SHAPING THE FUTURE IS HARD

FOSTERING SUSTAINABLE TRANSFORMATION BY IMPROVING ACCESS TO FINANCE FOR HARDWARE-BASED CLIMATE TECH STARTUPS

THE TEAM

FRIDTJOF DETZNER

Member of the Sustainable Finance Committee

ELISABETH LÖWENBOURG-BRZEZINSKI

Member of the Sustainable Finance Committee

CAROLINE SCHMID

Master in Impact Entrepreneurship & Innovation

CONSTANTIN GEHRING

Master in Management

OLIVIA SUCHY

Master in Impact Entrepreneurship & Innovation

THEORETICAL FOUNDATION

DEFINITION: HARDWARE-BASED CLIMATE-TECH STARTUP (1/2)

Hardware -based

- Develop and **implement complex hardware** solutions
- Often **supplemented** by a software component
- Innovation driven by **deep technical and scientific developments**
- Require **large-scale investments**
- Require **highly qualified individuals**
- Often operating in industries such as: materials science, manufacturing, chemistry

Climate -Tech

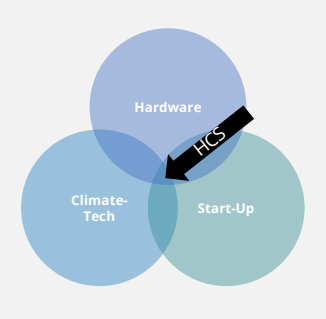
- Wide range of innovations aiming to **mitigate the effects of climate change** or improve approaches to coping with consequences of global warming
- "Climate tech" is **interpreted in different ways** throughout literature but strongly connected to the terms "green tech" and "clean tech"
- Can be divided into **subcategories** such as: energy, agriculture & food, recycling & waste, manufacturing, transportation, buildings

Start-Up

- Founded by **entrepreneurs**
- Differ from conventional companies or SMEs
- Distinguished by the characteristic of "**novelty and innovation"**
- Are "**new**", "**active**" and "**independent**"
- Intend organizational or technological progress which is **scalable** or **replicable**
- business models focus on multidimensional **growth**
- Create **novel goods or services** based on innovation

Understanding of definitions was necessary to conduct the **quantitative analysis**

DEFINITION: HARDWARE-BASED CLIMATE-TECH STARTUP (2/2)



HCSs are early-stage companies driving innovation of physical systems to address the climate crisis. HCSs bear the potential to generate ground-breaking innovations in the most relevant technology but also encounter unique obstacles due to their distinctive features.

Characteristics

- **Market**: HCSs compete against established, non-sustainable players with often cost-effective and mature technologies in high volume markets. HCSs bring technologies to market internalizing negative externalities and therefore bear a green "premium".
- **Time Horizon**: HCSs development cycles last above ten years on average, making it impossible to penetrate the market in the short-term and therefore unfold their large-scale impact only in the long-term.
- **High Need for Resources**: HCSs require deep technological expertise and a high level of capital investment, up to $10-20 million for the first and hundreds of millions in subsequent investment.

Prime Example

MarvelFusion

- Eco-friendly energy source using laser-driven fusion, raised $25 Mio Series A
- Undertake complex and visionary hardware development and are exposed to significant technological and financial risk

Defining hardware-based climate-tech start-ups was necessary to give interviewees specific context in **the interview analysis**

FUNDING GAP

- Problem first identified in 1931 in the UK by members of Macmillan Committee
- "Market Failure" describes a situation where market mechanisms fail to allocate resources efficiently
- Often described as the cause of the "Funding Gap" phenomena and "Valley of Death"
- It refers to the disparity between the demanded capital by a startup to achieve its financial goals and the supplied financing options
    - **First Valley of Death**: faced during lab development, demonstration and early commercialization during a phase of of high technological risk
    - **Second Valley of Death**: lack funding as startups move from the initial revenue generation phase to the scale-up for widespread deployment

Information Asymmetries

- Present between the demand and supply sides of financing
- Cause substantial risk and leads to costly due diligence
- Greater level of complexity leads to increased asymmetries

Coordination Failures

- Arise when communication between parties is lacking
- Investors who aim to invest in projects that match their requirements for returns and risks cannot find suitable opportunities that need funding

Externalities

- Externalities, such as environmental sustainability and reduced emissions, may not be reflected in financial return
- Meaning that the undervaluation of natural resources can fuel an unwillingness for investors to fund

► Case of HCSs: **high technological risk**, **long development cycles, high capital expenditures** and **high uncertainty about exit opportunities**

A proper understanding of the funding gap was crucial for conducting **the quantitative analysis** and **for conducting interviews**

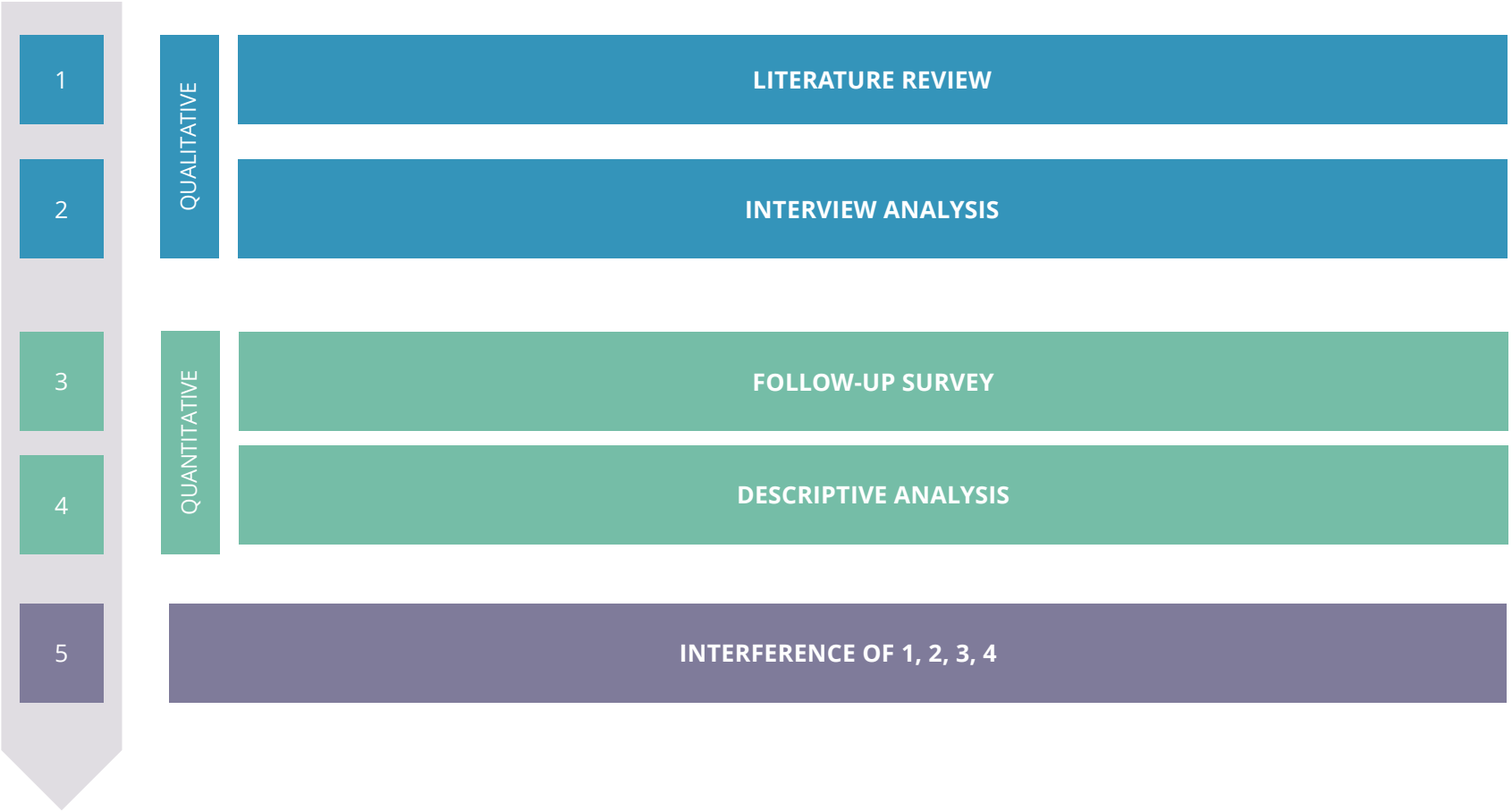
RESEARCH QUESTIONS

THREE QUESTIONS

1	Does a funding gap for HCSs exist in Germany?
2	If so, what factors contribute to the funding gap for HCSs in Germany?
3	If so, what are the potential solutions to solve this challenge?

METHODOLOGY

MIXED METHODS APPROACH



LITERATURE REVIEW

Methodology Creswell (1999)

Databases Scopus, Web of Science, Science Direct, Google Scholar

Keywords

- Funding Gap
- Finance Gap
- Financing Gap
- Valley of Death

+

- Hardware
- Green Tech
- Climate Tech
- Deep Tech
- Clean Tech
- Hard Tech

Initial Keyword Search (661)

Titel Scan (526)

Removing Duplicates (479)

Abstract Scan (157)

Full Text (120)

Total (88)

LITERATURE REVIEW

Review Process

Database	Query	Hits	Hits according to Document Type	Hits Titel and Abstract Analysis, excluding Duplicates	Full Text Analysis
ScienceDirect	("startup" OR "startups" OR "start-up" OR "start-ups" OR "new venture" OR "new ventures") AND ("hardware" OR "deep tech" OR "deep technology" OR "clean tech" OR "clean technology" OR "manufacturing" OR "heavy asset" OR "high tech" OR "high technology") AND ("funding" OR "financing" OR "capital")	245 (Last Check: 13.03.2023)	219	46	25
Scopus	("startup" OR "startups" OR "start-up" OR "start-ups" OR "new venture" OR "new ventures") AND ("hardware" OR "deep tech" OR "deep technology" OR "clean tech" OR "clean technology" OR "manufacturing" OR "heavy asset" OR "high tech" OR "high technology") AND ("funding" OR "financing" OR "capital")	156 (Last Check: 13.03.2023)	99	30	23
Google Scholar	("startup" OR "startups" OR "start-up" OR "start-ups" OR "new venture" OR "new ventures") AND ("hardware" OR "deep tech" OR "deep technology" OR "clean tech" OR "clean technology" OR "manufacturing" OR "heavy asset" OR "high tech" OR "high technology") AND ("funding" OR "financing" OR "capital")	120 (Last Check: 13.03.2023)	80 (Article)	46	12
Web of science	("startup" OR "startups" OR "start-up" OR "start-ups" OR "new venture" OR "new ventures") AND ("hardware" OR "deep tech" OR "deep technology" OR "clean tech" OR "clean technology" OR "manufacturing" OR "heavy asset" OR "high tech" OR "high technology") AND ("funding" OR "financing" OR "capital")	140 (Last Check: 28.03.2023)	128	35	28

Literature Matrix

Article	Topic				Focus		Geography				Else
	Funding Gap	Climate-Tech	Hardware-Based	Other	Challenges	Solutions	Germany	EU (General/Non-German)	US	Others/Generic	Methodology
Adams and Brace (2006)											x
Aernoudt, San José, and Roure (2007)						x		x			
Balachandra, Nathan, and Reddy (2010)	x	x	x		x	x				x	
Bell and McNamara (1991)				x						x	
Blank (2013)				x							
Blasig and Hemuf (2023)				x		x					
Bonetti, Gatti, and Caselli (2010)				x		x					
Bonini, Capizzi, and Zocchi (2019)				x		x		x	x		
Bouwer and Aerts (2006)											x
Braun and Clarke (2006)											x
Brown (2001)	x	x							x		
Byoun and Ru (2014)				x		x					
Cardozo (2019)	x	x								x	
Casanova, Cornelius, and Dutta (2018)				x		x				x	
Chorev and Anderson (2006)			x			x				x	
Churchill and Lewis (1983)				x						x	
Clark, Reed, and Sunderland (2018)	x	x			x						
Concini (2018)											x
Corbin and Strauss (2008)											x
Cotton (2020)	x			x	x			x	x		
Creswell (1999)											x
Creswell (2009)											x
Creswell (2011)											x
Criscuolo and Menon (2015)	x	x			x					x	
Cristoforoni (2023)		x					x				
Cumming (2007)				x		x				x	
Dalle, Besten, and Menon (2017)											x
Davila, Foster, and Gupta 2003				x						x	
Dey and Mishra (2022)	x	x	x			x				x	
Dhayal et al. 2023	x	x				x				x	
Egan (2022)				x		x			x		
Fini et al. (2023)			x		x				x		
Fink, Arbter, and Wagner (2023)			x		x	x				x	
Gaddy et al. (2017)	x	x			x					x	
Gatto and Re (2021)	x	x						x			
Gioia, Corley, and Hamilton (2013)										x	
Giorgis, Huber, and Sornette (2022)	x	x			x					x	
Goldstein et al. (2020)		x				x			x		
Gowan (2019)											x
Hafner et al. (2020)	x	x			x	x		x			
Harrer and Owen (2022)	x	x			x	x		x			
Heeb et al. (2023)				x	x					x	
Is, Monk, and Knox-Hayes (2020)	x	x							x		
Jiang (2023)		x			x					x	
Johnson and Onwuegbuzie (2004)											x
Kuratko, Morris, and Schindehutte (2015)				x						x	
Leach and Melicher (2011)				x						x	
Luger and Koo (2005)				x						x	
Mc Cahery et al. (2015)											x
McGiven (2009)											x
Mey and Mruck (2011)											x
Michelfelder et al. (2022)	x	x				x		x	x		
Migendt et al. (2017)		x			x		x		x		
Miles, Huberman, and Saldana (2014)											x
Morgan (1998)											x
Morse (1991)											
Mrkajic, Murtinu, and Scalera (2019)		x						x			
Murphey (2022)				x						x	
Nassiry and Wheeler (2011)		x				x				x	
Nedopoda et al. (2021)				x						x	
Nemet, Zipperer, and Kraus (2018)	x	x	x		x					x	
Oh, Jang, and Kwak (2022)	x		x	x						x	
Östlund et al. 2011											x
Ottman, Stafford, and Hartman (2006)		x				x					
Owen, Brennan, and Lyon (2018)										x	
Oziil (2022)		x								x	
Pearson et al. (2020)		x	x			x				x	
Phillips and Stawarski (2008)											x
Pimay, Surlemont, and Nlemvo (2003)				x					x		
Polzin (2017)		x			x	x				x	
Polzin, von Flotow, and Klerkx (2016)		x			x		x				
Polzin, Sanders, and Sembrakova (2021)		x						x			
Pręblewicz (2012)											x
Quas et al. (2022)	x			x				x			
Romme (2022)			x			x		x			
Saldaña (2011)											x
Saller and Klühr (2021)				x						x	
Savaneviciene, Venckuviene, and Girdauskiene (2015)	x			x		x		x			
Schuh and Latz (2022)			x		x	x				x	
Shane (2003)				x						x	
Singh et al. (2021)		x					x				
Sørheim et al. (2011)	x			x	x					x	
Suominen, Deschryvere, and Narayan (2023)				x	x						
Tammes et al. (2021)				x		x		x			
Tülüce and Yurtkur (2015)				x						x	
Upadhayayula et al. (2018)	x					x				x	
Verbeek & Lundquist (2021)											x
Wilson, Wright, and Kacer (2018)			x							x	
Xie et al. (2018)			x			x				x	
Yang et al. (2023)		x								x	
Yoshino, Taghizadeh-Hesary, and Nakahigashi (2019)	x	x								x	

INTERVIEW ANALYSIS

Goal

"We want to find out if there is a funding gap for HCSs in Germany, the reasons that are responsible for a potential funding gap and measures that can be taken (by the government) to close the gap."

Interview Process

Data Collection
Interviews after brief literature research

Sampling Approach and Size
Sample of 24 interviewees (22 interviews) elected based on expertise, accessibility, and availability

Data Analysis
Inductive coding approach using open, axial and selective coding
(Creswell 2009)

Interviewees

Sectors
Public Sector (7)
CVC (2)
VC (5)
PE (1)
Startups (5)
FoF (2)
Venture Debt (1)
NGO (1)

Position
Head of Unit *Financial Instruments* at European Commission
Managing Partner CVC
CFO & COO

Interview Structure

Part 1
The current state of the hardware/cleantech industry in Europe and Germany

Part 2
A potential financing gap in Germany

Part 3
The main reasons for a potential funding gap for HCSs in Germany

Part 4
Measures to increase financing for HCSs Germany

Quantitative information

Number of interviews
22

Number of interviewees
24

Average interview duration
44 min

Number of open codes
311

Number of categories
32

Number of themes
12

INTERVIEW PARTNER

Name	Position	Organisation
Stephanie Heller	Managing Partner	Bootstrap Europe SCsp
Stéphane Ouaki	Head of Unit for Financial Instruments	EU EIC Council
Matthias Koehler	Ministirial Director	Federal Ministry for Economic Affairs and Energy
Rafael Laguna de la Vera	Director	SPRIND Federal agency for disruptive innovation
Michael Jackson x	Venture Partner	Multiple Capital
Anne Lamp	Co-Founder & CEO	Traceless
Thomas Lange	Senior Advisor	Achleitner Ventures
Sebastian Schütz	Head of Capital Market Strategy, financial market monitoring and Eurosystem asset valuation	Bundesbank
Max Wirsching	Head of Investor Relations	KfW Capital
Hannes Ring	Associate	Meridiam
Philipp Offenberg	Senior Manager Europe	Breakthrough Energy
Isabelle Canu	Partner	Green European Tech Fund
Markus Solibieda	Managing Director CVC	BASF
Sebastian Heitmann	Co-Founder	Extantia
Peter Jorgensen	Partner	Maersk Growth
Christoph Stresing	Managing Director	Federal Association of German Startups e.V.
Danijel Višević	Founding Partner	WorldFund
Maren Eckloff-Böhme	Founder & CEO	Brightpoint Fund Services
Christoph Gründinger	Chief Evangelist	Enpal
Nicolas Burkardt	CFO	Marvel Fusion
Heike Freund	COO	Marvel Fusion
Helene Huby	Co-Founder & CEO	The Exploration Company

INTERVIEW ANALYSIS

OPEN	AXIAL	SELECTIVE
Break down interview in codes that reflect the key themes and ideas in the data.	Re-examine and reorganize the codes retrieved during open coding to identify patterns and connections that emerge from the data.	Form categories with purpose is to identify central topics that unify multiple categories.

- There's no strategic procurement that signalises commitment to investors and startups
- Insufficient pre-commercial procurement where the government buys a product before it even exists
- Regulations hinder innovative procurement (e.g., green cement)
- Compared internationally, procurement programs are more extensive and easily accessible
- Europe does not have procurement programs amongst gov. institutions and ministries
- Government fails to create market for innovative technologies
- Insufficient customer base for HCT hinders scale up

- Insufficient governmental focus on procurement and support of HCT
- Insufficient availability and size of contracts for HCSs to overcome VoD
- No customer base for HCSs

Lack of strategic procurement programs

FOLLOW-UP SURVEY

An online survey was conducted to enhance the comprehension of the interviewees' proposed solutions. The survey aimed to rank the challenges and potential solutions according to their relevance.

- The researchers presented the results to the interviewees using an **online survey**
- Interviewees were asked to **rate the relevance** of the challenges and solutions extracted from the interviews

Survey Design	Online survey, included all 16 challenges and 16 solution proposals, along with a brief description of the terms
Response Type	Ranking scale, which required participants to rank lists of items by order of relevance
Pilot Test	Pre-test of the survey was conducted between April 24th and April 30th with three researchers and one VC investor
Sample Size	Non-probability convenience sampling method with sample size reduced to the experts who had participated in the interviews
	18 interviewees responded to the survey, response rate of 75%
Data Collection	Survey was conducted using the Typeform platform from May 1st to May 10th, 2023
Data Analysis	The survey feedback was mapped with the interview responses and clustered to rank different types of recommendations

QUANTITATIVE ANALYSIS

Prędkiewicz (2012) remarks on the absence of studies: **"there are no specific reliable methodologies to measure the extent of a funding gap**". We have identified three pertinent examples, Mc Cahery et al. is as a current reference point, but later studies investigating novel sectors diverge.

- **Absolute Approach**: Exact demand-supply match
- **Relative Approach**: Estimate a relative gap compared to chosen benchmarks

Name	The European capital markets study: Estimating the financing gaps of SMEs.	Financing innovation in clean and sustainable mobility. Study on access to finance for the innovative road transport sector.	Artificial intelligence, blockchain and the future of Europe: How disruptive technologies create opportunities for a green and digital economy.
Authors	Mc Cahery et al.	Concini	Verbeek and Lundqvist
Year	(2015)	(2018)	(2021)
Approach	In-depth calculation of the absolute supply and demand match over all SMEs	Calculation of the funding gap with a relative approach	Calculation of the funding gap with a relative approach

We adopt the **third approach** because, because we **lack detailed data** specific to the new sector. Specifically, we do not have the necessary granularity to estimate supply and demand through a bottom-up analysis.

QUANTITATIVE ANALYSIS I Calculation 1 & 2

This calculation compares the investigated geographies chosen on maturity. The rationale is, that these have already developed more sophisticated supply-demand match mechanisms.

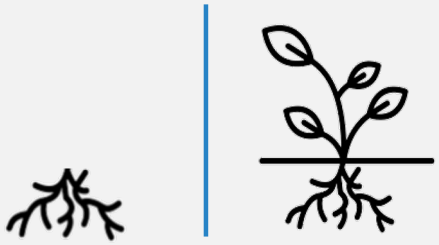
Calculation Reasoning & Databases

Sampling
California and the Nordics have reached greater their maturity. They have comparable GDP and inhabitants and are embedded in a single market.

Database
Build a database with input from the platforms Dealroom and Crunchbase

Commonalities
Searching by technology and subindustry filter

Maturity Approach



Calculation Approach

Financing rounds
Δ MEDIAN and Δ AVERAGE of investment rounds between 2018-2023

Number of startups
We scanned 950 existing startups individually and found 90 to be HCS

Alteration
We will increase the number of startups to project a future state

Financial Advantage = Δ MEDIAN *or* Δ AVERAGE Investment x Number of HCS in GER

QUANTITATIVE ANALYSIS I Calculation 3

This calculation serves as a triangulation performing a top-down approach. This is particularly meaningful trying to understand the relation to climate mitigation targets.

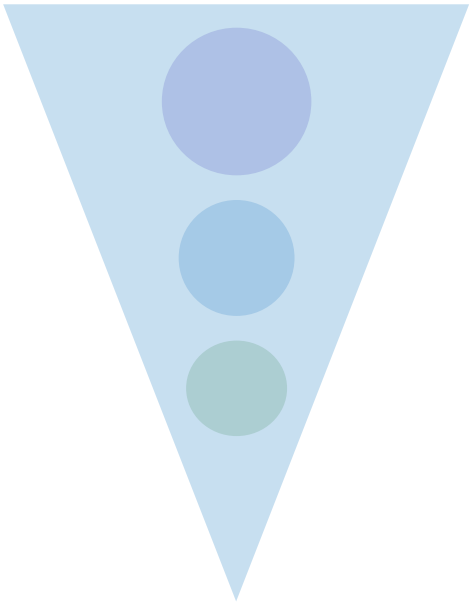
Calculation Reasoning & Databases

Sampling
The International Renewable Agency was mentioned in studies of Dhayal et al. (2023) and Polzin, Sanders, and Serebriakova (2021)

Database
They released a report with a global scenario analysis with investments targets

Commonalities
Hardware solutions in Energy, Circular Economy & Cabon Capture

Top-Down Approach



Calculation Approach

Climate mitigation goal
Annual investment demand

Inflow into the ecosystem
Of this total the share of innovation

Assumptions

1. How much potential does Germany have? Share of global GDP and beyond due to technological expertise
2. Potential of Startups to contribute? Startups have significant innovation capabilities to commercialize HCT

Scenario Demand = Global Demand ($4,4T) x 6% x Assumption1 x Assumption2

FINDINGS RESEARCH QUESTION 1

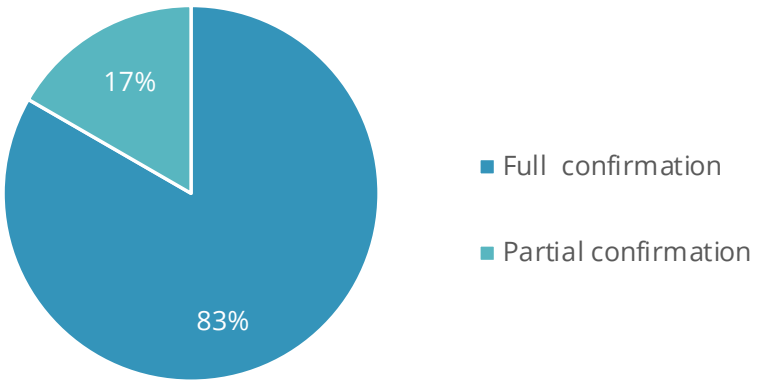
Does a funding gap for HCSs exist in Germany?

QUALITATIVE ANALYSIS

ANALYSIS OF INTERVIEWS CONFIRMS EXISTENCE OF A FUNDING GAP FOR HCSs IN GERMANY

"There is a funding gap because of the nature of the innovations that we are discussing here" *– Stéphane Ouaki, European Commission*

Does a funding gap for HCSs in Germany?



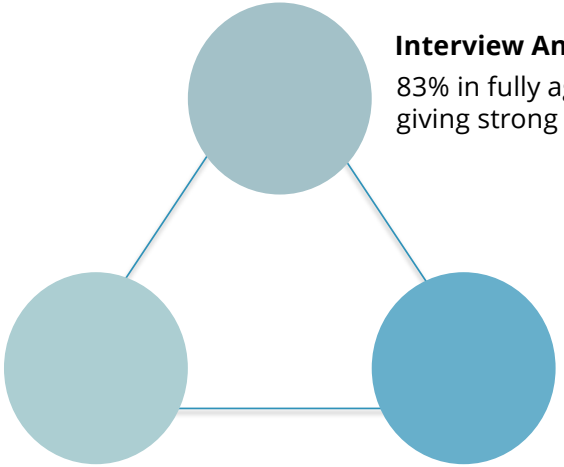
Does a funding gap for HCSs in Germany?

- Agree that a suboptimal investment situation exists explicitly highlighting the lack of funding when it comes to the **scaling** and the **commercialization** of the technology
- Most argue that closing the funding gap primarily needs **government intervention** addressing all stakeholders in the ecosystem to mobilize capital generic and in a "smart way"

TRIANGULATION

Triangulation of interview analysis with calculation 1, 2 & 3 indicates that the answer is:
YES, A FUNDING GAP FOR HCSs IN GERMANY DOES EXIST.

Triangulation



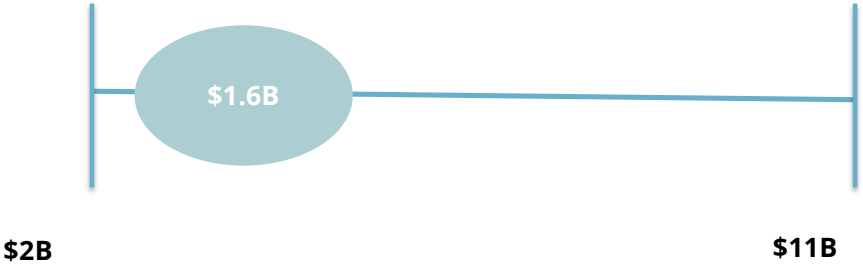
Interview Analysis
83% in fully agreeing giving strong indication

Literature Review
Strong indication and evidence from similar sectors

Quantitative Analysis
With less respect to the Nordics lower bound there is a strong indication

Range of Magnitude

The range of the magnitude lies between the upper bound values and the upper scenarios of the top-down analysis.



- ***Amount invested between 2018-2023***
- ***Required annual investements to close the gap***

RESEARCH QUESTION 2

What factors contribute to the funding gap for HCSs in Germany?

INTERVIEW ANALYSIS I EXCERPT

Challenges mentioned	Open	Axial	Selective
Risk of putting (gov.) money in technologies where tech/business proof of concept is not given	no strategic procurement and commitment to market (ex.. we	insufficient governmental focus on procurement of HCT	
No smart decision of capital allocation of VC and gov. (e-scooters)	no pre commercial procurement	insufficient governmental commitment to support HCT	
founder teams often problematic when it comes to scaling	no procurement programs amongst gov. institutions and mini	No customer base for HCSs	
combination of high capex and high risk scares investors	regulations hindering innovative and green procurement (eg., cement)		
logis is like "I am putting a lot of money so it has to work" even though with high risk tech it is the opposite	theres no extensive and easily accesible contracts for startups		**Lack of strategic procurement**
the bigger the tickets the bigger the risk aversion	tenders are not easily accessible for startups		
biz tickets require biz fonds (e.g.. institutional fonds) thus isntutionalisation and organiation increase and therewith also riska	Compared internationally, procurement programs are more extensive		
institutionally anchored risk aversion when it comes to entrepreneurship and alternativ einvestments	insufficient customer base for HCT hinders scaleup		
the more institutinal the money is the more risk averse it is	There's no strategic procurement that signalises commitment to investors and startups		
lack of business angels with high investment power	government needs to create market and base for products		
difficutly to bring the right team (industrial partner is important!)	first stages difficult there is no cutsomer from seed to series A		
support programs begin when it is not risky anymore (too late)			
programs are not as developed as they should be			
VC is the wrong instrument for deep tech, no alternatives	ROI not very visible for investors, time horizon	No alternatives to VC investments that take on risk	
need of more financing instruments that work with high risk	VC blueprint is more on short term (start ups that go directly fr	VC has wrong investment criteria for HCT	
investors do not have enough knowledge about specific market and are not visionary enough	VC is the wrong instrument for deep tech, no alternatives	VC investment horizon does not match HCT TRLs	
lack of technical knowledge and expertise of investors leads to risk aversion	VC focus on short term		
existing instruments do not reach full potential (wrong investment criteria for deep tech - EIB)	VC blueprint not suitable for HCS		**VC Investment Blueprint Does Not Fit HCSs**
lack of knowledge about the market itself (one mistake can destroy everything) makes investors risk averse	VC doesnt match for HCS		
lack of big tickets in Germany/Europe especially in early stages where machines have to be built etc.	VC focus on short term, blueprint not suitable		
first stages difficult there is no cutsomer from seed to series A	VC blueprint is more on short term (start ups that go directly from early to growth without the mid)		
to get venture debt startup has to be CF positive already which is a burden	commercial VC not necessarily fitting for digital deep tech (And therefore. It's very difficult to keep within the commercial VC time horizon for a return on investm		
too expensive to finance R&D with VC	misconceptions about exit potential and horizons from investors		
VC focus on short term			
lack of public money for R&D	financing gap because no goals from government and prices for carbon		
instruments do not reach potential	non-euroopean programs would help but they need to spend mon	no tax incentives for startups and funds (europe gotta decide what is the priority : pro business or	
lack of blended finance instruments	subsidies and grants that are not focused and given out focus bec	no commitment of government to take big decisons like inflaction reduction act from US	
VD needs recurring revenues which is hard for HW startups	gov. Focus on software (ex. EIFI -> large influence on LP's&cosvs	No commitment and focus on certain topics from government	
lack of focus on climate from government, no priority, no assigned pockets	No smart decision of capital allocation of VC and gov. (e-scooter	awareness is there politically but attention span is not sufficiently anchored	
VC blueprint not suitable for HCS	lack of focus on climate from government, no priority, no assigned pockets		
VC doesnt match for HCS	deep tech funds or government should be signalise investor which it doesnt		
not enough angel investors to siganlise and	lack of strategic direction and mission leads to no governmental	reliability (investors cannot rely on government since decisions are dogmatic not rational)	
VC investors are risk averse	no tech focus from government (eg., no ministry dedicated to tech), no tech champion		
unicorn vs. Zebra - if zebras are more frequent (non exit drive) instruments do not match	subsidies and grants that are not focused and given out focus because of lack of focus of government		**Lack of Strategic Direction and Guidelines Defined by the Government**
VC focus on short term, blueprint not suitable	Gov tends to do mostly subsidies		
lack of expertise in investment teams	lack of communcation of strategy for it to become real		
not enough commitment form public instuments	Government fails to guide market		
software preferred over hardware	more strategic gov. Focus (pick one vrtical and go hard in diff. Regions)		
public money is lot of effort to get, takes time	prioritisation of goals form government should happen but public institutions and or governments do ot datr to make decision		
ROI not very visible for investors, time horizon	no structured programs form government		
where there is market failure the gov. Has to fix	there is a lack of braveness		
government needs to create market and base for products			
there is a lack of braveness	HW is different type of investment profile than SW eg. No revenue projections in next 3 years is normal (investor needs to understand that)		
instruments do not reach full potential	lack of technical knowledge and expertise of investors leads to r	lack of technical knowledge leads to risk aversion	
Deep Tech fund suggest product development which is impossible for HW DT and hidnems investemnt	not enouth expertise and knowldeee from investors leads too ri	investors lack the capability to make informed decisions	
deep tech funds or government should be signalise investor which it doesnt	risk aversion in investment teams because not enough expertise	re nuclear fusion, deep tech	
funding rounds are too big and funds too small	lack of expertise in investment teams for novel technology (no c	lack of knowledge about the market itself (one mistake can destroy everything) makes investors r	**Lack of Technical Knowledge in Investment Teams**
funds are too small and therefore not able to spent more than 20 million	investors are risk averse when it comes to DT HW	combination of high capex and high risk scares investors	
not enouth expertise and knowledge from investors leads too ris aversion	lack of knowledge about deep tech blueprint from investors	investors do not have enough knowledge about specific market and are not visionary enough	
lack of biz base of (INTERNATIONAL) institutional investors because risk is too biz - cause anteil too biz (if they ex. Give 50	more climate funds than climate investors from capability perspective (not enough knowledge)		
organisational and burecreatic effort too big for the money that they get	expertise gap in investmentteams when it comes to HW (more climate funds than investors)		
risk aversion in investment teams because not enough expertise re nuclear fusion, deep tech	IMPORTANT ARE QUALIFICATIONS OF TEAMS, VC AND CONSULTANTS		
cut of alternative investments is underrepresented comapred to the american pension funds			
research money is too hard to get because of regulations and not enough money			
subventions beschrönkung auf 200k	alternative investment teams in inst. investors are investing in a	ll are crucial for scale up phase	
regulations hinder investments in VC from institutions (EK Umlegungsquote)	lack of biz base of (INTERNATIONAL) institutional investors bec	ll are crucial for big ticket sizes	
theres regulations ons what is impact invesment (article 8,9,10) that hinder investment	cut of alternative investments is underrepresented comapred to	ll are hinderned by vicious cycle	
capital for scaling is insufficent	reeulations hinder investments in VC from institutions (EK Umle	small ticket sizes pose problems for ll	
no market for deep tech solutions, hard to attract investors	isnstitutional investors say that they dont invest in VC because of	Solvency II etc which is not true	
Deep tech fund adresses early stage HOWEVER does not see VCs as co investors, who selects startups & makes them big	inst. investors etc. do not invest into VC and then lack knowledge about VC class		**Lack of Institutional Investment**
strenethen capital market and kapitalzedeckte Altersvorsorge becomes important again because first saaes are funded but n	inst. investor dare risk averse		
Forschungsförderung und Grundlagenforschung mit Ziel Kommerzialisierung (IP bei Kommerzialisierung)	institutionally anchored risk aversion when it comes to entrepreneurship and alternativ einvestments		
no capital in europe for the scaling phase, startups take international money which leads to value creation abroad	lack of institutional investors		
not (quick) enough money stream from private investors for spin offs	the bigger the tickets the bigger the risk aversion		
political will and instuements is here (DARPA, SPRIND) but still too many barriers (regualtory)	big tickets require big fonds (e.g., institutional fonds) thus isntutionalisation and organiation increase and therewith also riskaversion		
lack of expertise in investment teams for novel technology (no comparison, success stories)	the more institutinal the money is the more risk averse it is		
lack of success stories of deep tech that made it (if there were stories, there are gonna be more Funds for deep tech)	lack of big tickets in Germany/Europe especially in early stages where machines have to be built etc.		

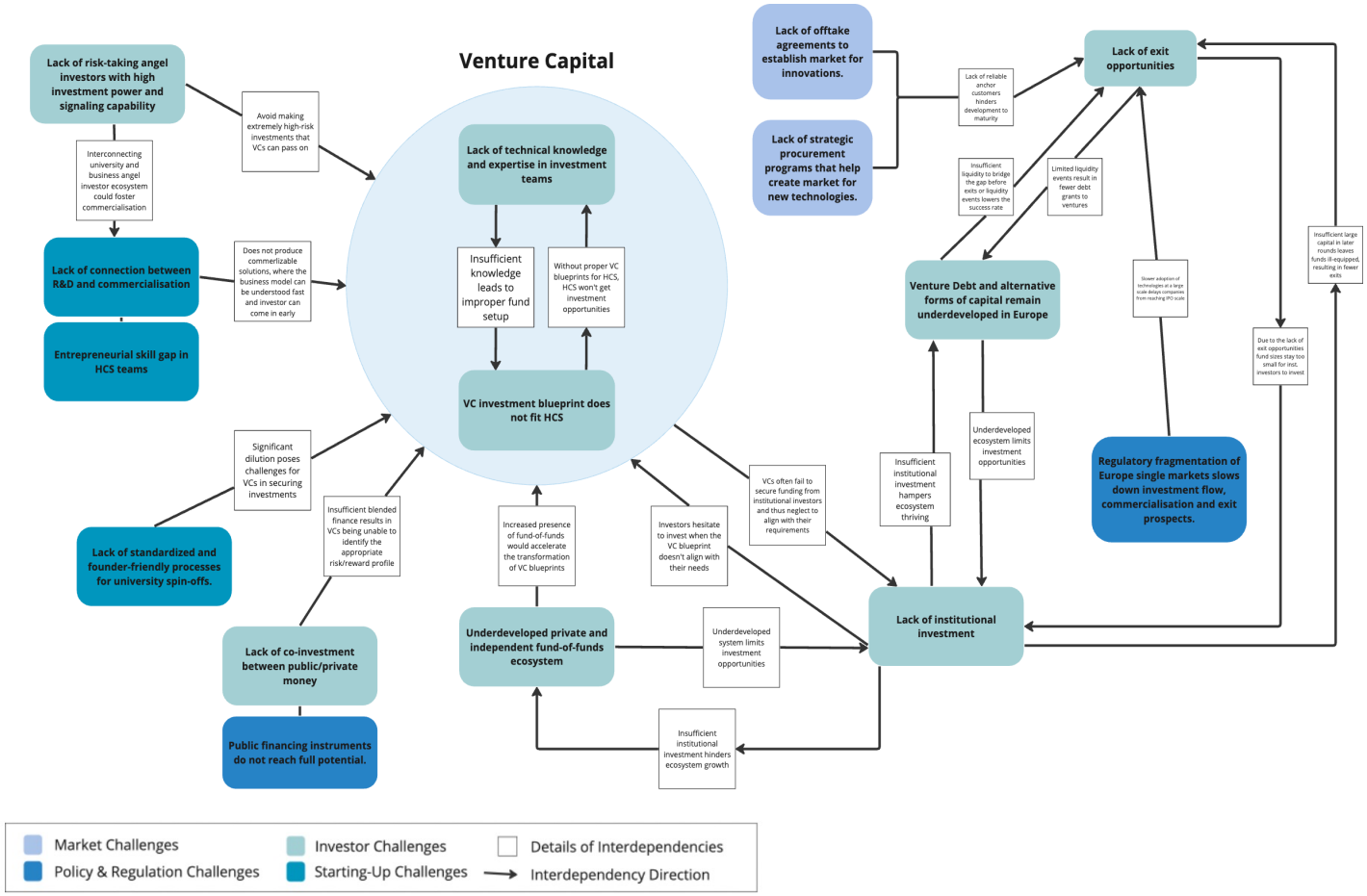
Excerpt of interview coding to demonstrate process.

INTERVIEW ANALYSIS

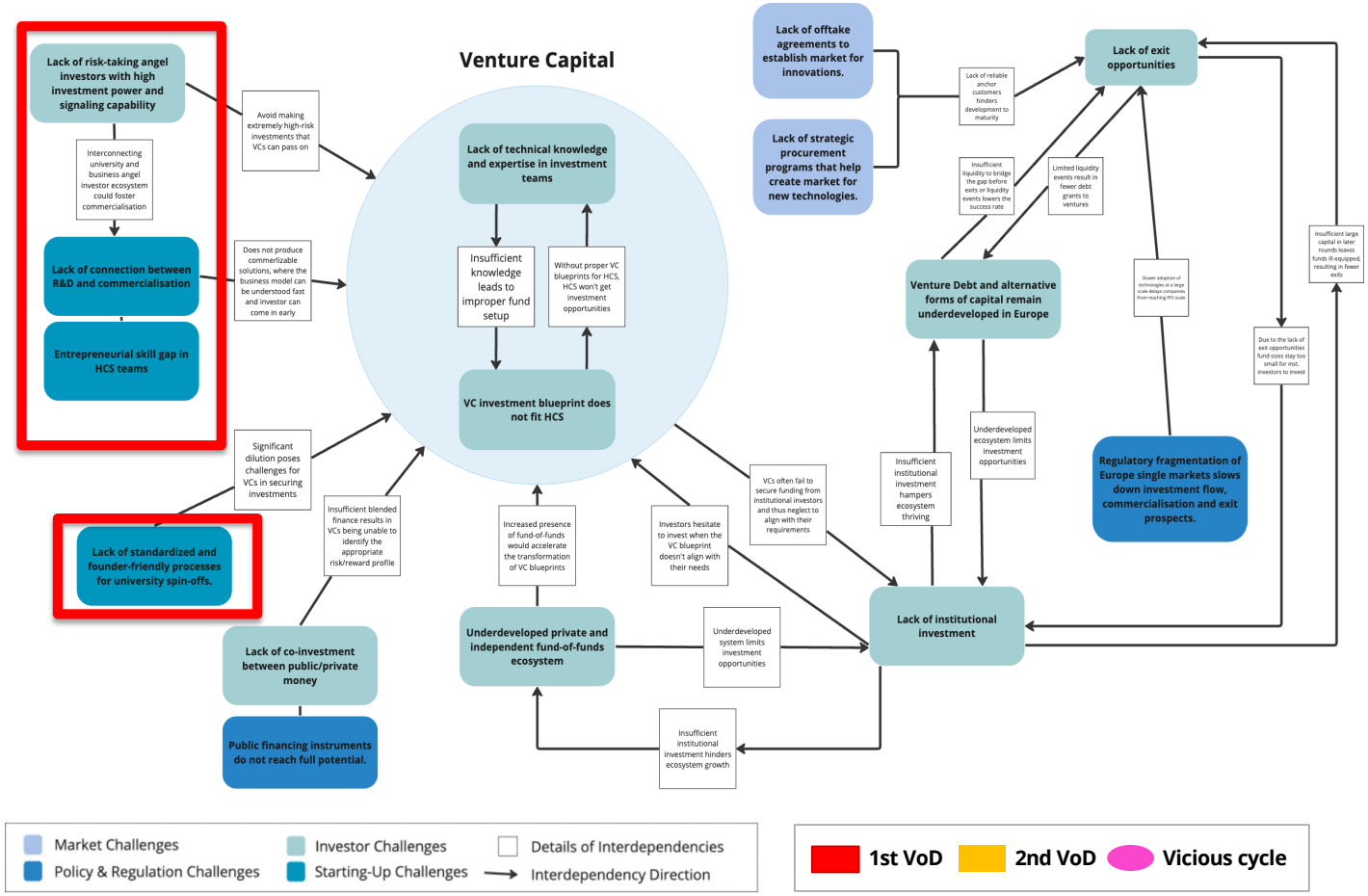
17 challenges were established and grouped **into 4 categories**.

STARTING UP CHALLENGES	MARKET CREATION AND COMMERCIALISATION CHALLENGES	REGULATION & POLICY CHALLENGES	INVESTOR CHALLENGES
Entrepreneurial Skill Gap in HCS Teams	Lack of Offtake Agreements	Lack of Strategic Direction and Guidelines Defined by the Government	Lack of Technical Knowledge in Investment Teams
Lack of Connection Between Research and Commercialization	Lack of Strategic Procurement Programs	Regulatory Fragmentation of Europe Single Markets Slows Down Investment Flow, Commercialisation and Exit Prospects	VC Investment Blueprint Does Not Fit HCSs
Lack of Standardized and Founder-Friendly Processes for University Spin-Offs		Public Financing Instruments Do Not Reach Their Full Potential	Lack of Risk-Taking Angel Investors with High Investment Power and Signalling Capability
			Insufficient Investment Volumes/VC Market Too Small for Institutional Investors
			Lack of Co-Investment Between Public/Private Money
			Underdeveloped Private and Independent Fund-of-Funds Ecosystem
			Underdeveloped Venture Debt and Alternative Forms of Capital in Europe
			Lack of Exit Opportunities
			Limited investment track record and data to meet regulatory and risk management requirements

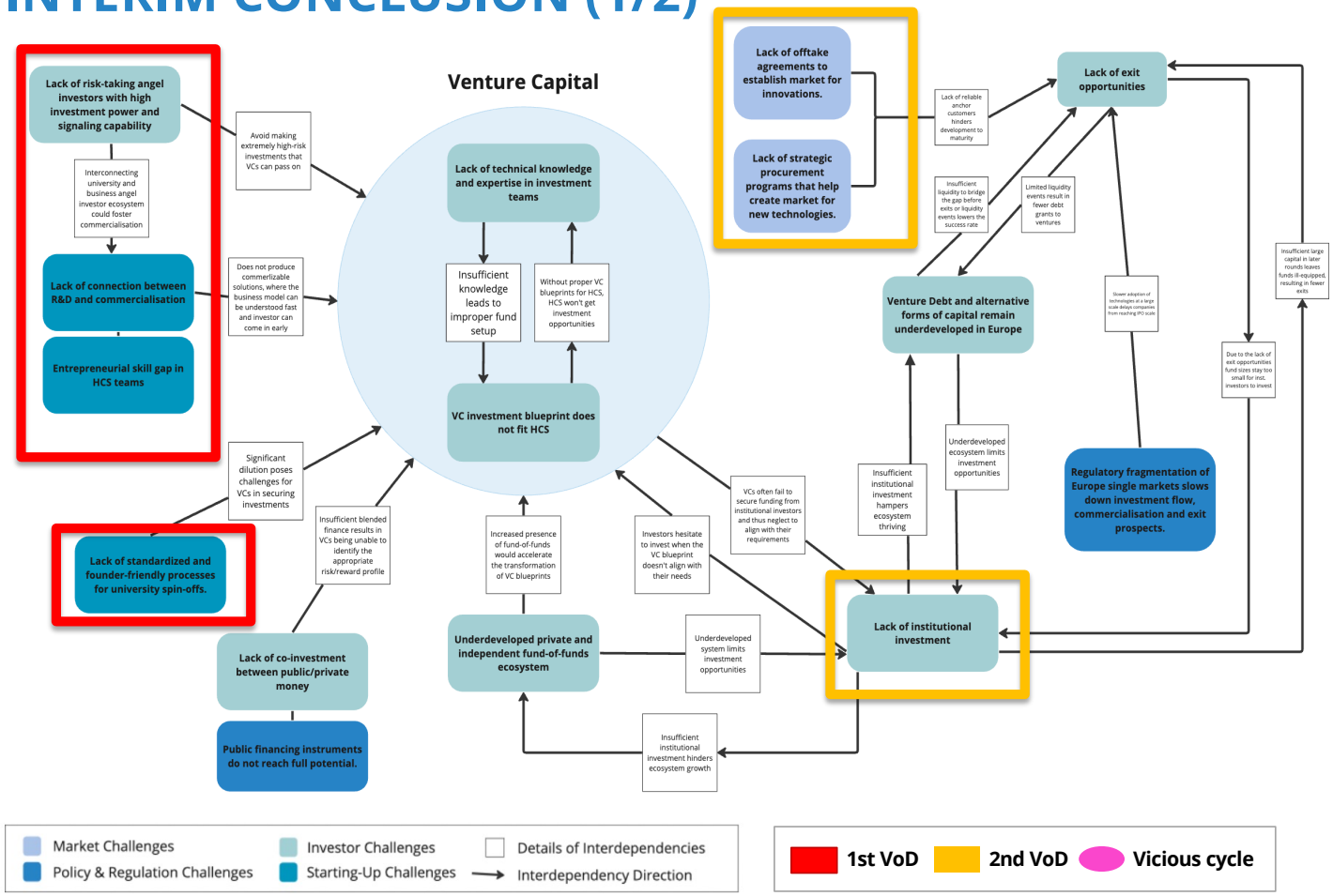
INTERIM CONCLUSION (1/2)



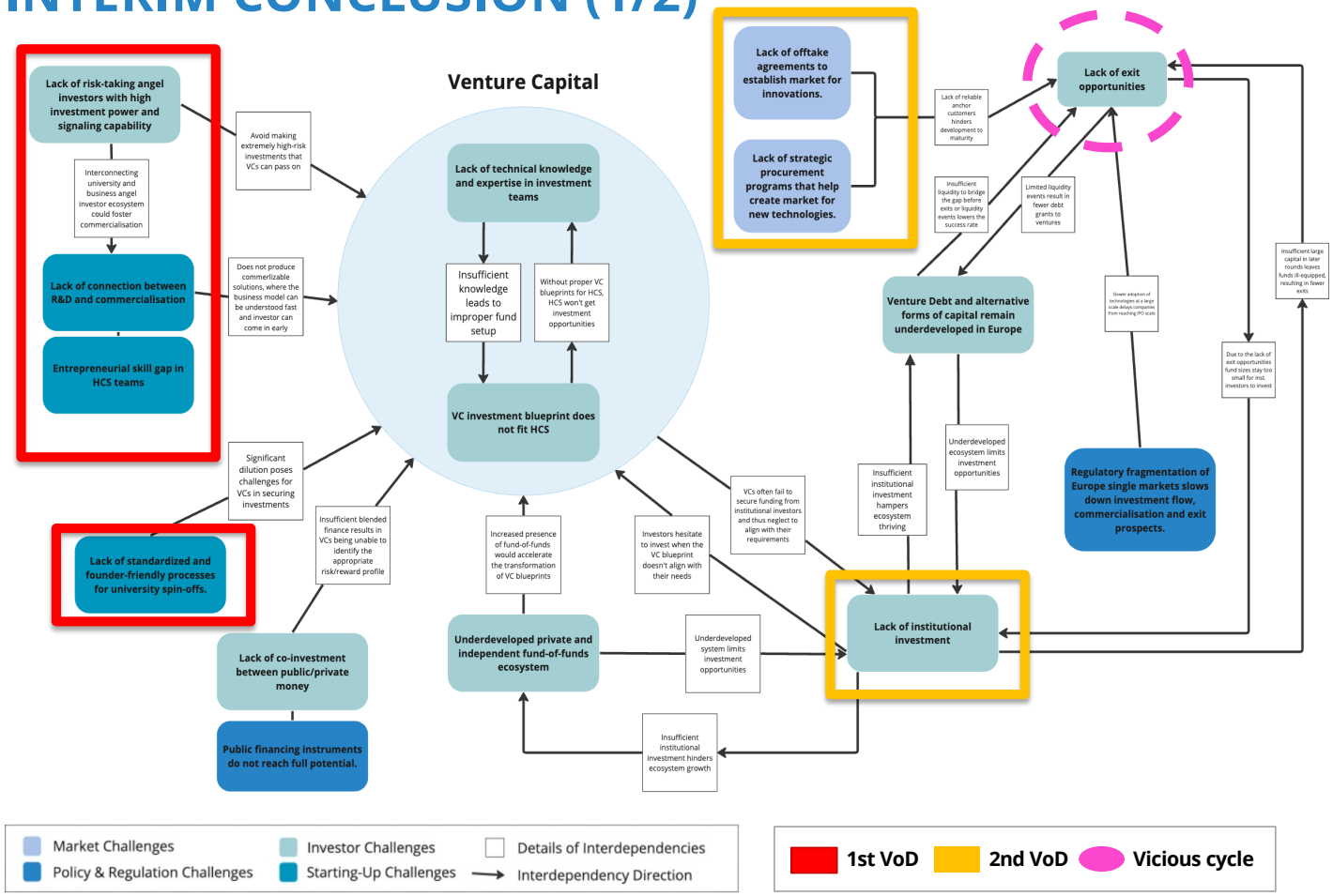
INTERIM CONCLUSION (1/2)



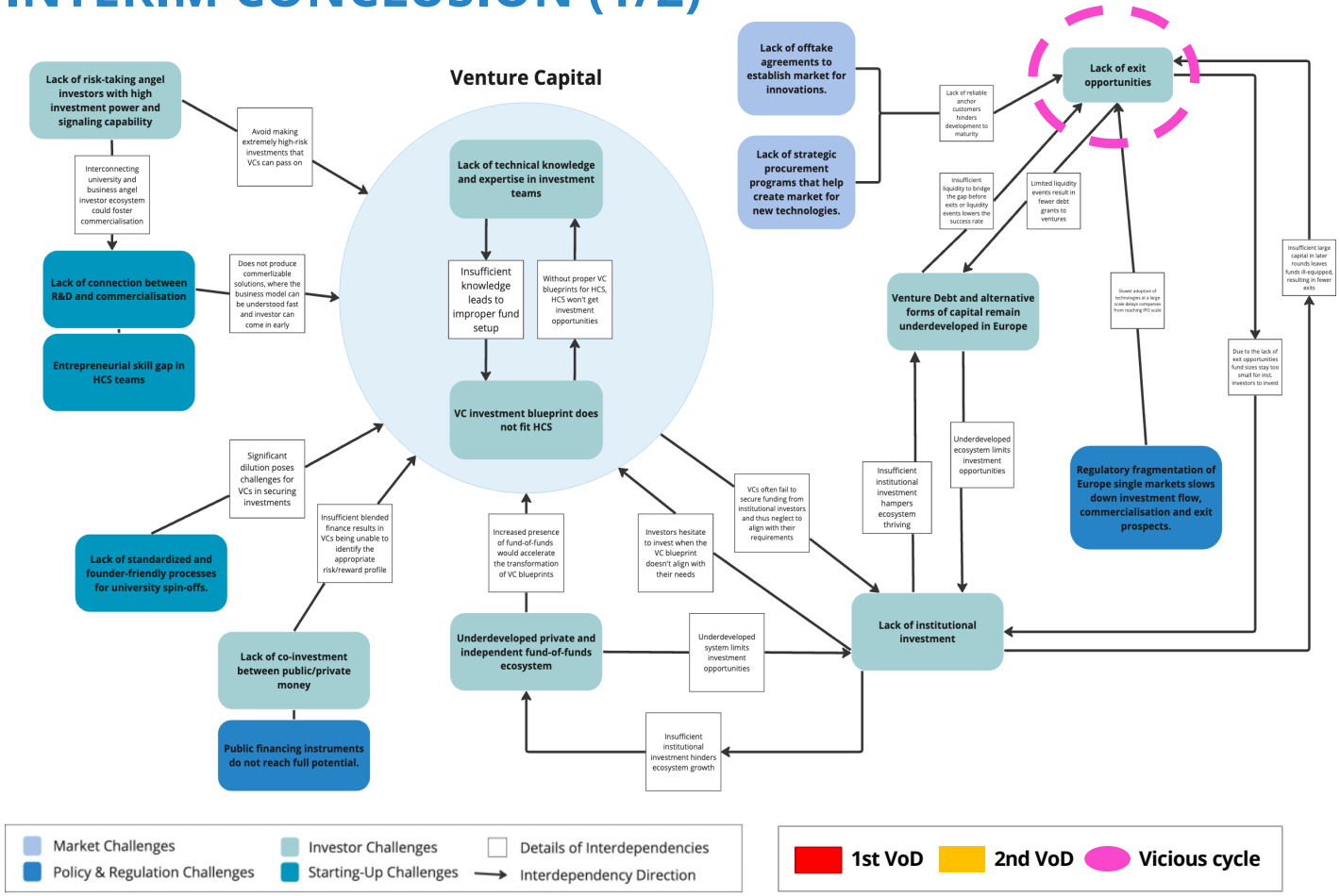
INTERIM CONCLUSION (1/2)



INTERIM CONCLUSION (1/2)



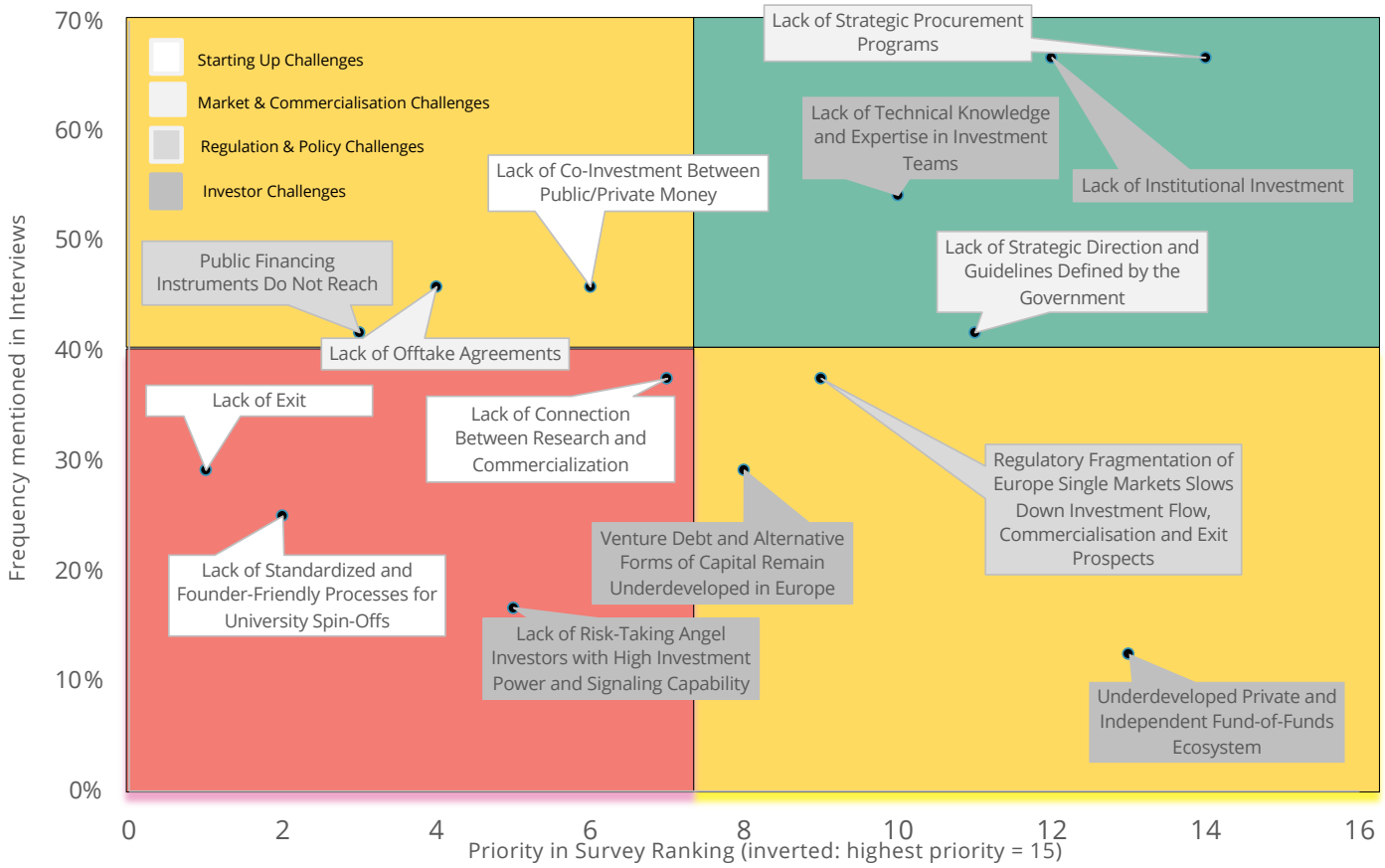
INTERIM CONCLUSION (1/2)



Vicious Cycle

- High investments are needed but only issued if the investors anticipate a timely exit
- HCSs ecosystem lacks exit opportunities which prevent investors from investing
- Due to lack of liquidity within ecosystem fund sizes stay too small to become attractive for institutional investors
- Vicious cycle inhibits the growth of the VC industry in Europe as a whole and prompts HCSs to seek exits overseas

FOLLOW-UP SURVEY



PRIORITISATION OF CHALLENGES

Survey prioritisation and frequency of mentions in interviews found the following challenges to be most impactful:

1. Lack of Strategic Procurement Programs
2. Insufficient Investment Volumes/VC Market Too Small for Institutional Investors
3. Lack of Technical Knowledge and Expertise in Investment Teams
4. Lack of Strategic Direction and Guidelines Defined by the Government

Mapping of challenges based on survey and interview results

INTERIM CONCLUSION (2/2)

CHALLENGES WITH HIGHEST INTERDEPENDENCIES WITHIN ECOSYSTEM

- Ticket sizes remain insufficient for amount of funding required partly due to **insufficient institutional investment** (from, e.g., insurance/pension funds and private fund-of-funds) - on the other hand, fund sizes are too small for institutional investors to invest
- **VC investment model** seeks risky investment however does not align with HCT and its TRLs
- A **Lack of Exit Opportunities** for HCSs initiate a vicious cycle that hinders money to be reinjected into the cycle (through IPOs, M&A's)

KEY TAKEAWAYS

» Successful introduction of HCT requires catalytic capital that effectively **mobilises a diverse range of investors** and to bring HCSs to maturity and realize exits

» Since VC investment model does not fully align with HCSs, additionally **alternative forms of capital** have to be explored

SURVEY RESULTS

- **Lack of Strategic Procurement programs** highly ranked and frequently mentioned indicating that a market/ customer base is missing for HCT
- **Institutional Investment** is perceived as highly relevant for ecosystem to thrive and benefit from big ticket sizes
- **The Lack of Exit Opportunities** was not perceived as relevant during the survey, indicating that the participants might perceive funding process for HCSs as linear
- **Lack of Technical Knowledge in Investment Teams** was highly ranked indicating that diversifying investor knowledge is crucial to improve investment decisions
- High ranking of **Lack of Strategic Direction and Guidelines Defined by the Government** calls for the governmental action

RESEARCH QUESTION 3

What are the potential solutions to solve this challenge?

INTERVIEW ANALYSIS

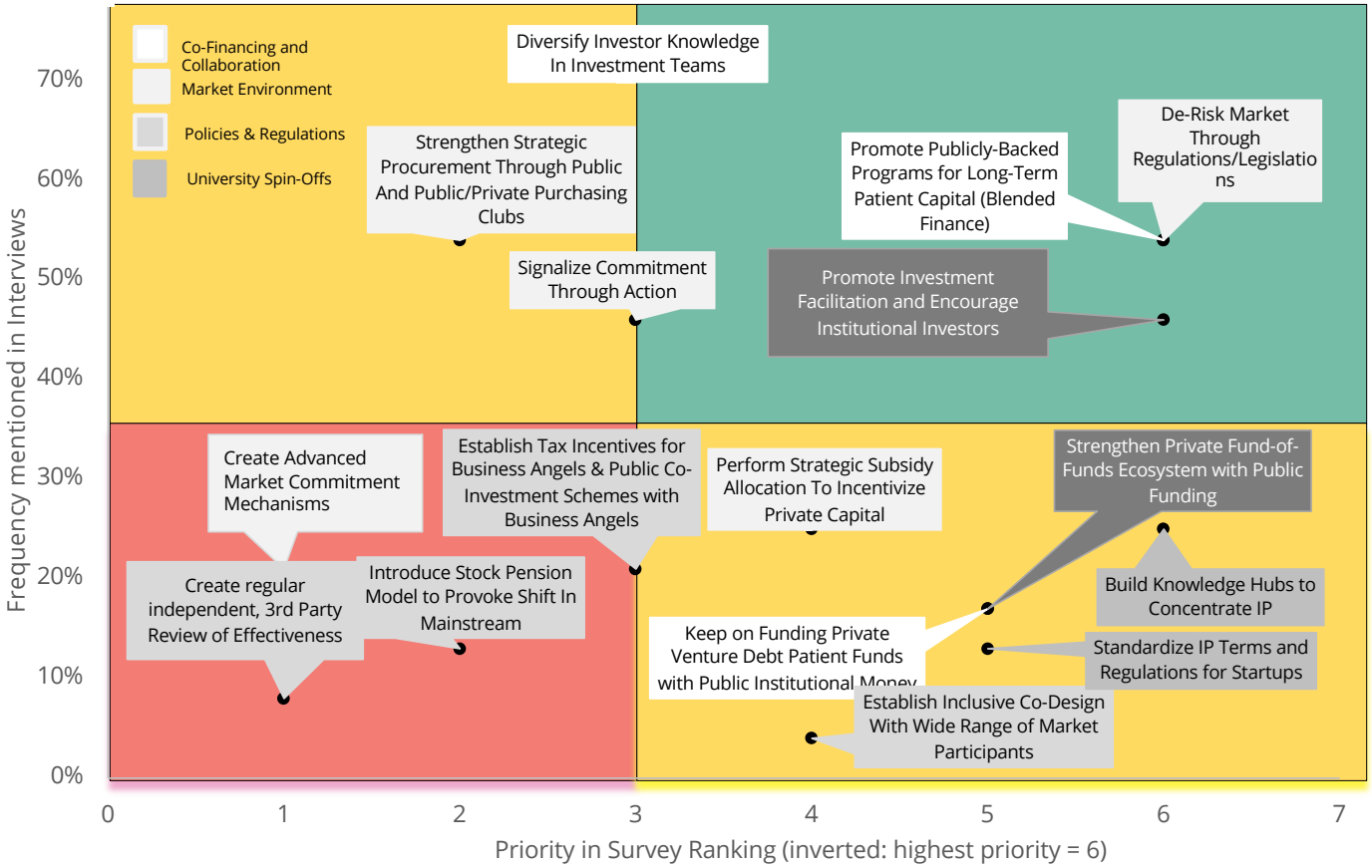
16 solutions (levers) were established and clustered **into 8 categories**. The categories were grouped into **4 overarching themes:**

REGULATORY AND POLICY ENVIRONMENT	MARKET ENVIRONMENT	CO-FINANCING AND COLLABORATION	UNIVERSITY SPIN-OFFS
Strengthen and Incentivise Inst. Investors to Invest in VC/VD/Fund-of-Funds**	Align Regulatory Environment and Perform Smart Capital Allocation According to Defined Environmental Strategy**	Strengthen Collaboration Amongst Players*	Create More Favourable Environment to Produce University Spin Offs*
Establish Good Policy Design & Review*	Establish Procurement Programs to Create Markets**	Increase Use of Blended Finance and Alternative Capital for Startups*	
Mobilise and Incentivise Private Capital*			

- Solutions obtained from interviews focus on **governmental intervention** and **vary in terms of depth and level of detail**.
- Multiple solutions are generic to the German ecosystem but become **particularly relevant** within the HCSs context.

* relevant to the startup ecosystem in general I **HCS-specific

FOLLOW-UP SURVEY



PRIORITISATION OF SOLUTIONS

Survey prioritisation and frequency of mentions in interviews found the following recommendations to be most important:

1. De-Risk Markets Through Legislations and Regulations
2. Promote Publicly Backed Programs for Long-Term Patient Capital
3. Promote Investment Facilitation and Encourage Institutional Investors

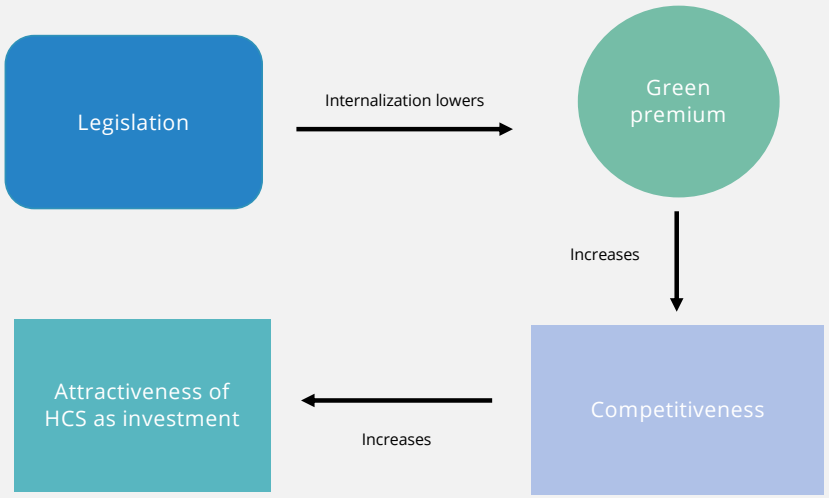
Mapping of solutions based on survey and interview results

ANALYSIS

RECOMMENDATION 1: DE-RISK MARKETS THROUGH LEGISLATIONS & REGULATIONS

"Legislation is necessary and an aligned legislation instead of what we've seen so far (...). It's super fragmented in the way it's done. It seems necessary to legislate with a long-term strategic perspective" *– I13 (2023)*

UNDERLYING MECHANISM



SPECIFIC RECOMMENDATIONS

► Literature provides evidence that public legislation **can reduce uncertainty by targeting the green premium**. Especially if there is **long-term stability** that incentivizes risk averse investors like institutionals to allocate their long-term capital.

Develop long term strategy

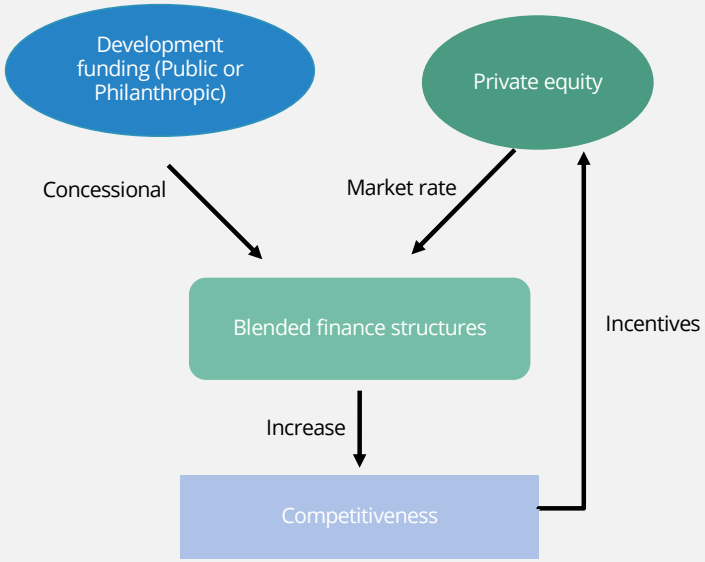
Government push mechanisms

Carbon tax

RECOMMENDATION 2: PROMOTE PUBLICLY BACKED PROGRAMS FOR LONG-TERM PATIENT CAPITAL

"What I find very relevant are these blended finance stories, which to my knowledge are not yet so widespread in Europe." – *I03 (2023)*

UNDERLYING MECHANISM



SPECIFIC RECOMMENDATIONS

1. Step in with guarantees provided by public catalyst funds

Private Public Partnerships to mobilize private capital

Matching grants: match a certain percentage of the private capital raised by public money

Best practice: Banque Publique d' Investissement (France) offers milestone-based financing for HCSs increasing certainty and thereby decreasing dilution

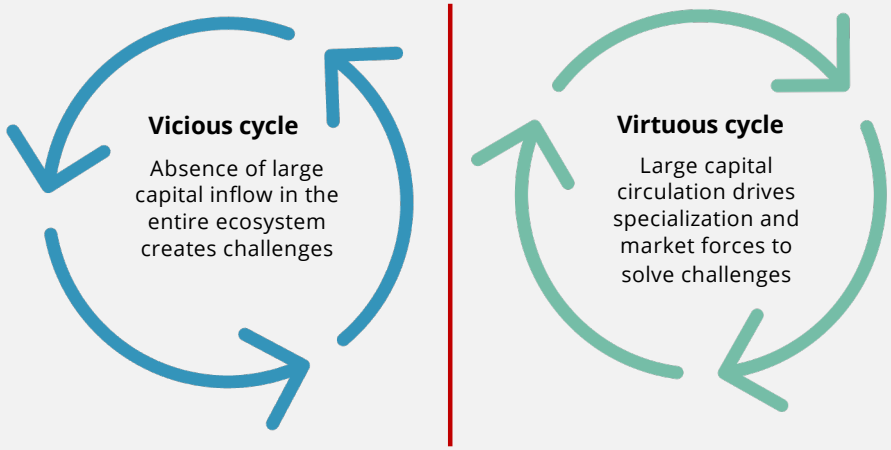
2. Make existing instruments more effective

Exploit: Review and double down on already existing loan instruments like the KFW or the EIB VD products

RECOMMENDATION 3: PROMOTE INVESTMENT FACILITATION AND ENCOURAGE INSTITUTIONAL INVESTORS

"Insurance companies and institutional investors must be allowed to invest larger parts in venture capital. That's why we only have small funds throughout Europe." *– I13 (2023)*

UNDERLYING MECHANISM



SPECIFIC RECOMMENDATIONS

Review prudential regulations with a view to cautiously developing risk appetite towards climate technologies

Conduct deep-dive with institutional investors (asset owners) to capture their full perspectives and design effective solutions

Orientate on international best practices to identify further solutions. Example: Danish Government incentivizes institutional investors to invest in VC and Growth capital funds.

CONCLUSION

IMPLICATIONS

RESEARCH QUESTION 1
Does a funding gap exist?

Confirmed the existence of a funding gap.

- **20 out of 24** interviewees fully and four partly approving.
- The range of the funding gap is estimated to be minimum **$2 billion** per year.

RESEARCH QUESTION 2
What factors contribute to the funding gap?

Identified **17 main challenges** with the most important ones being:

1. "Lack of procurement programs"
2. "Lack of strategic direction and guidelines from the government"
3. "Lack of Technical Knowledge and Expertise in Investment Teams"

RESEARCH QUESTION 3
What are potential solutions to solve this gap?

Identified **16 solutions** with the following rated as most relevant:

1. "De-risk market through regulations/legislations"
2. "Promote publicly backed programs for long-term patient capital"
3. "Promote investment facilitation and encourage institutional investors"

The specialization within the ecosystem is influenced by the **scale of capital flow**. The funding gap **disrupts this virtuous cycle** that cascades up from individual startups to the entire ecosystem

Challenges and solutions are **complex** and **highly interconnected**

Challenges from the macroeconomic environment for the entire ecosystem seem **especially relevant for HCT**, but are particularly hard to overcome

THANK YOU.