innovation criteria from Table 4 is the legal and regulatory framework.

Table 6: Innovation Criteria-Legal and regulatory Framework

Innovation Criteria	Corporate	Governmental
Legal and Regulatory Framework	Stricter regulations put a strain on companies to adapt → however promote	Stricter regulations aid the government to achieve its environmental targets as well as

• Stricter Regulations	innovation and create possible competitive advantages for companies (new products, higher sales, new markets, new customer segments)	are often seen as part of its responsibility. Providing the legal landscape acts as driver for change and has Push- and Pull Effect

Out of the corporate and governmental view, H1 (=Hypothesis 1 as defined in Chapter 4.1.4.) will be tested:

H1: Stricter legal and regulatory regulations promote green innovation.

"(…) China has incomplete environmental laws and supervision systems, therefore, it is necessary for government to coordinate the policy mix to encourage firms to conduct innovative activities and reduce carbon emissions." (Y.-J. Zhang et al., 2017, p. 26).
It is strict, rigorous formulated law that counts amongst the most effective driving factors in China, shifting corporates and entrepreneurs to environmentally friendly changes and adaptations (Lin et al., 2014) & (X. Chen et al., 2018). Proactive adaptions in order to avoid fines or comply with practices when audited or checked often work as a mechanism pushing companies to change sooner rather than later and initiate the process even before the regulation is final (Lin et al., 2014). The government therefore has a very powerful tool to not only increase competitiveness amongst firms, but also set the rules of the game to environmentally higher and more compatible ones. With new regulations and a change of the legal basis, new opportunities get created for businesses and companies' adaption or new ventures in the market. This is, what is known as regulatory push and pull effect (Rennings & Rammer, 2011) & (Lin et al., 2014), where "(…) government environmental regulations might help organizations overcome inertia, accept new ideas, stimulate creative thinking, alert the outdated facilities to resource inefficiencies and invest into technological improvements"(Lin et al., 2014, p. 65)

As the relationship been environmental regulations and corporate green innovation is U-shaped (L. Li et al., 2020), stricter environmental laws result in better green innovation efficiency. That firms profit from strict regulations in China has further been proven when the Renewable Energy Law in 2006 for example came into action. It has been especially

State Owned Enterprises though that benefited from green innovation prior to the regulatory change, yet pointing to an unfair and shifted system within the country (Dayong Zhang et al., 2019). However, state owned or not, the "excuse" to hinder firms with environmental regulations can be partially until the inflection point of the U-curve falsified. However, suitable laws are needed to be made, taking into consideration the needs and development/pollution/-stadiums of various areas (see: regional differences).

Political capital:

Political capital, money aiding a beneficial relationship to the government and officials in power, should have lost part of its importance with economic reforms, however still plays a key role in China as "(…) (b)y means of policies and regulations, the government determines rules of commerce and market structure through barriers to entry and changes in cost structures using regulation tools, subsidies and taxation." (Lin et al., 2014, p. 64). With regards to green innovation, political capital and the "option" to favorize situation destroys long term growth and efforts. That being said, it is not to be underestimated that in China, where property rights are developing but still not established and stable, bank and loan systems still strongly tied to the state-dominated financial system and regulations and fees partly strict and high, companies without political capital have two options: grow very fast and find political capital or not benefit from permit- and tariff reliefs and deal with their competitive disadvantage on the market pressures:

- by law
- by consumers
- by suppliers

Regional differences:

In China, a strong regional gradient from East to West can be seen with regards to green innovation (J. Chen et al., 2017): Regions in the East of China have - when looking at industrial enterprises - a green innovation efficiency of 0,738 (data: 2007-2019), and rank relatively high compared to the central Chinese area (0,451) or the west (around 0,415 green innovation efficiency) (L. Li et al., 2020). An explanation to this phenomenon is found in the regions' economic development. As companies settle where beneficial financial, human capital and production resources are found, agglomerations of efficiencies towards green innovation are also found in those areas (L. Li et al., 2020).

Therefore, policies specifically targeted to existing economic inequalities out in China should focus geographically in the west and center in order to register positive effects on green innovation efficiency. Efforts centered around R&D, funding as well as resource-flow-focus to those areas could together with an active promotion support green technology and innovation as well as benefit the area overall. Here, the link to China's 5 Year Plan can be drawn, hopefully not only seeing, but addressing these inequalities over the next period. Table 7 summarizes the policy learnings for Innovation criteria 1:

Table 7: Innovation Criteria-Legal and regulatory Framework -China Summary

Innovation Criteria	Corporate	Governmental
Legal and regulatory Framework	Stricter regulations put a strain on companies to adapt → however, promote innovation and create possible competitive advantages for companies (new products, overcoming inertia, higher sales, new markets, new customer segments)	Stricter regulations aid the government to achieve its environmental targets as well as are often seen as part of its responsibility. Providing the legal landscape acts as driver for change and has Push-and-Pull Effect. Success has been seen with the Chinese Renewable Energy Law in 2006
Country Specific	• relationship been environmental regulations and corporate green innovation is U-shaped → firms profit from strict regulations	

Learnings China	• State Owned enterprises benefit more from green innovation and stricter laws compared to non-state owned enterprises (imbalance) • Higher entry barriers exist for companies without political capital inhibiting green innovation → Country still controls property rights, has a strong state-dominated financial system, making it very difficult to grow & innovate • strong regional gradient from East to West → Policies should be adapted to development-/pollution-/innovation- state of region → regional gradations needed.
Hypothesis H1:	*Stricter legal and regulatory Regulations promote Green Innovation.* Verified.(Kesidou & Wu, 2020)

As overall learning, it can be concluded that favoritism and bias towards state-owned enterprises and politically close ones, or at least those providing the necessary political capital, is very strong in China. This phenomenon artificially shifts the market and competition and hence hinders green innovation. It is seen unlikely, that China will address this issue, as it is the government and political party in power that would need to initiate that change. It is seen unlikely, as it is that party and people who are also its biggest beneficiary. Take-away for other countries is that favoritism and party bias/political capital actively need to be minimized. This needs to be ensured with more budget disciple and through airtight frameworks applied to all.
Regional Gradations in policy making are an essential learning for other countries as well, as often only national policies are passed without addressing regional differences.

5.3.3. Analysis China: Entrepreneurial conditions and requirements competitiveness

The second innovation criteria from Table 4 are the entrepreneurial conditions and requirements for competitiveness. As before, country specific policy information will be presented before findings and a summary are found at the end of this chapter.

Table 8:Innovation Criteria- Entrepreneurial Conditions and requirements for competitiveness

Innovation Criteria	Corporate	Governmental
Entrepreneurial Conditions and requirements for Competitiveness	Entrepreneurial and innovative conditions need to be given in order allow innovation, entrepreneurship and new and existing firms to profit from Double externality effects (e.g. cost reduction through innovation and efficiency gains.	It is among the government's duties to help foster an entrepreneurial and innovative environment. Having strong entrepreneurial ecosystems however benefits the country as it, increases FDI, attractiveness, GDP and ensures long term growth.

When talking about entrepreneurship and innovation in China, 2015 marks a very important year and a change in the entrepreneurial landscape of the country, as with the implementation of the 13th Five Year Plan (FYP) put as response to high youth unemployment, unsustainable and too fast growth and previously lower innovation an unusually strong emphasis has been put on green, innovative solutions that promote economic growth.

For a country that was rather known to "imitate" rather than to "innovate", those meant big changes in multiple areas - starting from R&D investments, ranging to patent and law changes until entrepreneurship education (Ahlstrom, Yang, Wang, & Wu, 2018). Those were also amongst the points that have been heavily criticized before together with lacking property rights and no educational focus. China is partially wronged however, as the country has tried for 40 years to revive its innovative strength from the past (Abrami, 2014). Why have those efforts not been successful?

A necessary breath of fresh air was brought in when aiming and setting targets to being an "innovative society" by 2020 and a "science- and technological world leader" by 2050. While before financial means were used top-down, a shift resulted in high FDI and imports pouring onto the market. Big corporations and R&D centers settled in the country while China encouraged to buy R&D companies and knowledge that was lacking instead of renting it from Europe and the US - hence Chinese acquisitions have increased

(Abrami, 2014). When looking at the data and key indicators framing from 2015 upwards, a clear trend can be seen at cumulative nearly all the factors.

Table 9: Entrepreneurial KPIS over time 2015/2018/2020 - China

General	2015	2018	2020	Change	Development Direction	Source of Data
Global Innovation Index- place	29	17	14	rising trend	+	2
Global Innovation index	47,47	53,1	53,3	rising trend	+	1
Ease of doing business score (0= lowest performance to 100 = best performance)	62,27	73,30366	77,2842	rising trend	+	1
High tec exports (in % of manufactured exports	30,42194482	31,46749586	31,27390709	no strong changes		1
High tec exports (current USD)	6,52212E+11	7,31842E+11	7,57683E+11	rising trend	+	1
Amount of Unicorns (success/growth)	no data	45	16	#2 worldwide	+	3
% of total firms that are small businesses (< 300 employees)	no data	no data	98,64%	no trend derivable		4
Business Specific						-
Minimal operational/capital costs required to start a buisess	2.000 USD / no capital cost requirment			no trend derivable		1
SME tax rate	25% / reduced rate for high tech entreprises: 15%			no trend derivable		1
Time to start a business (measured in days)	31,3	8,5	8,5 (in 2019)	rising trend	+	1
R&D				rising trend	+	-
Patent applications by residents	133612	148187	152342	rising trend	+	1
Patent applications by non-residents	968252	1393815	1344817	(overall) rising trend	+	1
R&D Expentidures in % of GDP	2,05701	2,14058	2,41	rising trend	+	1
Researchers in R&D (per million people)	1150,81931	1307,12128	no data	rising trend	+	1
Charges for the use of intellectual property, payments (BoP, USD)	22022366055	35782953953	37781733950	rising trend	+	1
Charges for the use of intellectual property, receipts (BoP, USD)	1084600061	5561288668	8554460470	rising trend	+	1

Sources for table: 1) (WorldBank, 2022) 2) (Statista, 2022) 3) (Tracxn, 2020) 4) (OECD, 2020b)

When looking at Table 9, entrepreneurial and innovation KPIs are shown during a period of five years (in 2015, 2018 and 2020). The overall change is analyzed as well as the development direction, which is predominantly positive. The change of the Global Innovation Index from place 29 in 2015 to place 14 in 2020 outlines the overall direction China is going: towards a more innovative country. A developing business score further aids the entrepreneurial environment in the country. When looking at the number of unicorns, a startup with a valuation of over 1 billion, a rise can be seen as well in absolute and relative terms. After the US, China is globally therefore on place two, hosting the second most companies with unicorn status. This shows that not only startups, but scaling early stage companies find a beneficial environment in the country (e.g. investors, capital). Factors such as decentralized and fast decision making, wide and easy access to finances as well as unbureaucratic processes usually have proven to allow innovative ideas to prosper and develop: The capital required to fund and operate a business is with no legally required amount of 2.000 USD also very startup- and founding friendly, reducing the entry barrier to the market. Tremendous progress could be identified with regards to the time required to start a business: While in 2015 it still took around one month (31,3 days), to start a business, a big lift in the bureaucratic hurdle was made with a reduction to 8,5 days by 2018. A reduced tax rate for high-tech enterprises underlines the industry-focus China aims to promote. With regards to R&D, more patent applications have been submitted by residents as well as non-residents, and R&D expenditures with

regards to GDP have been continuously increasing (2015: 2,05% vs. 2020: 2,41%.) At a first glance, all KPIs have been either not changing, or improving. One might conclude that the innovative and entrepreneurial landscape in China is positive. It is increasing, however, more in depth analysis is needed to outline some of the shortcomings, bottlenecks and need for altered policies.

Scholarly, evidence from China proves that green innovation provides an efficient solution in addressing environmental challenges. Especially relevant for green innovation proved to be energy efficiency, R&D, patents as well as spillover effects of innovation (Y.-J. Zhang et al., 2017). As China has seen an improvement and positive trend especially in the past five years in the mentioned areas and outlined in Table 9, one might suggest that its policy efforts are working in the suggested direction, although a lag effect from green innovation with regards to CO_2 emission reductions can be seen. Nevertheless, R&D promotion in China have a positive correlation with green innovation, as do patents. While both need a further ongoing policy focus, the patent landscape in China needs a stronger stimulus and stabilization. In various studies, patents have been classified as highly uncertain. Due to a limited number given out by the government, they are additionally difficult to get (L. Li et al., 2020), although at first glance the patents landscape seemed to improve. Furthermore, subsidies for patents could explain or at least be partly responsible for the surge seen in Table 9, as a few years earlier a change in provincial-level policy subsidized patenting and more firms, individuals, research institutions and universities applied for intellectual property protection (X. Li, 2012). It can be argued that with China's promotion of innovation to the rest of world through specifically set up internet sites (e.g. CNIPA website (http://www.sipo.gov.cn/), a strong, strategic positioning as innovative county has been planned. While more applications are overall a positive trend, it remains questionable as more patents could, but do not necessarily mean, a higher level and quality of (green) innovation, nor a stronger patent system. When looking more in depth, a positive correlation can be found between green-patenting and state owned enterprises (majority is owned by state and not by (an) individual(s)) (Dayong Zhang et al., 2019), proving once again a favoritism towards state ownership.

Scholars as well as various publications voice and request stronger green innovation policy efforts by the country as positive effects for sustainable development gets predominant across various areas (Peng, Yin, Kuang, Wen, & Kuang, 2021).

Table 10: Innovation Criteria- Entrepreneurial Conditions and requirements for competitiveness- China Summary

Innovation Criteria	Corporate	Governmental
Entrepreneurial Conditions and requirements for Competitiveness	Entrepreneurial and innovative conditions need to be given in order allow innovation, entrepreneurship & new and existing firms to profit from Double externality effects (e.g. cost reduction through innovation, efficiency gains)	It is among the government's duties to help foster an entrepreneurial and innovative environment. Having strong entrepreneurial ecosystems however benefits the country as it, increases FDI, attractiveness, GDP and ensures long term growth.
Country specific Learnings	• Putting focus on making entrepreneurship and innovation allowed policies and goals to be reached after years without significant progress → Green Innovation is not a side show, and investments top-down only do not bring the results aimed at nor long-term change • Progress has been made in various areas (see Table 7) due to focus, investment and facilitation and promotion of entrepreneurial conditions (e.g. time to start a business, ease of doing business, innovation KPIs) • Although progress has been made and nearly all analyzed Chinese entrepreneurial & innovation KPIs show a positive trend (see Table 7), more in detail analysis are necessary to understand the exact reasons (e.g. subsidized patents & possible strategic positioning of China). • Patens are not as strong in China, and strong favoritism towards State-Owned Enterprises has once again been identified→ more focus and stabilization is required	

Hypotheses H2:	*H2: Good innovative and entrepreneurial conditions need to be given in order to foster green innovation.* Verified. (Sabban, 2020)

5.3.4. Analysis China: financial and tax system

As with the two prior innovation criteria, the third one will be analyzed and the hypotheses verified or falsified.

Table 11: Innovation Criteria- Financial and Tax System

Innovation Criteria	Corporate	Governmental
Financial and tax system	Companies are often struggling to find financial capital for innovative changes. An adaption and/or reform of financial existing systems would aid green innovation in corporate settings	Financial change as well as possible tax reduction and other financial incentives are needed to possibly counteract and balance (stricter) environmental laws.

A link to green finance cannot be neglected when discussing green innovation, as also a positive correlation can be found in China between Green Capital Policies, linking loans to green actions, and green innovation (Hu, Wang, & Wang, 2021). It will not come as a surprise that with increasing financial costs and constraints, (green) innovation is substantially hindered (Yu, Wu, Zhang, Chen, & Zhao, 2021). Similar to patent applications, state owned enterprises are at an advantage with financial funding as well, leaving privately owned enterprises yet once again at a competitive disadvantage (Yu et al., 2021). This results in a disadvantage for privately owned companies and hinders green innovation, as well as in the bigger picture the country's green innovation ability. Especially high potential and a possible leverage has been found in innovative, private companies with high financial constrains as well as companies operating in highly competitive markets (Hu et al., 2021). Those especially suffer from lacking or insufficient financial resources. Therefore, the learning from China is to simultaneously ensure green finance to boost green innovation, and possibly think about including it in future policy

packages. Options to resolve the financial constraints could prove very effective through implementing regional financial funds focusing on green development as well as elaborate on criteria for green loans and project financing used by banks (Yu et al., 2021). Helpful would be a banking and loan reform, where firstly projects with a positive environmental impact benefit from more affordable financing. Secondly, not only state-owned enterprises should have access to capital, but all on an equal, transparent and just way to avoid market distortions.

Whenever funds on a national level reach their limits or are not accessible to certain groups, money from abroad becomes more attractive. Therefore, FDI does play an essential role in China. Although the first thought in connection with China and FDI is outgoing money strategically invested in Africa, it is inflowing FDI that is relevant for this paper. As the European and U.S. development of financial markets and foreign direct investment kicked off earlier that the one in China, especially lacking funding from the private and banking sector was filled up with European and US-FDI. With it, foreign companies often settled in China, and did so especially with high polluting and CO_2 emitting industries (L. Li et al., 2020). Those were often not allowed or economically feasible due to stricter pollution laws in Europe or the US. While this is per se not illegal to move businesses and headquarters to areas with more lenient environmental laws, it was predominantly high-energy consuming and high polluting industries that found especially attractive and settled there (Lv et al., 2021). Additional emissions and heavy industry then logically intensify the country's already existing and heavy strain on the environment. Eliminating that loophole for firms and aiming for FDI that is qualitative, green and sustainable would be an essential step. This, however, is yet once again achieved through a change in legislation. Lifting existing financial constraints in China, that foreign often linked to high environmental costs - FDI is either not possible anymore, or compared to other domestic green alternative, not attractive (Lv et al., 2021). An ease of existing financial constraints can and should be combined with overall financial reforms. FDI especially proves once more the importance of a change in environmental laws combined with the need to change the financial structure in that policy mix as well.

Table 12: Innovation Criteria- Financial KPIs over Time- 2015/2018/2020 - China

General	2015	2018	2020	Change	Development Direction	Source of Data
Financial and Loans						
Interest payments (% of revenue)	3,237969553	2,762214482	no data	falling trend	+	1
Interest rate spread (lending - deposit rate) general	2,85	2,85	2,85	no changes		1
Domestic credit to private sector (% of GDP)	152,5944998	157,8120786	182,4326259	rising trend	+	1
Borrowers from Comercial Banks (per 1.000 adults)	346	no data	536	rising trend	+	1
Interest rates for SMEs	5,23%	5,17%	4,84%	faling trend	+	2
Interst rates large firms	5,26%	5,07%	5,06%	falling trend	+	2
Interest rate spread (lending - deposit rate) in % points	-0,03	0,1	-0,22	falling trend	+	3
Collateral, SMEs (% of SMEs needing collateral to obtain bank lending)	55,67%	50,28% (data: 2017)	no data	falling trend	+	3
Venture and grwoth captial (stock) (RMB billion)	336	411 (in 2017)	563,6 (in 2019)	rising trend	+	1
Share of short term loans (% of total SME lending)	47,56%	41,62	40,76	falling trend	-	2

Sources for table: 1) (WorldBank, 2022) 2) 2015-2018:(OECD, 2020c) & 2020:(OECD, 2022b) 3) (OECD, 2020c)

Some exemplary financial and loan KPIs have been researched over time and summarized in Table 12. Overall, the trend within the country is, despite all practiced criticism, going into the right direction. Interest payments have been decreasing while borrowers from banks per 1.000 adults increasing (from 2015 to 2020: +154,9%). Surprisingly, interest rates for SMEs have had marginal reductions from 2015 to 2018 (delta: 0,06%), however major reductions from 2018 to 2020 (delta: 0,33%). A substantial reduction between 2015 and 2018 (delta: 0,19%) and minor between 2018 and 2020 (0,01%) for interest rates of large firms can be observed. The interest rates until 2018 were especially attractive for larger firms, while the country could possibly have realized that conditions for SMEs need to be more attractive. This could possibly explain the shift from large companies towards SMEs around 2018. However, it is found that the interest rate spread is negative and deepening its negativity around 2020. This negative interest rate spread can be explained by a focus set by the government during the Covid-19 pandemic in support of SMEs. Within that focus, financing funds have been established (OECD, 2022a).

Lastly, as mentioned during the introduction to China, taxation of CO_2 intense products could be an essential policy tool. As trade openness is positively coupled with CO_2 emissions, it is important to differentiate between CO_2 producers and consumers with products and trade (Dou, Zhao, Malik, & Dong, 2021). Although CO_2 overall could be a thesis topic of its own, it cannot be neglected and will shortly be discussed here. Taxing low carbon products less compared to high carbon products would allow a clearer balance and incentive to not outsource emissions. Incentivizing low-carbon products trade only within the Free Trade Agreement between China, Japan and South Korea would already positively affect the countries' CO_2 balance. Due to a positive CO_2 import and negative CO_2 export connection, China needs to pay more focus to exports (Dou et al., 2021).

Taxing CO_2 would ensure that less countries with high emissions outsource their environmental burden to China as well as promote green innovation and transitions within the country and its trading partners (possible spillover effect).

To summarize, Table 13 outlines the country specific learnings drawn for China with regards to the Financial and Tax System:

Table 13: Innovation Criteria- Financial and Tax System- China Summary

Innovation Criteria	Corporate	Governmental
Financial and tax System Adapted financial system	Companies are often struggling to find financial capital for innovative changes. An adaption and/or reform of financial existing systems would aid green innovation in corporate settings	Financial change as well as possible tax reduction and other financial incentives are needed to possibly counteract and balance (stricter) environmental laws.
Country specific learnings	• In order to boost green innovation, a simultaneous focus on green finance needs to be set in order to lift financial constraints- a consideration for future policy packages. • China would benefit from a banking and loan reform in order to address capital (in)- accessibility. First efforts have been made as response to Covid-19 aiding SMEs with a negative interest rate spread and financing funds. Attention needs to be paid to further build a transparent and just financial system without favoritism of state-owned enterprises. • Attracting qualitative, green and sustainable FDI can only be done once loopholes are closed and environmental standards risen. China should not allow foreign high-energy consuming and high polluting industries to act in their country in order to avoid → Standardization of environmental regulations and examination of foreign capital and companies is needed to avoid environmental outsourcing.	

	• Further ease of financial constraints is necessary in all sectors and industries, as financial resources often inhibit green innovation. Furthermore, additional new/or stricter regulations could be connected to an additional financial burden on companies. • CO2 taxation would help resolve the emission-export / out-sourcing dramatically.
Hypotheses H3:	*H3: An adapted financial system is necessary to aid green innovation and incentivize cooperation to change* *verified.* (Hu et al., 2021) & (Yu et al., 2021)

On an individual, micro-level, investments of firms into green innovation and technologies have a positive effects, although state owned companies in China are currently still the ones benefiting most (Dayong Zhang et al., 2019). On a policy level, that clearly existing bias (also found in patent and political capital) needs to be removed and incentives for private corporations as well as non-politically close parties at least brought to an even level. The listed changes and trends found in Table 10 are a first step in the right direction- however only that: the first of many!

5.4.1. Re-evaluation of hypotheses in the case of China

H1: Stricter legal and regulatory regulations promote green innovation

H2: Favorable innovative and entrepreneurial pre-conditions need to be given in order to foster green innovation

H3: An adapted financial system is necessary to aid green innovation and incentivize cooperation to change

All three hypotheses H1-H3 have been verified in the chapters above for China. These verifications have been done through scholarly papers and underlined and proven with additional data provided.

5.4.2. Four Learnings from China – what worked well, what did not

Learning 1: Innovation and green innovation need to be in the center and focus.
Only after China realized, that its current growth is not sustainable and that a focus towards innovation could additionally solve a list of other struggles the country has been dealing with (e.g. mass youth unemployment) mass innovation had a prominent role in China's Five Year Plans and government efforts

Learning 2: Legally, strict environmental regulations have the biggest effect in China in terms of green innovation.
The current legal situation still provides a bottleneck as well as loophole for countries and companies to grow and expand at the expense of the environment. Currently expandable, research found out that that efficiency increases with stricter environmental requirements.

Learning 3: Regional differences require regionally adapted policies.
China's different development provides with a strong regional gradient from East to West. These regional differences not only result in inequalities and possible social tensions as seen in China, but also require different policies. Regional differences also need to be addressed during policy making for them to be effective, reachable and efficient. As the central and western region of China is less developed and economically weaker than the east, different policies are needed there.

Learning 4: Foci on legal, patents as well as R&D worked well.
In order to favor green growth, China should not forget the inclusive bit while further working on the regulatory environment fostering green innovation. It has been seen, that especially important is the legal framework, factors overall supporting innovation as well as strong, independent patents and increased R&D funding.

6. Country 2: The United States of America

Before the US is evaluated against the three pre-defined Innovation Criteria outlined in Table 4, the current situation in the country will be described. Chapter 6.1. will give an introduction and elaborate on the relevance of eco-innovation and the role environmental degradation currently plays in the US. By explaining the US' current environmental struggles, their narrative and motivation towards a green and quick transition becomes clearer. In order to further understand its current political focus, a short introduction and presentation on the policy level follows a brief outline of macroeconomic, political and environmental trends in the US (chapter 6.2.). Chapter 6.3. deals with policies relevant for green innovation and evaluates the country against the three pre-defined Innovation Criteria. A summary with relevant policy-learnings is given after each criterion, as are the verifications/falsifications of the tested hypotheses.

6.1. Introduction to and relevance of the US

Before even starting the discussion and introduction for the United States of America (USA), it is important to point out that eco-innovation is, from a language perspective, not commonly used in the United States. Hardly found in published scholarly papers, however, the term "environmental innovation" / "environmental sustainable innovation"/ "clean technology innovation" is. As also found in various scholarly sources (e.g.: (Hellström, 2007), (OECD, 2008)), those terms will be used interchangeably and are seen as synonyms.

That being said, the USA ranks second after China with regards to GDP (TheWorldBank_USA, 2022) and economic performance. When looking at the country's Environmental Performance Index (EPI), Rank 24 out of 180 is held with an EPI score of 69,3 (comparison: China: #120/180, EPI Score 37,7) (Yale Center for Environmental et al., 2020). The persistency of #2 is kept when looking at global CO_2 emissions: Although there have been policy efforts to reduce the country's CO_2 emissions, those are still at 4,46 Gt in 2021, accounting for 18 % of global emissions - oil still being identified as biggest contributor. CO_2 emissions from coal, as well as oil stay below 2019 levels in 2021 though, showing a downward trend and reduction throughout the pandemic (IEA, 2021). However, also first successes from changes and policy efforts can be seen: The

countries' CO_2 emissions are on a continuing downward trend since their peak in 2005 (R. Wu, Wang, Wang, & Feng, 2021). A change in energy generation and shift from coal to more natural gas and renewables through technological progress, as well as tax incentives proved to be successful (Service, 2021a). Although a historic decline (since 1983) in energy-related CO_2 emissions has been noticed in 2020 due to the pandemic (EIA, 2021a), this decline has been historic and provides a lot of potential for (policy) learnings. Nevertheless, caution is advised, as partly responsible for a CO_2 reduction was for example a change in electricity generation (making up the biggest CO_2 emitting sector) from high-carbon emitting coal to still CO_2-relevant gas (Zeke, 2017).

It is important to understand that the US outsources a majority of emissions to less developed countries with less strict environmental regulations (Dai, Duan, Liang, & Ng, 2021), China being one of them. That is way emission responsibilities are bypassed. However, the US has a strong incentive to counteract high CO_2 emissions and fight against results of climate change and stop expanding and growing at the cost of the environment. "(…) Policymakers in the USA are encouraged to establish policies that control the excessive use of natural resources, promote sustainable lifestyles, develop energy-efficient carbon pricing, and fix the ecological budget to secure a sustainable future for the country." (Khan, Hou, & Le, 2021, p. 1).

Environmentally, the US has been challenged on multiple fronts as well, feeling the impacts and first effects of global warming. Long lasting droughts, water shortages as well as growing inequalities put pressure on the governments and point out the realities of climate change. Although the effects are there, climate change deniers stick to their opinion and will need to be addressed separately, adding to the list of policy and communication efforts of the upcoming years: Only 72% of adults currently in the US believe, that global warming is happening, and only 57% believe that is predominantly caused by human activities (Yale Program on Climate Communication2022).

6.2. Analysis of the current situation and trends in the US

Over the past decades, the US has grown tremendously with high GDP, increasing population growth rates and flourishing industry. This growth, similar to the current growth in China, has been largely borne by the environment, dependent on natural resources and its (over-) consumption of especially fossil fuels. In the US, the predominant amount of energy is produced from non-renewable sources (Khan et al., 2021), outlining a big problem and required policy change. From the 4.116 billion kWh produced in 2021, 61% originated from fossil fuels while 19% nuclear and 20% was made by renewables (+2,5% compared to 2019) (EIA, 2021b) & (Khan et al., 2021). Although an increase towards renewables has been noticed - this can only be the beginning, considering that the US with less than 5% of the global population uses nearly 16% of the global energy (comparison: China: 18% of global population and uses 20% of global energy) (Center for Sustainable Systems, 2021). Bigger investments and a stronger focus on also producing the energy required needs to be set.

Under the former president Donald Trump, the US left the Paris Agreement. President Joe Biden now aims to restore and make up for four years of lost time and absence in the international climate community. Next to financial cuts, underfinanced term cooperation and research as well as more difficult political relationships, it have been local and state policy efforts stepping up due to lacking federal action (B. Yuan et al., 2022), (Y.-X. Zhang, Chao, Zheng, & Huang, 2017) & (Khan et al., 2021).
The US is seen as key actor and essential driver due to its high GHG/CO_2 emission and economic power. The country's commitments, Nationally Determined Contributions (NDCs) and policies are essential in order to meet defined goals and accelerate the global transition. After the election of Joe Biden and with his efforts, previously destroyed credibility of the US could be restored, a clear, committed line followed, and focus on (green) innovation, financial change and international and national actions stronger set (Nathan Hultman, 2021).

According to the Kuznets Curve, a U-shaped relation between economic development and pollution/environmental impact can be found. This means, that until a certain point, a positive relationship exists for developing countries with regard to pollution (as GDP grows, so do CO_2 emissions until a certain point/turning point) (Aslan et al., 2018). After

that income level, rising R&D investments as well as green technology are responsible for a shift. According to research, the US and efforts in the past have proven to be successful, and the Kuznets Curve as well as the turning point in the curve has been reached in the United States (Aslan et al., 2018). The described phenomenon and turning point is still ahead in China.

Past the Kuznets Curve, it is the country's focus to ensure eco-policies, that bring the country forward. The possibilities vary greatly, from "(…) flexible air permits, offering regulatory incentives for environmental improvements, (or) innovative ways to regulate small businesses (…)" (OECD, 2008, p. 5). Here, various frameworks and policy guiding documents have been provided, allowing each State to foster innovation slightly differently (e.g. "State Innovation Grant Program"). Through this financial support, states have the freedom to examine different procedures in "(…) environmental permitting, environmental management systems and performance-based leadership programs" (OECD, 2008a, p. 6).

6.3. Policies for green innovation found in the US

In order to give a comprehensive picture of the US and its policy landscape, chapter 6.3.1. will outline the role pressures play in the US policy landscape while the analysis of the three chosen criteria follows 6.3.2.- 6.3.4., followed by a summary of the learnings 6.3.5. onwards.

6.3.1. Introduction to the US policy landscape and role of pressures

Table 14: US- the role of pressures

USA	Pressure from institutions	Pressure from consumers/market demand	Pressure from suppliers	Conclusion
Type of pressure	Coercive and normative pressure (Porter &	Consumer pressure & employee/management pressure	Supplier-pressure	All pressures - from in-stitutions,

	Van der Linde, 1995)			consumers as well as suppliers' impact and possibly advance green innovation .
Effect on green innovation ?	Yes (positive) Negative correlation between institutional pressures and organizational slack on green innovation (Berrone, Gelabert, Fosfuri, & Gómez-Mejía, 2008)	Yes (positive) Strong correlation between management pressure and green innovation in companies found as well as few green alternative products in certain industries (→ push towards green product innovation (Rezende, Bansi, Alves, & Galina, 2019)	Yes (positive) A correlation between environmental friendly action and adaption along the supply chain; suppliers provide definitely a strong leverage for change(Azevedo, Cudney, Grilo, Carvalho, & Cruz-Machado, 2012)	All three stake-holders can excerpt resulting in the positive advance-ment of green inno-vation

At table 14, it can be seen that the mentioned pressures do result in pressures and changes – hence have an impact on green innovation. Nevertheless, in the case of the US, the effects regulatory pressures and changes on green innovation are slightly more disputed.

Interestingly, it has been proven that managers and companies with organizational slack impact green innovation negatively, as slack allows more cautious strategies and respond worse to regulatory changes and transformations (Berrone et al., 2008). Managers play a significant role in pushing green innovation internally and have, according to studies, the biggest effect on green innovation. However, the managers' effect in the United States is shrinking, once this change is suggested by the government or regulators. It has been suggested, that policy makers lack to communicate the potential and positive effects of new greener governmental regulations (Eiadat, Kelly, Roche, & Eyadat, 2008). Furthermore, consumers play a strong role, as in certain areas a lack of green alternative products is found. Therefore, the resonance has been very positive with new greener products and a stronger push for green product innovation is found (Rezende et al., 2019).

6.3.2. Analysis US: Legal and regulatory framework

Table 15: Innovation Criteria: Legal and regulatory framework- USA

Innovation Criteria	Corporate	Governmental
Legal and regulatory Framework Stricter Regulations	Stricter regulations put a strain on companies to adapt, however, promote innovation and create possible competitive advantages for companies (new products, higher sales, new markets, new customer segments).	Stricter regulations aid the government to achieve its environmental targets as well as are often seen as part of its responsibility, providing the legal landscape acts as driver for change and has *Push- and Pull Effect.*

The regulatory framework and changes in those are a bit more complex in the US than in China, considering their legislative system and division into federal, state and local level. Before the decision under the Clean Air Act in 2007 in Massachusetts giving the Environmental Protection Agency (EPA) authority regarding GHG topics and classifying CO_2 as air pollutant (Freeman & Vermeule, 2007), the nation implemented voluntary climate change efforts. Examples are amongst many others the "Energy Policy and Conservation Act", "Energy Conservation and Production Act" (Congressional ResearchService, 2021a, p. 6). Not surprisingly, voluntary commitments, actions and

programs have little effect (Lyon & Maxwell, 2007) & (Southworth, 2009). Since then, US Congress has been differently involved, however votes on climate legislation are out of the ordinary.

On a state and local level, multiple actions have been seen: Initiatives and coalitions such as, for example, the United States Climate Alliance, consisting of governors and states not agreeing with Trump's exit of the Paris Agreement show the role and importance states have and can play in the US. Although the general country attitude during the Trump administration was contrary, the Alliance committed to staying with the set targets from the Paris Agreement, demonstrating state-led actions and commitments. Through investments, energy efficiency and policies, the Alliance achieved a 14% GHG reduction between 2005-2016 (United States Climate Alliance, 2019).

However, not only geographical differences, but also regional political differences need to be resolved: The action of independent states leads to varying levels of energy policies, strictness and a high dependance on the state to act. While California for example set up a carbon trade program reducing GHG emissions (-40% by 2030; -80% by 2050 compared to 1990), Washington introduced slightly different goals (-45% by 2030; -70% by 2040 and -95% by 2050) (Dai et al., 2021). Although the state efforts are going in similar directions, strong regional differences could possibly impact companies and processes. Results range from the loss of the state's competitive advantages to different impacts on the population and overall success. This makes a heavily state dependent policy more complex and possibly not streamlined, unfair and less efficient.

The struggle and vagueness with different efforts and various responsibilities continues far beyond a state versus national level: It has been suggested, that policies should be closer examined on state- as well as metropolitan area level, as great differences are found and criticism is often voiced regarding to who should set, achieve and implement at which level (Congressional Research Service, 2021a). This applies also to the role of existing authorities and the role of new founded ones, which is often vague. It appears that next to a complex legislative system, clear responsibilities need to be defined. A streamlined path and direction have been partially missing, as did a clear division of roles and accountability of institutions and states. It has been found that CO_2 emissions and environmental diplomacy only have a global short-term effect. Although treaties are

signed, CO_2 emissions keep rising. It has therefore been suggested, that instead of signing more treaties and more guidelines, more effort should be put into staying within the limits of the existing ones (G. Li, Zakari, & Tawiah, 2020).

One needs to find out if in the case of the US, additional guidelines overall would be necessary, as a roadmap partially seems to be lacking. Exactly that direction given through concrete and strict policy implications could allow the necessary Push-and Pull factor from the government and further the green innovation agenda. Also here, a positive correlation between stricter environmental laws and green innovation could be found, proving the hypothesis (Hassan & Rousselière, 2022) & (Dan Zhang, Zheng, Feng, & Chang, 2022). When the value is communicated properly, firms including multinationals, derive a long-term added value (stronger in some industries compared to others) and improvements in firm value through green innovation sparked by stringent regulatory frameworks (Kim, Pantzalis, & Zhang, 2021).

Table 16 will summarize the key learnings in the case of the US for the legal and regulatory framework-criteria:

Table 16: Innovation Criteria- Legal and regulatory Framework- USA- Summary and Learnings

Innovation Criteria	Corporate	Governmental
Legal and regulatory Framework Stricter Regulations	Stricter regulations put a strain on companies to adapt, however promote innovation and create possible competitive advantages for companies (new products, overcoming inertia, higher sales, new markets, new customer segments).	Stricter regulations aid the government to achieve its environmental targets as well as are often seen as part of its responsibility. Providing the legal landscape acts as driver for change and has Push- and Pull Effect. The changing US political landscape and existing complex system has made long-lasting governmental efforts more difficult, resulting in individual approaches

Country Specific Learnings US	• Missing responsibilities and a clear roadmap for state vs. national policy efforts results in inefficiencies and a dismembered patchwork rug of policy efforts and effects • State level efforts can have great power when organized properly (e.g. done during the Trump Administration: United States Climate Alliance). If areas disagree or see progress not happening fast enough, forming sub-organizations or clusters might be a good alternative. • Agencies without clear responsibilities and the authority needed are a waste of resources and add unnecessary complexity → slim model • Voluntary Commitments and actions have little effect in the US.
Hypothesis H1:	*Stricter legal and regulatory Regulations promote Green Innovation.* Verified. (Hassan & Rousselière, 2022) & (Dan Zhang et al., 2022)

6.3.3. Analysis US: Entrepreneurial conditions and requirements for competitiveness

When looking at Table 17, and the shown entrepreneurial conditions and trends between 2015-20, it is clearly visible that overall, conditions ameliorated.

Table 17: Analysis - Entrepreneurial Conditions and Requirements for Competitiveness- USA

General	2015	2018	2020	Change	Development Direction	Source of Data
Global Innovation Index- place	5	6	3	rising trend	+	2
Global Innovation index	no data	no data	61,3	rising trend	+	1
Ease of doing business score (0= lowest performance to 100 = best performance)	83,59247	83,57395	no data	no strong changes		1
High tec exports (in % of manufactured exports	21,38094103	18,4740538	19,48384895	no strong changes		1
High tec exports (current USD)	1,75244E+11	1,53808E+11	1,41539E+11	rising trend	+	1
Amount of Unicorns (success/growth)	no data	71	90	#1 worldwide	+	3
% of total firms that are small businesses (< 500 employees)	no data	no data	99,90%			4
Business Specific						-
Time to start a business (measured in days)	5,6	5,6	no data	rising trend	+	1
R&D						1
Patent applications by residents	301075	312046	327586	rising trend	+	1
Patent applications by non-residents (attravtice to found there?) increasing or decreasing?	288335	285095	269586	(overall) rising trend	+	1
R&D Expentidures in % of GDP	2,71742	2,83283	no data	rising trend	+	1
Researchers in R&D (per million people)	4267,83919	no data	no data	rising trend	+	1

Sources for table: 1) (WorldBank, 2022) 2) (Buchholz, 2021) 3) (Tracxn, 2020) 4) (OECD, 2020b)

The US managed to climb from place five in 2015 to place three in 2020 in the Global Innovation Index (GII). With regards to unicorns, a similarly rising trend can be observed. The dimensions are a lot bigger when looking at the US in comparison to China. It is especially important to point out that San Francisco (24) as well as New York City (15) (Tracxn, 2020) hold a non-neglectable amount of unicorns already, showing the

importance of hubs and innovation areas with talent, risk capital and entrepreneurial mindset focus within a country. Those regional differences, referred to as Clusters of Innovation (COI), are closely linked governmental policy as well. In Silicon Valley for example in the 1980s, Trademark Law Changes sparked entrepreneurship and were a game changer for the area (Engel, 2015). As lessons learned from the US, it is important to use existing strengths, industries and competitive advantages and support those rather than trying to attract new ones. Policies need to center around stakeholders and "(…) need to be congruent with the local economic, social, political, legal, institutional, and cultural environment." (Engel, 2015, p. 53). Room for cooperation, a strong voice and respect for the entrepreneurial scene as well as streamlined policy efforts on a national and regional level (not as found in areas of China, where policy efforts are acted in opposition to the applied preference and help of state-owned enterprises) are key. With regards to a realistic role definition, "(…) (g)overnments cannot be relied upon to provide the answers for Cluster of Innovation development, but rather they must focus on providing enabling environments and allow the answers to emerge" (Engel, 2015, p. 54). When looking more into the regional hubs and technology hotspots in 2020, the USA is leading with 25 (including San Francisco, Boston, New York City, San Diego, Washington, Los Angeles, Houston) followed by China with 17 (including Hong Kong, Beijing, Shanghai, Nanjing)(Carsten, 2020). Continuously rising tech exports, as well as a very high percentage of SMEs (99,9% under 500 employees) and a low time (5,6 days) to found a company prove that entrepreneurial as well as business conditions are already on a good path and bureaucratic hurdles are/were dismantled and reduced. With regards to spending on a R&D level, the private sector has in the past partly compensated for the declining or constant state investment and has nearly constantly increased since 1995 (federal share: 21,2%, business share: 70,7% in 2019), where the majority was invested in development and applied research (Congressional Research Service, 2021b). It could be suggested that the prior decrease in government spending could be balanced through joint projects from the state as well as private sector. Partnerships with a strong focus on green innovation as well as environmentally friendly technologies could be fostered and so a focus and stronger incentive set (Sun, Yesilada, Andlib, & Ajaz, 2021). Though subsidizing, the government could further incentivize a change in the production cycles and spark a transition (Sun et al., 2021). This would especially be helpful, as industry-focused R&D investment is rather product- development based (Porter & Van der Linde, 1995). The U.S. has gone against a general trend- which is an increase in R&D spending. More

money has been allocated in the 2022 budget again, however not only focusing on green innovation. When looking at a country's/America's focus, it is important to consider the overall budget. The President's FY2022 budget requests more than $10 billion in "clean energy innovation across nondefense agencies.". This includes additional funding for clean energy, climate innovation as well as nuclear technologies. With the establishment of the "Advanced Research Projects Agency for Climate (ARPA-C)", more funding for new projects would be secured. Next to a new agency, which is supposed to add focus and advance climate research projects, the president would like to invest in the existing Advanced Research Projects Agency-Energy. The aim of the agencies would be to both support high-risk funding of climate change adaptation/resilience as well as the GHG mitigation technology development. A financial focus has been set, and a governmental spending focus with (joint) research projects was emphasized. Table 18 summarized the key take-aways for the American Entrepreneurial conditions:

Table 18: Innovation Criteria: Entrepreneurial Conditions and requirements for competitiveness- USA- - Summary and Learnings

Innovation Criteria	**Corporate**	**Governmental**
Entrepreneurial Conditions and requirements for Competitiveness Innovation conditions & KPIs	Entrepreneurial and innovative conditions need to be given in order allow innovation, entrepreneurship & new and existing firms to profit from *Double externality effects* (e.g. cost reduction through innovation, efficiency gains)	It is among the government's duties to help foster an entrepreneurial and innovative environment. Having strong entrepreneurial ecosystems however benefits the country as it, increases FDI, attractiveness, GDP and ensures long term growth.
Country specific Learnings	• Government spending and incentives could be created through joint research projects and partnerships • Existing strengths, industries and competitive advantages need to be elaborated on, possibly building	

Hypotheses H2:	*H2: Good innovative and entrepreneurial conditions need to be given in order to foster green innovation.* Verified. (Sabban, 2020)

6.3.4. Analysis US: financial and tax system

The divergence between ever-increasing environmental concerns and the drive for constant growth has not stopped in the financial and monetary spheres in the U.S. either. As part of Biden's plan, "(…) hundreds of billions of dollars in new federal funding and tax incentives would stimulate technological advancements and enhance competitiveness of low- or no-GHG emitting technologies" (Congressional Research Service2021a, p. 31). In order to achieve Biden's goal of decarbonized US by 2030, especially policies on a federal level as well as financial means are needed to accelerate development, innovation and new technological advances (Devashree Saha, 2021).

This can be achieved through combining tax benefits with spending increases and higher standards. Interestingly, scenario analysis found out that although enlarging taxation benefits and spendings do already attain significant reductions by 2030, the 2050 climate goals will not be met (Devashree Saha, 2021). A combination of policy tools including taxation credits, spending increases coupled with the introduction of stricter sector-based performance standards however would aid the achievement of those targets.

Tax credit expansion is one of them and acts as supply push policy, enabling new companies to innovate and reach the market, while existing can expand their share. By lowering the financial burden and bringing down costs, a focus on faster development and hence faster market fit innovations results. The US had positive evolutions when using that strategy for the development and cost reduction of wind and solar energy as well as aiding financially in the rollout of electric cars (Devashree Saha, 2021). As this strategy has successfully worked previously, it could be thought about using it again in a broader rollout with regards to green innovation projects.

Another learning could be found by looking at the strongly set tax focus, especially with regards to energy efficiency in housing. Multiple tax credits for various stakeholders (e.g. Non- Business Energy Property Tax Deduction/ Residential Energy Property Credit) were provided, although applying tax credits to other sectors is slightly more complex as

the impact depends greatly on the sector they are applied to. In various scenario analysis, it has been found that in order to reach the US GHG emission cut of 50-52% by 2030, more industry specific reforms are required. An Emission Cap or alternatively a low-carbon product standard is necessary, as industry in the US account for approximately 23,9% (2020) of GHG emissions (Statista, 2020), while overall tax credits prove only partially helpful. By setting a benchmark however and raising the required level, a concept along the lines of carbon pricing could be implemented. Making high carbon emitting products more expensive could also result in a push towards green innovation and a re-evaluation of supply chains and production lines.

Currently, several bills in Congress are discussed or introduced concerning the financial industry as well as green banks and climate financing (Congressional Research Service, 2021a). Decisions and the amount of money made available remains to be seen in the near future. Table 19 also proves, that the overall trends are going in the right direction:

Table 19: Financial KPIs over Time- 2015/2018/2020 - US

General	2015	2018	2020	Change	Development Direction	Source of Data
Financial and Loans						
Interest payments (% of revenue)	12,33958709	14,9950778	15,06264293	raising	-	1
Interest rate spread (lending - deposit rate) general (% points)	no data	no data	no data			-
Domestic credit to private sector (% of GDP)	179,5906889	179,4611502	215,9461341	rising trend	+	1
Borrowers from Comercial Banks (per 1.000 adults)						-
Interest rates for SMEs	3,33%	5,16%	2,82%	Strong falling trend	+	1
Interst rates large firms	3,26%	4,90%	3,25%	falling trend	+	1
Interest rate spread (lending - deposit rate) in % points	0,07	0,26	-0,43	falling trend	+	1
Collateral, SMEs (% of SMEs needing collateral to obtain bank lending)	no data (2017: 92,2%)	94,30%	51,10%	falling trend	+	1
Venture and growth capital (USD billion)	82	1,32	1,562	rising trend	+	1
Share of short term loans (% of total SME lending)	no data	no data	no data			-

Source Table: 1) (OECD.Stat, 2020)

When looking at the general financial trends in the US in the time period between 2015-2020, one can see that interest rates overall rose, and so did those for SMEs from 2015 onwards. Loan improvements as well as loan performance is increasing and what has become easier and more accessible over the past years is additionally, according to Data from the US Federal Reserve System, loan availability as well as lending standards, especially for SMEs (OECD, 2022a)& (OECD, 2020b).

The recent shifts and positive trends have been partly achieved through programs including the “Loan Program” or the “Certified Development Corporation”, helping (new) small businesses to come up with working capital loan guarantees or asset funding (OECD, 2022a) (OECD, 2020b). Furthermore, “The Small Business Investment

Company (SBIC)" behaves as a fund and VC-opportunity, while the "Minority Business Development Agency" supports and ensures the growth of minority owned businesses. While these mentioned programs are by no way a complete list, it does show the support and targeted help the SMEs and startups are provided with in the US (OECD, 2022a) (OECD, 2020b). After a strong decline in risk financing, startup funding and loans due to Covid-19, governmental support to SME funding pots (including: Paycheck Protection Program: + 5,2 million additional loan volume worth 525 billion; SBA +,4 million + 5,7 advances worth 191 billion and 20 billion respectively; SBA-loans exceeding 28 billion (OECD, 2022a)) has been crucial in protecting the startup-sector in the country. "(…) (t)hese programs account for the declining interest rates and interest rate spreads between SMEs and large enterprises and the large decline in the share of SMEs requiring collateral to obtain a loan, despite the crisis. They also likely play a role in the decline in bankruptcies relative to 2019." (OECD, 2022a, p. Country Snapshot US). Although fewer deals have been registered and closed showing the effect of Covid on the VC-sector, that positive governmental shift and investment has been echoed and transferred to the VC sector, an important financial pillar in the US financing for early stage companies and ideas, where in 2020 a record high of +13% of raised capital compared to 2019 outlines. A summary of the key findings and country specific learnings is given in Table 20:

Table 20: Innovation Criteria- Financial and Tax System - USA- Summary and Learnings

Innovation Criteria	**Corporate**	**Governmental**
Financial and Tax System Adapted financial System	Companies are often struggling to find financial capital for innovative changes. An adaption and/or reform of financial existing systems would aid green innovation in corporate settings	Financial Change as well as possible tax reduction and other financial incentives are needed to possibly counteract and balance (stricter) environmental laws.
Country specific Learnings	• In order to boost green innovation, one could think about using policy tools such as tax credit expansions, which have successfully worked in other sectors previously. One could therefore learn from different sectors and the past and apply those mechanisms with regards to green innovation.	

	• An Emission Cap or alternatively a low-carbon product standard is necessary or a concept of carbon pricing, as with current efforts, goals and thresholds cannot be met. • Declining interest rates and favorable financial conditions though governmental aid especially for SMEs fosters entrepreneurship and green innovation and has spillover effects in other sectors (e.g. VC sector)
Hypotheses H3:	*H3: An adapted financial system is necessary to aid green innovation and incentivize cooperation to change* Verified (G. Yuan, Ye, & Sun, 2021).

6.3.5. Re-evaluation of the hypotheses in the case of the US

The three hypotheses summarized:

H1: Stricter legal and regulatory regulations promote green innovation

H2: Favorable innovative and entrepreneurial pre-conditions need to be given in order to foster green innovation

H3: An adapted financial system is necessary to aid green innovation and incentivize cooperation to change

All three hypotheses H1-H3 could have been verified as outlined in the chapters and tables above for the United States. There has also been additional further scholarly proof added.

6.3.6. Four Learnings from US – what worked well and what did not

Learning 1: Voluntary commitments and actions have little effect, however actions with alliances do.

Although it has been found that voluntary commitments do have little to no effect, one presented example in the US during the Trump-area, the United States Climate Alliance, shows that alliances do and can be considered a valuable alternative.

Learning 2: Fewer instances and levels could reduce complexity.

In the US with the federal, state and local level, a lot of complexity and inefficiency is added. Not only geographical and regional differences need to be taken into account, but various instances of approval and responsibility. One way is to ensure streamlined, well communicated responsibility and roadmaps, additional to policies on a state level that provide clear guidance and direction. Explicit definitions of responsibilities could reduce the currently existing complexity.

Learning 3: Need for increased joint (research) projects, partnerships and spending.

An increase in necessary funds as well a push in a stronger research direction could be ensured through partnerships and joint spending. Mutual interests such as the elaboration of (existing) competitive advantages, leading programs and innovative solutions strongly plays into the interests of both, the corporate as well as the governmental wing.

Learning 4: Stronger use of successful policy tools from the past combined with an emission cap

Each country has policies, that have worked especially well in the past. Using those policy frameworks in other sectors has been a learning from the US. When in combination with new foci (e.g. emission caps or low-carbon product standards), current thresholds and reductions could be met.

7. Implications and learnings for Europe

As the thesis aims to draw learnings from the USA and China and question if they can be applied to Europe, it is essential to first understand the role green innovation currently plays in Europe (7.1.). Acknowledging where Europe stands currently and which learnings from abroad could be implemented in the short-, medium- and possibly long-term, fostering green innovation is the focus of chapter 7.2. It needs to be stated right here, that Europe, similar to the US and China has great regional differences. Those are very pronounced, as the (economic) development as well as foci varies greatly among the countries. Especially when it comes to green foci, economically more strongly developed

countries (e.g. Germany, France) have a different potential as well as lever compared to economically weaker countries. When referred to Europe, the overall European approach is meant with policies streamlined through EU institutions focusing predominantly on the European Commission. Due to the scope of this paper, the individual countries cannot be included on a policy level.

7.1. Europe's current situation and current efforts

With the European Green Deal and its aim regarding climate neutrality by 2050, extensive shifts and transitions on a holistic level as well as on a more industry-specific and energy-source level are needed. The question might arise, why a coordinated approach by the EU is as detrimental compared to individual actions and targets by member states. The answer lies in the fundamentals of the EU: the single market. Common EU policies not only allow for transparency and a clear direction, but also ensure that the EU has a similar playing field for companies within, and *one* competitive market with high green standards to the outside. Secondly, "(…) only a much broader policy - also encompassing economic, industrial, fiscal, labor, innovation and social policy aspects - can meet such a vast challenge (referring to climate neutrality by 2050), creating more winners than losers" (Tagliapietra & Veugelers, 2020, p. 12).

On an EU level, "Horizon Europe", "New Industrial Strategy for Europe", the "EU Innovation Fund" or the "European Innovation Council" provide examples of a few programs that outline the stronger innovation focus found within the Union. Addressing global competitiveness as well as mastering the digital and climatic challenges are amongst Europe's top missions and goals for the upcoming years (Tagliapietra & Veugelers, 2020).

Green industrial policy plays an especially crucial role, as non-action or timely implementation, is beyond troublesome. The EU has, as the exemplary list above outlines, set a previous focus on green innovation.

Before diving into the three defined categories and applying learnings, it is important to point out that Europe as a whole is referred to, and not to single countries. Similar to the

economic development, the development stages as well as progress with regards to the (green) transition vary greatly, however, the average is taken in comparisons and analyses. Documents from the European Commission or similar organizations are taken as reference. Due to not individually singling out of specific countries, the tables to describe trends in Europe have not been found helpful. Especially with indicators, rankings and environmental KPIs, it is predominantly individual countries which are ranked rather than the EU as a whole.

7.1.1. Methodology for deriving learnings and the application for Europe

In order to derive and pick out the best and most actionable learnings for Europe, each section per country previously had a short summary box in the tables before the hypothesis have been verified or falsified. These points are taken and subsumed in three learnings per country. With those three, a summary with learnings specifically relevant for Europe is drawn (see table 21). Similar to a funnel, the starting point included a handful learnings, followed by a reduction to six (3 per country), and resume of the most important and applicable ones for Europe. A strong emphasis has been put on selecting few but applicable learnings which could result in the most impactful or easily applicable policies. This, however, does in no way imply that the other learnings are inferior or less important. Based on research, the EU Commission's focus and previous policy as building blocks, more detail and elaboration has been added after the table specifically for the derived specific learnings for Europe. Depending on the policy, this could range from a policy action recommendation to evaluation of current policies and suggestion for improvements.

Table 21: Methodology for deriving and streamlining learnings for Europe

Indicator:	China	USA
Country specific Learnings streamlined	Three learnings from China possibly relevant for the EU	Three learnings from the USA possibly relevant for the EU

Derived specific Learnings relevant for the EU	Summary of the learnings seen most potential with. Important keywords and concepts will be explained in more detail in the text body

Furthermore, some learnings, even though they are essential for the specific country (e.g. favoritism of state owned enterprises in China), are not as relevant for the EU as others. Due to the scope of this paper, the learnings will be minimized through the reduction and focus added by the table. This funnel-system allows to reduce and provide more context for a few specific points in comparison to a broader setup.

7.1.2. Legal and regulatory framework

Table 22 outlines the learnings regarding the legal and regulatory framework from China and the USA. The learnings include both, the corporate as well as the governmental side.

Table 22: Legal and regulatory Framework: Corporate & Governmental- Learnings from China & US for Europe

Legal & regulatory framework	China	USA
Country specific Learnings streamlined	• Clear and strict environmental regulation benefit the corporations and help governmental goals (Push-and Pull Effect). • Transparent and non-political capital driven institutions and processes are a pre-condition for green innovation (e.g. patent, property rights and financial process strongly influenced).	• Strict environmental regulations are needed- no effect of voluntary commitments in the US • Attention that voluntary efforts, too vague strategies and missing roadmaps results in an inefficient patchwork rug of policies adding complexity • Slim, understandable model and agencies with clearly

	• Regional graduations needed in policies.	defined roles foster green innovation.
Country specific Learnings relevant for the EU	1) Stricter environmental laws and regulations generate the push-pull effect and are beneficial for corporate as well as governmental goals 2) Transparency in combination with a clearly defined roadmap reduces complexity and inefficiency 3) Regional differences must be taken into account also on a policy level without creating a policy patchwork rug- a tightrope act	

It has been found, that a positive correlation between green innovation and stricter environmental rules exists in both, the US and China. This correlation could further be proven in the past by Porter's theory (Porter, 1999). Therefore, stricter regulations generate the push-and-pull effects needed for a shift and the achievement of environmental goals. The EU could and should set the standards that act as example for other states and nations - rules that can globally be applied. Setting a carbon price and having a strict and green emissions trading system needs to encourage a shift in production and consumption rather than the migration or the outsourcing of emissions. Carbon leakage needs to steer clear from the EU market though taxing and pricing CO_2 at the EU-boarder.

Once carbon leakage is avoided/reduced, multiple other CO_2-related challenges are easier to solve. One amongst those: R&D investments as well as competitive loans and the investment conditions. Both declining and outlining the connection to subchapter "Financial and Tax System" (e.g. 6.3.4. & 5.4.3.), it is especially R&D that plays a key role in creating and sustaining a national/international competitive advantage in the EU. New technology and its development is often closely related to or seen as synonym to high risk, high uncertainty and high levels of complexity. Spillover effects to other industries/ countries and areas within the European Union are among the merits for a more radical change.

The second and third learning from the US and China centers around a clear, transparent roadmap combined with considered regional differences.

Due to the high complexity of the topic as well as the existing differentiated national policy landscape, strong guidance on an EU-level is needed. This includes sub-steps and goals with clearer communicated action plans on how certain visions are to be concretely achieved. Uncertainty is reduced and with concrete sub steps a clear path drawn. The reason why point 2 and 3 from the recommendations table are summarized- due to a very fine line between defining a clear path and overregulating/underregulating. The EU should keep its umbrella term, defining an overarching, clear and strict regulatory framework that ensures EU wide environmental standards. Room for specialization and national directives, however clearly outlining their part in the overarching framework should not be forgotten, considering the regional and national differences and strengths of countries. It would be admirable if the stronger focus and increased transparency would result in more awareness, inclusion and accountability also excreted by civil society.

7.1.3. Entrepreneurial conditions and requirements for competitiveness

Table 23 shows the entrepreneurial conditions and competitiveness criteria that have been derived from analyzing the case of China and the USA:

Table 23: Entrepreneurial Conditions and Requirements for Competitiveness: Corporate & Governmental-Learnings from China & US for Europe

Entrepreneurial conditions & competitiveness	China	USA
Country specific learnings streamlined	• Green innovation is not top-down only but has various dimensions to bring long term results. • Entrepreneurial conditions and the improvement of those has beneficial effects on green innovation (e.g. facilitation of starting a business). • Patens and strong independent and non-political allocation of those is a key identified pillar required for a push in green innovation.	• Government spending and incentives could be created through joint research projects and partnerships. • Existing strengths, industries and competitive advantages need to be elaborated on, possibly building and bridging the private vs. governmental investment gap.
Country specific learnings relevant for the EU	1) Partnerships between the public and private sector are seen as key to bridge possible investment gaps and build a stronger civil society involvement. 2) Strong, independent patents are seen as key with regards to entrepreneurial conditions - for both: protecting innovation and fostering green innovation. 3) Higher R&D spending is needed – possibly through partnerships but also on a governmental level.	

Amongst the key learnings is the topic partnerships- where a differentiation between partnerships with institutions and partnerships between the private and public sector needs to be made. On the one side, partnerships between institutions increase

collaboration, effectiveness and efficiency. Here, especially a separation of roles and responsibilities with clear mandates is crucial. On the other side, partnerships between the public as well as private sector are often referred to as "make or break" regarding the success of the green industrial efforts of the European Green Deal (Tagliapietra & Veugelers, 2020). Those collaboration includes a more active involvement of civil society as well as stronger relationship-building of public-and private projects (Tagliapietra & Veugelers, 2020). Especially with regards to the green transition, the inclusion of all stakeholders and drivers of that transition is trivial (European Economic and Social Committee, 2020). Fostering dialogues, strengthening existing dialogues and cooperation programs on an international and national level is considered key. As example, it is often suggested that the ECB should be stronger included in rule making and research promotion, allowing for valuable input to be directly included in the policy making chain, as well as the implementation and focus of those policies subsequently.

Better coordination on an EU level is required. Policy efforts including for example RIS3 (European Comission, 2014), investment foci and embodied actions into regional programs ensured a stronger focus on the European single market. A continuous effort is need for the single market as well as companies and implemented policies to flourish. For the avoidance of an impenetrable and too complex patchwork carpet of polices as well as the strengthening of the EU single market is key. Her the examples from China, the US as well as first indications in policy learning documents outline that countries and regions need the specialization and a competitive angle without disrupting the policy goal. Experts from academia, the industry as well as civil society would need to be further included.

Additionally, a strong European R&D focus is needed. In 2017, Europe's private and public R&D investment in relation to its GDP ranked with under 2,06% behind China 2,07% and the USA 2,8% (Japan: 3,2%; South Korea: 4,5%). Although Horizon Europe is a step, allocating 35% of its 100 billion Euro budget to climate change, it is and can be only the beginning. As pilot resulting from Horizon Europe, the European Innovation Council (EIC) was set up to fund innovative green project and help companies scale. Through the EIC Pathfinder, research projects are funded, while the EIC Accelerator grants and equitizes SME who have the potential to scale innovative, green ideas (Tagliapietra & Veugelers, 2020). Additional programs such as for example the "Green

Innovation Programme (GIP)" prove exactly that stronger set focus by ensuring "(…) R&D and deployment of green products, technologies or business models which have beneficial impacts in terms of climate change mitigation, resilience to climate impacts, pollution control or the circular economy" (EBRD, n.d., p. 1) for 12 EU countries.

7.1.4. Financial and tax system

The hypothesis H3 (*An adapted financial system is necessary to aid green innovation and incentivize cooperation to change)* could be verified for both the USA and China. Different learnings however resulted in three recommendations and learnings each, summarized in Table 24:

Table 24: Financial and Tax System: Corporate & Governmental- Learnings for Europe

Financial and Tax System:	China	USA
Country specific learnings streamlined	• Green finance as well as a banking and loan reform are simultaneously needed next to green innovation in order to lift the (possibly additional) financial strain on SMEs and businesses due to changed regulations. • FDI and investment conditions are only attractive as soon as legal and financial loopholes are closed. • CO_2 taxation would be a possibility to price high CO_2 emitting goods and reduce emission out-sourcing.	• Using tools and policy instruments from the past- tax credit expansion could be one tool. • Emission Cap or low-carbon product standards could be helpful to meet current goals • Declining interest rates and favorable financial conditions though govern-mental aid foster green innovation and spillover effects.

Country specific learnings relevant for the EU	1) For green innovation to be successfully implemented, simultaneous financial help needs to be given to SMEs and business in order to lift the additional financial burden. This could be through historically successful policy tools (e.g. tax credit in US) or easing the investment landscape. 2) Investment conditions and FDI becomes more attractive as legal loopholes are closed, uncertainty is reduced and interest rates lower the burden to invest (e.g. CO_2 taxation/emission cap throughout the entire EU combined with low interest rates).

With regards to the European investment landscape, it is clear that improvements are needed. On the one hand, financial help is necessary in order to lift the additional financial burden and ease competitive imbalances between countries/areas. Overall, green investments need to be more attractive. As currently fossil fuels are dominating, this is the first lever that needs adjustment. As the externalities produced from fossil fuel consumption are not priced nor included, pricing is uneven and continuous low fossil fuel prices, similar to the past years, hinder investments in green technology even further.

It turns out that Europe's efforts so far have paid off, as the investment landscape in climate mitigation is better than that of the United States, although China is still leading. Nevertheless, still a lot of room for improvement is given when aiming to fulfill a GHG reduction of 55% by 2030: Investments in certain areas such as, for example, in energy systems would still must more than double (average: 1,3% over the past 10 years to 2,8% of the GDP annually) to be able to reach the target (EIB, 2021). Especially the investment landscape and reduction resulting from Covid-19 has on top put Europe's strong global positioning in green and digital innovation at risk (EIB, 2021). Additionally, post pandemic investment spendings will be approximately one quarter less in the years succeeding the crisis although "(…) investment in digitalization, innovation and climate will be more important than ever before" (EIB, 2021, p. 1). It is detrimental to modify and adapt best to now existing investment gaps in the private as well as public sector. Risk sharing as well as a stronger focus on equity capital could be key to unlocking and stimulating further and currently needed private investment (EIB, 2021).

Next to fostering more partnerships as stated earlier to reduce risk, (financial) risk reduction could also include learnings from China and the US regarding political changes. While China's political cycles and planning-horizons are very long-term, the US are close to the opposite. President Trumps' term showed, how quickly international agreements can be left and uncertainty increased. Avoidance includes European long term committed roadmaps as well as guarantees for loans independent of political change. Reducing the partially strong lobbies of certain industries and ensuring the inclusion of all stakeholders in dialogues in combination with the decoupling of actions with electoral cycles and political terms of office and candidatures would benefit Europe as well. That way, "(…) (g)reen industrial policy should (& can) address the meta-problems associated with the transformative change climate change brings, rather than seeking to boost the competitiveness of targeted sectors and firms" (Tagliapietra & Veugelers, 2020, p. 44).

To conclude, it can be said that as multiple changes are happening in the investment landscape, a revision of the investment and stronger focus and innovation and technology fostering clean, green alternatives is required. Potential spillover effects could ensure a "greening" of other sectors as well. Subsidizing green technologies in combination with a tax/price for externalities caused by fossil fuels ensures a substantial push. This mix of demand pull and technology push factors (Kemp & Never, 2017) (e.g. through subsidies and financial incentives) could ensure the turnaround for Europe's CO_2 emissions.

8. Discussion & Conclusion

8.1. Discussion

During the discussion, several selected points will be presented, that are either key findings, or points from the author.

Overall, the findings from China and the US proved to be applicable for Europe, proving that a lot can be learned from other countries and best case policy-scenarios are essential for the other country's learning. The lack of sharing this kind of information could be ameliorated in the future, as a complex and broad topic such as the climate crisis will not be solved without countries pulling together and learning from each other. It is easier to share best-practices compared to poor practices, as vulnerability and mistakes are easier swept under the carpet.

Additional to sharing knowledge, the data landscape would be another point for discussion. While data for the analysis as well as scholarly papers have been found easily for China, the US proved to be surprisingly more difficult. The majority of papers regarding that topic either focus on China, or are written and published by Chinese universities and research institutions. More scholarly research is needed also from other countries.

What has not been discussed during the thesis, but plays an essential role, is the cultural aspect and its effect on green innovation. Very recent first studies outline, that "(…) certain national cultural dimensions such as masculinity and long-term orientation enhance environmental innovation, while other dimensions such as power distance, individualism, uncertainty avoidance, and indulgence reduce it" (Ullah et al., 2022, p. 3). Especially in long-term orientation, the political systems of the US and China could not be more different. Although that is not easily changeable in the short term, cultural factors can impact climate change and the effects on policy efforts and should therefore be stronger included in the eco-innovation discussions. Here as well, further scholarly research would be needed.
In a further research step, one could also explore the dimension of the specific countries in the EU/states within the US/provinces within China to granulate and add more detail.

8.2. Conclusion

One outcome of this thesis is that green policy clearly needs an individual learning curve for each and every country. The learnings can be much faster implemented if a joint approach is applied. In order to combat the climate crisis, a challenge that could not be more complex, interconnected and urgent efforts, best-practice approaches and learnings need to be accessible by all countries and solutions worked on jointly. It is not the race and win of one state, but the race of all states to ensure our set climate targets are achieved. The consequences of not prioritizing this topic are dramatic, affect us all and will change the life we know in an irreversible and lasting way.

It is important to point out, that policies and certain strategies might not be a good fit for other countries - what works in country A might not necessarily work in country B. Adaptions are needed and the consideration of cultural as well as regional differences ensures its successful implementation. Three overarching categories (table 4) proved to be a valuable selection within the thesis, as the insights gained and learnings drawn from both countries differed, yet they could be applicable in other countries such as the EU. As the specific policy recommendations and takeaway learnings have been summarized in tables 22-24 for each criterion (Legal and Regulatory Framework, Entrepreneurial Conditions & Competitiveness, Financial and Tax System), no detailed summary will be given here. However, an emphasis needs to be set on the strong interconnectedness and interplay between governmental and corporate factors for the innovation criteria chosen. If for example, stricter environmental laws and standards were implemented, an action (e.g. reduction) would be advisable with regards to financial and tax, in order to lift the financial pressure that comes with the change. This is especially relevant for startups and small and medium sized companies (SMEs), where financial capital and buffer might be limited or non-existent. Adapting the tax or inflation rate and favoring smaller companies, aids the green innovation within the country. This example has been presented in order to give a better understanding, however, a mix of policy instruments needs to be applied. Within that mix, R&D investments act as essential lever for fostering green innovation. Furthermore, partnerships should not only be formed among countries and institutions, but also between the corporate and governmental sector. Financial strains can so be reduced, directions and roadmaps influenced by both sides towards green innovation and a win-win situation for the government, as well as corporates created.

Although no universal definition for green innovation exists, drivers and levers have been identified with an in-depth analysis of two countries, resulting in policy recommendations for the EU. This thesis has not only had an incredibly steep learning curve during the writing and reading process of over 200 scholarly papers, but hopefully was able to provide new impulses for the European policy in the next years. Key in the climate crisis, however, is the action taken *within the next years*. Although we also need long-term commitments and goals, the action of the near future decides upon the warming and progression of the warming curve. The time to act, to implement and to change is now!

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