Technische Universität München
TUM Campus Straubing für Biotechnologie und Nachhaltigkeit

Resource Mobilization of Cleantech Startups: Perspectives on Political Ideology and Product Digitization

Susanne Kurowski

Vollständiger Abdruck der von der promotionsführenden Einrichtung TUM Campus Straubing für Biotechnologie und Nachhaltigkeit der Technischen Universität München zur Erlangung einer

Doktorin der Wirtschafts- und Sozialwissenschaften (Dr. rer. pol.)

genehmigten Dissertation.

Vorsitz:	Prof. Dr. Magnus Fröhling
Prüfer*innen der Dissertation:	1. Prof. Dr. Claudia Doblinger
	2. Prof. Dr. Hanna Hottenrott

Die Dissertation wurde am 17.08.2022 bei der Technischen Universität München eingereicht und durch die promotionsführende Einrichtung TUM Campus Straubing für Biotechnologie und Nachhaltigkeit am 01.02.2023 angenommen.

Acknowledgments

I would like to express my deepest gratitude to my supervisor Claudia Doblinger. Her enthusiasm for contributing to sustainable development and the academic community alike is inspiring and has motivated me throughout the time of my dissertation. I want to thank her for sharing key perspectives on research-related matters as well as offering encouraging words throughout my PhD. Working with and learning from Claudia helped me grow professionally and personally. Further, I want to thank Hanna Hottenrott for joining the dissertation committee as a second advisor and for showing interest in my dissertation. Our paths already crossed during the PhD course on applied econometrics and it is therefore fulfilling to be able to present my dissertation to her now. I also thank Magnus Fröhling for chairing my dissertation committee. The exchanges I had with him throughout my time at the TUM Campus Straubing were certainly enjoyable.

I further want to convey my gratitude to Jojo Jacob from Grenoble Ecole de Management for collaborating on the paper on political ideology. Driven by positive attitude and dedication toward research, he provided timely statistical advice and shared novel ideas on theoretical framing, advancing our paper. I also give thanks to Kavita Surana from the University of Maryland for enabling me to dive deeper into the cleantech startup data and providing me with valuable feedback on the product digitization paper. I am grateful for the opportunity to work with Adrian Rumpold; sharing coding knowledge and discussing scripts were extremely helpful and enjoyable. I also want to thank the interview participants for taking time and sharing their views, which gave me new, qualitative insights.

Further, I am grateful to my colleagues from the Professorship of Innovation and Technology Management as well as the TUM Campus Straubing for making pre-COVID times at the campus and virtual meetings joyful. I also thank the office management team and the research assistants for their support.

Finally, I share my profound gratitude toward my family and friends. I value their open minds, trust, and advice on how to navigate specific situations and life in general. I deeply appreciate their presence and support in this inspiring, and sometimes wavering, journey.

Abstract

This dissertation examines entrepreneurial resource mobilization of cleantech startups. Recognizing the increase of both political polarization and product digitization, this dissertation presents novel perspectives on the role of political ideology and product digitization in startups' resource mobilization. The dissertation comprises three studies, with the first study focusing on political ideology and the subsequent two studies examining product digitization. Considering the environmental contribution toward tackling climate change, the research setting is the U.S. cleantech industry.

The first study examines the effect of VC investors' political ideology on investment decision-making. The results obtained by analyzing data from 415 U.S. cleantech and fintech ventures from 2008 to 2018 indicate that conservative investors are less likely to finance new ventures and that this effect is contingent on investors' ideological congruence with the ventures and their spatial environment. The results reveal no significant difference in the effect of VC investor ideology on investment rounds between the cleantech and fintech sectors. This study contributes to entrepreneurship research by focusing on the role of investor characteristics, in particular their political ideology, in venture financing.

The second study deals with product digitization and investigates its effect on venture growth. The study further clarifies the relevance of dependencies in startup/VC investor networks for venture growth. Building on a sample of 461 startups in the U.S. cleantech sector from 2004 to 2018, the findings suggest that product digitization is positively associated with venture growth. Furthermore, diversified startup dependence has a more positive effect on venture growth than centralized startup dependence. The findings also indicate that diversified startup and VC investor dependence are beneficial for startups having a higher degree of product digitization. This study contributes to the literature on venture growth and resource dependence in the entrepreneurial context.

The third study introduces a typology of non-digital, hybrid, and digital startups and provides an understanding of how the three startup types differ in terms of resource mobilization. Based on a qualitative analysis of 16 semi-structured interviews with stakeholders in the U.S. cleantech industry as well as supplementary secondary data, this study introduces a novel framework that identifies the different resource mobilization approaches and associated life cycle dynamics of the three startup types. This study contributes to the theory on entrepreneurial resource mobilization as well as the literature on digital and environmental entrepreneurship.

Zusammenfassung

Diese Dissertation befasst sich mit der Ressourcenmobilisierung von Cleantech-Start-ups. In Anbetracht der zunehmenden politischen Polarisierung und der Digitalisierung von Produkten bietet diese Dissertation neue Perspektiven zur Rolle der politischen Ideologie und der Produktdigitalisierung in der Ressourcenmobilisierung von Start-ups. Die Dissertation umfasst drei Studien, wobei die erste Studie den Einfluss politischer Ideologie analysiert und die beiden folgenden die Rolle der Produktdigitalisierung in der Ressourcenmobilisierung von Start-ups untersuchen. Vor dem Hintergrund des ökologischen Beitrags zur Bewältigung des Klimawandels ist der empirische Kontext der US-amerikanische Cleantech-Sektor.

Die erste Studie der Dissertation untersucht die Auswirkungen der politischen Ideologie von VC Investoren auf deren Investitionsentscheidungen. Die Ergebnisse, die durch die Analyse von 415 US-amerikanischen Cleantech- und Fintech-Start-ups zwischen 2008 und 2018 gewonnen wurden, zeigen, dass konservative Investoren weniger wahrscheinlich in Start-ups investieren. Dieser Effekt ist von der ideologischen Übereinstimmung der Investoren mit den Start-ups und ihrem räumlichen Umfeld abhängig. Gemäß der Ergebnisse gibt es jedoch keinen signifikanten Unterschied im Effekt der politischen Ideologie von VC Investoren auf deren Investitionsentscheidungen zwischen den Sektoren Cleantech und Fintech. Diese Studie leistet einen Beitrag zur Entrepreneurship-Literatur, indem der Fokus auf Merkmale von Investoren, insbesondere deren politische Ideologie, bei der Finanzierung von Start-ups gelegt wird.

Die zweite Studie befasst sich mit der Digitalisierung von Produkten und untersucht deren Auswirkung auf das Wachstum von Start-ups. Die Studie betrachtet darüber hinaus die Bedeutung von Abhängigkeiten in Netzwerken von Start-ups und VC Investoren für das Start-up-Wachstum. Basierend auf einer Analyse von 461 Start-ups im US-amerikanischen Cleantech-Sektor zwischen 2004 und 2018 zeigen die Ergebnisse, dass die Produktdigitalisierung einen positiven Einfluss auf das Start-up-Wachstum hat. Darüber hinaus legen die Ergebnisse dar, dass die diversifizierte Start-up-Abhängigkeit einen positiveren Effekt auf das Start-up-Wachstum als die zentralisierte Start-up-Abhängigkeit hat. Die Ergebnisse deuten auch darauf hin, dass diversifizierte Start-up- und VC Investor-Abhängigkeiten besonders für Start-ups mit digitaleren Produkten von Vorteil sind. Diese Studie leistet einen Beitrag zur Literatur zum Start-up-Wachstum und zur Ressourcenabhängigkeit im Kontext von Start-ups.

Die dritte Studie führt eine Typologie nicht-digitaler, hybrider und digitaler Start-ups ein und liefert Erkenntnisse darüber, wie sich die drei Typen von Start-ups in Hinblick auf die Ressourcenmobilisierung unterscheiden. Basierend auf einer qualitativen Analyse von 16 semi-strukturierten Interviews mit Akteuren im US-amerikanischen Cleantech-Sektor sowie ergänzender Sekundärdaten stellt diese Studie ein neuartiges Konzept vor, welches die unterschiedlichen Ansätze zur Ressourcenmobilisierung und die damit verbundene Lebenszyklus-Dynamik der drei Typen von Start-ups identifiziert. Diese Studie leistet einen Beitrag zur Theorie der Ressourcenmobilisierung von Start-ups sowie zur digitalen und ökologischen Entrepreneurship-Literatur.

Table of contents

Acknowledgments .... **III**

Abstract .... **IV**

Zusammenfassung .... **V**

Table of contents .... **VII**

List of figures .... **X**

List of tables .... **XI**

List of abbreviations .... **XII**

1 Introduction **1**
- 1.1 Motivation 1
- 1.2 Research setting, objectives, and design 3
- 1.3 Structure of the dissertation 8

2 (No) Politics at work? The relevance of political ideology for new venture VC financing **10**
- 2.1 Introduction 10
- 2.2 Theoretical background and hypotheses development 12
  - 2.2.1 VC investor political ideology: A value and identity-based perspective 12
  - 2.2.2 VC investor values, uncertainty, and venture investment decisions 14
  - 2.2.3 The moderating effect of the venture’s ideological identity 15
  - 2.2.4 The moderating effect of the venture’s spatial ideological identity 16
  - 2.2.5 The moderating effect of the venture’s industry orientation 17
- 2.3 Methods 19
  - 2.3.1 Sample and data sources 19
  - 2.3.2 Variables 19
- 2.4 Results 24
  - 2.4.1 Main results 24
  - 2.4.2 Sensitivity analyses 29
- 2.5 Discussion and conclusion 30
  - 2.5.1 Summary of the findings and theoretical contributions 30
  - 2.5.2 Managerial implications 32
  - 2.5.3 Limitations and future research opportunities 33

3 Digitize and grow? How product digitization affects new venture growth......... 35
3.1 Introduction 35
3.2 Theoretical background 38
3.2.1 Drivers for venture growth: Network composition and the nature of products 38
3.2.2 Product digitization: A novel dimension of the nature of products 39
3.3 Hypotheses development 40
3.3.1 Product digitization and venture growth 40
3.3.2 Dependencies, product digitization, and venture growth 41
3.4 Methods 45
3.4.1 Empirical setting 45
3.4.2 Sample and data collection 46
3.4.3 Variables and model specifications 47
3.5 Results 54
3.5.1 Main results 54
3.5.2 Sensitivity analyses 57
3.6 Discussion and conclusion 59
3.6.1 Summary of the findings and theoretical contributions 59
3.6.2 Managerial implications 61
3.6.3 Methodological implications 62
3.6.4 Limitations and future research opportunities 62

4 From atoms to bits: Resource mobilization of non-digital, hybrid, and digital cleantech startups 64
4.1 Introduction 64
4.2 Theoretical background 67
4.2.1 Entrepreneurial resource mobilization and life cycle dynamics 67
4.2.2 A typology of non-digital, hybrid, and digital startups 69
4.3 Research context 71
4.3.1 The U.S. cleantech industry 71
4.3.2 Cleantech startups 72
4.4 Methods 73
4.4.1 Data sampling 73
4.4.2 Data collection 74
4.4.3 Data analysis 75
4.5 Results 78
4.5.1 Non-digital startups 78
4.5.2 Hybrid startups 82
4.5.3 Digital startups 85

4.6 Discussion and conclusion 89
4.6.1 Summary of the findings and theoretical contributions 89
4.6.2 Managerial implications 92
4.6.3 Policy implications 92
4.6.4 Limitation and future research opportunities 94

5 Conclusion and outlook 96

Appendix A 100
A-1 Results of the sensitivity analyses 100

Appendix B 102
B-1 Overview of digital keywords and stemmed digital keywords 102
B-2 Results of the sensitivity analyses 103

Bibliography 106

List of figures

Figure 1-1: U.S. cleantech VC investments from 2004 to 2021 3
Figure 2-1: Venture sector and venture location 25
Figure 2-2: Venture sector and VC investor ideology 25
Figure 2-3: Interaction effect: VC investor ideology x Ideological congruence............. 28
Figure 2-4: Interaction effect: VC investor ideology x Spatial congruence 28
Figure 3-1: Hypothesized effects of product digitization and dependencies on venture growth 45
Figure 3-2: Frequency distribution of startups according to cleantech sub-sectors........ 47
Figure 3-3: Kaplan-Meier graph of the growth likelihood... 48
Figure 3-4: Cleantech sub-sectors and product digitization of startups 50
Figure 3-5: Interaction effect: Product digitization x Startup dependence 57
Figure 3-6: Interaction effect: Product digitization x VC investor dependence 57

List of tables

Table 2-1: Correlation analysis between VC investment rounds and VC amount 20
Table 2-2: Descriptive statistics of variables used in the analysis 24
Table 2-3: Correlations of variables used in the analysis 24
Table 2-4: Estimated coefficients of Poisson regressions of investment rounds 27
Table 3-1: Descriptive statistics and correlations of variables used in the analysis 54
Table 3-2: Estimated hazard ratios of Cox proportional hazard models of growth events within 14 years after founding 56
Table 4-1: Overview of interview participants 74
Table 4-2: Product characteristics, startup characteristics, resource mobilization, and exit of non-digital, hybrid, and digital startups 77

List of abbreviations

AME	Average marginal effect
CPVI	Cook partisan voting index
CEO	Chief executive officer
Cleantech	Clean energy technology
Fintech	Financial technology
GHG	Greenhouse gas emission
IPO	Initial public offering
IT	Information technology
MSA	Metropolitan statistical area
R&D	Research and development
ROI	Return on investment
SPAC	Special purpose acquisition company
VC	Venture capital

1 Introduction

1.1 Motivation

We are in the epoch of the Anthropocene. This epoch refers to the current period when human activities alter components of the climate system beyond the normal year-to-year variability (Steffen, Crutzen, & McNeill, 2007). Over the last decades, there has been a significant increase in greenhouse gas (GHG) emissions, of which CO_2 emissions from fossil fuel combustion are the strongest driver of anthropogenic climate change. When comparing the global mean surface temperature of the pre-industrial baseline period (1850-1900) with the present (2011-2020), there is already a 1.09°C increase. The consequences are evident in all components of the climate system and include, for instance, changes in precipitation patterns, melting of glaciers, ocean acidification, and sea level rise. These changes to the climate system also have consequences for the human system. For example, changing precipitation patterns affect agricultural activities, and sea level rise causes the inundation of coastal regions. Therefore, limiting the severe, and often irreversible, consequences is imperative (Intergovernmental Panel on Climate Change, 2022).

Recognizing this urgency, the Paris Agreement was adopted in 2015. This agreement is the most important climate agreement to date and sets the long-term goal of limiting global temperature increase to well below 2°C above the pre-industrial level and taking efforts to keep it below 1.5°C. To achieve this goal, the target of net-zero by 2050 has been introduced as the central global pathway to attain a balance between anthropogenic emissions by sources and removals by sinks (United Nations Framework Convention on Climate Change, 2015). Taking a closer look at the emission sources among sectors, the energy sector is the largest source of global GHG emissions. Thus, decarbonizing the energy sector is crucial to achieve net-zero within the next three decades. By 2050, it is projected that almost half of the CO_2 emission reductions will stem from clean energy technology (cleantech) innovations that are currently in the early conception stage (International Energy Agency, 2021). Accordingly, the relevance of cleantech innovations to reach long-term climate goals is remarkable and motivates my research.

Cleantech innovations are primarily driven by startups. Compared with incumbent firms, cleantech startups are more innovative and flexible, and bring new technologies to markets more quickly (Doblinger, Surana, & Anadon, 2019; Hockerts & Wüstenhagen, 2010; Howell, 2017). As startups have limited resource endowments, a central task for them is to mobilize resources (Clough, Fang, Vissa, & Wu, 2019). This is often challenging because startups are small, young firms lacking track records, which makes them suffer from the liabilities of smallness and newness (Baum, Calabrese, & Silverman, 2000; Stinchcombe, 1965). Prior research has identified financial resources, especially venture capital (VC), as essential for cleantech startups to bridge the "valley of death", denoting the funding gap in the conception and commercialization stage (Cumming, Henriques, & Sadorsky, 2016; Gaddy, Sivaram, Jones, & Wayman, 2017). Recognizing the contributions that cleantech startups make toward tackling climate change and thus providing value for the public good, there is growing interest in understanding the resource mobilization of cleantech startups (Vedula et al., 2022). However, in the context of resource mobilization, two major factors have remained unexplored so far: *political ideology* and *product digitization.*

First, *political ideology* has been an increasingly polarizing force over the last decades (Bonica, 2014; Wasserman & Flinn, 2017). Research has identified political ideology as an important predictor of climate change views (McCright & Dunlap, 2011), investment decisions in financial markets (Bonaparte, Kumar, & Page, 2017; Hong & Kostovetsky, 2012), and strategic decision-making in the corporate setting (Chin, Hambrick, & Treviño, 2013; Gupta, Briscoe, & Hambrick, 2018). However, whether VC investors' investment decisions in general, and concerning cleantech startups in particular, are biased by their political ideology has not been studied yet. Thus, it is promising to examine whether political ideology plays a role in financial resource mobilization, and if so, whether cleantech startups are more susceptible to such biases.

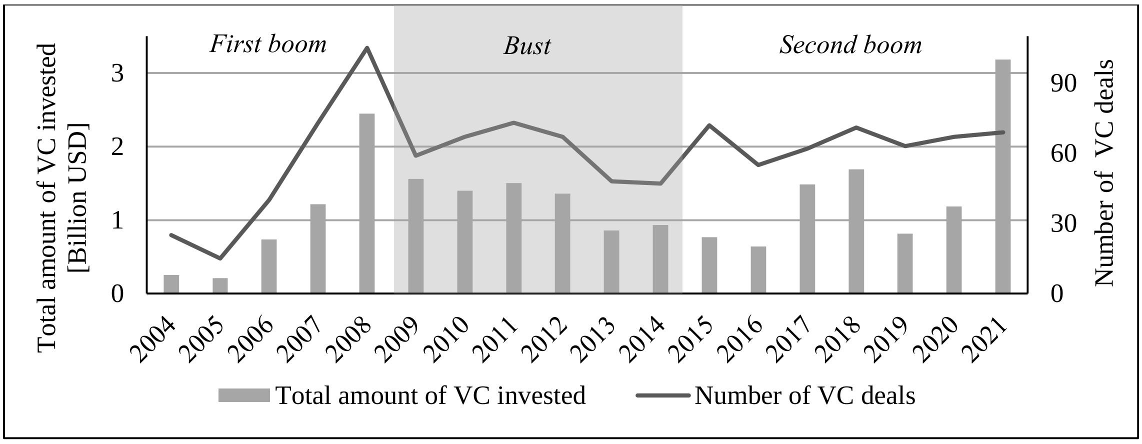
Second, digitization has affected the cleantech sector substantially, and modes of *product digitization* vary across cleantech startups (Gaddy et al., 2017; International Energy Agency, 2017). Recent entrepreneurship studies have begun to compare entrepreneurial processes of non-digital and digital startups, pointing to different business model evolution patterns (König, Ungerer, Baltes, & Terzidis, 2019) and different types of partners for cooperation (Kollmann, Stöckmann, Niemand, Hensellek, & De Cruppe, 2021). However, beyond the binary non-digital/digital startup distinction, a measure for quantifying granular differences in product digitization is lacking. Overall, there is anecdotal evidence that startups with increasingly digitized products experience a growth event through an exit more quickly (CB Insights, 2016). Nevertheless, the effect of product digitization, along with dependence configurations in startup/VC investor networks, on venture growth outcomes has not been studied empirically.

In addition, it is exciting to look beyond the well-studied subject of resource mobilization of VC investors (Clough et al., 2019) and provide a more holistic picture of the resource mobilization of startups with different degrees of product digitization. In this regard, it is interesting to explore whether the mobilization of financial, social, human, and other resources differs between the three main types of non-digital, hybrid, and digital startups in the cleantech sector.

On the whole, this dissertation focuses on VC-backed cleantech startups and helps to understand mechanisms and processes in resource mobilization associated with political ideology and product digitization.

1.2 Research setting, objectives, and design

The central topic of my dissertation is entrepreneurial resource mobilization, and specifically, I provide novel perspectives on the role of political ideology and product digitization. The research setting is the U.S. cleantech sector from 2004 to 2021. As I focus on VC-backed cleantech startups throughout my dissertation, Figure 1-1 gives an overview of the developments in VC-backed cleantech startups in the U.S. from 2004 to 2021. The figure shows both the total amount of VC invested and the number of VC deals per year. When placing Figure 1-1 in the context of U.S. macroeconomic, political, and cleantech-specific developments, three phases of VC investment activity in cleantech can be identified: the *first boom*, the *bust*, and the *second boom*. These phases are described in more detail as follows.



Notes: Figure 1-1 is based on data from Crunchbase retrieved in February 2022. It includes U.S.-based startups with Crunchbase industry assignments of biomass energy, energy efficiency, energy storage, fuel cell, smart home, solar, and wind. These industry assignments best align with the cleantech sub-sectors of the i3 Cleantech Group database. All VC deals that were assigned to a Series A or any later round are included. The total amount of VC invested refers to deals with disclosed amounts on Crunchbase.

Figure 1-1: U.S. cleantech VC investments from 2004 to 2021

The *first boom* covers the time from 2004 to 2008. Figure 1-1 shows that the annual VC investments in cleantech increased from 250 million USD in 2004 to more than 2 billion USD in 2008. During the first boom, VC investors mainly focused on startups that developed and commercialized renewable energy generation technologies. In 2005 and 2006, the international initial public offerings (IPOs) of Q-Cells, Sunpower, Suntech, and First Solar were considered benchmarks of successful cleantech VC investments (Gaddy et al., 2017). Furthermore, the introduction of the Investment Tax Credit in 2006 served as one of the most important energy-related federal policies in the U.S. and catalyzed cleantech VC investments, specifically in renewable energy generation technologies (Olson-Hazboun, Howe, & Leiserowitz, 2018). However, the financial crises of 2007 and 2008 took away much of the VC investors' gains and caused a decline in cleantech VC investments (Cumming et al., 2016).

The following *bust* from 2009 to 2014 was characterized by fewer VC deals and lower total amounts of VC invested compared with the peak year of 2008. Until 2012, VC investors continued to deploy some capital into cleantech startups. However, besides the aftermath of the financial crisis, there were several other factors limiting cleantech VC financing activities in the bust phase. In 2011 and 2012, many solar companies went bankrupt, with Evergreen Solar and Solyndra being prominent examples. The bankruptcies of solar startups were linked to the scaling up of the solar panel production in China, which made U.S. solar startups less competitive on the global market, consequently impeding cleantech VC investments (Sivaram & Norris, 2016; Temple, 2020). Furthermore, natural oil prices plummeted in 2009. This made the business prospect of cleantech innovations as substitutes of fossil fuel-based energy generation technologies less lucrative, leading to fewer VC deals and lower total amounts of VC invested (Cumming et al., 2016). During the end of the bust phase, the acquisition of the startup Nest Labs by Google for more than 3 billion USD caused VC investors to become enthused about newer cleantech sub-sectors such as energy efficiency, where products incorporate smart technologies (McCrone, 2014).

The *second boom* of cleantech VC investments started in 2015, lasting until today. During these past years, there was a back-and-forth with regard to U.S. supportive climate policies at the federal level, including joining, withdrawing, and rejoining the Paris Agreement. Despite the developments at the federal level, the state level Renewable Energy Portfolio Standards have become an important policy to expand renewable energy generation and were increasingly established and renewed (McMichael, 2021;

Olson-Hazboun et al., 2018). This development sent signals to VC investors. Accordingly, Figure 1-1 shows that the number of VC investments in cleantech startups grew, although more slowly than during the first boom. Overall, VC investors increasingly funded asset-light startups in cleantech sub-sectors such as energy efficiency and smart grid to avoid high losses as experienced with investments made during the first boom. These prior investments were mainly associated with asset-heavy renewable energy generation startups (Gaddy et al., 2017; Ghosh & Nanda, 2010). Acknowledging the urgency to combat climate change and the expectations of a growing cleantech market in the future, from 2020 onwards, many large VC investors (e.g., Koshla Ventures, Kleiner Perkins, and Union Square Ventures) set up specialized climate funds. This climate emphasis of VC investors already manifested in the VC investment activity as of 2021. Figure 1-1 shows that 69 VC deals were closed and the total amount of VC invested was at an all-time high with more than 3 billion USD in 2021.

The focus on VC-backed cleantech startups is suitable for exploring the role of political ideology and product digitization in entrepreneurial resource mobilization. First, the research setting is appropriate to study the role of VC investors' political ideology in investment decision-making because biases might be particularly observable in the liberal-leaning cleantech sector, where innovations generate environmental value (Hockerts & Wüstenhagen, 2010). When studying the effect of VC investors' political ideology on investment decision-making, my co-authors and I added the politically neutral sector of financial technology (fintech) to the research setting to provide comparative evidence of potential investment biases (Bonica, 2014). Second, the cleantech sector also ties in with the purpose of studying the role of product digitization for venture growth and different resource mobilization approaches because products with varying degrees of digitization are developed and commercialized by cleantech startups (Gaddy et al., 2017; International Energy Agency, 2017).

The overarching objective of this dissertation is to generate new insights related to resource mobilization of cleantech startups. In the following paragraphs, I describe the specific research objectives and the corresponding research designs of the three studies entailed in this dissertation. While *research objective 1* pertains to providing novel insights on the role of *political ideology* in the resource mobilization of cleantech startups, *research objectives 2* and *3* are contingent upon the role of *product digitization*.

Political ideology is a fundamental factor that affects decision-making. As mentioned in the previous section, political ideology has been shown to shape investment decisions in financial markets (Bonaparte et al., 2017; Hong & Kostovetsky, 2012) and strategic top-management decisions in corporations (Chin et al., 2013; Gupta et al., 2018). In the entrepreneurial context, political ideology might also shape VC investment decisions in mitigating uncertainty associated with young ventures (De Clercq, Fried, Lehtonen, & Sapienza, 2006; Swigart, Anantharaman, Williamson, & Grandey, 2020). However, non-market logics in general, and political ideology in particular, have received little attention in entrepreneurial resource mobilization (Clough et al., 2019). With notable exceptions (Fu & Tietz, 2019; Matusik, George, & Heeley, 2008), few studies have examined the role of VC investors' attributes in affecting investment decision-making. Therefore, my first research objective is as follows:

Research objective 1: *To create an understanding of the extent to which VC investors' political ideology shapes their investment decisions and identify the role of startup attributes to this end.*

This research objective is covered in chapter 2. My co-authors and I build on a panel of 225 U.S. cleantech and 190 U.S. fintech startups from 2008 to 2018. Based on publicly available donation data, we construct an index-based measure to quantify the political ideology of VC investors and startups (Chin et al., 2013). We further measure the ideological stance of the ventures' spatial environment by relying on the Cook partisan voting index (CPVI) (Wasserman & Flinn, 2017). We use Poisson regression models to assess the effect of VC investors' conservatism on VC investment rounds received by startups. To study the role of startup attributes, we introduce interaction effects of startup attributes and VC investors' political ideology on VC investment rounds received by the ventures.

Besides political ideology, *product digitization* might shape entrepreneurial outcomes. Apart from attracting VC, achieving a growth event through an acquisition or IPO is the long-term milestone for startups and VC investors alike (De Clercq et al., 2006). Scholars have already identified the nature of products as a determinant for ventures that seek to grow and specifically highlighted the radical/incremental distinction of products that affects growth outcomes (Robinson, 1990; Zahra & Bogner, 2000). Given that products have become increasingly digitized (Lyytinen, Yoo, & Boland, 2016), product digitization, as part of the product's nature, requires reconsideration as a predictor of venture growth. Furthermore, resource exchanges between startups and VC investors create bidirectional dependencies, which is the central concept of resource dependence theory (Pfeffer & Salancik, 1978). Dependencies between startups and investors have been shown to influence entrepreneurial performance (Cox Pahnke, McDonald, Wang, & Hallen, 2015; Hallen, Katila, & Rosenberger, 2014; Katila, Rosenberger, & Eisenhardt, 2008), yet they are overlooked in the context of venture growth. This leads to the following research objective:

Research objective 2: *To create an understanding of the extent to which the startups' degree of product digitization shapes startup growth and identify the role of dependencies in startup/VC investor networks to this end.*

I address this research objective in chapter 3. With my co-authors, I draw on a sample of 461 U.S. cleantech startups from 2004 to 2018. To quantify the granular differences in the startups' degree of product digitization, we introduce a novel, text-based measure by scraping the product and technology webpages of startups using Python. We then operationalize the dependencies in startup/VC investor networks by borrowing from network theory and classifying dependencies as diversified or centralized (Brandes, 2016; Hochberg, Ljungqvist, & Lu, 2007). To study the direct effect of the startups' product digitization and the direct effect of dependencies in startup/VC investor networks on venture growth, we rely on Cox proportional hazard models. We further present the interaction effects of startup and VC investor dependencies and product digitization on venture growth to provide insights into which dependence compositions benefit startups with various degrees of product digitization.

Besides resources from VC investors, startups need to mobilize further resources to navigate the life cycle (Clough et al., 2019; Fisher, Kotha, & Lahiri, 2016). While non-digital and digital startups have already been compared concerning business model evolution and cooperation patterns (Kollmann et al., 2021; König et al., 2019), resource mobilization approaches across different life cycle stages have been overlooked. Furthermore, a hybrid startup type has emerged, whose products often contain smart components (Yoo, Boland, Lyytinen, & Majchrzak, 2012; Yoo, Henfridsson, & Lyytinen, 2010). Yet, the resource mobilization approaches of non-digital, hybrid, and digital startups along the entrepreneurial life cycle have not been clarified. Thus, the research objective is as follows:

Research objective 3: *To create an understanding of how non-digital, hybrid, and digital startups mobilize financial, social, human, and other resources along the life cycle.*

This research objective is covered in chapter 4. Empirically, I rely on 16 semi-structured interviews with U.S. cleantech startups, investors, and industry experts to get an in-depth understanding of the resource mobilization approaches of the three startup types. I combine this primary data with secondary data from publicly available information from company websites and LinkedIn posts. For analyzing the qualitative data, I apply a combination of the deductive and inductive approaches and rely on a mix of concept-driven and data-driven coding. My results are summarized in a holistic framework that clarifies the resource mobilization approaches of non-digital, hybrid, and digital startups.

Overall, the objective of this dissertation is to generate new insights on the resource mobilization of cleantech startups related to political ideology and product digitization. I intend to make theoretical contributions, derive managerial implications for startups and VC investors, and determine policy and methodological implications.

1.3 Structure of the dissertation

This dissertation comprises three studies that cover mechanisms and processes related to resource mobilization by cleantech startups. While the study in chapter 2 explores the role of political ideology in resource mobilization, the studies in chapter 3 and 4 provide novel perspectives on product digitization. In the following, I describe the structure of this dissertation.

Chapter 2 titled "*(No) Politics at work? The relevance of political ideology for new venture VC financing*" explores the extent to which VC investors' political ideology affects their investment decisions. In the beginning, the topic is introduced (see section 2.1). In terms of the theoretical background, my co-authors and I build on the value- and identity-based perspectives related to the political ideology of VC investors. We then develop the first hypothesis concerning the effect of VC investors' political ideology on investment rounds received by the venture and further propose three contingencies of startup attributes that moderate this effect (see section 2.2). The following section describes the methods including the sample of cleantech and fintech ventures, data sources, and the variables used in the models (see section 2.3). Subsequently, we present the results of the regression and sensitivity analyses (see section 2.4). Finally, we describe how the theoretical contributions of this study advance our understanding of the resource mobilization of new ventures. We also outline managerial implications for ventures and VC investors, as well as limitations and future research opportunities (see section 2.5).

Chapter 3 titled "*Digitize and grow? How product digitization affects new venture growth*" examines the effects of product digitization and dependencies in startup/VC investor networks on growth outcomes. After an introduction (see section 3.1), my co-authors and I review the theoretical background in section 3.2. We focus on network composition and the nature of products as drivers of venture growth and specifically pay attention to product digitization as a novel dimension of the nature of products. We subsequently develop our hypotheses and theorize how product digitization and startup/VC investor dependencies induced in networks might affect venture growth (see section 3.3). Subsequently, the methods employed in this quantitative study are described in section 3.4. Accordingly, we elaborate on the research setting of U.S. cleantech startups, the sample and data collection, and the variables and specifications used in the models. The following section describes the results of the quantitative analyses of predictors of venture growth (see section 3.5). After presenting the main results, we also describe the results of the sensitivity analyses to ensure robustness. In conclusion to this chapter, in section 3.6, we provide a summary of the findings and present theoretical, managerial, and methodological implications. We also elaborate on the limitations of this study and identify future research directions.

Chapter 4 titled "*From atoms to bits: Resource mobilization of non-digital, hybrid, and digital cleantech startups*" investigates how non-digital, hybrid, and digital cleantech startups mobilize financial, social, human, and other resources along the life cycle. This chapter begins with an introduction (see section 4.1). Afterward, I explain the theoretical background of this study (see section 4.2). To this end, I review the literature on entrepreneurial resource mobilization and life cycle dynamics and elaborate on the typology of non-digital, hybrid, and digital startups. The next section describes the research context of the U.S. cleantech industry, specifically cleantech startups (see section 4.3). Thereafter, the methods employed in this qualitative study are described in section 4.4. The following section presents the results in terms of a novel framework that clarifies the resource mobilization approaches of non-digital, hybrid, and digital startups along the entrepreneurial life cycle (see section 4.5). This chapter closes with a discussion and conclusion (see section 4.6). Accordingly, I summarize the findings and expound the theoretical, managerial, and policy implications, as well as this study's limitations and future research opportunities.

Chapter 5 concludes the dissertation, summarizing the main findings and implications of the three studies and providing an outlook for future research.

2 (No) Politics at work? The relevance of political ideology for new venture VC financing[1]

2.1 Introduction

Access to VC is critical for new ventures to overcome the "valley of death", i.e., the funding gap in the technology development and commercialization phase (De Clercq et al., 2006; Frank, Sink, Mynatt, Rogers, & Rappazzo, 1996; Lee, Lee, & Pennings, 2001). While there is growing evidence that founder-related factors such as human capital influence investors' funding decisions (Bosma, Van Praag, Thurik, & De Wit, 2004; Brüderl, Preisendörfer, & Ziegler, 1992; Cassar, 2006; Tzabbar & Margolis, 2017), few studies have focused on investors' characteristics. Among the limited research that has considered investor characteristics, Matusik et al. (2008) highlight that investors' personal value systems, specifically process values, can affect how they judge venture quality. In this regard, a potentially influential dimension of investors' personal value about which we have little understanding is the one emanating from their political ideology (Swigart et al., 2020).

Ideology has been an increasingly polarizing force over the last decades. In particular, the U.S. liberal/conservative divide has been on the ascendency for many years, much before its more visible recent manifestations such as the Tea Party movement (Bonica, 2014; Wasserman & Flinn, 2017). Research has identified the critical importance of political ideology in decisions related to investment in financial markets (Bonaparte et al., 2017; Hong & Kostovetsky, 2012; Jiang, Kumar, & Law, 2016; Kaustia & Torstila, 2011) and strategic choices by firms (Chin et al., 2013; Christensen, Dhaliwal, Boivie, & Graffin, 2015; Gupta et al., 2018; Hutton, Jiang, & Kumar, 2014). These studies demonstrate that ideology influences the behavior of a range of actors, from retail investors and financial analysts to employees and corporate executives. This makes it compelling to understand whether and how ideology affects the behavior of VC investors, with potentially major implications for entrepreneurship research and practice.

This paper examines the impact of the political ideology of VC investors in shaping their assessments of new ventures' quality and, in turn, their investment decisions. Research shows that people of different ideologies have different tolerances to uncertainty

[1] This study is co-authored by Claudia Doblinger (Technical University of Munich) and Jojo Jacob (Grenoble Ecole de Management). All authors made equal contributions to this study. I presented prior versions of this study at the 2021 Academy of Management Annual Meeting and the 2019 Strategic Management Society Conference.

(Jost et al., 2007), so the political ideology of VC investors is likely to be a salient influence in the uncertain setting of new ventures. We conceptualize political ideology as representing both a set of values and identities that translate into specific patterns of judgments and behaviors (Jost, 2006). Characterizing political ideology along a liberal/conservative spectrum, we suggest that the different value orientations of conservatives and liberals translate into a lower tolerance to uncertainty for the former compared with the latter (Jost, Nosek, & Gosling, 2008; Swigart et al., 2020). Building on this premise, we first propose that higher VC investor conservatism may result in fewer investment rounds received by a venture. We further investigate the effect of VC investor ideology by adopting an identity perspective, which considers political ideology as a label that unites individuals, including those with different personal values, making them emotionally sensitive to the events pertaining to their common social group (Ellis & Stimson, 2012; Levitin & Miller, 1979). Research has documented the significance of ideological identity in enabling individuals to make sense of their environment in uncertain situations and arrive at decisions (Swigart et al., 2020). We build on these insights to suggest that ideological congruence of conservative VC investors with ventures, as well as with the spatial setting in which the ventures operate, could attenuate their low tolerance to uncertainty. Furthermore, we consider whether ideologically sensitive issues, in particular climate change, accentuate the liberal/conservative divide. We examine this by testing whether the effect of VC investor conservativism on venture investments is stronger in the sensitive cleantech sector compared with that in the relatively ideologically neutral fintech sector.

Our analysis of 415 U.S. cleantech and fintech ventures between 2008 and 2018 suggests that VC investor conservatism lowers the likelihood of their investments in ventures. Importantly, the results also indicate that the effect of investor conservatism weakens when the ideology of the venture is congruent with that of the VC investor or if the venture operates in a conservative spatial environment. Finally, contrary to our predictions, we find no significant difference in the effect of VC investor ideology between the cleantech and fintech sectors, suggesting that conservative investors after all may not have a strong negative attitude towards environmental action.

By bringing political ideology into focus in the context of VC investment decisions, this paper advances our understanding of resource mobilization in new ventures in several ways. *First*, in comparison with the dominant focus in the literature on venture characteristics for resource mobilization, we add to the limited research that has paid attention to the significance of investor characteristics (Fu & Tietz, 2019; Matusik et al., 2008). Specifically, we focus on investors' political ideology as an essential dimension of their value systems. Furthermore, we examine the interplay of the ideology of investors with that of both the ventures and their spatial environment. *Second*, our research responds to the concern raised recently about the lack of research on non-market logics of resource access (Clough et al., 2019), by demonstrating how ideological priorities – and not simply pure economic rationality – guide investment decisions. *Third*, our approach of combining the value and identity perspectives of political ideology advances the treatment of ideology in the broader management literature in which the attention was primarily on the value dimension of ideology (Chin et al., 2013; Christensen et al., 2015; Hutton et al., 2014). Our research highlights important ways in which the identity dimension of political ideology can serve as a boundary condition for the impact of ideologies' value dimension on investment behaviors and decisions. Finally, our findings offer critical practical insights for ventures on how VC investors' political ideology can color their assessment of ventures, enabling ventures to guard against important biases arising from the ideology of investors.

2.2 Theoretical background and hypotheses development

2.2.1 VC investor political ideology: A value and identity-based perspective

Political ideology represents a set of deeply held and interconnected values and beliefs about desirable outcomes (Simons & Ingram, 1997). Therefore, it serves as a cognitive filter through which actors gather and process information in ways that enable them to derive conclusions that meet their cognitive goals (Swigart et al., 2020). Political ideology is widely recognized to influence a range of critical organizational decisions, such as hiring employees, engaging in corporate social responsibility, or response to chief executive officer (CEO) misconduct (Gupta, Nadkarni, & Mariam, 2019; Park, Boeker, & Gomulya, 2020; Roth et al., 2020).

Political ideology research typically compares the opposing ideologies of liberalism and conservativism, focusing on their different values and identities to explain ideology-driven differences in behaviors (Tedin, 1987). The *value-based perspective* of political ideology refers to personal beliefs, such as preference for tradition vs. universalism, while the identity dimension relates to emotional connections with ideologically similar actors (Swigart et al., 2020). From a value-based perspective, those possessing liberal values, i.e., liberals, have a prosocial, universalistic orientation that motivates them to challenge the established order and bring about social change, such as a more egalitarian society or a cleaner environment (Graham, Merges, Samuelson, & Sichelman, 2009; Jost et al., 2007). Conservatives, in contrast, believe that individuals possess the agency to change their situations themselves, and hence prefer to preserve the established order rather than change it (Fielding & Hornsey, 2016; Graham et al., 2009). Political psychology literature explains these different value orientations of liberals and conservatives in terms of their different psychological needs (Jost, Glaser, Kruglanski, & Sulloway, 2003). In particular, compared with liberals, conservatives have a greater need to reduce uncertainty and threat, making them resist change because of the uncertainty and chaos it may create.

From an *identity-based perspective*, political ideology triggers a social categorization process that sorts actors along ideological lines into ingroups and outgroups, such as liberals or conservatives (Devine, 2015; Levitin & Miller, 1979). Actors are emotionally attached to those who belong to their ingroup and judge them as superior to those in the outgroup. This manifests in favored treatments of ingroup members, for example in evaluations and resource distributions, compared with outgroup members (Fielding & Hornsey, 2016). Uncertainty can make actors accentuate their similarities in attitudes and behaviors with their ingroup members and differences in these with their outgroup members (Hogg, 2014). This accentuation of ingroup similarities and outgroup differences is likely to be stronger for conservatives because of their preferences for certainty and safety. Therefore, conservative actors may especially rely on ideological identity in order to arrive at decisions under uncertainty (Graham et al., 2009).

Ideology-based social categorization can also derive from the ideological leanings of actors' spatial locations that may offer clues about actors' ideological leanings (Gift & Gift, 2015). This process of social categorization can assume particular importance in contexts where actors' ideology is unknown or ambiguous, as with new ventures who have a short history. The third source of social categorization based on ideological identity is the common position that members of the ideological ingroup take on key issues, even when not all ingroup members may believe in those positions. As a result, when an idea is perceived as associated with a certain ideology, it may trigger emotionally charged ingroup/outgroup polarization, as it is often the case with several key social and environmental issues (Fielding & Hornsey, 2016).

We mobilize these insights on values and identities associated with liberalism and conservativism to explain different ways that ideology influences VC investments in the uncertain setting of new ventures. The lower tolerance to uncertainty for conservatives than for liberals can mean that these two types of investors may have different propensities to invest in ventures. The different tolerances for uncertainty of liberals and conservatives can also mean that these two categories of VC investors rely on ideological identities differently to arrive at investment decisions under uncertainty. We will then argue that VC investors may compensate for new ventures' short history by inferring ventures' ideological leanings using those of the spatial locations in which the ventures operate. Finally, we will use both value and identity lenses to propose that liberal and conservative VC investors may have different preferences for investments in industries that are ideologically sensitive, such as cleantech.

2.2.2 VC investor values, uncertainty, and venture investment decisions

Political psychology research identifies contrasting preferences for change and stability between liberals and conservatives. The uncertainty-threat model of political conservatism by Jost and colleagues argues that underlying these divergent preferences is the psychological need of conservatives, compared with that of liberals, to seek certainty (Jost et al., 2003). Subsequent research confirms a good fit between the different tolerances for uncertainty between liberals and conservatives and their different personal and cognitive preferences (Bonanno & Jost, 2006; Caparos, Fortier-St-Pierre, Gosselin, Blanchette, & Brisson, 2015). Specifically, studies report that conservatives score low on open-mindedness, curiosity, and novelty-seeking in line with their preference for cognitive closure, certainty, order, and stability (Carney, Jost, Gosling, & Potter, 2008; Jost et al., 2007; Price, Ottati, Wilson, & Kim, 2015). Liberals, in contrast, score high on intellectual curiosity, creativity, and openness to new experiences, reflecting their outlook of the world as complex and uncertain (Carney et al., 2008; Costa & McCrae, 1992; Jost et al., 2007).

Ideology-based differences manifest strongly not solely in political domains (Carney et al., 2008; Swigart et al., 2020) but also in the organizational context. Studies reveal that when experiencing uncertainty, organizational leaders' ideological values play a critical role in their decision-making (Chin et al., 2013; Gupta et al., 2018). Therefore, given the high uncertainty surrounding the new venture context, it is likely that political ideology is an important factor in explaining the decisions of VC investors. VC investors confront significant difficulties in predicting ventures' growth potentials owing to the information asymmetry problems arising from the intangible nature of ventures' assets and their limited track records (Clough et al., 2019; Islam, Fremeth, & Marcus, 2018). The literature suggests that in this situation of limited objective information about new ventures and the high uncertainty surrounding them, VC investors arrive at decisions based on the emotions and biases emanating from their value systems (Gimmon & Levie, 2010; Oaksford, Morris, Grainger, & Williams, 1996; Zacharakis & Shepherd, 2001). Matusik et al. (2008) provide empirical evidence for this style of decision-making, revealing that the personal values of VC investors play a key influence on their decisions under uncertainty.

Taken together, the different behaviors emanating from conservative and liberal value systems on the one hand and VC investors' dependence on their value systems on the other, lead us to suggest that political ideology is a notable influence on VC investments in new ventures. The unpredictability and the trial and error process associated with venture growth contrast with the conservative disposition for stability and order but fit with the liberal orientation towards curiosity, creativity, and flexibility. Conservative VC investors may be less comfortable with the chaos and uncertainty surrounding new ventures. Studies on managerial behavior support this prediction about political ideology and tolerance to uncertainty, pointing out that conservatives engage in less-risky corporate tax avoidance strategies (Christensen et al., 2015) and are less debt-averse than liberals in financial investment decisions (Hutton et al., 2014). We thus propose the following hypothesis:

Hypothesis 1: *Higher VC investor conservatism is negatively associated with the number of VC investment rounds received by a venture.*

2.2.3 The moderating effect of the venture's ideological identity

The distinct identities of liberalism and conservativism generate a social categorization process that creates ingroup favoritism and outgroup derogation (Iyengar, Sood, & Lelkes, 2012). The effect of this social categorization process extends beyond the realm of politics, influencing critical organizational decisions such as hiring (Gift & Gift, 2015; Roth et al., 2020) and mergers and acquisitions (Alnahedh & Alhashel, 2021; Chow, Louca, Petrou, & Procopiou, 2022).

Uncertain contexts magnify social categorization because actors accentuate similarities with the ingroup and differences with the outgroup for resolving uncertainty (Hogg, 2014). Therefore, social categorization can be particularly salient for VC investors' decision-making, given the highly uncertain context of new ventures as well as the emotional decision-making style of VC investors. Indeed, research shows that VC investors positively evaluate their ingroups, defined by non-ideological dimensions that include both observable characteristics such as ethnicity (Bengtsson & Hsu, 2015; Hegde

& Tumlinson, 2014) and gender (Brooks, Huang, Kearney, & Murray, 2014; Marlow & Patton, 2005), as well as less observable characteristics such as decision-making processes (Murnieks, Haynie, Wiltbank, & Harting, 2011) and process values (Matusik et al., 2008).

Combining the views that political ideology is a critical dimension of identity and social categorization on the one hand and that VC investors' emotional decision-making style makes social categorization important on the other, we conjecture that ideology-based social categorization influences VC investment decisions. Specifically, we expect that conservative VC investors may rely more on ideological identity than liberal VC investors because of the former's need for reducing uncertainty (Devine, 2015). This suggests that ideological congruence between VC investors and new ventures may weaken the negative effect, proposed in Hypothesis 1, of VC investor conservatism on their investments:

Hypothesis 2: *VC investor conservatism has a less negative impact on the number of VC investment rounds when a venture has a conservative ideology than when it has a liberal ideology.*

2.2.4 The moderating effect of the venture's spatial ideological identity

VC investors may further make social categorization of new ventures by assessing the political ideology of the venture's spatial location. Political science research shows that the ideological atmosphere of a spatial location has a strong influence on its inhabitants' ideological orientations (Iyengar et al., 2012; Williamson, 2008). Spatial ideological identity can thus facilitate the ideological stereotyping of actors inhabiting it (Swigart et al., 2020), serving as a heuristic to sort actors into either the ideological ingroup or outgroup (Hogg & Terry, 2000; Kunda & Spencer, 2003). A study in a non-venture context finds that ingroup/outgroup categorization based on spatial ideology results in the favorable treatment of actors in the ideological ingroup, compared with those in the outgroup (Gift & Gift, 2015).

Bringing these insights into the venture context, ventures' newness and their limited operational history may mean that VC investors confront information asymmetry problems related to ventures' ideological leanings. This can make the spatial ideological identity of the venture a heuristic to assess the venture's ideology. A new venture can thus get a liberal or conservative label from the VC investor depending on the ideological dispositions of the spatial location where it is embedded. Spatial ideology can thus supplement venture ideology in shaping the effect of uncertainty on VC investment decisions. Therefore, similar to venture ideology, we expect that the congruence of the venture's spatial ideology and VC investor ideology will weaken the negative effect of VC investor conservatism on VC investments in ventures:

Hypothesis 3: *VC investor conservatism has a less negative impact on the number of VC investment rounds when the venture operates in a conservative spatial location compared with when it operates in a liberal spatial location.*

2.2.5 The moderating effect of the venture's industry orientation

The liberal/conservative divide also manifests in different attitudes, beliefs, and actions on major issues, such as those related to the environment. There is wide agreement that conservatives have much lower concerns about environmental issues, in particular climate change, compared with liberals (Jenkins-Smith et al., 2020; Kemper, Ballantine, & Hall, 2018; McCright & Dunlap, 2011). Political psychology literature explains this difference in terms of the different values and social identities of liberals and conservatives.

From a value-based perspective, environmental action represents challenging the status quo and upending traditional arrangements (Jost et al., 2007). This goes against conservatives' treasured values of tradition and conformity and may even represent an attack on their way of life, but it aligns with liberals' prized values of universalism and benevolence (Hornsey, Harris, Bain, & Fielding, 2016; Jost et al., 2007). Confirming these different value preferences, research reveals that conservatives score lower than liberals on social value orientation (Sheldon & Nichols, 2009; Van Lange, Bekkers, Chirumbolo, & Leone, 2012) and altruism (Zettler & Hilbig, 2010; Zettler, Hilbig, & Haubrich, 2011).

The liberal/conservative divide on environmental issues reflects not only investors' different value preferences but also their distinct identities. Environmental campaigns are generally associated with liberals, such that environmental action is built into the ingroup norms of liberals and the outgroup norms of conservatives. In other words, environmental action is a salient dimension of social categorization between liberals and conservatives as it rallies liberals to support it and conservatives to oppose it (Fielding & Hornsey, 2016). This further implies that even if actors' personal values do not have any bearing on their attitude towards environmental action, their group allegiances may lead them to support or reject it (Brown, 2000; Hewstone, Rubin, & Willis, 2002).

Summarizing, personal values and ideological identity jointly make conservatives hold a rather negative attitude, and liberals a positive attitude, towards environmental action. This may suggest that conservative VC investors have a lower preference for investment in environment-related industries, such as cleantech, compared with relatively ideology-free industries, such as fintech (Goldfarb, Buessing, & Kriner, 2016; Gromet, Kunreuther, & Larrick, 2013; Olson-Hazboun et al., 2018). Cleantech innovations provide environmental value that benefits society as a whole (Hockerts & Wüstenhagen, 2010), making the sector ideologically controversial. There is some evidence that ideological biases loom large on economic activities that generate social value creation. For example, studies on corporate social responsibility demonstrate that conservatives are less supportive of corporate social responsibility activities than liberals (Chin et al., 2013; Gupta, Briscoe, & Hambrick, 2017; Gupta et al., 2019), and studies on investment portfolios suggest that conservatives are less likely to invest in socially responsible industries (Aiken, Ellis, & Kang, 2020; Hong & Kostovetsky, 2012). Overall, these results align with the view that conservatives are less inclined to believe that economic activity should serve a moral function, such as protecting the environment, compared to liberals (Cruz, 2017; Hornsey et al., 2016).

Unlike cleantech, fintech represents an ideologically neutral industry in which positive externalities in terms of social value creation are largely absent or have not stirred ideology-based controversies. In general, the financial sector is ideologically unaligned with either liberals or conservatives (Bonica, 2014). Recent research on bank directors reveals that they are largely evenly distributed across the liberal/conservative spectrum (Ainsley, 2021).

Summarizing, factors related to personal values and ideological identity combine to make the cleantech sector liberal-leaning, while fintech represents an ideologically neutral sector. Conservative VC investors, in the extreme, may perceive cleantech ventures as threatening the existing social order and as carrying a liberal agenda. Therefore, the ideological overtones associated with the cleantech sector may accentuate the effect of uncertainty, further reducing conservative VC investors' preference for venture investment in this sector. This leads us to propose the final hypothesis of the study as follows:

Hypothesis 4: *VC investor conservatism has a more negative impact on the number of VC investment rounds for cleantech ventures compared with fintech ventures.*

2.3 Methods

2.3.1 Sample and data sources

To maximize the generalizability of our findings, we constructed a panel dataset that contains new ventures from two sectors of different ideological sensitivity: cleantech, which is generally considered highly ideologically sensitive, and fintech, which is ideologically neutral. We randomly chose the names of 300 cleantech ventures from the i3 Cleantech Group database and 300 fintech ventures from Crunchbase; we used the categories “fintech” and “finance” in Crunchbase to identify fintech ventures. We incorporated funding data from the databases ThomsonOne, Preqin, and Crunchbase. To be considered a venture in our panel, a firm had to be younger than 10 years in year *t*, with t_0 defined as 2008. We only included ventures with U.S headquarters that have received at least one investment round with at least one VC investor being involved during the panel period between 2008 and 2018. The resulting dataset contained 415 ventures, consisting of 225 cleantech and 190 fintech ventures.

2.3.2 Variables

Dependent variable

Investment rounds. We measure new venture financing as the number of investment rounds received by venture *i* in year *t*. The number of investment rounds is related to the financial resources received by a venture in exchange for equity (De Clercq et al., 2006), thus indicating the ventures’ ability to attract VC investors’ investment commitments. We collected this information annually from the ThomsonOne, Preqin, and Crunchbase databases.

Furthermore, for sensitivity analyses, we also collected information on VC investment amounts received by the venture from the same sources. Our preference for the number of investment rounds is because of the rather sensitive nature of information on the magnitude of financing rounds, which makes this information often not consistently available; in contrast to the readily available information on the occurrence of an investment round (Howell, 2017). Therefore, we chose to focus on the number of rounds instead of the amount received in our main models. We were able to obtain information on the investment amounts for 64.61% of the financing rounds included in our sample. The positive and highly significant correlation between VC investment rounds and VC investment amounts received (see Table 2-1) reassures us about the salience of our measure in capturing VC investments in new ventures.

Variables	1	2	3
1 Investment rounds	1		
2 VC amount (total)	0.377***	1	
3 VC amount (average, by venture age)	0.379***	0.829***	1

Notes: *** p<0.01, ** p<0.05, * p<0.1

Table 2-1: Correlation analysis between VC investment rounds and VC amount

Independent variable

VC investor ideology. We construct our political ideology indexes for VC investors by first measuring individual level political ideologies, in line with Chin et al. (2013), and then aggregating them to the organizational level (Christensen et al., 2015; Gupta & Wowak, 2017). We retrieved the names of VC investors from the ThomsonOne, Preqin, and Crunchbase databases, and then applied two filters to select the final set of investors. First, we only included professional VC firms as investors, since their investments have the same motive of equity growth and they, furthermore, make investments in all venture funding stages (De Clercq et al., 2006). Second, we only considered U.S.-based VC investors, enabling us to measure ventures' and VC investors' ideologies in a consistent manner, i.e., in relation to the U.S. political system.

We distinguish political ideology in terms of the bipartite division of the U.S. political system between the Democratic Party and the Republican Party. This aligns with the widely-held view that conservative individuals are drawn to the Republican Party, whereas political liberalism is associated with the Democratic Party (Hutton et al., 2014; Layman, Carsey, & Horowitz, 2006). A rich body of research has used the Democrat vs. Republican distinction to distinguish individuals along ideological lines (e.g., Jost, 2006; Poole & Rosenthal, 1984). We follow the approach in prior research of using political donations to the two major parties to proxy ideological orientation (Gupta et al., 2017; Hong & Kostovetsky, 2012; Hutton et al., 2014). Thus, we identify individuals as liberal-leaning or conservative-leaning based on their donations to the Democratic Party or the Republican Party (Gupta et al., 2017). Specific to our research, the advantage of this approach is that donation data, for the most part, are publicly available, enabling the construction of VC investors' ideology in a consistent manner.

We premise that VC investors' ideology is a composite of their employees' ideologies (Gupta et al., 2017). We measured VC investors' ideology on an annual basis using information on political donations of employees to the Democratic Party and the Republican Party. In line with Chin et al. (2013), we retrieved political donations from the Center for Responsive Politics[2], which reports the exact donation data as the U.S. Federal Election Commission. In the database of the Center for Responsive Politics, we searched for donations of VC investors' employees from 2008 to 2018. We subsequently made use of online resources such as LinkedIn, AngelList, and websites of VC investors to ensure that donors are matched correctly with VC investors they are employed with. We excluded donations to independent candidates, political action committees that give money to both the Democratic and Republican Party, and other parties than the Democratic and Republican Party. This yielded 20,055 donations that we coded as either Democratic or Republican.

Our political ideology measure is based on a multi-item index developed by Chin et al. (2013). It includes four indicators that measure the level of four different commitments to an ideological orientation. First of these is *behavioral commitment*, measured by dividing the number of donations to the Democratic Party by the number of donations to both parties. Second is *financial commitment*, calculated as the dollar amount donated to the Democratic Party divided by the dollar amount donated to both parties. The third indicator is the *persistence of commitment*, calculated as the number of years – over a 5-year time window maximum – donations were made to Democrats divided by the number of years donations were made to both parties. We shortened the time window from 10 to 5 years maximum. The original index was designed to measure political ideology on an individual level. Since we measure political ideology on an organizational level, where employee turnover has to be taken into account, a 5-year time window seemed to be more appropriate. If the VC investor did not have a 5-year history, i.e., the VC investor was younger than 5 years in year *t*, the length of the time window is the difference between year *t* and the founding year of the VC investor. Fourth of these indicators is the *scope of commitment*, calculated as the number of distinct Democratic recipients divided by the total number of distinct recipients of both parties. We calculated one overarching score by taking the simple average of the four commitment indicators.

In cases where no donations were made, we assigned a score of 0.5, which denotes the middle of the ideological spectrum (Christensen et al., 2015). If a venture has attracted investments from a group of VC investors, the ideology index constitutes the average value of political ideologies of investors in that group (Gupta & Wowak, 2017). Lastly, we inversed all values to yield a political conservatism measure where scores closer to 1 indicate more conservative and scores closer to 0 reveal more liberal-oriented investors.

[2] https://www.opensecrets.org, accessed on July 4, 2022

Moderator variables

Ideological congruence. We operationalized ideological congruence, i.e., the congruence of VC investors' and ventures' ideologies, by calculating the absolute difference between the VC investors' and ventures' ideologies on an annual basis. We used the median of the absolute ideological difference as a cut-off point and defined ideological congruence as a binary variable, which takes the value of 2 when the absolute difference between VC investors' and ventures' ideologies is smaller than the cut-off value, and 1 otherwise.

Spatial congruence. We constructed spatial congruence, i.e., the congruence of VC investors' ideology and the ventures' spatial ideology, in a similar manner as the ideological congruence variable. Here, we focus on the political ideology of the environment in which the venture is headquartered. We proxy the ideological environment of a venture in terms of the ideological leaning of the congressional district and the state where the venture is located. We use the CPVI[3], which is widely used in political science research as a measure of regional political sentiment (e.g., Ellis, 2013; Hertel-Fernandez, 2017). This index captures how strongly a congressional district or state leans toward the Democratic or Republican Party compared to the nation as a whole. We characterize a congressional district or state as Democratic-leaning if the CPVI is greater than D+5 and Republican-leaning if the CPVI is greater than R+5 (Wasserman & Flinn, 2017). Thus, we classify a venture's environment as Democratic-leaning if the CPVIs of both congressional district and state are greater than D+5, and as Republican-leaning if the CPVIs of both congressional district and state are greater than R+5.

We divide the political ideology spectrum of VC investors at the cut-off of 0.5, the neutral political ideology score of the measure, and define VC investors' political ideology as Democratic when the ideology is smaller than 0.5 and Republican when the ideology is greater than 0.5. We then define spatial congruence as a binary variable that takes the value of 2 if the political ideology of the ventures' environment and the VC investors' ideologies are the same, and 1 if the political ideologies are different.

Sector. This is a dummy variable that takes the value of 1 for ventures belonging to the cleantech sector and 0 for those belonging to the fintech sector. As described above, we assigned the sector cleantech to ventures identified from the i3 Cleantech Group database and fintech to ventures that belonged to the "fintech" and "finance" categories in the Crunchbase database.

---

[3] https://www.cookpolitical.com, accessed on July 4, 2022

Investment stage. We include the VC investment stage of the venture to account for the uncertainty associated with the venture. In early-stage investment rounds, compared with late-stage rounds, a venture has a lower track record, which creates higher uncertainty about the quality of the venture (Matusik & Fitza, 2012; Sorenson & Stuart, 2008). Therefore, we include a binary variable that takes the value of 1 for early-stage investment rounds, i.e. seed, Series A, or Series B investment rounds, and 0 for all later-stage rounds. We used the ThomsonOne, Preqin, and Crunchbase databases to obtain this information.

Control variables

Venture ideology. We use venture ideology as a control variable to account for the ideological orientation of the focal venture. We calculated venture ideology analogously to the political ideology of the VC investor, as a multi-item index in line with Chin et al. (2013).

Pre-sample investment round. We control for the impact of prior investment by including a binary variable that takes the value of 1 if the venture has received an investment round prior to 2008, and 0 otherwise. To derive this information, we used the ThomsonOne, Preqin, and Crunchbase databases.

Venture age. We controlled for the ventures' age to account for the uncertainty associated with ventures. We calculated the age as the time difference since the founding year.

Location. We control for the geographical location of the venture because ventures in high-tech entrepreneurial ecosystems with concentrated VC activity might have better access to VC financing. We mapped the zip codes to the metropolitan statistical areas (MSAs) and included a location dummy for the following MSAs: San Francisco-Oakland-Fremont, New York-Northern New Jersey-Long Island, San Jose-Sunnyvale-Santa Clara, Boston-Cambridge-Quincy (57% of ventures are based in these four MSAs), and others.

Year. We included year dummies to recognize time effects of general economic conditions, which may affect VC investment activities.

2.4 Results

2.4.1 Main results

Table 2-2 reports a summary of the descriptive statistics for the 415 ventures (225 cleantech and 190 fintech) in our sample, averaged over time. The ventures in our sample attracted approximately one VC investment round every three years (mean=0.262 per firm-year) with an average volume of 4.821 million USD. Interestingly, the descriptive statistics show similar values for the VC investment rounds of the cleantech (mean=0.263) and fintech (mean=0.262) sub-samples. The ventures are on average five years old. We find that both VC investors and ventures are slightly more on the liberal side (mean<0.5). Figure 2-1 shows the geographic distribution of ventures, revealing a greater percentage of fintech ventures in the New York area, whereas cleantech ventures dominate the other regions. Figure 2-2 compares the distribution of fintech and cleantech ventures among liberal and conservative VC investors, indicating that conservative investors have invested nearly equally in the two types of ventures while liberals tend to invest proportionately more in cleantech (60%). Table 2-3 reports correlations between the main variables, revealing no serious cases of correlation.

	Total sample				**Cleantech sub-sample**				**Fintech sub-sample**			
	Mean	**S.D.**	**Min.**	**Max.**	**Mean**	**S.D.**	**Min.**	**Max.**	**Mean**	**S.D.**	**Min.**	**Max.**
Investment rounds	0.262	0.484	0	3	0.263	0.475	0	2	0.262	0.494	0	3
VC investor ideology	0.481	0.082	0.009	0.960	0.476	0.088	0.013	0.960	0.486	0.073	0.009	0.920
Venture ideology	0.461	0.140	0.005	0.975	0.446	0.151	0.007	0.975	0.478	0.122	0.005	0.964
Pre-sample inv. round	0.398	0.489	0	1	0.604	0.489	0	1	0.141	0.349	0	1
Venture age	5.009	2.891	0	10	5.482	2.875	0	10	4.422	2.804	0	10
Observations	3,696	3,696	3,696	3,696	2,048	2,048	2,048	2,048	1,648	1,648	1,648	1,648

Table 2-2: Descriptive statistics of variables used in the analysis

Variables	**1**	**2**	**3**	**4**	**5**
1 Investment rounds	1				
2 VC investor ideology	-0.405***	1			
3 Venture ideology	-0.034*	0.057***	1		
4 Pre-sample inv. round	0.034*	-0.042*	-0.0707***	1	
5 Venture age	-0.197***	0.107***	-0.086***	0.303***	1

Notes: *** p<0.01, ** p<0.05, * p<0.1

Table 2-3: Correlations of variables used in the analysis

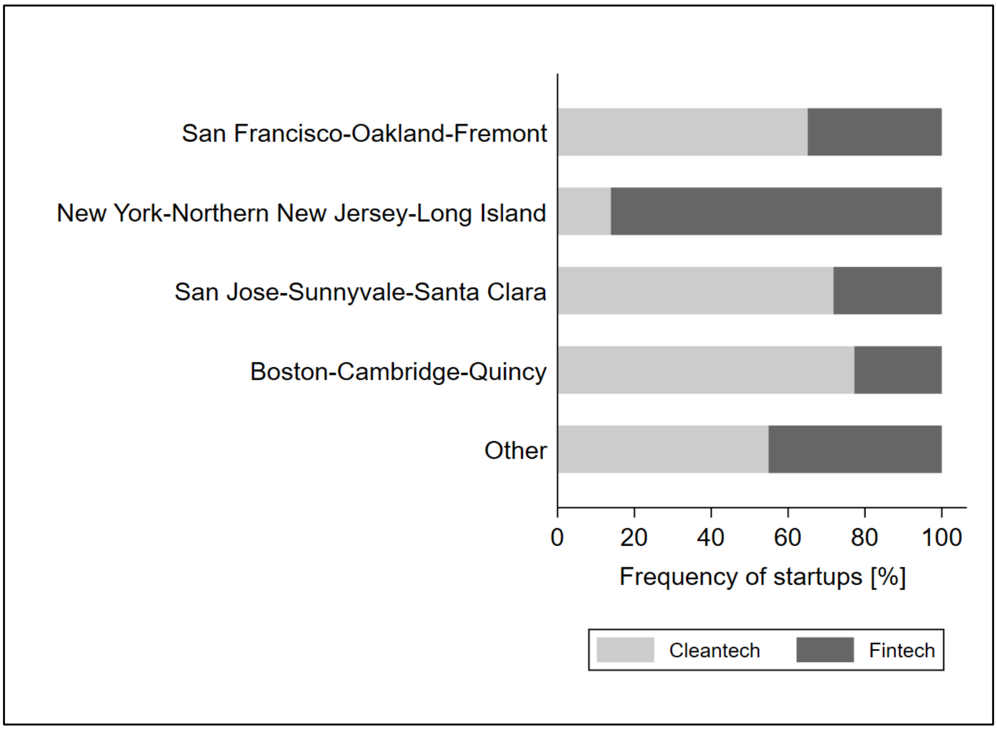


Figure 2-1: Venture sector and venture location

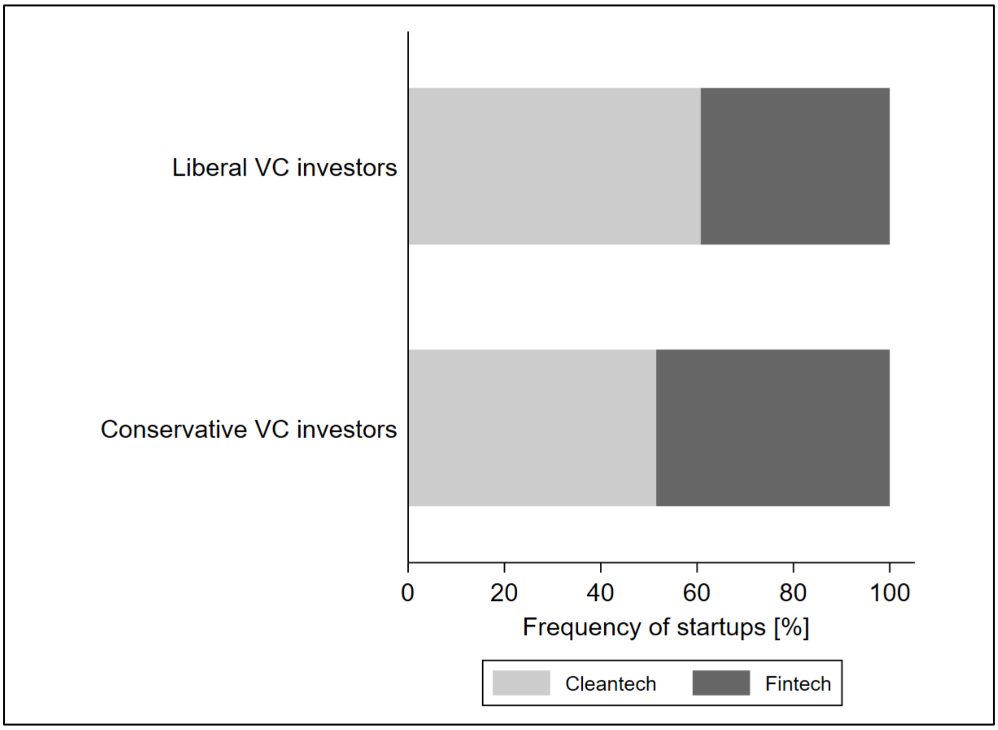


Figure 2-2: Venture sector and VC investor ideology

To examine the impact of VC investor political ideology on the likelihood of VC investment rounds in a new venture, we employ a Poisson regression model because our dependent variable, VC financing rounds, is a count variable. We tested for overdispersion using the goodness of fit test statistic, which revealed insignificant test statistics for all our models. We estimate our models with standard errors clustered by the venture and include fixed effects for sector (fintech vs. cleantech), geographic location of the venture (MSA), and time (year) (see Table 2-4). We adopted a hierarchical estimation approach starting with a model that consists of only the control variables (Model 1). Model 2 adds VC investor ideology, while the subsequent models incorporate the moderating effects sequentially. Model 3 adds the interaction between VC investor ideology and the ideological congruence between VC investors and ventures, Model 4 the interaction between VC investor ideology and spatial congruence, i.e., the congruence between VC investor ideology and the ideology of the venture's spatial context. Model 5 introduces the interaction between VC investor ideology and sector (fintech vs. cleantech). We include location and year dummies, which are not reported to conserve space.

Table 2-4 reports the results of the Poisson regression models explaining investment rounds. We find that VC investor conservatism leads to less investments in the venture (β =-4.405, p-value=0.000, Model 2), which supports Hypothesis 1. The incidence rate ratio indicates that a one unit increase in ideology, i.e., from liberal to conservative (from 0 to 1), is associated with a 98.8% reduction in VC investment rounds (incidence rate ratio=0.012; 1-0.012=0.988). Looking at the moderating effect of ideological congruence, we find, in support of Hypothesis 2, that the negative effect of conservative ideology of VC investors is weaker when the venture also holds a conservative ideology (see Model 3 and Figure 2-3). As depicted in Figure 2-3, the predicted number of VC investment rounds for ideological congruence of VC investor and venture ideology (dashed line) evolves from 0.629 (10% percentile, indicating very liberal investors) to 1.982 (90% percentile, indicating very conservative investors). For difference between VC investor and venture ideology (solid line), we observe the opposite trend, where the predicted number of VC investment rounds reduces from 2.579 (10% percentile) to 0.004 (90% percentile). We also confirm Hypothesis 3 by finding that a conservative spatial environment mitigates the negative effect of VC investors' conservative ideology (see Model 4 and Figure 2-4). Figure 2-4 suggests that the predicted number of VC investment rounds for spatial congruence of the VC investor and the venture's spatial ideology (dashed line) evolves from 0.980 (10% percentile, indicating very liberal investors) to 1.144 (90% percentile, indicating very conservative investors). For difference between VC investor ideology and the venture's spatial ideology (solid line), we again observe the opposite trend, with the predicted number of VC investment rounds reducing from 1.177 (10% percentile) to 0.022 (90% percentile). However, while we expected that conservative investors would more likely invest in fintech ventures, whereas liberal investors would favor cleantech (Hypothesis 4), we could not find statistical support for a differential effect of VC investor ideology between the two sectors (see Model 5).

DV: Investment rounds	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
	Controls	VC investor ideology	VC investor ideology # Ideological congruence	VC investor ideology # Spatial congruence	VC investor ideology # Sector	VC investor ideology # Investment stage (sensitivity)
VC investor ideology		-4.405*** (0.000) [0.257]	-6.508*** (0.000) [0.359]	-3.957*** (0.000) [0.599]	-4.459*** (0.000) [0.304]	-4.889*** (0.000) [0.314]
Ideological congruence			-1.410*** (0.000) [0.178]			
Spatial congruence				-0.183 (0.509) [0.277]		
Sector	0.100 (0.274) [0.091]	0.145 (0.112) [0.091]	0.094 (0.153) [0.065]	0.104 (0.141) [0.070]	0.085 (0.686) [0.210]	0.145** (0.039) [0.070]
Investment stage						-0.315* (0.054) [0.163]
VC investor ideology # Ideological congruence			7.655*** (0.000) [0.453]			
VC investor ideology # Spatial congruence				4.112*** (0.000) [0.601]		
VC investor ideology # Sector					0.142 (0.776) [0.498]	
VC investor ideology # Investment stage						5.103*** (0.000) [0.373]
Venture ideology	-0.575** (0.012) [0.228]	-0.373* (0.075) [0.209]	-1.439*** (0.000) [0.278]	-0.087 (0.619) [0.174]	-0.369* (0.078) [0.210]	0.142 (0.370) [0.159]
Pre-sample inv. round	0.398*** (0.001) [0.115]	0.365*** (0.001) [0.110]	0.207** (0.015) [0.085]	0.239** (0.012) [0.095]	0.366*** (0.001) [0.111]	0.283*** (0.002) [0.091]
Venture age	-0.152*** (0.000) [0.026]	-0.125*** (0.000) [0.025]	-0.050*** (0.008) [0.019]	-0.103*** (0.000) [0.023]	-0.125*** (0.000) [0.025]	-0.193*** (0.000) [0.023]
Constant	-0.413*** (0.007) [0.152]	1.140*** (0.000) [0.155]	1.784*** (0.000) [0.203]	0.466* (0.087) [0.272]	1.157*** (0.000) [0.163]	1.013*** (0.000) [0.143]
Location FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	3,696	3,696	3,696	3,696	3,696	3,656
Pseudo R2	0.042	0.100	0.292	0.174	0.100	0.223

Notes: P-values are displayed in parentheses and standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 2-4: Estimated coefficients of Poisson regressions of investment rounds

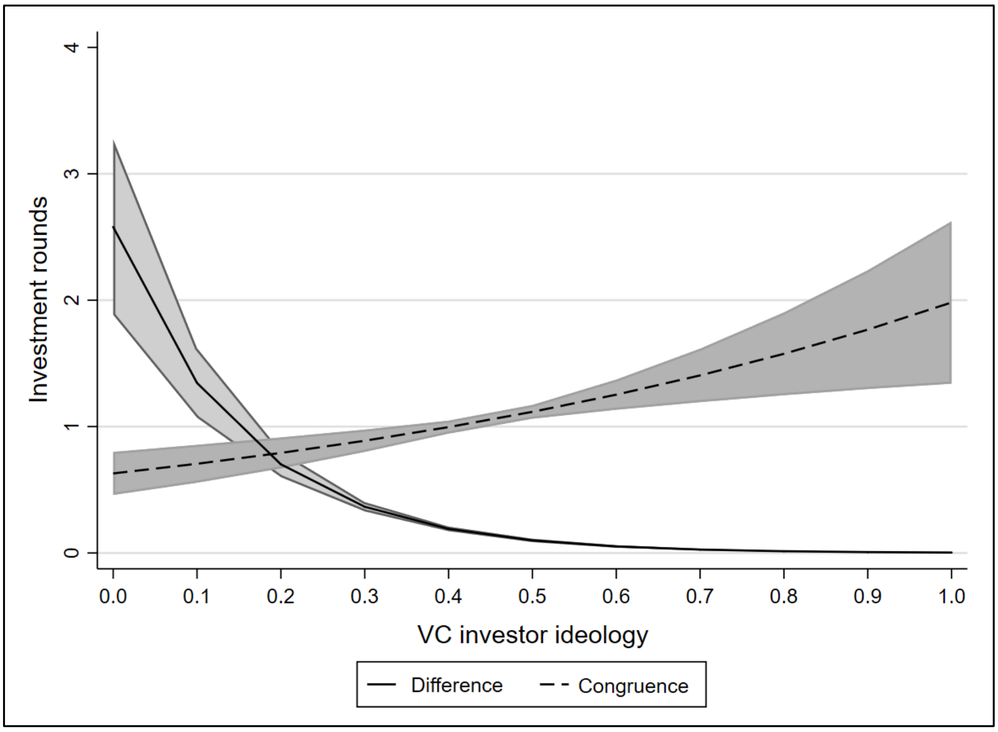


Figure 2-3: Interaction effect: VC investor ideology x Ideological congruence

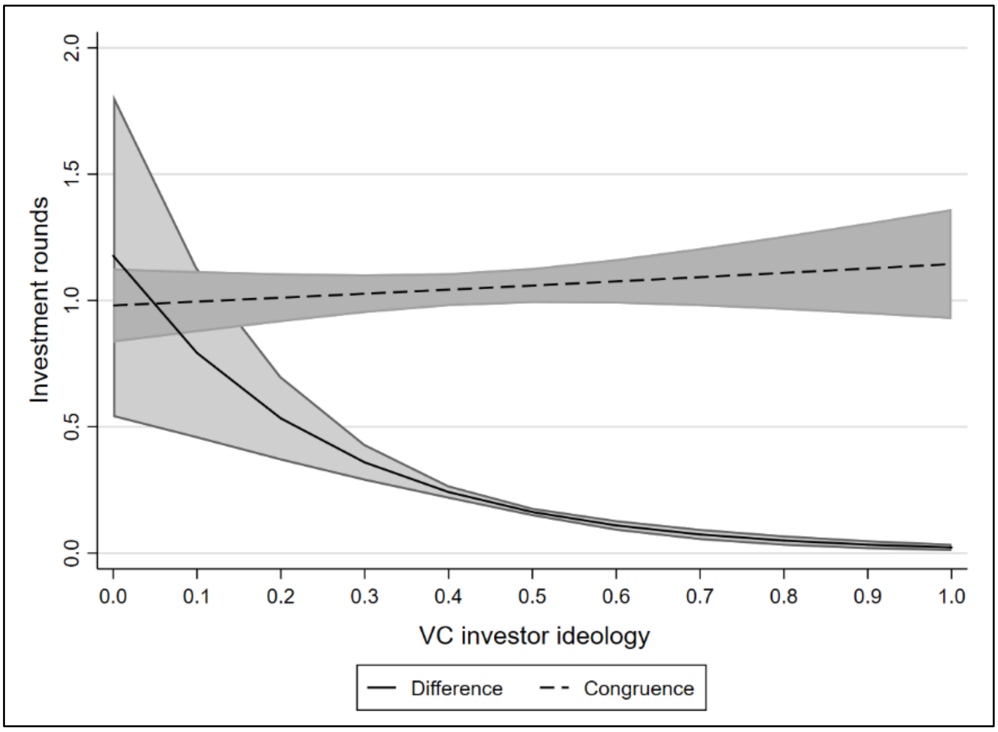


Figure 2-4: Interaction effect: VC investor ideology x Spatial congruence

2.4.2 Sensitivity analyses

To check the robustness of our results, rule out alternative explanations, and garner more nuanced insights, we experimented with different models and variables. First, given that the uncertainty involved for the VC investor might be higher for early-stage ventures (Matusik & Fitza, 2012; Sorenson & Stuart, 2008), we used investment stage as another moderator. Our analysis revealed that conservative investors are more likely to engage in late-stage investments, whereas liberal investors are more likely to invest when dealing with early-stage investments (see Table 2-4, Model 6 and Appendix A-1, Figure A-1.1). This reinforces our argument that conservative VC investors are less likely to invest in new ventures owing to the uncertainty surrounding them.

Although we found that our dependent variable, number of VC investment rounds, is highly correlated with the amount of VC investment (see Table 2-1), we tested for potential differences in the effect of VC investor ideology on these different variables for a smaller sample for which information on investment amount was available. The ordinary least square regression revealed almost identical results (see Appendix A-1, Table A-1.1, Model 1). Moreover, we tested whether there is a difference in the hypothesized effects on acquiring the first VC investment round, compared with the number of rounds. A logit regression analysis produced comparable results (see Appendix A-1, Table A-1.1, Model 2). The innovation quality of the ventures might represent another signal to investors. Therefore, we included patent citations, available only for the cleantech sub-sample, as an additional control variable, which again revealed robustness of our findings (see Appendix A-1, Table A-1.1, Model 3).

Our dependent variable has a larger number of zeros, some of which could be because some ventures chose not to receive VC investments in specific years. Considering this possibility, we employed a zero-inflated Poisson regression model. This model combines a logit model, with age included as an additional predictor of “certain” zero investments, and a Poisson model for the rest of the sample. The results confirm the robustness of the estimates (see Appendix A-1, Table A-1.2). The finding on the effect of venture age in the logit model reveals that the logarithmic odds of an excessive zero increase by 1.089 for each additional year. This means that the older the venture, the more likely it is that it has not applied for VC funding in the first place.

We also address potential endogeneity concerns resulting from unobserved heterogeneity, i.e., omitted variables that may affect VC investment decisions, by assessing the robustness of our results using an instrumental variable regression analysis

(Wooldridge, 2020). We use the investor location in a conservative or liberal U.S. state as an instrument for investors' political ideology (Briscoe, Chin, & Hambrick, 2014; Chin & Semadeni, 2017). We collected information on the state where investors are located from Crunchbase and the websites of investors. We matched investors' states and years of their venture investment with the state level CPVIs that indicate the ideological orientation of U.S. states. We categorized U.S. states as conservative (liberal), when the state level CPVI deviated from 0 toward the Republican (Democratic) side (Wasserman & Flinn, 2017). To accommodate investor syndication, we created a factor variable that indicates if investors are based in only liberal U.S. states, only conservative U.S. states, or both conservative and liberal U.S. states. The ideology of an investor's region is unlikely to have a direct effect on VC investors' investments while it could affect the political ideology of the investors, which points to this variable's suitability as an instrument. Using this instrument, we estimated a two-stage least square model. The F-statistic for the first stage model, evaluating the strength of the instrument, is 9.41, which is just below the threshold of 10 and therefore almost a strong instrument (Stock & Watson, 2007). We performed a Durbin and Wu-Hausman test of exogeneity after the two-stage least square regression. Both tests are not significant, indicating that VC investor ideology is an exogenous variable and suggesting no particular benefit from an instrumental variable estimation approach (Baum, Schaffer, & Stillman, 2003). Finally, we replaced the two-stage least square model with an instrumental variable Poisson regression model, which confirmed the significant negative association between VC investor ideology and investment rounds (see Appendix A-1, Table A-1.3, Model 1).

2.5 Discussion and conclusion

2.5.1 Summary of the findings and theoretical contributions

This paper explores the influence of political ideology in the entrepreneurship context, focusing on how the values and identities associated with VC investors' ideologies shape their investment decisions in new ventures. Building on the notion that different ideologies embody different value systems, we argue that conservative VC investors are likely to have a lower tolerance to uncertainty compared to liberal VC investors. Our analysis of 415 U.S. cleantech and fintech ventures over the period 2008-2018 lends support to this view, revealing that investor conservatism reduces the likelihood of attracting investments in the highly uncertain context of new ventures. We further proposed three contingencies related to the identity dimension of ideology that moderate the effect of conservative VC investors' low tolerance to uncertainty. We observe that the likelihood of attracting investments from more conservative investors is higher when the ideology of the venture is congruent with that of the VC investor or if the venture operates in a conservative environment. However, while we expected that the polarizing nature of environmental issues might cause conservative VC investors to prefer fintech over cleantech ventures, the results revealed no such differences between these sectors. Our findings on the role of political ideology in resource mobilization by new ventures contribute to the entrepreneurship literature in three ways.

First, the increasing ideological polarization over the past decade makes political ideology an important, yet understudied, concept in the context of organizations. Adding to the research in the broader management literature that has identified the relevance of political ideology in top management decision-making (Carnahan & Greenwood, 2018; Chin et al., 2013; Gupta, Fung, & Murphy, 2021; Gupta & Wowak, 2017; Park et al., 2020), our study applies political ideology to the entrepreneurial context (Swigart et al., 2020). The findings of our research suggest that political ideology is a critical dimension of VC investors' decision-making processes, offering an important answer to the question, how ventures find the right VC investors if they have a choice (De Clercq et al., 2006). Our study responds to the recommendation made by recent research to pay greater attention to the characteristics of the investor rather than those of only the venture, as well as to the interplay between investor and venture characteristics (Fu & Tietz, 2019; Matusik et al., 2008).

Second, our focus on investors' political ideology provides a nuanced understanding of the non-market logics affecting resource mobilization, which the literature has not examined so far. While market logics, i.e., the self-interest and (bounded) rationality of the investors in achieving higher returns, are well understood in the context of resource mobilization, our research adds details to the general assumption that non-market logics are related to higher goals than self-interest (Clough et al., 2019). We show that ideological priorities of investors influence their decisions: Conservative investors are more reluctant to invest in new ventures, but their reluctance is weakened when there is congruence between their ideology and that of either the venture or the spatial location of the venture. At the same time, our finding that VC investor ideology exerts no differential effect between the fintech and cleantech sectors highlights that instrumental motives, such as similarly compelling financial rewards from investing in cleantech and fintech ventures (Gupta et al., 2018), may weaken the potential effect of polarizing issues such as climate change and climate action. Overall, these insights show how non-market logics, as exemplified by ideological priorities, shape decision-making in the entrepreneurship context (Gupta & Briscoe, 2020).

Third, we introduce a value and identity perspective on ideology to understand the underlying mechanisms of this non-market logic in venture investments. The mechanisms that underlie empirical patterns of differences in behavior across resource providers (i.e., VC investors) and seekers (i.e., ventures) have so far remained understudied (Clough et al., 2019). Adopting the value and identity perspectives enables us to explain why ideological differences between conservative and liberal investors may lead them to attach differential importance to the same venture attributes. The value perspective helps in understanding how higher investor conservatism is associated with fewer investments, especially early-stage investments, by highlighting the conservative tendency for uncertainty avoidance. The identity perspective adds to this by demonstrating that a common identity between investors and ventures or venture contexts can help mitigate the effect of values underlying investors' ideologies, thereby weakening conservative investors' lower propensity to invest in ventures.

2.5.2 Managerial implications

Our findings on ideology-related biases in investment decisions have practical implications for ventures and VC investors. For ventures, a major consideration can be that the importance of alleviating uncertainty associated with their quality and growth prospects to access much-needed resources is likely to depend on investors' ideological leanings. Therefore, new ventures should pay attention to the VC investors' political ideology to pre-assess their likelihood of receiving investment from them. In this sense, ventures might consider evaluating publicly available information (e.g., donations and statements) that may help reveal VC investors' political ideology. In addition to considering the VC investors' ideology in general, they should evaluate their own attributes in light of the investors' ideology. The need to develop awareness of VC investors' ideology is more pertinent for early-stage ventures because of the higher uncertainty surrounding new ventures at this stage and thus the greater role that ideology may play in conservative VC investors' decisions. Accordingly, there may be a greater need for early-stage ventures to send quality signals to conservative VC investors to alleviate part of the uncertainty surrounding them. At the same time, ventures should be conscious of the expression of their own political ideology and the political orientation of their local environment, given that conservative-leaning VC investors especially value congruence in these attributes.

For VC investors, given that their ultimate goal is to maximize their return on investment (ROI) by investing in the most promising ventures, it is important to recognize that their organizational ideology could bias their investment decisions. When holding a conservative-leaning ideology, investors should be aware that ideology-related uncertainty can have a detrimental effect on their ability to invest in new ventures in general and in early-stage ventures in particular. Furthermore, our findings suggest that the influence of identity-based social categorization, and the associated phenomenon of ingroup preference and outgroup derogation, may make conservative-leaning VC investors invest in ideologically like-minded ventures and those based in environments with similar ideological leanings. However, the choice of investment targets in such a manner may not reflect a preference for venture quality, raising the risk that conservative investors miss out on promising investment opportunities.

Finally, our findings on the fintech and cleantech sectors suggest that instrumental motives might be more important than ideologies' positions on contentious issues such as climate change. Contrary to the common assumption that liberals are more likely to support cleantech ventures in helping them overcome the "valley of death" (Goldstein, Doblinger, Baker, & Anadón, 2020), we find no particular bias by conservatives against investing in cleantech ventures. This has therefore positive implications for founders who like to operate in ideologically sensitive, environmental-oriented sectors as well as for policymakers in relation to promoting entrepreneurship in environmentally beneficial areas.

2.5.3 Limitations and future research opportunities

Our study analyzed the relevance of political ideology for investments by examining ventures belonging to the fintech and cleantech sectors. While these two sectors are not representative of the economy as a whole, they are arguably at different ends in terms of their ideological sensitivity, thus providing some indication of the generalizability of our findings across industries. At the same time, both of these are high-tech sectors and may thus have a liberal drift compared with low-tech sectors. Furthermore, while our focus on the U.S. provides us with the opportunity to take advantage of the ideologically divisive environment there in recent years, ideological differences may play out differently in other settings. Therefore, we encourage future research to investigate the importance of VC investor ideology for new venture investments in other industries and countries.

Finally, we benefitted from an 11-year panel (2008-2018) and included year-fixed effects in all our models to account for changes such as increasing ideological polarization on a general level. Yet, U.S. ideological polarization might have further increased towards the end of the last administration in early 2021. This is an effect that we cannot explore in our panel, but we invite future research to focus on it in more detail.

As having explored the relevance of political ideology in VC financing, the next chapter deals with product digitization. In particular, chapter 3 covers the role of product digitization and startup/VC investor dependencies for venture growth.

3 Digitize and grow? How product digitization affects new venture growth[4]

3.1 Introduction

Entrepreneurship scholars have long been interested in understanding the drivers of venture growth (Gilbert, McDougall, & Audretsch, 2006). More than two decades ago, scholars identified the nature of product innovation in terms of a radical/incremental distinction as a growth predictor (Robinson, 1990; Zahra & Bogner, 2000). Current developments of digitization have led to the emergence and diffusion of digitized products that are increasingly developed and commercialized by new ventures (Nambisan, 2017; Steininger, 2019). Recent practical examples suggest that product digitization might be a novel driver for venture growth. As such, most startups that have experienced the fastest growth events via an acquisition or IPO, e.g., Airwatch, Oculus, and Instagram, are intuitively associated with higher product digitization (CB Insights, 2016). While anecdotal observation seems consistent, it is ultimately an empirical question as to what extent product digitization affects venture growth (Elia, Margherita, & Passiante, 2020).

The cleantech sector is an ideal setting for studying this effect. Resulting from the integration of decentralized renewable sources and modular grid structures, digitization is a major trend in the cleantech sector (Di Silvestre, Favuzza, Riva Sanseverino, & Zizzo, 2018; International Energy Agency, 2017). Prior research has identified two cleantech waves, offering a plausible hardware/software separation for products. Starting in the early 2000s, products in the first wave centered on hardware components for renewable energy supply. Around 2013, when the second wave began, software products related to demand, cost, and efficiency optimization were prevalent (Bumpus & Comello, 2017). While the hardware/software separation provides the first indication to classify products, it omits the interrelated aspect of software and hardware. Indeed, many products, such as smart home solutions for energy efficiency purposes, often lie in the middle of a hardware/software spectrum (Porter & Heppelman, 2014; Yoo et al., 2012). These products are also denoted as hybrid products (Bharadwaj et al., 2013). In other words, products developed and commercialized by cleantech startups have differential degrees

[4] This study is co-authored by Claudia Doblinger (Technical University of Munich), Kavita Surana (University of Maryland), and Adrian Rumpold (UnternehmerTUM). I am the lead author of this study. I presented prior versions of this study at the 2021 DRUID Conference, the 2021 Interdisciplinary European Conference on Entrepreneurship Research, and the 2021 Sustainability Management Conference of the German Academic Association of Business Research (Verband der Hochschullehrerinnen und Hochschullehrer für Betriebswirtschaft e.V.).

of *product digitization*. Yet, the effect of product digitization on venture growth has not been studied empirically.

Entrepreneurship research has also shown that access to financial and social resources provided by VC investors is a critical precondition for ventures to achieve a growth event. In return for guaranteeing resource access, VC investors receive equity in the venture (De Clercq et al., 2006; Huang & Knight, 2017). These resource exchanges between actors create bidirectional dependencies, which is the central concept of resource dependence theory (Pfeffer & Salancik, 1978). Scholars have already applied resource dependence theory in the context of entrepreneurial financing. Specifically, scholars have studied dependencies induced by direct ties with corporate VC investors. Notably, Katila et al. (2008) and Hallen et al. (2014) showed that ventures use defense strategies when exposed to dependencies with so-called corporate sharks. Researchers have also begun to study dependencies induced by indirect ties. In this context, Cox Pahnke et al. (2015) found that indirect ties to competitive startups through VC investors impede innovation. However, dependencies induced by direct and indirect ties with VC investors were overlooked when studying venture growth. As pointed out above, financial and social resources provided by VC investors are essential for ventures to achieve growth outcomes (De Clercq et al., 2006). Hence, such dependencies might affect growth outcomes. In addition to the direct impact of dependencies on venture growth, we do not know which dependence compositions benefit startups with various degrees of product digitization. There is good reason to assume that dependencies, which we classify as diversified or centralized, might benefit startups with higher degrees of product digitization differently. Studies have already shown that digital startups follow a diversified approach to investments and profit from diversified interorganizational ties (Cavallo, Ghezzi, Dell'Era, & Pellizzoni, 2019; Kollmann et al., 2021). This diversity gives rise to the notion that startups with higher degrees of product digitization benefit more from diversified dependencies induced in startup/VC investor networks.

In this study, we develop a model of how product digitization affects venture growth. We further explore resource dependence theory with a network lens to theorize about the relationship between startup/VC investor dependencies and venture growth and the moderating role of the dependencies in the product digitization/growth effect. In particular, we consider two types of dependencies: startup dependence on the VC investor (hereafter *startup dependence*) and VC investor dependence on the startup (hereafter *VC investor dependence*). While startup dependence is contingent upon direct ties to VC investors (Sorenson & Stuart, 2008), VC investor dependence is contingent upon indirect ties, i.e., ties of the VC investors to other startups (Cox Pahnke et al., 2015). We classify dependencies with a centralized/diversified distinction (Hoang & Antoncic, 2003; Hochberg et al., 2007). Accordingly, dependence is *diversified* when many distinct tie partners are involved, or it is *centralized* when few distinct tie partners are involved.

Given the contribution that cleantech startups make to mitigate climate change (Doblinger et al., 2019; Gaddy et al., 2017), our empirical setting is the emerging U.S. cleantech sector from 2004 to 2018. Drawing on a sample of 461 VC-backed cleantech startups, we quantify the impact of product digitization and the startup and VC investor dependencies on venture growth outcomes. Our findings suggest that product digitization and diversified startup dependence are positively associated with venture growth. Startups thus benefit from product digitization and diversified startup dependence, implying many direct ties to VC investors, to pursue growth outcomes. However, this does not hold for diversified VC investor dependence, indicating that VC investors have many ties to other startups. In addition, our results suggest that diversified startup and VC investor dependence are beneficial for startups with higher product digitization.

By studying product digitization and dependencies as predictors of venture growth, our study makes three important theoretical contributions. *First*, we expand the literature on venture growth (Gilbert et al., 2006) by identifying product digitization as a novel dimension of the nature of products that affects growth (Robinson, 1990; Zahra & Bogner, 2000). *Second*, we contribute to resource dependence theory (Pfeffer & Salancik, 1978) by providing insights on resource dependence in the context of entrepreneurial financing (Cox Pahnke et al., 2015; Hallen et al., 2014; Katila et al., 2008). *Third*, we clarify the configurations between product digitization and dependencies in startup/VC investor networks that lead to venture growth. By showing that diversified dependencies are beneficial for startups with higher product digitization, our insights indicate that these startups prosper with diversified direct and indirect ties to external actors (Cavallo et al., 2019; Kollmann et al., 2021). We are also able to make methodological contributions by introducing a novel, text-based measure that reflects the product digitization of the ventures. Thus, we respond to the call to use "*text analyses [that] can help to reveal patterns in the application of emerging "general purpose technologies" (for example, [artificial intelligence], robotics and the Internet of Things) to climate change*" (Stern & Valero, 2021, p. 7). Finally, we derive managerial implications and outline limitations and future research directions.

3.2 Theoretical background

3.2.1 Drivers for venture growth: Network composition and the nature of products

Previous research on new venture growth has focused on understanding the drivers for the long-term success of new ventures (Gilbert et al., 2006). The meaningful growth event of an exit preferably occurs through an acquisition or IPO and represents a milestone in the long-term performance of new ventures. In particular, VC-backing is a vital requirement for ventures to experience an exit (De Clercq et al., 2006). This is why many prior empirical studies (e.g., Chahine & Zhang, 2020; Chang, 2004; Gulati & Higgins, 2003), and ours as well, make VC-backing a precondition when studying further venture growth drivers.

Entrepreneurship scholars have identified various drivers that lead ventures to experience an exit, which can be classified into individual, team, industry, and firm level drivers. Previous studies identified individual level drivers such as prior CEO experience (Yang, Zimmerman, & Jiang, 2011) and CEO replacement (Chahine & Zhang, 2020) as drivers for growth. Scholars also explored team level drivers and found that the prior management experience of the team (Higgins & Gulati, 2006) and the functional structure of the team (Beckman & Burton, 2008) enhance the venture's likelihood to experience a growth event. Researchers also considered industry level drivers, where high industry competitiveness (Huyghebaert & Van de Gucht, 2007) and the number of exits within an industry (Beckman, Burton, & O'Reilly, 2007) have shown to influence venture growth. Lastly, and most critically in the context of this study, in the firm level domain, entrepreneurship scholars have identified network composition through external affiliations as a crucial growth predicator. In this context, prior studies have found that large and diverse strategic alliance networks of startups are positively related to venture growth (Chang, 2004; Hoehn-Weiss & Karim, 2014). The literature stream on external affiliations has focused on network composition, but it has largely neglected the role of dependencies in relations with partners in the external environment (Pfeffer & Salancik, 1978; Wry, Cobb, & Aldrich, 2013). Dependencies between resource exchange partners influence entrepreneurial performance (Cox Pahnke et al., 2015; Hallen et al., 2014; Katila et al., 2008), yet they are overlooked in the context of venture growth.

We define dependencies in line with the startup/VC investor network composition. Specifically, as startups and VC investors are embedded in a set of financing ties that compose networks, network structure, i.e., the "*pattern of direct and indirect ties between actors*" (Hoang & Antoncic, 2003, p. 170), is essential for characterizing dependencies.

From the startup's point of view, *direct ties* are investment ties that a startup has formed with VC investors to accumulate resources (Sorenson & Stuart, 2008). *Indirect ties* are investment ties that VC investors have formed with other startups to diversify the portfolio risk (Cox Pahnke et al., 2015). Accordingly, *startup dependence* (on the VC investor) is contingent upon direct ties, and *VC investor dependence* (on the startup) is established for indirect ties. We further characterize dependencies in VC financing networks with a centralized/diversified distinction (Hoang & Antoncic, 2003; Hochberg et al., 2007). Accordingly, we classify dependencies as *diversified*, implying many distinct tie partners, or *centralized*, implying a limited number of distinct tie partners in the network.

In addition to network composition, scholars have identified the nature of product innovation as a determinant for ventures that seek to grow. More than two decades ago, Robinson (1990) and Zahra & Bogner (2000) pointed to the radical vs. incremental nature of product innovation that affects a venture's strategy and growth. Specifically, while Robinson (1990) pointed to a negative association between incremental product innovation and market share growth, Zahra & Bogner (2000) found a positive association between radical product innovation and market share growth. Therefore, the nature of products and venture growth have already been examined in conjunction, where market share growth was considered as the venture growth outcome. Given that products have become increasingly digitized during the last decades (Lyytinen et al., 2016), the nature of products requires reconsideration as a predictor for new ventures that seek to achieve a growth event through an exit. Consequently, we pay attention to the current developments of digitization and explore its effect on venture growth in terms of an exit event.

3.2.2 Product digitization: A novel dimension of the nature of products

In recent decades, products have become increasingly digitized (Lyytinen et al., 2016). Digitized product innovations [5] entail "*new combinations of digital and physical components to produce novel products*" (Yoo et al., 2010, p. 725). Accordingly, we consider digital and physical components intertwined.

To understand the digitized product nature, it is essential to capture the characteristics and resulting architecture that distinguish digitized from non-digitized products. In this context, Yoo et al. (2010) highlight three distinguishing characteristics

[5] In this study, we use the terms "digitized product innovation" and "digitized product" as synonyms.

of digitized products: reprogrammability, homogenization of data, and self-referential. While reprogrammability enables the product to execute different functions, homogenization of data allows for the processing of different file formats. Self-referential implies that digitized products depend on digital technologies, and consequently, greater availability of digitized products results in the broader application of digital technologies. These three product characteristics provide the basis for the layered modular architecture of digitized products. Specifically, the layered modularity allows decoupling of different product layers (Brunswicker & Schecter, 2019; Yoo et al., 2010). As a result of these various characteristics and architectural composition, the nature of increasingly digitized products differs and needs to be reconsidered in the context of entrepreneurial performance and specifically venture growth.

As advancements in digitization have changed the very nature of products (Yoo et al., 2012), they have also transformed entrepreneurship, including modified entrepreneurial processes and outcomes (Nambisan, 2017; Steininger, 2019). Recent studies have made sub-group comparisons of non-digital and digital startups to investigate differences in entrepreneurial processes. For example, König et al. (2019) distinguish non-digital from digital ventures based on the tangibility of the product that is core to the business model and find that non-digital vs. digital ventures follow different evolutionary business model patterns. Furthermore, Kollmann et al. (2021) distinguish non-digital from digital ventures based on the industry assignment and find that different combinations of internal and external characteristics spur innovations in non-digital and digital ventures. By extension, we focus on product digitization as a novel, continuous dimension of the nature of products and explore its impact on the long-term outcome of venture growth.

3.3 Hypotheses development

3.3.1 Product digitization and venture growth

Prior research suggests that ventures with increasingly digitized products may indeed face different entrepreneurial outcomes. To begin with, one might point out the challenges and argue that such ventures face lower entry barriers, which might lead to a higher level of competition (Koch & Windsperger, 2017; Li, Shang, & Slaughter, 2010) and potentially lower growth outcomes. Another challenge may result from the increased environmental complexity because digitized products usually include a digital ecosystem that needs to be managed (Koch & Windsperger, 2017; Steininger, 2019).

Apart from these potential challenges, a substantial body of research has explicitly highlighted growth opportunities for ventures with increasingly digitized products. Lanzolla et al. (2020) suggest that "*firms are, and will be, operating within new growth […] paradigms enabled by digital technology*" (p. 347). More particularly, it has been argued that ventures with increasingly digitized products have a shorter product development stage (Bharadwaj et al., 2013; Gaddy et al., 2017; Lyytinen et al., 2016). Because the development stage is shorter for ventures with digitized products, they transit to commercializing their products more quickly. In the commercialization stage, the scaling advantage of startups with digitized products is facilitated by low marginal costs of production (Giarratana & Fosfuri, 2007; Li et al., 2010). This leads to increased speed of product launches and profitability for these startups (Bharadwaj et al., 2013; El Sawy & Pereira, 2013). Accordingly, acquirers and investors on the public market might value the high-growth opportunities of startups with higher product digitization, leading to faster exit events through an acquisition or IPO (Carter, Strader, & Dark, 2012; Gautier & Lamesch, 2021). Hence, we conjecture that the high-growth opportunities derive from the nature of digitized products. Consequently, we argue that both the high-growth opportunities associated with faster transition through the life cycle and the scalability advantage outweigh the challenges of increased competition and the higher environmental complexity of startups with digitized products. Accordingly, we postulate that product digitization of startups is positively related to the ability to scale and grow quickly. Thus, we posit:

Hypothesis 1: *Product digitization of a startup will be positively related to the startup's speed to grow.*

3.3.2 Dependencies, product digitization, and venture growth

In addition to product digitization, dependencies induced in startup/VC investor networks can influence venture growth. VC investments are transfers of resources and a precondition for startups to achieve meaningful growth events (De Clercq et al., 2006). In such resource exchange relations, each participant gives and receives (Huang & Knight, 2017). Thus, VC investors confer essential financial and social resources to startups, and in return, they receive equity in the venture (De Clercq et al., 2006; Huang & Knight, 2017). Resource exchange relations create bidirectional dependencies between participating actors (Pfeffer & Salancik, 1978). As such, the startup depends on the VC investor, as it needs access to financial and social resources. Conversely, the VC investor also depends on the startup because its performance determines the ROI. These dependencies are thus related to the startup/VC investor network.

Scholars have already demonstrated that tie diversity influences entrepreneurial performance. The predominant view suggests an enabling effect of tie diversity, indicating that tie diversity facilitates venture performance. For example, Baum et al. (2000) demonstrated that direct ties to many diverse partners increase venture performance due to access to a larger pool of resources. Furthermore, Ozcan & Eisenhardt (2009) found that startup performance improves with more diversified alliance portfolios since ventures are better equipped for coping with environmental complexity. Therefore, we base our line of arguments on this enabling characteristic of tie diversity, i.e., the beneficial role of diversified dependence for entrepreneurial performance in terms of venture growth.

In the following, we distinguish between financial and social resource transfers contingent upon different types of dependencies. *Financial resource transfer* is contingent upon direct ties to VC investors and hence startup dependence. *Social resource transfer* is contingent upon indirect ties, i.e., VC investors' ties to other startups, and thus VC investor dependence.

Financial resource transfer: Startup dependence, product digitization, and venture growth

Startups usually form direct ties with more than one VC investor to accumulate resources (Sorenson & Stuart, 2008). When startups establish a diverse set of direct ties with VC investors, they have access to a larger pool of *financial resources* (Gompers & Lerner, 2001). Indeed, the involvement of VC investors and associated financial resource transfer is crucial for ventures to expand their operations and gain legitimacy (Clough et al., 2019; Fisher et al., 2016). Empirical research also supports that access to large pools of financial resources from VC investors positively affects venture growth (Chang, 2004; Davila, Foster, & Gupta, 2003; Shane & Stuart, 2002). Consequently, we argue that diversified startup dependence as prevalent in the startup's distinct and direct ties to VC investors enables it to access a larger pool of financial resources. We thus expect that diversified startup dependence, compared to centralized startup dependence, influences the long-term performance of startups more positively. Accordingly, we hypothesize that diversified startup dependence, implying many direct ties to VC investors, as compared to centralized startup dependence, denoting few direct ties to VC investors, is more positively related to the startup's speed to grow:

Hypothesis 2: *Compared with centralized startup dependence, diversified startup dependence will be more positively related to the startup's speed to grow.*

Returning to the relation between product digitization and venture growth, in Hypothesis 1, we argued that product digitization is positively related to the startup's speed to grow. Our theoretical discussion also revealed that ventures with digitized products usually bring along a digital ecosystem (Elia et al., 2020; Koch & Windsperger, 2017). The interacting participants in the ecosystem are, on the one hand, essential for value co-creation. On the other hand, they create environmental complexity that has to be managed by the venture (El Sawy & Pereira, 2013; Lyytinen et al., 2016; Steininger, 2019). Managing environmental complexity requires resources (Pfeffer & Salancik, 1978). Therefore, we argue that financial resource transfer helps startups with increasingly digitized products to manage environmental complexity so that they can benefit from the accompanying value co-creation efforts in the digital ecosystem. Consequently, diversified startup dependence may enable these startups to access a larger pool of financial resources and thus achieve growth outcomes more quickly. Hence, we expect that the effect of product digitization on the speed of growth outcomes accentuates when startup dependence is diversified than when startup dependence is centralized. We posit:

Hypothesis 3: *The positive effect of product digitization of a startup on the startup's growth speed will be stronger when startup dependence is diversified than when it is centralized.*

Social resource transfer: VC investor dependence, product digitization, and venture growth

VC investors invest in several startups to diversify their portfolio risk (Guler, 2007). When a VC investor has formed a diverse set of investment ties with other startups, the focal startup also benefits from the VC investor's management expertise and possible intra-portfolio collaborations with other startups (Hsu, 2004; Lindsey, 2002; Matusik & Fitza, 2012). VC investors have a strong incentive to share management expertise and facilitate intra-portfolio collaborations since the startup's success drives their own fund performance (Lee et al., 2001). VC investors thus transfer *social resources* to add value to the focal venture (Wang, Wuebker, Han, & Ensley, 2012).

Hochberg et al. (2007) found that VC investors who are better networked with other VC investors face a significantly better fund performance, as measured by the proportion of startups that experience a growth event through an acquisition or IPO. In our context, we assume that VC investors who are better networked with other startups affect venture growth positively as they can share management expertise and facilitate intra-portfolio collaborations as part of their social resource transfer. Accordingly, we argue that VC investors add more value to the venture through sharing social resources when they have formed investment ties with many distinct startups, i.e., when VC investor dependence is diversified. We hence conjecture that the startups with diversified VC investor dependence, as compared to centralized VC investor dependence, experience a growth event more quickly:

Hypothesis 4: *Compared with centralized VC investor dependence, diversified VC investor dependence will be more positively related to the startup's speed to grow.*

As we have argued previously in Hypothesis 1, product digitization of a startup is positively related to the startup's speed to grow. To this end, VC investor dependence might influence this relation because startups with various product digitization degrees might benefit from social resource transfer from VC investors differently. In particular, if VC investor dependence is diversified, the diversified portfolio configuration endows VC investors with a higher ability to convey social resources in terms of management expertise and intra-portfolio collaborations (Hsu, 2004; Lindsey, 2002; Matusik & Fitza, 2012). Both sharing management expertise and facilitating intra-portfolio collaborations are especially beneficial for ventures with digitized products. Startups with higher product digitization often face management challenges, which are often business model-related (Elia et al., 2020; Steininger, 2019). In this regard, VC investors' management expertise can add value to ventures with digitized products. By contrast, startups with non-digitized products often face technical challenges, and hence, VC investors' managerial expertise adds comparably little value (Gaddy et al., 2017; Kollmann et al., 2021). Moreover, facilitating intra-portfolio collaborations is more beneficial for startups with digitized products as collaborative efforts are relevant for value co-creation (El Sawy & Pereira, 2013; Lyytinen et al., 2016). In particular, startup collaborations, which are supported by an entrepreneurial climate and pace of action, can drive the entrepreneurial performance of ventures with digitized products (Kollmann et al., 2021). By contrast, startup connections add comparably little benefit to startups with non-digitized products because other startups often lack the required technical experience, facilities, and distribution channels that are essential for further growth prospects. Following this line of argument, we expect that diversified VC investor dependence is more beneficial for startups with increasingly digitized products compared to centralized VC investor dependence. We thus hypothesize that diversified VC investor dependence positively moderates the relation between product digitization of startups and growth:

Hypothesis 5: *The positive effect of product digitization of a startup on the startup's growth speed will be stronger when VC investor dependence is diversified than when it is centralized.*

Taken together, Figure 3-1 provides an overview of the hypothesized direct effect of product digitization on venture growth (Hypothesis 1) as well as the direct and interaction effects of startup dependence (Hypothesis 2 and Hypothesis 3) and VC investor dependence (Hypothesis 4 and Hypothesis 5) on venture growth.

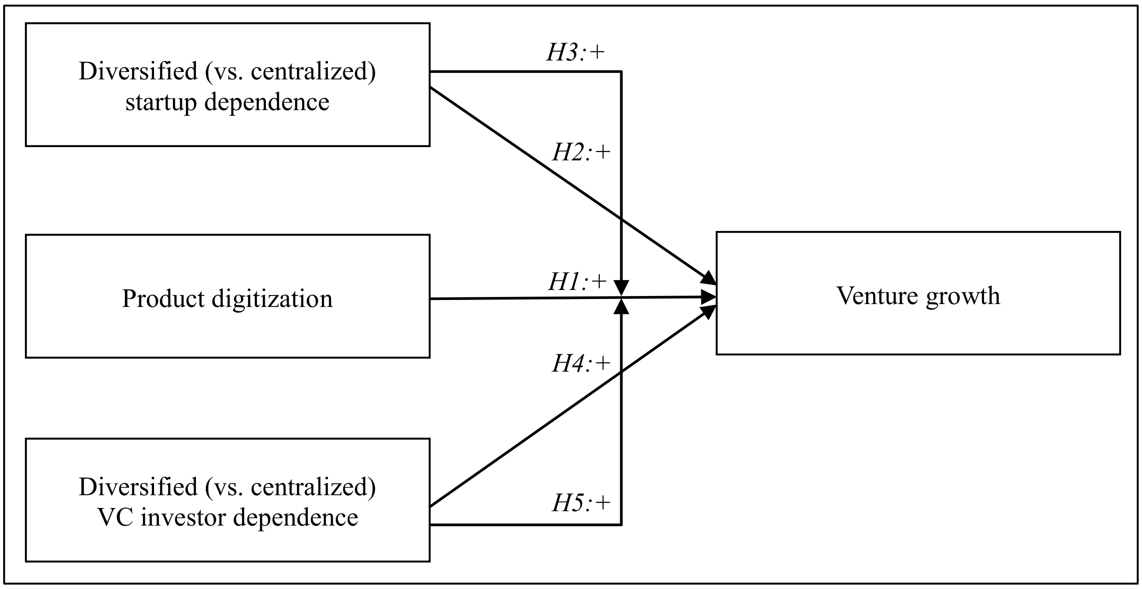


Figure 3-1: Hypothesized effects of product digitization and dependencies on venture growth

3.4 Methods

3.4.1 Empirical setting

To test our hypotheses, we study the role of product digitization in an emerging, sustainability-oriented sector, where differences in product digitization are observable (Gaddy et al., 2017; International Energy Agency, 2017). Furthermore, VC is an essential financing source for cleantech startups to transit through the life cycle and finally achieve a growth event (Cumming et al., 2016; Ghosh & Nanda, 2010). Therefore, the cleantech sector can reveal important insights into the role of product digitization and dependencies in startup/VC investor networks that enable venture growth.

Our sectoral limitation to cleantech is relevant because both the growth mechanism and the time to growth differ between cleantech startups and startups in traditional VC target sectors, such as information technology (IT) and biotechnology, for two primary reasons. First, the growth mechanism is different because utilities and other large energy firms have not been proven to be active acquirers. By contrast, in the IT and biotechnology sectors, large software and pharmaceutical companies consider the acquisition of ventures as complementary assets, actively pursuing venture acquisitions (Cumming et al., 2016; Ghosh & Nanda, 2010). Yet, a more detailed consideration reveals that startups with digitized products are increasingly attractive to utilities and other large energy firms for acquisition due to a lack of internal digital capabilities combined with the general trend of digitizing the energy value chain (Francetic, 2019; International Energy Agency, 2017). Second, for cleantech startups, product development in the conception stage involves high technological complexity and engineering. Therefore, the conception stage of cleantech startups, especially for those with less digitized products, is usually longer than for startups in other sectors such as IT and biotechnology (Bergset, 2018; Gaddy et al., 2017). This leads to a longer time to growth for cleantech startups compared with startups in other sectors. Examples from our sample, where the growth event took place after 10 or more years, include acquisitions of the cleantech startups SolarCity and Inovus Solar.

3.4.2 Sample and data collection

We draw on a sample of 461 VC-backed startups in the U.S. cleantech sector in the period from 2004 to 2018. Startups founded during that period were included in our dataset. We thus considered a firm to be a startup if it is younger than 14 years in year t, with t_0 being 2004. The period from 2004 to 2018 covers the growing development and commercialization of digitized products in the cleantech sector (Bumpus & Comello, 2017; International Energy Agency, 2017).

We relied on the i3 Cleantech Group database to identify the startups in our sample. This database has been increasingly used for research in recent years, and it is one of the richest databases for cleantech startups (Doblinger et al., 2019; Islam et al., 2018). Based on the sectoral assignment by the i3 Cleantech Group database, we included startups that operate in the following nine cleantech sub-sectors: biomass generation, energy efficiency, energy storage, fuel cells and hydrogen, geothermal, hydro and marine power, smart grid, solar, and wind. To study the dependencies related to financial and social resource transfer, we included only startups in our sample that have received at least one

VC investment from a VC investment firm during our sample time. To get a sense of the startup distribution according to the cleantech sub-sectors, Figure 3-2 illustrates the frequency distribution of startups in our sample. Accordingly, startups are most frequently assigned to the sub-sector of energy efficiency (54%), followed by solar (22%) and energy storage (13%).

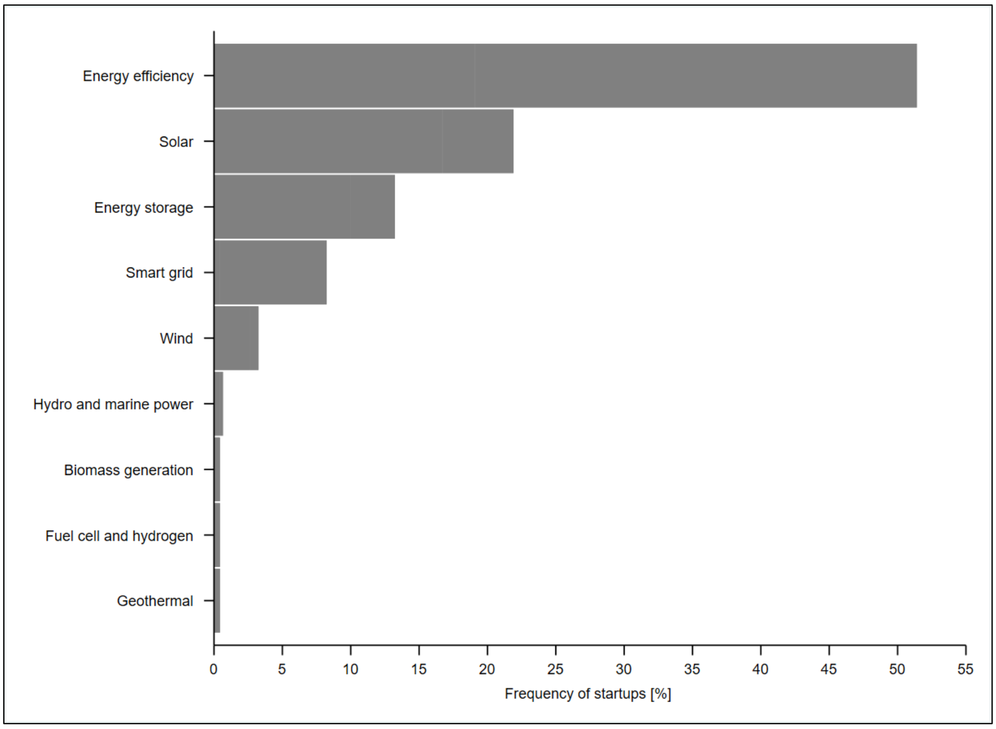


Figure 3-2: Frequency distribution of startups according to cleantech sub-sectors

3.4.3 Variables and model specifications

Dependent variable

Hazard of growth. Our theory is primarily concerned with the long-term venture success of meaningful growth. We measured our dependent variable as the hazard of growth for a startup *i* during our sample time from 2004 to 2018. The hazard of growth considers both the growth event occurrence and the time to growth (Blossfeld & Rohwer, 2002; Guler, 2007). Therefore, we generated two variables. First, we created a dichotomous variable for growth occurrence. Growth occurrence was defined by a startup experiencing an acquisition or IPO during our sample time (Guler, 2007; Roche, Conti, & Rothaermel, 2020). Given that development cycles are longer and technological complexity is higher for startups in the cleantech sector (Bergset, 2018; Gaddy et al., 2017), the time to growth requires a longer time window. Thus, we expanded the time window to 14 years. Consequently, we identified all growth event occurrences for our sample of 461 startups. We retrieved the information on venture growth (and survival) from Crunchbase, the startup webpages, and publicly available webpages such as Bloomberg and Forbes. Second, we created a continuous variable measuring the time to growth in years (Roche et al., 2020). If no growth event occurred, we set the time to growth equal to the number of years the startup remained in our sample. Because 58 startups did not survive during our sample period, we treated these cases as censored, but we kept them in our sample (Hosmer, Lemeshow, & May, 2008). Figure 3-3 displays the non-parametric Kaplan-Meier estimate for the growth variable. Hence, the probability of a startup to experience a growth event after 6, 10, and 14 years is 14 (1-0.86), 32 (1-0.68), and 37 (1-0.63)%.

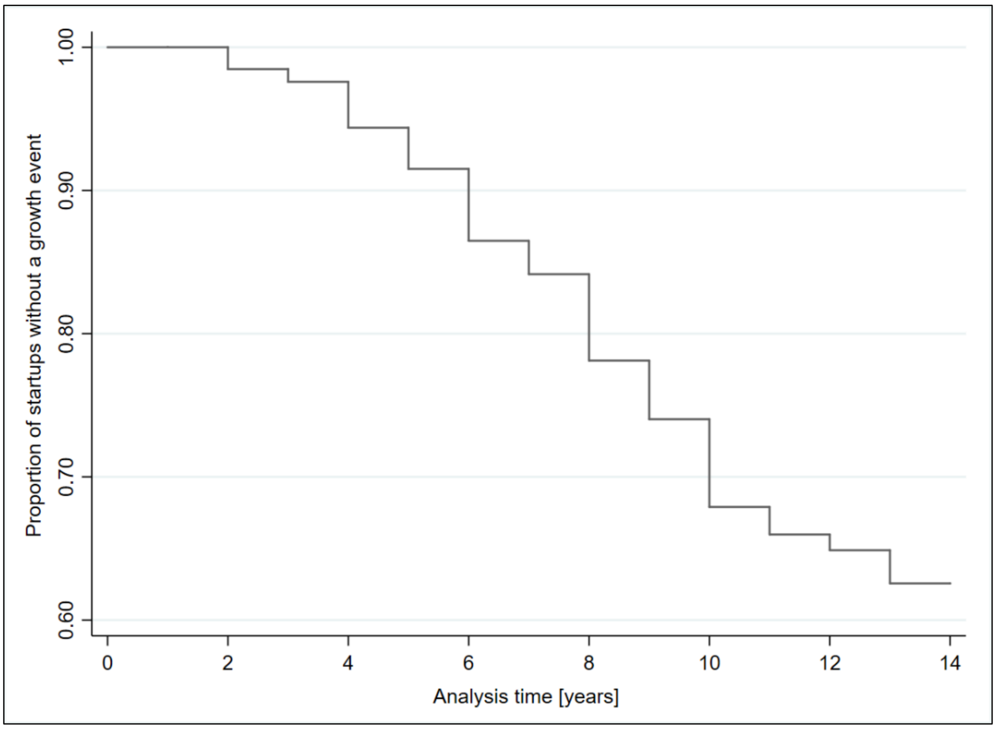


Figure 3-3: Kaplan-Meier graph of the growth likelihood

Independent variables

Product digitization. Product digitization refers to the digitization of a product (or product portfolio) that a startup develops and commercializes. We build on the idea of constant product digitization over time since the ventures in our sample are young and resource-constrained. They deploy their resources for developing and commercializing one product or a small product portfolio, so dramatic shifts in product digitization are unlikely. Beyond classifying the startups' products as entirely non-digitized or digitized (Bumpus & Comello, 2017; Howell, 2017), products often fall in the middle of the digitization spectrum (Porter & Heppelman, 2014). For capturing the differences on the product digitization axis more granularly, we constructed a novel, continuous product digitization measure. It is based on a digital keyword density of scraped startup product webpages. Linguistic communication via the webpages is critical for firms to communicate details on products (Tetlock, Saar-Tsechansky, & Macskassy, 2008). Quantifying language based on webpage texts is already widely used in the finance literature to derive new measures (see Caporin & Poli, 2017 for a review).

A recent study by Kindermann et al. (2021) relied on text analysis and word lists to operationalize the digital orientation of firms. However, to the best of our knowledge, there is no digital keyword dictionary available for digitized products. Therefore, we developed a comprehensive list of digital keywords that describe digitized products. We adopted Fuller's (2008) and Peters' (2016) lists of digital key terms as a basis, merged the two lists, split key terms into one-word terms, and deleted duplicates. Then, two external researchers independently analyzed whether or not the keyword described a digitized product. In the rare case of discrepancy, a third internal researcher decided whether to include the keyword or not. This process resulted in a final list of 116 digital keywords (see Appendix B-1 for an overview of the digital keywords). In the next step, we manually identified the 2,200 distinct webpage links of our sample of 461 startups that contain product and technology descriptions. We identified both product and technology descriptions because they are often blurred on webpages. When a startup's webpage did not exist anymore (this is the case when a startup did not survive or was acquired), we searched for the webpages via the Internet Archive[6], where it is possible to access the digital archive of the web. For these startups, we accessed the webpage at that past time when the webpage was completely displayed by the Internet Archive. After collecting all relevant webpages, we scraped the webpage texts using Python. Subsequently, we excluded stop words based on the Python NLTK package version 3.4, which are not relevant to our analysis. Afterward, we applied the Porter stemming algorithm for stemming the webpage texts and the 116 keywords, which resulted in a wildcard version of the digital keywords (see Appendix B-1 for an overview of the stemmed digital keywords).

Next, we counted the number of stemmed digital keywords and the total stemmed words appearing on the webpages. In line with the approach of Tetlock et al. (2008), we then calculated the digital keyword density by dividing the number of stemmed digital keywords by the total number of stemmed words. If we identified more than one webpage that described the startup's products and technologies, we aggregated the number of appearing stemmed digital keywords and the total number of stemmed words and then

[6] http://www.archive.org, accessed on July 4, 2022

calculated our digital keyword density. Finally, we normalized the digital keyword density to yield product digitization on a scale from 0 to 1. Values closer to the lower boundary of 0 indicate lower product digitization, and values near the upper boundary of 1 imply higher product digitization.

In Figure 3-4, we see the cleantech sub-sectors of startups and the associated product digitization. This figure indicates that most startups follow a hybrid approach to product digitization. The two sub-sectors with the highest mean product digitization values are smart grid (mean=0.398) and energy efficiency (mean=0.314). The two lowest mean product digitization values are attributable to the sub-sectors of biomass generation (mean=0.176) and wind (mean=0.171).

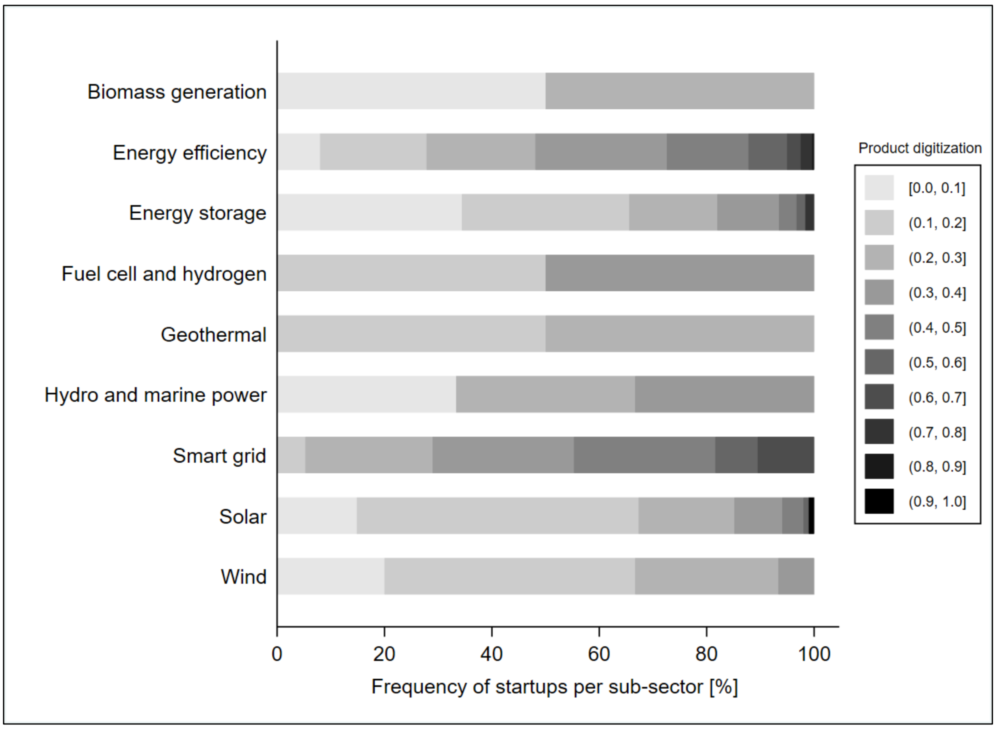


Figure 3-4: Cleantech sub-sectors and product digitization of startups

To ensure the validity of the new product digitization measure, we further hand coded the startups' products according to five categories. To define the categories, we borrowed from Gaddy et al. (2017), who already identified five cleantech sub-categories of products. Although they established these categories to investigate risk-return profiles of VC investments, they provided an appropriate starting point. Therefore, we took this categorization as a base and set up our product digitization categories in an iterative process by cycling between product and technology descriptions of the startups' webpages and the categories. Finally, we arrived at five product digitization categories, to which we assigned an increasing product digitization score from category 1 to 5. In particular, category 1 *hardware, materials, or manufacturing processes* includes hardware, materials, or manufacturing processes as products. Category 2 *hardware integration* encompasses product bundles where hardware is the main product, but it is extended by software. Category 3 *other* includes other products and services such as consulting and project development. Category 4 *software integration* encompasses products, where software is the main product, but it is extended by hardware. Finally, category 5 *software* includes purely intangible software products. After establishing the categories, two external researchers assigned the startups' product digitization categories on the 5-point interval scale. In the case of discrepancy, a third internal researcher made the final decision of categorizing the startups' products. Then, we calculated the Pearson correlation coefficient between these categorical scores and the digital keyword density. The coefficient of 0.50 ($p<0.001$) indicates that our novel keyword-based product digitization measure is acceptably valid.

Startup dependence. For constructing the dependence measures, we borrow from the degree centrality measure in network theory, counting the number of distinct ties formed by an actor (Brandes, 2016). In the VC financing context, a higher number of distinct ties indicates diversified dependence, whereas few distinct ties indicate centralized dependence (Hochberg et al., 2007). Consequently, we operationalize startup dependence in conjunction with direct ties to VC investors by building the multiplicative inverse of the degree centrality measure.

For identifying the VC investors, we relied on ThomsonOne, Preqin, and Crunchbase as data sources. We counted the number of distinct VC investors that the startup has formed investment ties with yearly and calculated the multiplicative inverse. We assume that startup dependence persisted in the following years until a new investment round was closed. Subsequently, we averaged yearly startup dependencies to arrive at an overarching startup dependence score for every startup. Finally, we used the median of the startup dependence scores in our sample as a cut-off point (Iacobucci, Posavac, Kardes, Schneider, & Popovich, 2015). We operationalized startup dependence as a categorical measure of the startup dependence mode. We classified startup dependence as diversified (category 1) when values were smaller than the median cut-off point or centralized (category 2) when values were equal or greater than the median cut-off point.

To check whether the financial resource transfer induced in diversified vs. centralized startup dependence is significantly higher, we conducted a t-test. To determine the financial resource transfer, we relied on the total VC funding amount from the startups' founding year to 2018 or the dataset exit year if the startup did not survive or experienced an exit. We relied on Crunchbase as a data source and retrieved total funding amounts for 70% of startups in our sample. The one-tailed t-test with unequal variances revealed a t-statistic of 2.41 ($p<0.01$), supporting a significantly higher mean in total funding for startups with diversified vs. centralized startup dependence.

VC investor dependence. We similarly designed VC investor dependence and calculated it as the multiplicative inverse of the VC investor's degree centrality. VC investor dependence is based on indirect ties, i.e., investment ties that VC investors have formed in addition to the focal cleantech startup (Cox Pahnke et al., 2015). We searched for all other investments that these VC investors made using ThomsonOne, Preqin, and Crunchbase as data sources. We constructed the VC investor dependence for every VC investor by dividing the number of investments in the focal cleantech startup by the total number of distinct startups in which the VC investor has made investments in a given year. Concerning VC investor syndication, we averaged the VC investor dependence scores of all VC investors that made investments in the focal cleantech startup yearly. We assume that VC investor dependence persisted in the following years until a new investment round was closed by the focal cleantech startup. Such as in the case of startup dependence, we averaged the yearly VC investor dependencies to arrive at an overarching VC investor dependence score that we assigned to every startup. Eventually, we took the median of the VC investor dependence scores as a cut-off point. We classified VC investor dependence as diversified (category 1) when the VC investor dependence score was smaller than the median cut-off point and centralized (category 2) when values were equal or greater than the median cut-off point.

Control variables

Patent citations. We aim to rule out the effect that ventures with high-quality patent portfolios are more likely to experience growth events. To account for the heterogeneous patent quality of startups, we relied on forward citations (Hall, Jaffe, & Trajtenberg, 2005). We collected data from the U.S. Patent and Trademark Office and included the accumulated number of patent citations during the sample time in our analysis. We logged this measure to compensate for skewness.

Grant. Grants provide financial support for startups from public sources (Audretsch, Colombelli, Grilli, Minola, & Rasmussen, 2020). Specifically, for startups in the cleantech sector, prior studies have shown that grants have a positive effect on entrepreneurial outcomes (Goldstein et al., 2020; Howell, 2017; Islam et al., 2018).

Consequently, despite the importance of VC, we controlled for grants. Due to the central role of the Department of Energy for public financing of cleantech startups in the U.S., we retrieved information on grants of the Department of Energy from the USAspending database. We included a binary variable, indicating whether a startup has received at least one grant from the Department of Energy during our sample time. We identified that 14% of startups in our sample received at least one grant.

Sector. We controlled for nine cleantech sub-sectors to capture differences across these sub-sectors: biomass generation, energy efficiency, energy storage, fuel cells and hydrogen, geothermal, hydro and marine power, smart grid, solar, and wind. In line with Doblinger et al. (2019), we relied on the sectoral assignment of the i3 Cleantech Group.

Location. We controlled for the geographic location of the startup to account for the effect that a higher growth likelihood exists for startups located in regional entrepreneurial hotspots (Guzman & Stern, 2015). Therefore, we collected information on the startups' zip codes using the i3 Cleantech Group database and startup webpages and mapped these zip codes to the MSAs of 2010. Following a commonly accepted approach, we subsequently captured the percentage of total startups located in the corresponding MSA (e.g., DeCarolis & Deeds, 1999; Doblinger et al., 2019). We identified that 53% of startups were located in four hotspot regions (San Francisco-Oakland-Fremont, San Jose-Sunnyvale-Santa Clara, Boston-Cambridge-Quincy, and New York-Northern New Jersey-Long Island), but the rest of the startups were located across the country. Consequently, we measured location as a categorical variable with five categories and included fixed effects in all models.

Model specifications

We relied on the Cox proportional hazard model and thus used an event history analysis that takes into account both growth event occurrence through an acquisition or IPO and the time *t* in years of startup *i* to achieving a growth event (Blossfeld & Rohwer, 2002; Roche et al., 2020). We tested the fundamental proportionality hazard assumption of the Cox proportional hazard model by using scaled Schoenfeld residuals and found no violation of proportionality. Our Cox proportional hazard model takes on the functional form:

$$\lambda\,(t|Z_i) = \lambda_0(t)\exp(\alpha DIGIT_i + \beta Z_i)$$

This equation indicates that the hazard function $\lambda(t)$ is determined by the baseline hazard $\lambda_0(t)$, the product digitization variable of interest $DIGIT_i$, and a set of controls included in Z_i. There are several advantages of using the Cox proportional hazard model.

First, this model is semiparametric. It implies that no particular shape of the hazard function is required, and the underlying distribution is unspecified, which leads to the model being more general in nature (Blossfeld & Rohwer, 2002). Second, this method is not biased concerning right censoring data. This factor is relevant to our dataset, where many startups did not experience a growth event during our observation period, which may cause the data to be right-censored. Third, we can calculate the time to growth when using the hazard function. Consequently, an increase in the hazard function can indicate a decrease in time to growth (Allison, 2005).

3.5 Results

3.5.1 Main results

To examine the impact of product digitization and startup/VC investor dependencies on growth, we used the Stata 16 software. Table 3-1 provides descriptive statistics and a correlation matrix for the variables used in the study. Our dependent variable is not highly correlated with any of the other variables. Further, we conducted tests for multicollinearity by examining the variance inflation factors. In all models, the variance inflation factor mean level scores are well below 2, thus ruling out potential multicollinearity problems. Table 3-1 reveals that approximately one out of four startups in our sample experienced a growth event during the sample time (mean=0.243). Interestingly, the startups' products are, on average, placed on the non-digitized side of the product digitization axis (mean=0.271). The hand coded categorical product digitization measure that we used to test the validity also revealed that 54% of startup products fall into the categories 1 *hardware, materials, or manufacturing processes* and 2 *hardware integration.* This result again reflects that less digitized products make up the majority of the startups' products in our sample.

Variables	Mean	S.D.	Min.	Max.	1	2	3	4	5	6
1 Growth	0.243	0.429	0	1	1					
2 Product digit.	0.271	0.164	0	1	0.119***	1				
3 Startup dep.	1.497	0.501	1	2	-0.128***	-0.095**	1			
4 VC investor dep.	1.501	0.501	1	2	-0.021	-0.089*	0.011	1		
5 Patent citations	1.976	2.317	0	8.728	0.205***	-0.052	-0.161***	-0.021	1	
6 Grant	0.139	0.346	0	1	0.007	-0.182***	0.003	-0.013	0.222**	1

Notes: *** p<0.01, ** p<0.05, * p<0.1

Table 3-1: Descriptive statistics and correlations of variables used in the analysis

In Table 3-2, we report hazard ratios from the Cox proportional hazard models, which predict the time to growth of startups. Hazard ratios greater (smaller) than one indicate a positive (negative) relationship with the risk of achieving a growth event. In Table 3-2, Model 1 shows the baseline model that contains control variables only.

Model 2 introduces the direct effect of product digitization to test Hypothesis 1. While Model 3 contains the direct effect of startup dependence to test Hypothesis 2, Model 4 displays the direct effect of VC investor dependence to test Hypothesis 4. To test the interaction effects of startup and VC investor dependencies with product digitization, we used the recommended sample splits as the multiplicative approach may arrive at inappropriate conclusions for non-linear models (Nadkarni, Pan, & Chen, 2019). Accordingly, Model 5 and Model 6 show the sub-group comparisons of diversified and centralized startup dependence to test Hypothesis 3. Similarly, Model 7 and Model 8 contain the sub-group comparisons of the diversified and centralized VC investor dependence to test Hypothesis 5. Regarding the interaction effects, we further visualized the effects of product digitization on growth for diversified and centralized dependencies. We chose a visualization without confidence intervals (Nadkarni et al., 2019). We also graphed the interaction effect with confidence intervals, which appeared to be overlapping. This overlapping, however, does not exclude the statistical significance of the interaction effects (Knezevic, 2020). In all models, we include sector and location dummies, which are not reported to conserve space.

In Hypothesis 1, we predicted that product digitization of a startup will be positively related to the startup's speed to grow, i.e., a higher likelihood to grow. We found that the hazard ratio of product digitization is greater than one and significant for growth events (hazard ratio=4.305, p=0.005, Model 2), supporting Hypothesis 1. When considering the magnitude, a startup with the highest product digitization value of 1 was found 4.3 times as likely to achieve a growth event during our analysis time as compared to a startup with the lowest product digitization value of 0.

In Hypothesis 2, we predicted that, compared with centralized startup dependence, diversified startup dependence will be more positively related to the startup's speed to grow. The results support this prediction since the hazard ratio of diversified startup dependence is greater than one and statistically significant (hazard ratio=1.557, p=0.025, Model 3).

In Hypothesis 3, we predicted that the positive effect of product digitization on the startup's growth speed will be stronger when startup dependence is diversified than when it is centralized. Models 5 and 6 show the sub-group comparisons of diversified and centralized startup dependence. In the diversified startup dependence sub-group, the effect of product digitization on growth is positive and significant (hazard ratio=4.470, p=0.024, Model 5). However, this effect is weaker and not statistically significant in the centralized startup dependence sub-group (hazard ratio=2.659, not significant, Model 6). Figure 3-5 visualizes that the slope of the effect of product digitization on growth is positive and steeper when startup dependence is diversified (dashed line) as compared to centralized startup dependence (solid line). In sum, these results support Hypothesis 3.

In Hypothesis 4, we stated that, compared with centralized VC investor dependence, diversified VC investor dependence will be more positively related to the startup's speed to grow. Although we found a positive relationship between diversified VC investor dependence and startup growth, it is not statistically significant (hazard ratio=1.292, not significant, Model 4), lending no support for Hypothesis 4.

In Hypothesis 5, we predicted that the positive effect of product digitization on the startup's growth speed will be stronger when VC investor dependence is diversified than when it is centralized. Our results reveal that the effect of product digitization on growth is positive and statistically significant in the diversified VC investor sub-group (hazard ratio=7.140, p=0.012, Model 7). However, the effect is weaker and not significant in the centralized VC investor dependence sub-group (hazard ratio=2.504, not significant, Model 8). In Figure 3-6, we see that the slope of the effect of product digitization on growth is positive and steeper when VC investor dependence is diversified (dashed line) than when VC investor dependence is centralized (solid line). Overall, these results support Hypothesis 5.

DV: Hazard of growth	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**
	Controls	Product digit.	Startup dep.	VC investor dep.	Product digit. # Startup dep.		Product digit. # VC investor dep.	
					Div. startup dep.	Cent. startup dep.	Div. VC investor dep.	Cent. VC investor dep.
Product digit.		4.305***			4.470**	2.659	7.140**	2.504
		(0.005)			(0.024)	(0.301)	(0.012)	(0.228)
		[2.224]			[2.968]	[2.514]	[5.554]	[1.906]
Div. startup dep.			1.557**					
			(0.025)					
			[0.307]					
Div. VC investor dep.				1.292				
				(0.170)				
				[0.242]				
Patent citations	1.063	1.069*	1.050	1.061	1.046	1.076	1.079	1.059
	(0.127)	(0.094)	(0.233)	(0.142)	(0.370)	(0.276)	(0.175)	(0.335)
	[0.043]	[0.043]	[0.043]	[0.043]	[0.053]	[0.072]	[0.061]	[0.063]
Grant	0.774	0.848	0.795	0.775	0.957	0.692	1.035	0.663
	(0.350)	(0.555)	(0.404)	(0.354)	(0.907)	(0.405)	(0.931)	(0.331)
	[0.212]	[0.236]	[0.219]	[0.213]	[0.362]	[0.305]	[0.412]	[0.280]
Sector FE	YES	YES	YES	YES	YES	YES	YES	YES
Location FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	461	461	461	461	232	229	230	231
Growth events	112	112	112	112	69	43	58	54
LogLikelihood	-626.8	-623.8	-623.4	-621.1	-335.2	-206.5	-280.2	-264.7

Notes: P-values are displayed in parentheses and standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 3-2: Estimated hazard ratios of Cox proportional hazard models of growth events within 14 years after founding

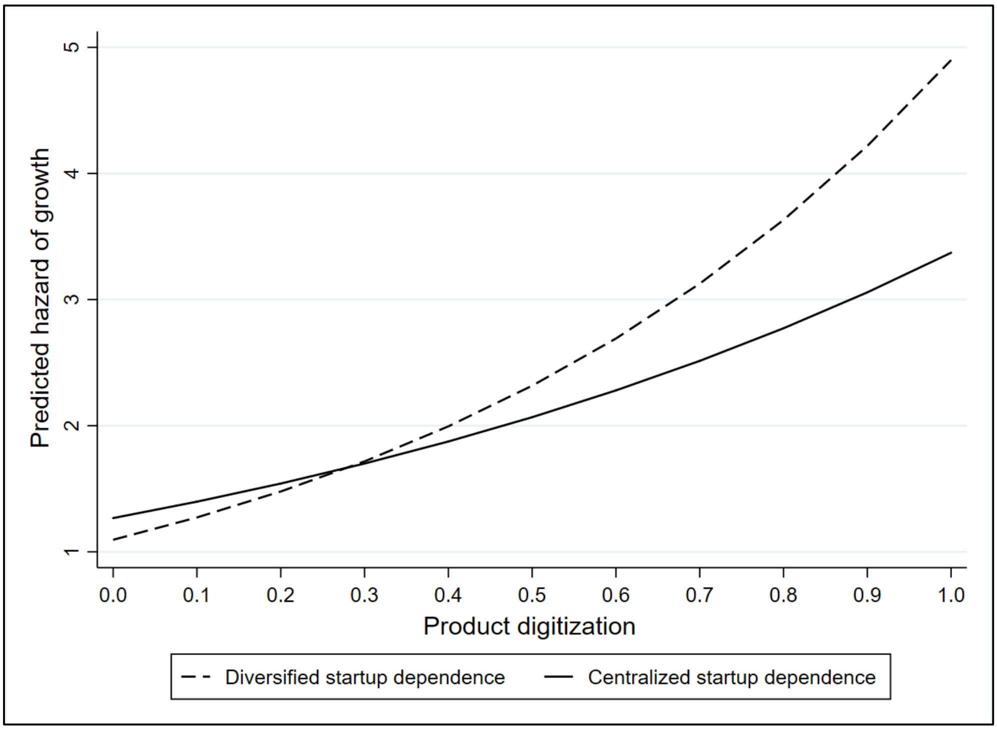


Figure 3-5: Interaction effect: Product digitization x Startup dependence

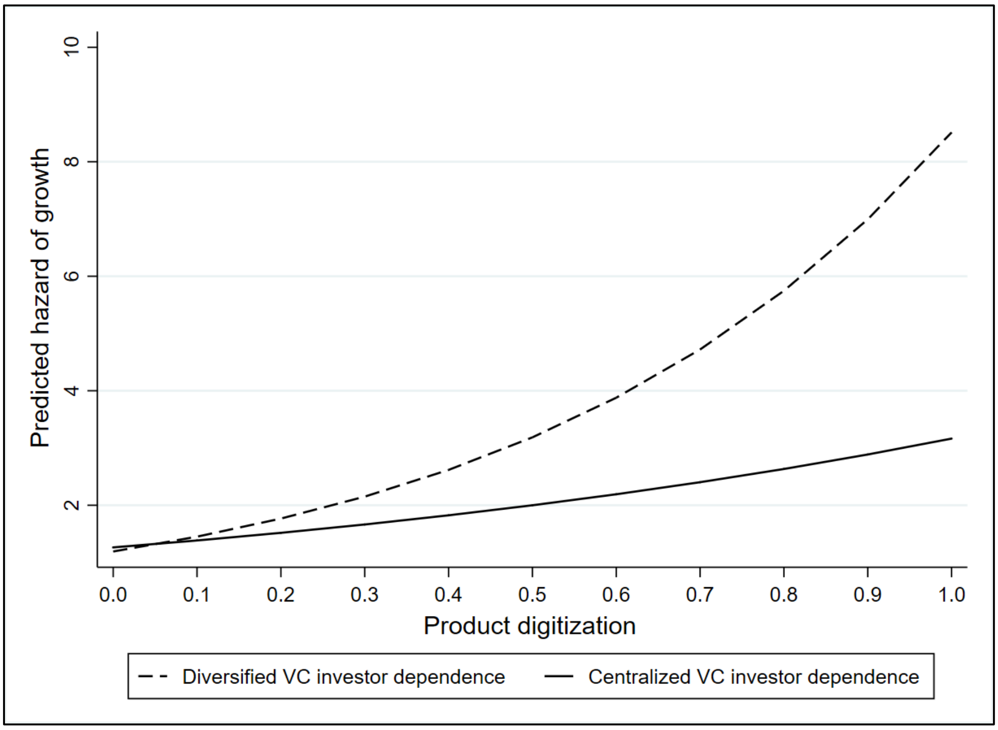


Figure 3-6: Interaction effect: Product digitization x VC investor dependence

3.5.2 Sensitivity analyses

To confirm the robustness of our results, we specified three alternative econometric models (see Appendix B-2 for the results of the sensitivity analyses). First, we reran the models by limiting the growth time window as part of the hazard of growth to 10 years (see Appendix B-2, Table B-2.1). The results are consistent with our main results and support Hypothesis 1, Hypothesis 2, Hypothesis 3, and Hypothesis 5. Similar to the main results, this robustness test does not support the positive and direct effect of diversified VC investor dependence on venture growth of Hypothesis 4. Second, we estimated the models with the surviving startups only (see Appendix B-2, Table B-2.2). Again, the results remained consistent with our main model and supported all hypothesized effects except for Hypothesis 4. Third, we reran the models with logit regressions operationalizing venture growth as a binary outcome variable that takes the value of 1 when the startup experienced an IPO or was acquired and 0 otherwise (Guzman & Stern, 2015). In the logit models, we additionally controlled for the venture's age in 2018 to account for the fact that older firms have a higher likelihood to achieve a meaningful growth event (Stuart, Hoang, & Hybels, 1999). In the result tables of the logit models, we report both coefficients from the logit models and average marginal effects (AMEs) (see Appendix B-2, Table B-2.3). The sign of the logit coefficient indicates the direction of the effect. The magnitude of the effects can be interpreted via the AME, which refers to the change in probability of the growth outcome event from a one unit increase in the independent variable (Plummer, Allison, & Connelly, 2016). For example, a one unit increase in product digitization, i.e., a change from the lowest product digitization of 0 to the highest product digitization of 1, increases the probability of a growth event by 32.2% (AME=0.322, p=0.008, Model 2). In sum, the results from the logit models echo our findings in the main model.

A further concern is that unobserved factors, i.e., omitted variables, are correlated with both product digitization and venture growth. To address this concern and strengthen our confidence that potential endogeneity is not present in the association between product digitization and venture growth, we relied on the recommended two-stage procedure and included an instrumental variable approach (Wooldridge, 2020). We used the predicted hazard of growth of the baseline model as a dependent variable. As an instrumental variable, we relied on the number of broadband subscriptions in the U.S. in the dataset exit year of the startup. We retrieved this information from the International Telecommunication Union. The instrument meets the relevance criterion because the number of broadband subscriptions serves as a proxy for the degree of a digital economy and is likely to influence the digitization of the startups' products. The exogeneity criterion applies to the instrument because the number of broadband subscriptions does not affect the startups' growth speed. In the first stage, the instrumental variable correlates with product digitization ($p<0.05$). In the second stage, we used the fitted values of product digitization. The results from the two-stage least squares regression confirm the positive association between product digitization and venture growth (see Appendix B-2, Table B-2.4). However, the F-statistic for assessing instrument strength was 4.94, indicating that the number of broadband subscriptions is a rather weak instrument (Stock & Watson, 2007). We also performed a Durbin and Wu-Hausman test of exogeneity after the two-stage regression. Both tests are not significant, indicating that the variables in our model are exogenous, and estimations with the instrumental variable do not necessarily result in improvements (Baum et al., 2003).

3.6 Discussion and conclusion

3.6.1 Summary of the findings and theoretical contributions

In this study, we examined predictors of venture growth in the emerging cleantech sector. Specifically, we focused on product digitization and dependencies induced in startup/VC investor networks as drivers for growth. We find that product digitization is positively related to the startup's speed to grow. Regarding the direct effects of dependencies, we found that diversified vs. centralized startup dependence is more positively related to the startup's speed to grow. However, we do not find support for the direct effect of diversified vs. centralized VC investor dependence on the startup's speed to grow. Our results further indicate that the positive effect of product digitization of a startup on the startup's growth speed is stronger when startup and VC investor dependencies are diversified vs. centralized. These findings make important theoretical contributions to the literature on venture growth and resource dependence theory.

First, we contribute to the literature on venture growth, a central topic for entrepreneurship scholars (Gilbert et al., 2006). While the nature of products has been identified as an essential factor that affects market share growth, prior studies have examined the incremental/radical nature of products as the underlying distinction (Robinson, 1990; Zahra & Bogner, 2000). We additionally identify product digitization of startups as a novel dimension of the nature of products that shapes growth outcomes in terms of an exit.

Second, our findings also contribute to resource dependence theory (Pfeffer & Salancik, 1978). Specifically, we provide novel insights into resource dependence and entrepreneurial performance (Cox Pahnke et al., 2015; Hallen et al., 2014; Katila et al., 2008) by advancing our understanding of how diversified and centralized dependencies between resource exchange partners enable venture growth. Further, we shed light on the role of bidirectional dynamics in startup/VC investor relations as conduits of resource flows that have implications for venture growth (Huang & Knight, 2017). In agreement with the beneficial role of financial resource transfer for venture growth, our findings indicate that diversified vs. centralized startup dependence is more positively associated with venture growth. This result is in line with prior studies that have already shown that an accumulation of financial resources helps ventures to grow (Chang, 2004; Davila et al., 2003; Shane & Stuart, 2002). In the context of social resource transfer, we have also examined the role of VC investor dependence for venture growth. Interestingly, we do not find a positive relation between diversified VC investor dependence and venture growth. A possible explanation might be that VC investors' indirect ties to competitive startups in the portfolio lead to information leakage of young firms (Cox Pahnke et al., 2015), which might affect venture growth negatively in the long term.

Third, we also clarify the configurations between product digitization and dependencies in startup/VC investor networks that lead to venture growth. We find that diversified dependencies are beneficial for startups with higher product digitization. Thereby, we show that these startups benefit from diversified direct and indirect ties with external actors (Cavallo et al., 2019; Kollmann et al., 2021). Specifically, our research demonstrates that the product digitization/growth effect accentuates when startup dependence is diversified vs. centralized. This finding indicates that startups with increasingly digitized products face increased environmental complexity in ecosystems, which must be managed (El Sawy & Pereira, 2013; Lyytinen et al., 2016; Steininger, 2019). The management of a higher level of environmental complexity requires substantial financial resources that are, by consequence, crucial for the startups with digitized products to benefit from value co-creation in digital ecosystems and grow quickly. We also studied the interaction effect of VC investor dependence and product digitization on venture growth. We found support for a positive interaction effect of diversified VC investor dependence and product digitization. Accordingly, diversified VC investor dependence leverages VC investors' social resource transfer that adds value to startups with increasingly digitized products. In fact, as part of the VC investors' social resource transfer, management expertise is essential for startups with digitized products (Elia et al., 2020; Steininger, 2019). By comparison, startups with non-digitized products require technical expertise (Gaddy et al., 2017; Kollmann et al., 2021). Moreover, intra-portfolio collaborations are facilitated by a common entrepreneurial pace and climate

(Kollmann et al., 2021), and benefit, in particular, startups with increasingly digitized products for collaboration and associated value co-creation efforts (El Sawy & Pereira, 2013; Lyytinen et al., 2016). Thus, for startups with increasingly digitized products, the beneficial social resource transfer of VC investors might compensate for the negative consequences of information leakage induced in indirect ties (Cox Pahnke et al., 2015).

3.6.2 Managerial implications

Our study offers several practical implications for startups and VC investors. In addition to considering innovations as radical or incremental, ventures should recognize that product digitization shapes their ability to grow through an acquisition or IPO. Moreover, ventures should carefully consider the dependence compositions in which they engage. Independent of product digitization, we suggest that startups are encouraged to engage in many distinct ties to VC investors, i.e., diversified startup dependence, to accumulate financial resources. Our findings also suggest that startups with increasingly digitized products should establish diversified startup dependence because it equips them with financial resources, which is relevant for managing higher levels of environmental complexity and thus enables them to grow quickly. Moreover, startups should also pay attention to the VC investors' portfolios. In this sense, many distinct VC investor ties to other startups, i.e., diversified VC investor dependence, might not only have positive consequences. Negative consequences for the startups' long-term success might occur due to information leakage of VC investors as intermediaries (Cox Pahnke et al., 2015). However, startups with increasingly digitized products should engage in diversified VC investor dependence compositions. In this regard, diversified VC investor dependence adds value to the venture when VC investors share their management expertise and facilitate intra-portfolio collaborations among startups.

At the same time, this finding also has implications for VC investors on how to structure their investments and take on the broker role in the network of portfolio ventures. It might be beneficial for VC investors to build up a diversified investment portfolio of startups with increasingly digitized products that complement each other. VC investors may thus occupy an active broker role to facilitate intra-portfolio collaborations. This mechanism of promoting alliances between portfolio ventures is, for example, suggested by Kleiner & Perkins' "keiretsu" approach of VC financing (Hsu, 2004; Lindsey, 2002).

3.6.3 Methodological implications

Our study also makes a methodological contribution by introducing a novel measure of product digitization. Our measure of product digitization offers new insights beyond the binary non-digital/digital startup comparisons (Kollmann et al., 2021; König et al., 2019). Specifically, we allow placing products of startups on a continuous digitization scale. Therefore, we integrate product hybridity into our novel measure (Bharadwaj et al., 2013; Porter & Heppelman, 2014). Overall, we respond to the call by Stern & Valero (2021) to use text analyses for revealing patterns of digital technologies related to climate change.

Our results suggest that most cleantech startups follow a hybrid approach to product digitization. More particularly, the products of cleantech startups are, on average, placed on the non-digitized side of the digitization continuum. We also see differences in product digitization across the cleantech sub-sectors, indicating that startups in sub-sectors related to renewable energy generation (e.g., biomass generation and wind) develop and commercialize rather non-digitized products, although the startups' products in other cleantech sub-sectors (e.g., smart grid and energy efficiency) are increasingly digitized. This result agrees with the broad hardware/software separation by Bumpus & Comello (2017), where hardware products are attributable to renewable energy supply sub-sectors, and software products refer to efficiency optimization sub-sectors. We designed the product digitization measure so that it is not specific to the sector or firm size. The measure can thus be transferred to other industries and firms of different sizes to operationalize product digitization.

3.6.4 Limitations and future research opportunities

As with any empirical study, our research has limitations, which provide opportunities for future research. While we examine the impact of product digitization on venture growth, we only focus on startups in the U.S. cleantech sector. It is relevant to study effects in the cleantech sector as product innovations contribute to mitigating climate change (Doblinger et al., 2019; Gaddy et al., 2017). Nevertheless, it would further be interesting to conduct comparative studies in different countries and sectors (e.g., healthcare, transportation), where innovations with different product digitization degrees are developed and commercialized by startups. Furthermore, our measure of digitization focuses on products. Additionally, other digitization dimensions, such as the digitization of the startups' operations, will be interesting when studying venture growth.

When studying dependencies, we only focused on VC investment firms. The study of VC investment firms is appropriate because they serve as the most critical resource providers when ventures strive to achieve an exit. Furthermore, their aim of achieving high ROIs is alike (De Clercq et al., 2006). Therefore, dependence configurations in startup/VC investor networks are comparable and fit the aim of our research. By extension, it would be interesting to consider dependencies induced in networks with other resource providers, such as business angels and corporate VC investors. In this sense, examining dependencies in a comprehensive network could be a fruitful avenue for future studies.

Moreover, our findings on the direct and interaction effects of the dependencies suggest considering the dependencies of startups and VC investors separately. It is appropriate to examine dependencies separately because they have not been examined in prior studies in the VC financing context. Given our results, this gives rise to further research that might combine dependencies, introducing the concept of power as the inverse of dependencies (Pfeffer & Salancik, 1978). In this regard, the approach of considering mutual and asymmetric dependencies might be a compelling avenue for future research (e.g., Gulati & Sytch, 2007; Villanueva, Van de Ven, & Sapienza, 2012).

Finally, we measure venture growth in terms of the hazard of growth and define growth occurrence as an acquisition or IPO. Overall, this is a widely accepted measure when studying the long-term performance of a new venture (Guler, 2007; Roche et al., 2020). Nevertheless, ventures might also experience growth during the sample period but not from an acquisition or IPO. Thus, market share and sales growth might serve as additional growth measures in future studies.

We considered product digitization and dependencies in startup/VC investor networks as important venture growth predictors in the cleantech sector. The next chapter introduces three startup types according to their degree of product digitization: non-digital, hybrid, and digital startups. The following chapter further presents a novel framework that looks beyond resources provided by VC investors and identifies the resource mobilization approaches and associated life cycle dynamics of the three startup types in more detail.

4 From atoms to bits: Resource mobilization of non-digital, hybrid, and digital cleantech startups[7]

4.1 Introduction

Climate change is one of the most critical challenges in this century to prevent human-induced temperature changes and associated environmental degradation (Intergovernmental Panel on Climate Change, 2022). To limit severe consequences, the goal of the Paris Agreement is to restrict temperature rise to well below 2°C above the pre-industrial level, which implies reaching net-zero emissions by 2050 (United Nations Framework Convention on Climate Change, 2015). Research agrees that this target is only achievable with accelerating cleantech innovations (International Energy Agency, 2021; Sivaram & Norris, 2016). Cleantech startups play a significant role in developing and commercializing cleantech innovations. This role is due to their advantages of agility, flexibility, and innovativeness over incumbent firms. Thus, cleantech startups bring their novel technologies to market more quickly than established companies (Audretsch et al., 2020; Doblinger et al., 2019; Howell, 2017). However, startups suffer from the liability of newness and smallness, making it more difficult to mobilize their vital resources (Baum et al., 2000; Stinchcombe, 1965).

Recent research has found that cleantech startups face additional, sector-specific challenges while mainly focusing on financial resource mobilization. One stream of studies emphasized public support in terms of grants that are necessary for cleantech startups to bridge the long and costly research and development (R&D) time (Goldstein et al., 2020; Howell, 2017; Islam et al., 2018). Another stream of studies has investigated the challenges of mobilizing financial resources from VC investors. The literature points to product complexity, low expectations regarding the ROI, and poor cleantech startup performance in the past that limit the investment appetite of VC investors (Bergset, 2018; Cumming et al., 2016; Gaddy et al., 2017). In all prior studies, entrepreneurial resource mobilization is implicitly linked to life cycle trajectories. Indeed, grants assist cleantech startups in R&D endeavors in the early conception stage, and VC helps cleantech startups pursue commercialization endeavors in the commercialization stage. Interestingly, Howell (2017) shows that grants are more useful for hardware than for software cleantech startups in raising follow-up VC. Further, Gaddy et al. (2017) find that the underperformance of cleantech VC investments is largely driven by "deep tech"

[7] This study is single-authored. I presented a prior version of this study at the 2022 DRUID Conference.

innovations that include material, chemical, and hardware innovations. These studies give rise to the notion that resource mobilization approaches and associated life cycle dynamics may differ when distinguishing between non-digital and digital startups. Indeed, cleantech innovations are driven by digitization as a major trend in the energy sector (Di Silvestre et al., 2018). This fact emphasizes the practical relevance of differentiating startup types according to a digital typology in the cleantech sector.

The differentiation between non-digital and digital startups has already been studied in the digital entrepreneurship literature. Recent studies in digital entrepreneurship have begun to compare non-digital and digital startups in terms of business model evolution, strategic patterns, and entrepreneurial orientation (Kollmann et al., 2021; König et al., 2019). However, there are two shortcomings. First, the critical task of startups to mobilize resources during the life cycle has been overlooked in studies on non-digital/digital startup comparisons. Second, beyond the non-digital/digital startup comparison, a third, hybrid startup type has emerged. The hybrid type has already been associated with smart products and described conceptually in the information systems literature (Yoo et al., 2010; Yoo et al., 2012). However, to the best of my knowledge, the literature on digital entrepreneurship has not referred to it in sufficient detail.

Entrepreneurship scholars have long studied entrepreneurial resource mobilization and life cycle dynamics in conjunction (Clough et al., 2019; Fisher et al., 2016; Tzabbar & Margolis, 2017). They presumed that the mobilization of resources is essential for startups to transit successfully through the stages in the life cycle (Kazanjian & Drazin, 1989). Yet, we have a limited understanding of the resource mobilization approaches and life cycle dynamics of startups, especially related to different degrees of digitization of the startups' products. One might assume that startups with various product digitization degrees follow different approaches to resource mobilization because the product-related technology is fundamentally different, especially regarding the level of integration of IT in the product (Kollmann, 2006; Lyytinen et al., 2016; Yoo et al., 2012). To provide a more nuanced understanding of the approaches to resource mobilization, it is essential to develop a typology that discretely categorizes startups that develop and commercialize products with distinct product digitization degrees. Based on this, the resource mobilization approaches and associated life cycle dynamics can be compared across the startup types.

In response to these gaps, this study introduces a typology of non-digital, digital, and hybrid – an intermediate type of non-digital and digital – startups. Considering the products, I relate the startup type, i.e., non-digital, hybrid, and digital startups, to the product innovation type, i.e., non-digital, hybrid, and digital products (Kohli & Melville, 2019; Yoo et al., 2010). The aim of this study is to develop a novel framework that clarifies the resource mobilization approaches of non-digital, hybrid, and digital startups along the entrepreneurial life cycle. Empirically, I rely on a qualitative analysis of 16 semi-structured interviews with cleantech startups, investors, and industry experts to get an in-depth understanding of the resource mobilization approaches of the three startup types. I combine this primary data with secondary data from publicly available information from company websites and LinkedIn posts. My findings reveal that resource mobilization patterns differ across the startup types of non-digital, hybrid, and digital startups. Specifically, I find that non-digital startups face severe challenges in mobilizing financial resources after the conception stage. My findings also reveal that hybrid startups benefit from alliances with corporate VC investors in the commercialization stage and digital startups are more attractive to VC investors than the other startup types. They further benefit from alliances with corporates and digital startups for social resource mobilization in the commercialization stage.

These findings enable three theoretical contributions. *First*, I contribute to the theory of resource mobilization in conjunction with life cycle theory by clarifying the resource mobilization specifics for non-digital, hybrid, and digital startups (Clough et al., 2019; Fisher et al., 2016). *Second*, I contribute to the literature on digital entrepreneurship by exploring the fundamental assumption that digital products have distinct characteristics, which shape entrepreneurial processes and outcomes (Berger, Von Briel, Davidsson, & Kuckertz, 2021; Nambisan, Wright, & Feldman, 2019). This study also extends the established distinction between non-digital and digital startups, and introduces a third type of hybrid startups (Kollmann et al., 2021; König et al., 2019). *Third*, I extend insights into the domain of environmental entrepreneurship by conceptualizing cleantech startups as impact-focused ventures with different carbon reduction potentials based on the startup type (Vedula et al., 2022). I also determine critical policy implications for support mechanisms of cleantech startups that are tailored to the startup type as well as managerial implications.

4.2 Theoretical background

4.2.1 Entrepreneurial resource mobilization and life cycle dynamics

A startup is a temporary and innovative organization that delivers a new product, facing a high-growth potential under conditions of extreme uncertainty (Blank & Dorf, 2020; Ries, 2011). Technology startups differ from mainstream startups by pursuing opportunities through technical innovations (Beckman, Eisenhardt, Kotha, Meyer, & Rajagopalan, 2012). Furthermore, VC-backing of startups points to the startups' aim to liquidate the assets through a successful exit (De Clercq et al., 2006). As a consequence, technology, VC-backed startups have different resource mobilization approaches and life cycle dynamics than mainstream startups without VC backing (Fisher et al., 2016; Puri & Zarutskie, 2012). This makes a scope limitation necessary. In this study, I limit the scope to technology, VC-backed startups.

Startups are nascent organizations and typically have limited initial resource endowments. Consequently, *resource mobilization* is a central task for startups and encompasses processes by which startups assemble resources to exploit opportunities. Resource mobilization enhances survival and long-term evolution chances (Clough et al., 2019; Villanueva et al., 2012). Resources are commonly grouped into the four types of financial, social, human, and other resources (Clough et al., 2019). While financial resources refer to monetary assets (Drover et al., 2017), social resources relate to interorganizational ties through which non-monetary resources are obtained (Adler & Kwon, 2002; Hallen et al., 2014). Human resources include capabilities, knowledge, and skills residing in and utilized by individuals related to the startup (Tzabbar & Margolis, 2017). For technology, VC-backed startups, other resources commonly include resources that comprise tangible and intangible technological assets (Bruton & Rubanik, 2002; Yoo et al., 2012) and manufacturing resources (Hallen et al., 2014; Katila et al., 2008). Leveraging these resources is a crucial and challenging endeavor for startups to transit successfully through stages in the life cycle (Clough et al., 2019; Fisher et al., 2016).

Organizational *life cycle theory* conceptualizes a staged life cycle, where organizations evolve predictably to achieve organizational growth (Chandler, 1962; Kazanjian & Drazin, 1989). Kazanjian's (1988) seminal work considers established organizations and distinguishes four life cycle stages: conception and development, commercialization, growth, and stability. Due to the focus on technology, VC-backed startups, this paper excludes the last stage of stability (Fisher et al., 2016). The terminology regarding the stages may differ, and the number of life cycle stages may vary in entrepreneurial life cycle models (e.g., Hegeman & Sørheim, 2021; Overall & Wise, 2015). However, they reveal consistent patterns that are either condensed or expanded according to the number of stages presented in the life cycle model. I build on the tripartite division of life cycle stages by Fisher et al. (2016) that focuses on technology, VC-backed startups and encompasses three stages of conception, commercialization, and growth. First, the *conception stage* centers on scientific and engineering R&D. Second, the *commercialization stage* comprises further technological development, including the identification and resolution of technical problems, technology demonstration, and market introduction. Third, in the *growth stage*, startups thrive to achieve tangible performance metrics.

Empirical research has confirmed the role of the four resource types for technology, VC-backed startups to achieve progress in transiting through the life cycle stages. Regarding *financial resources*, empirical research has provided evidence that accelerators (Hochberg & Fehder, 2015), business angels (Dutta & Folta, 2016), government support such as grants (Islam et al., 2018), as well as impact investors (Holtslag, Chevrollier, & Nijhof, 2021) enable startups to progress in the conception stage. Moreover, empirical research has shown that mobilizing financial resources, particularly from traditional and corporate VC investors, enables startups to advance in the commercialization stage toward the growth stage (see Drover et al., 2017 for a review). *Social resources* in the conception stage occur in terms of technology alliances with research institutes and other non-profit organizations (Doblinger et al., 2019). Furthermore, incubators are important in the conception stage as they assist startups with space, administrative services, legal advice, networking opportunities, and potential access to financial resources (Amezcua, Grimes, Bradley, & Wiklund, 2013). In the commercialization stage, social resources in the form of ties to corporates and other startups enhance the venture’s performance (Hsu, 2004; Lindsey, 2002; Stam & Elfring, 2008). When considering *human resources*, empirical research points to the importance of the technical knowledge and skills of individuals in the conception stage (Colombo & Grilli, 2005; Roche et al., 2020). In the commercialization stage, business-related knowledge and skills improve venture performance (Hsu, 2007). Regarding *technological resources*, scholars have mainly considered patents, which indicate the invention output of R&D activities in the conception stage (Goldstein et al., 2020). Other empirical studies have shown that patents also function as quality signals to mobilize financial resources in the commercialization stage, although they continue to play an enhancing role in the growth stage (Hsu &

Ziedonis, 2013; Mann & Sager, 2007). Finally, research has demonstrated that *manufacturing resources* are critical in the later life cycle stages of commercialization (Hallen et al., 2014; Katila et al., 2008).

In summary, entrepreneurial resource mobilization and the life cycle dynamics of startups are closely intertwined. While financial, social, human, and technological resources are relevant in the conception and commercialization stage for technology, VC-backed startups, manufacturing resources are critical in the later life cycle stages of commercialization only. Resource mobilization in conjunction with life cycle dynamics thus serves as the theoretical base for this study.

This research further clarifies the specifications related to resource mobilization and associated life cycle dynamics between non-digital, hybrid, and digital startups. It is relevant to provide a more nuanced understanding on resource mobilization and associated life cycle dynamics because the underlying technology of the products differs fundamentally (Kollmann, 2006; Lyytinen et al., 2016; Yoo et al., 2012). The following section introduces a typology of non-digital, hybrid, and digital startups.

4.2.2 A typology of non-digital, hybrid, and digital startups

Researchers from entrepreneurship have called to examine digital startups from non-digital startups separately. This manifests in the literature stream on digital entrepreneurship (Nambisan et al., 2019; Zaheer, Breyer, & Dumay, 2019). In prior empirical studies on resource mobilization, the startup type separation appears only implicitly by a sectoral focus on either digital software startups (e.g., Bajwa, Wang, Nguyen Duc, & Abrahamsson, 2017; Cavallo et al., 2019) or non-digital, for instance, biotechnology startups (e.g., Alvarez-Garrido & Dushnitsky, 2016; Baum & Silverman, 2004). The direct comparison of non-digital and digital startups has been previously assessed only to a limited extent, where two recent empirical studies are remarkable. While König et al. (2019) compare business model evolution patterns, Kollmann et al. (2021) compare strategic patterns and the entrepreneurial orientation of non-digital and digital startups. I integrate this suggested separation of non-digital and digital startups into the startup typology. Furthermore, there is evidence from the information systems literature that the previous two startup types converge into a third type. This convergence of the non-digital and digital dimensions is evident in firms that develop and market smart products that have been conceptually described in the information systems literature (Yoo et al., 2010; Yoo et al., 2012). Examples of products of hybrid startups are smart meters and smart demand response products (International Energy Agency, 2017). This makes the introduction of a third category of hybrid startups relevant. Overall, I take a product-centric perspective to relate the startup type, i.e., non-digital, hybrid, and digital startups, to the product innovation type, i.e., non-digital, hybrid, and digital products (Kohli & Melville, 2019; Yoo et al., 2010).

Digital startups are characterized by digital product innovations that contain IT-enabled product components (Kohli & Melville, 2019; Lyytinen et al., 2016). Accordingly, IT enables and manifests in digital product innovation and is thus essential for the value creation (Elia et al., 2020). In essence, digital startups develop and commercialize digital product innovations as the output of entrepreneurial operations. The digital product innovation contains digital, not physical, product components only.

By contrast, *non-digital startups* are characterized by non-digital product innovations, where the product contains physical components only. Accordingly, IT is not manifested in the non-digital product innovation as an outcome, but IT can be relevant in supporting value creation activities (Kollmann et al., 2021).

In addition to digital and non-digital startups, a third startup type has emerged that combines the characteristics of the previously described two types. The so-called hybridity refers to the conceptualization of product innovation as the combination of IT-enabled digital and physical components to form new products (Yoo et al., 2010). Hybrid product innovations thus reflect the convergence of the digital and non-digital spheres (Yoo et al., 2012). According to a product centric-perspective, *hybrid startups* are characterized by hybrid product innovation as the output of entrepreneurial operations.

Although the presented typology conceptually differentiates the three startup types and theoretical frameworks for resource mobilization and life cycle dynamics are well established (see section 4.2.1), this study connects the typology with resource mobilization and life cycle dynamics. While the integration of IT into products is evident in many sectors (Lanzolla et al., 2020), the focus of this study is the U.S. cleantech sector.

In the following section, I explain why the U.S. cleantech industry is a relevant and appropriate context. I also elaborate on the peculiarities of cleantech startups. The following chapter comprises interview quotes. The general topics of the U.S. cleantech industry and cleantech startups occurred naturally in the conversations, due to the semi-structured character of the interviews (see section 4.4.3 for coding).

4.3 Research context

4.3.1 The U.S. cleantech industry

The focus on the cleantech industry is important because innovation in this industry is part of climate action, mitigating environmental degradation and adapting to changing circumstances induced by climate change (Intergovernmental Panel on Climate Change, 2022; Sivaram & Norris, 2016). Researchers and policymakers highlight the urgent need to develop and bring cleantech innovations to market to reach net-zero emissions by 2050 (International Energy Agency, 2017; Sivaram & Norris, 2016; United Nations Framework Convention on Climate Change, 2015). Accordingly, it is relevant to understand resource mobilization and life cycle dynamics of cleantech startups. It is important to clarify this by distinguishing between non-digital, hybrid, and digital cleantech startups because major differences appear in the products (see section 4.2.2) and presumably in resource mobilization and associated life cycle dynamics. It is therefore important to identify shortcomings and opportunities for firms in the cleantech industry based on the typology of non-digital, hybrid, and digital startups.

The U.S. cleantech industry is an interesting research context because digitization accounts as a major trend in the energy sector (Di Silvestre et al., 2018). As such, innovations in the cleantech industry have become increasingly digital within the last decade (Bumpus & Comello, 2017). The digitization trend in the cleantech industry is driven by novel opportunities that occur due to improved advancements of digital technologies, where specifically "*artificial intelligence and machine learning become a big part of cleantech*" (I5). The interview participants also revealed that novel opportunities in the digital space occur due to cost drops of commoditized hardware technologies and IT infrastructure, making data collection and analysis, and thus new business models, economically more lucrative. Additionally, the interview participants noted that more digital firms rebrand themselves as "digital cleantech" because it overcomes the negative consequences associated with the past cleantech bubble burst. The interview participants also stated that public awareness for climate change has been increasing, so software engineers are increasingly motivated to tackle climate-related problems and provide solutions, which generally increases the supply of digital firms in the cleantech industry.

Although the digitization trend is prevalent in the U.S cleantech industry, commercializing non-digital and hybrid product innovations remains vital to tackle climate change (International Energy Agency, 2021). In this sense, the interview participants emphasized the limits of the environmental impacts of digital cleantech innovations. For example, one investor elaborated that "*the atmosphere does not clean itself by software*" (I3), while another investor provides an example of the limits of digital product innovations in the cleantech industry: "*If the grid still has natural gas-fired peaker plants and the baseload power comes from coal, it does not really matter how efficient software makes the grid*" (I4). Accordingly, aside from digital product innovations, there is a need for hybrid and non-digital product innovations to decarbonize the energy system. One investor describes the tripartite differentiation of cleantech products as follows: "*I saw everything from hard tech, for example, deep material science, to others that were all purely software, and others that were a combination of hardware and software*" (I7).

4.3.2 Cleantech startups

Innovations in the cleantech industry are predominately driven by startups. Incumbents in the energy industry "*do not want to change the game and therefore, the entrepreneurial route is much better for cleantech*" (E2). Overall, the interview participants highlighted three intertwined peculiarities of cleantech startups that distinguish cleantech startups from startups in other high-tech sectors: hybrid value creation, the double externality problem, and sensitivity to policies.

First, cleantech startups face a hybrid value creation, which induces environmental and economic value creation that exist together (Hoogendoorn, Van der Zwan, & Thurik, 2020; York, O'Neil, & Sarasvathy, 2016). On the one hand, cleantech startups create environmental value by providing products that mitigate or adapt to climate change-related environmental degradation. Accordingly, cleantech startups are considered impact-driven ventures (Vedula et al., 2022). Cleantech startups thus create environmental gains for society (Hoogendoorn et al., 2020). Relatedly, a startup founder described this aspect as follows: "*The societal focus of cleantech startups is triggered by the necessity to address environmental degradation, such as wildfires, hurricanes, tornadoes, and heat waves*" (S2). On the other hand, cleantech startups create economic value by pursuing private wealth generation (Hoogendoorn et al., 2020). In this regard, one investor stated that cleantech startups need to generate financial attraction by having "*many customers, revenue, and profit*" (I1).

Second, the double externality problem implies that positive externalities occur not only through the usual knowledge externalities of R&D in the conception stage. In addition, positive externalities also accrue in the commercialization and growth stages through environmental value creation, which makes the cleantech innovation socially desirable. Because of this double-source market failure, private returns of R&D are usually lower than social returns, justifying the need for public support in terms of policies and regulations (Horbach, Oltra, & Belin, 2013; Rennings, 2000). One investor emphasized that the "*government is the right support mechanism when the ROI is very much going to be a collective or societal benefit, but it is not necessarily going to accrue precisely to a company*" (I4).

Third, the need for public support leads cleantech startups to be sensitive to policies and regulations which overcome lower innovation incentives and support the commercialization of products (Cojoianu, Clark, Hoepner, Veneri, & Wójcik, 2020; Hegeman & Sørheim, 2021). All interview participants pointed to the direct and strong dependence of cleantech startups on policies and regulations. In addition to the push/pull support policies, superordinate pro-environmental policies, such as national strategies, also mitigate the risk for private investors, encouraging them to make investments. One investor stresses the importance of policies as follows: "*VC investors typically try to be the vanguards of what is next. However, in some way, they are laggards as they are waiting for others to drive down the costs and risks. […] It is like waiting for the policy to come – almost like the game of chicken*" (I6). Therefore, policies and regulations send important signals to private investors, giving them the confidence to invest in cleantech startups.

4.4 Methods

4.4.1 Data sampling

The research design is qualitative and reflects the novelty of relating the typology of non-digital, hybrid, and digital cleantech startups to specific resource mobilization approaches. To gain rich information, I relied on a purposeful sampling strategy. In particular, I employed a combination of quota and knowledgeable sampling (Patton, 2015). I used quota sampling to "*fill important categories*" (Patton, 2015, p. 406) of participants. In this sense, I balanced the number of participants between the two main categories of investors and startups. Within each category, I attempted to cover different perspectives so that I included agnostic and cleantech-focused investors as well as startups from various cleantech sub-sectors and types. As a third category, I additionally included industry experts because they hold great knowledge without being directly involved in startup or investment activities themselves. Across all categories, I relied on key knowledgeables as "*important sources of specialized issues*" (Patton, 2015, p. 430).

I defined key knowledgeables in the three participant categories as follows. The investors need to have made at least one investment in a cleantech startup and at least five years of work experience in investing. The cleantech startups need to have received at least one VC investment and at least five years of work experience in a startup. The experts need to have at least five years of work experience in the cleantech industry.

All interview participants were approached via email, containing a brief personal introduction and the purpose of the interview. Table 4-1 provides an overview of the 16 participants, which include seven investors, six startups, and three industry experts. Table 4-1 also shows the classification and specification of the participant's associated firm, the position of the participant, and the number of venture investments made by an investor or the number of investors who made investments in a startup (data retrieved from Crunchbase in August 2021) as well as the recording time of the interview in minutes.

Acronym[1]	**Classification (specification)**	**Position of the participant**	**Venture investments**[2]	**Recording time (in min.)**
I1	Investor (agnostic)	Founding partner	I: 201	56
I2	Investor (agnostic)	Partner	I: 96	30
I3	Investor (agnostic)	Managing partner	I: 350	28
I4	Investor (cleantech-focused)	Partner	I: 24	29
I5	Investor (cleantech-focused)	Partner	I: 6	30
I6	Investor (cleantech-focused)	Managing director	I: 36	47
I7	Investor (cleantech-focused)	Director	I: 61	50
S1	Non-digital startup (energy efficiency)	Founder; CEO	S: 6	31
S2	Digital startup (energy efficiency)	Co-founder; CEO	S: 8	26
S3	Non-digital startup (energy efficiency)	Founder; CEO	S:13	29
S4	Hybrid startup (energy storage)	Vice president	S:3	37
S5	Non-digital startup (geothermal)	CEO	S:15	41
S6	Hybrid startup (smart grid)	Founder; CEO	S:1	30
E1	Expert (energy consulting)	Associate director	E: NA	34
E2	Expert (startup consulting)	CEO	E: NA	22
E3	Expert (sustainability consulting)	Founder	E: NA	28
				Total: 548

Notes: [1] I = investor; S = startup; E = expert
[2] Number of investments made by an investor I; number of investors who made investments in a startup S; NA = not assigned to expert E

Table 4-1: Overview of interview participants

4.4.2 Data collection

I collected the data through semi-structured interviews. Semi-structured interviews follow a pre-formulated structure while allowing interviewers to add questions and participants to reveal additional insights as they appear during the conversation. Furthermore, semi-structured interviews allow a deep exploration of the details of a topic (Myers, 2009). I carried out 16 semi-structured interviews between June 2021 and August 2021. I covered four core themes: product characteristics, startup characteristics, resource mobilization, and exit of non-digital, hybrid, and digital cleantech startups. To account for the expertise of participants and maximize the insights gained, I slightly adjusted the interview guidelines as the research progressed. All interviews were held via Zoom.

At the beginning of the interview, I assured the participants that all data will be treated anonymously to reveal additional insights (Gioia, Corley, & Hamilton, 2013). All interviews were recorded. The interview recording lasted between 22 and 56 minutes. In total, I obtained 548 minutes (approximately 9 hours) of audio recording. The audio memos were transcribed verbatim. I compiled the transcripts with secondary data sources of publicly available information on company websites as well as LinkedIn posts of the companies and participants to obtain further information on the "*retrospective and real-time accounts by those people experiencing the phenomenon*" (Gioia et al., 2013, p. 19).

4.4.3 Data analysis

I used content analysis to analyze my data. I applied a combination of the deductive and inductive approaches and relied on a mixture of concept-driven and data-driven coding (Mayring, 2000). For the deductive approach and thus the concept-driven coding, I contemplated the theory on resource mobilization, and specifically the resource types, as well as the established life cycle stages (Clough et al., 2019; Fisher et al., 2016). Regarding cleantech-related matters, I specifically recognized that cleantech startups are impact-driven ventures in the environmental domain (Vedula et al., 2022).

All interviews were coded manually using the software MAXQDA version 2020. For the coding frame, I initially assigned the statements to the startup type they were referring to, i.e., non-digital, hybrid, and digital startups. For example, the interview participants elaborated on a non-digital startup that developed and commercialized energy efficient window inserts, a hybrid startup that offered smart solar-plus-storage systems, and a digital startup that provided the software for smart building management systems.

Then, I deductively set up seven main categories for coding that reflect the four core themes of the interview for each type of startup. In line with Clough et al. (2019), I specified resource mobilization based on the resource type. Accordingly, the seven main categories are product characteristics, startup characteristics, mobilization of financial, social, human, and other resources, and exit. I examined all transcripts and inductively established two to seven sub-categories for each main category. In the second round of transcript examination, I adapted the sub-categories in an iterative process by cycling between the inductive sub-categories and theoretical foundations (Gioia et al., 2013). Finally, I assigned a life cycle stage, i.e., conception, commercialization, or growth, to each sub-category (Fisher et al., 2016). The assignment of life cycle stages agrees with the theoretical framework of resource mobilization and life cycle theory (see section 4.2.1) and indicates the most appropriate fit between the life cycle stages and sub-categories. The assignment does not exclude resources as being relevant in other life cycle stages as well. Table 4-2 summarizes the arrangement of the four core themes, seven main categories, and associated sub-categories as well as the assignment of life cycle stages distinguished by the three types of non-digital, hybrid, and digital startups. Table 4-2 also summarizes the findings for each startup type, which appear in more detail in the next section.

Besides the coding frame, I coded any statement about general matters of the U.S. cleantech industry and cleantech startups as context. I coded other unrelated statements as other.

	Main category	Sub-category	Stage[1]	Non-digital startup	Hybrid startup	Digital startup
Prodcut characteristics	Product characteristics	Product characteristics	NA	"Deep tech" • Physical nature of the product • Analog artifacts as the product • Leveraging material engineering, mechanical engineering, and other scientific research as an integral part of the product's functioning	"Smart tech" • Physical and digital nature of the product • Hardware/software bundle as the product • Leveraging commoditized or proprietary hardware to collect data that the software processes to conduct analyses	"Tech" • Digital nature of the product • Software as the product • Leveraging analog information that is digitized and analyzed and pushed through IT infrastructure to the customer
		Cleantech product examples	NA	• Energy efficient window inserts • CO_2 reducing manufacturing processes • Hydrogen fuels	• Smart solar-plus-storage systems • Smart grid analytic systems • Smart inverters for photovoltaic systems	• Software for smart building management systems • Customer engagement platforms for utilities • Virtual power plant software
		Product tangibility	NA	Tangible	⟷	Intangible
		Carbon reduction potential	NA	Extensive	⟷	Limited
Startup characteristics	Startup characteristics	Capital intensity	1	High	⟷	Low
		Time of R&D	1	Long	⟷	Short
		Technology uncertainty	1	High	⟷	Low
		Market uncertainty	1	High	⟷	Low
		Competition intensity	2	Low	⟷	High
		Main challenge	2	Lower costs	⟷	Ensure interoperability
Resource mobilization	Financial resource mobilization	Investment horizon[2]	NA	Long	⟷	Short
		Accelerators	1	Less prevalent	⟷	More prevalent
		Impact business angels	1	More prevalent	⟷	Less prevalent
		Government support	1	More prevalent	⟷	Less prevalent
		Impact investors	1	More prevalent	⟷	Less prevalent
		Corporate VC investors	2	Less prevalent	↔ More prevalent ↔	Less prevalent
		VC investors	2	Less prevalent	⟷	More prevalent
	Social resource mobilization	Research institutes	1	R&D alliances	⟷	Not relevant
		Incubators	1	Space, administrative support, and networking opportunities		
		Corporates	2	Development alliances	↔ Manufacturing alliances ↔	Customer alliances
		Startups	2	Informal alliances	⟷	Value co-creation alliances
	Human resource mobilization	Technical knowledge and skills	1	Engineering knowledge and skills	⟷	IT knowledge and skills
		Business knowledge and skills	2	Collaboration and scaling knowledge and skills		
	Mobilization of other resources	Technological resources	NA	Facilities, lab equipment, patents	↔ Commoditized or proprietary hardware ↔	Data, IT infrastructure
		Manufacturing resources	2	Manufacturing facilities	⟷	Not relevant
Exit	Exit	Time to exit	NA	Long	⟷	Short
		Acquisition	3	Less prevalent	⟷	More prevalent
		IPO	3	Less prevalent	⟷	More prevalent
		SPAC	3	More prevalent	⟷	Less prevalent

Notes: [1] Life cycle stages: 1 = conception stage; 2 = commercialization stage; 3 = growth stage; NA = not assigned, i.e., applicable across all stages
[2] Investment horizon does not reflect financial resource providers per se, but it is relevant in the context of financial resource binding. Therefore, the sub-category of investment horizon is attributed to the main category of financial resources.

Table 4-2: Product characteristics, startup characteristics, resource mobilization, and exit of non-digital, hybrid, and digital startups

4.5 Results

4.5.1 Non-digital startups

Product characteristics

The product characteristics of non-digital startups are related to "deep tech", which stresses the engineering and scientific aspects of non-digital products. The interview participants highlighted the physical nature and analog artifacts that compose the product. Specifically, they emphasized that material and mechanical engineering and other scientific research are integral parts of the product's functioning. Examples of non-digital product innovation in the cleantech industry are energy efficient window inserts, CO_2-reducing manufacturing processes (for instance, CO_2-reducing steel and cement production processes), and hydrogen fuels. Overall, the products are entirely tangible. Interestingly, the interview participants classified the carbon reduction potential of non-digital products in the cleantech industry as extensive, which depends on technological specifics and product quantity sold.

Startup characteristics

Regarding startup characteristics, the interview participants emphasized the high capital intensity of non-digital startups in the conception stage. In addition, they judged the time of R&D as long. Both the high capital intensity and the long period of R&D contribute to an extremely long and deep "valley of death." In the conception stage, the interview participants characterized the technology uncertainty as high. In addition, the market uncertainty was evaluated as high, because of, in the extreme case, the absence of a market in the future.

In the commercialization stage, the competition intensity of non-digital startups was characterized as low due to the engineering and scientific complexity of the non-digital products, which makes it challenging to imitate products. The main challenge for non-digital startups in the commercialization stage is to lower production costs to sell the product at lower prices. For example, the CEO of a non-digital geothermal startup noted that in the commercialization stage, it is important to have "*more efficient drilling tools that lower the costs*" (S5).

Financial resource mobilization

Mobilizing significant amounts of financial resources is important but challenging for non-digital startups. Due to a long conception stage and scaling challenges in the commercialization stage, the interview participants assessed the investment horizon across all life stages as long. To meet such challenges, cleantech-focused investors pointed to restructuring funds to extend the investment time horizon.

Regarding financial resource providers in the conception stage, accelerators are less prevalent for non-digital startups than for the other two startup types. Although accelerators can be beneficial for non-digital startups to secure initial pre-seed and seed funding, it is often challenging for non-digital startups to get accepted. The founder and CEO of a non-digital startup described the experience in the accelerator as follows: "*We were literally the only hardware company [in the accelerator]. We were like a zoo exhibit*" (S1).

Apart from accelerators in the conception stage, impact business angels, government support, and impact investors are more prevalent. Aligned with the description of a non-digital startup founder, impact business angels are "*angel investors who appreciate the work where climate change is addressed*" (S3). Non-digital startups agreed that impact business angels were prevalent and vital in the first life cycle stage.

Moreover, mobilizing financial resources through government support – especially grants, loans, and state-funded programs for pilot projects – is prevalent for non-digital startups. According to the interview participants, government support is crucial to fund non-digital startups that, on the one hand, have a high carbon reduction potential, but on the other hand, suffer from the disregard of private investors. Overall, an important advantage of government support is that startups can buy some time to continue working on their product innovations without being pushed into the timelines of traditional VC investors: "*At the early R&D stage, scientists and engineers may suffer from the distraction of interacting with commercial VC investors. […] Once a company takes VC financing, the timeline starts becoming specific. A precise timeline does not necessarily fit with the search and R&D for a breakthrough in a technology*" (I4).

In the conception stage, impact investors also play a critical role for non-digital startups. Impact investors typically invest before VC investors participate. The interview participants revealed that impact investors structure funds either by pooling the money from philanthropic, individual donors or by relying on large funds of corporate foundations. Impact investors have a "*heavy climate lens*" (I6) focusing on the deep decarbonization potential of the product innovation, which is predominately given by non-digital startups. Their expectation regarding the ROI is positive but not as high as that of VC investors. Funds of impact investors usually have a longer investment time horizon, potentially including evergreen funds, and often function on a revolving basis.

Impact investors also serve to bridge the weaknesses of government support, where mobilizing financial resources can take very long due to structural and administrative burdens. Moreover, some impact investors have set up specific programs, including "*non-dilutive R&D capital […] to cover living expenses of fellows enabling them to advance their technology*" (I6). Impact investors often have internal technical experts or access to expert knowledge via partnerships with universities and laboratories. They can therefore conduct due diligence on non-digital startups competently.

In the commercialization stage, corporate VC investors are less prevalent. Corporate VC investors can be advantageous partners for non-digital startups to mobilize financial and other resources. For example, the CEO of a non-digital, geothermal startup explained that they were interested in corporate VC investors such as home builders as they can "*install geothermal pumps from the start*" (S5). However, another non-digital startup founder mentioned that a "*strategic partner could understand the technical aspects. […] However, there was ultimately divergence on intellectual property considerations*" (S1), so the deal was not closed.

With regard to VC investors, the interview participants assessed them as less prevalent for non-digital startups. This decision was due to the extremely long and deep "valley of death", which is "*not compatible with venture-style returns*" (I5). VC investors also stated that material and engineering science is very complex so that they are not able to conduct due diligence of non-digital startups competently. All non-digital startup founders and CEOs agreed that it was difficult to raise money from traditional VC investors. However, the interviews also stressed that traditional VC investors increasingly set up climate-oriented funds, where VC investors intend to make more investments in non-digital cleantech startups acknowledging their high carbon reduction potential. Interestingly, many non-digital startup founders and CEOs highlighted that it was beneficial if the VC investor already had made investments in another non-digital startup before. For example, a founder and CEO of a non-digital startup described this issue as a "*predictor of whether to have a good conversation with a VC investor or not*" (S3).

Social resource mobilization

In the conception stage, research institutes are significant partners for non-digital startups to build R&D alliances to access physical resources, such as facilities and laboratories, as well as human resources, such as the technical knowledge and skills of employees at the research institute. Furthermore, in the conception stage, incubators are vital social resource providers enabling startups to access space, administrative support, and new personal networks.

In the commercialization stage, corporates can play a role for non-digital startups by forming development alliances. For example, the founder and CEO of a non-digital startup described that the startup had a contract with a corporate for non-recurring engineering.

In the commercialization stage, alliances with other startups have an informal character and include the exchange of business-related knowledge. These kinds of relations are collegial and contain knowledge exchange about "*fund-raising plans*" (S1), and "*learn about the mistakes of others*" (S5).

Human resource mobilization

Non-digital startups in the conception stage strive to mobilize technical knowledge and skills, which typically include engineering knowledge and skills. In the commercialization stage, the focus shifts toward business knowledge and skills – especially in terms of collaboration and scaling – which are necessary for non-digital startups to commercialize their non-digital products.

Mobilization of other resources

Throughout all life cycle stages, technological resource mobilization is important for non-digital startups. It includes access to facilities and lab equipment in the tangible dimension and patents in the intangible dimension. This mobilization of these technological resources can occur through alliance formation, as described in the section of social resource mobilization above.

Furthermore, mobilizing manufacturing resources is vital for non-digital startups in the commercialization stage. The interview participants revealed two options for non-digital startups to mobilize manufacturing resources: building or contracting. As it requires "*tons of capital expenditure to build plants*" (I5), the building option is rarely chosen by non-digital startups. Accordingly, the interview participants emphasized that contracting is a more suitable option for non-digital startups to mobilize manufacturing resources. Public-private partnerships can come into play by connecting non-digital startups, public research institutes that focus on manufacturing non-digital products, and private manufacturing centers. These connections are especially vital when the product cannot be manufactured by assembling existing product components but is entirely new.

Exit

Non-digital startups typically require more time to transit from the conception to the commercialization stage than the two other startup types. They face additional challenges in the commercialization stage – particularly mobilizing financial resources from VC investors and manufacturing resources – which takes extra time. Therefore, the interview participants assessed the time to exit, i.e., the time from startup birth to the liquidation event, as longer for non-digital startups, compared to hybrid and digital startups. Overall, the interview participants noted that acquisitions and IPOs are less prevalent for non-digital startups in the growth stage. However, exits through special purpose acquisition companies (SPACs) are more prevalent. Investors compare SPACs of non-digital startups with large late-stage funding rounds of VC investors for digital startups, which "*theoretically are a good fit for climate-related technologies that are hardware intensive*" (I6). The investors admit that SPACs take non-digital startups public that "*otherwise would not be ready to go public*" (I7). The interviews reveal that non-digital startups that experience an exit through a SPAC often face an absence of track records and profitability.

4.5.2 Hybrid startups

Product characteristics

The characteristics of products of hybrid startups are related to "smart tech". The product nature is characterized as both physical and digital. The interview participants described a hybrid product as a hardware/software bundle. Specifically, the software processes data, which was collected by commoditized or proprietary hardware, to conduct analyses. These data analyses often include predictive models. The hardware could potentially function without the software, but the value of the hybrid product is created through tying the software to the hardware. Examples of hybrid products in the cleantech industry include smart solar-plus-storage systems, smart grid analytic systems, and smart inverters for photovoltaic systems. As the hardware components of the product are tangible and the software components are intangible, the interview participants assessed the tangibility degree as moderate, positioned between the extremes of tangible and intangible. The interview participants indicated that the carbon reduction potential of hybrid products is moderately high, i.e., lower than for non-digital cleantech products but higher than for digital cleantech products.

Startup characteristics

The capital intensity of hybrid startups in the conception stage was assessed as moderate. While software-related product development is less capital intensive, hardware-related product development is more capital intensive, especially in the case of proprietary, compared with commoditized, hardware. According to the interview participants, the time for R&D is moderately long. The interview participants revealed that the user experience is compelling for hybrid startups in the conception stage, where short iterations of development and testing overall lead to a shorter time of R&D compared with non-digital startups. Regarding technological and market uncertainty, both are lower than for non-digital startups and evaluated as moderately high.

In the commercialization stage, the competition was characterized as moderately intense and higher than for non-digital startups. Many investors stated that easy access to and cost drops of commoditized hardware, and particularly sensors, pave the way for more startups to work on hybrid products, which increases the competition intensity. The challenge for hybrid startups in the commercialization stage centers on lowering costs, which is the focal commercialization challenge of non-digital startups. They must also ensure interoperability, which accounts for the main commercialization challenge of digital startups. In particular, industry experts noted that interoperability with other smart, i.e., hybrid, products and the existing IT infrastructure, poses a crucial challenge for hybrid startups in the commercialization stage.

Financial resource mobilization

Across all life cycle stages, the investment horizon of hybrid startups is moderately long and thus shorter than for non-digital startups, which is closely linked to the shorter time of R&D in the conception stage as well as better access to financial resources from VC investors in the commercialization stage as outlined below.

Regarding financial resource providers in the conception stage, accelerators and impact business angels are moderately prevalent. Government support for hybrid startups was also assessed as moderately prevalent. The interview participants indicated that government support is not as vital and prevalent as for non-digital startups due to better access to financial resources from private investors.

Impact investors in the conception stage were evaluated as moderately prevalent. Regarding the double-bottom line of impact investors consisting of economic and environmental values, all hybrid startups noted that they were asked to quantify the environmental impact in terms of a "*carbon analysis to support the product*" (S4).

Interestingly, the interview participants stated that corporate VC investors are more prevalent for hybrid startups than non-digital and digital startups. The hybrid startups identified hardware manufacturers and telecommunication and IT firms as promising corporate VC investors. Corporate VC investors do not only convey financial resources but also other resources. While hardware manufacturers provide manufacturing resources, telecommunication and IT firms provide technological resources such as IT infrastructure in terms of, for example, cloud storage and servers.

Commercial VC investors are moderately prevalent in the commercialization stage of hybrid startups. The investors perceived that hybrid startups achieve higher ROIs than non-digital startups. Hybrid startups noted that they emphasized the software components and deemphasized the hardware component when pitching to agnostic VC investors, as VC investors generally prefer investments in digital startups.

Social resource mobilization

R&D alliances with research institutes are less relevant for hybrid startups than for non-digital startups. Indeed, hybrid startups are not as dependent on the resource transfer from research institutes because facilities, engineering, and scientific knowledge and skills are not that pertinent. Similar to non-digital startups, incubators are important social resource providers for hybrid startups in terms of the provision of space, administrative support, and networking opportunities.

In the commercialization stage, hybrid startups establish ties with corporates to contract manufacturing resources. Known hardware product components are assembled by the manufacturing corporates. These corporates may be prior corporate VC investors. Depending on whether hybrid products tend to be more non-digital or digital, the alliances with corporates can include development alliances or customer alliances.

Startup alliances have a mixed purpose for hybrid startups. On the one hand, informal exchange, such as in the case of non-digital startups, is prevalent. On the other hand, they also pursue value co-creation endeavors, such as in the case of digital startups.

Human resource mobilization

In the conception stage, hybrid startups mobilize technical knowledge and skills. On the one hand, this encompasses engineering knowledge and skills for hardware R&D engineering, and on the other hand, it includes IT knowledge and skills for software development. Regarding business skills and knowledge in the commercialization stage, they universally include collaboration and scaling knowledge and skills.

Mobilization of other resources

Across all life cycle stages, hybrid startups need to mobilize technological resources. According to the interview participants, leveraging commoditized or proprietary hardware is essential and can occur, as described above, through corporate alliance and prior corporate VC investor affiliations. Moreover, the interviews revealed that data and IT infrastructure account as vital technological resources, which become increasingly important with more digital components embedded in the hybrid products. Technological resources can also comprise the ones of non-digital startups, i.e., facilities, lab equipment, and patents. These resources become increasingly important if more non-digital components are embedded in the hybrid product and the proprietary hardware is developed in-house.

The mobilization of manufacturing resources in the commercialization stage incurs less difficult challenges than for non-digital startups. Contract manufacturers can manufacture the hardware required for hybrid products as the hardware consists of existing product components.

Exit

Hybrid startups typically face a shorter time to exit than non-digital startups since the transition from the conception to the commercialization stage is faster and mobilizing financial resources from VC investors in the commercialization stage is more prevalent, enabling them to achieve scale more quickly. Regarding the liquidation events in the growth stage, the interview participants stated that acquisitions are moderately prevalent, where telecommunication and IT firms and hardware manufacturers were mentioned as the most important acquirers of hybrid startups. Furthermore, the IPO was assessed as moderately prevalent and thus more prevalent than for non-digital startups. Finally, for hybrid startups, SPACs were assessed as moderately prevalent. According to the interview participants, better access to financial resources of VC investors and greater prevalence of IPOs for hybrid startups make SPACs less prevalent than for non-digital startups.

4.5.3 Digital startups

Product characteristics

The product characteristics of digital startups are related to "tech", which indicates the digital nature of the software product. Specifically, the analog information is digitized and analyzed by the software. Results of (predictive) data analytics are then pushed to the customer using an IT infrastructure. Digital cleantech products comprise, for example, software for smart building management systems, customer engagement platforms for utilities, which provide detailed home energy reports to customers, and software for virtual power plants. Overall, digital products were characterized as purely intangible. Interestingly, the carbon reduction potential of digital products was assessed as limited. According to the interview participants, digital products induce environmental efficiency improvements of existing products or infrastructure. Thus, the carbon reduction potential of digital products depends on the potential environmental efficiency improvement of an existing product or infrastructure and the product quantity (e.g., licenses) sold.

Startup characteristics

In the conception stage of digital startups, the interview participants assessed the capital intensity as low and the time for R&D as short. Furthermore, both the technology and market uncertainty of digital startups in the conception stage were estimated as low. In the commercialization stage, the competition intensity was evaluated as high. The interview participants indicated that low capital intensity and widely available IT knowledge and skills facilitate the imitation of digital products and thereby increase the competition intensity among digital startups. The interviews revealed that the main challenge of digital startups in the commercialization stage centers on ensuring interoperability. As digital products in the cleantech industry improve the environmental efficiency of existing products or infrastructure, digital products need to be interoperable with such.

Financial resource mobilization

The interview participants noted that the investment horizon of digital startups is short because digital startups have a shorter conception stage and can achieve scale in the commercialization stage more quickly.

Regarding financial resource providers in the conception stage, accelerators are more prevalent for digital than for non-digital and hybrid startups. The interviews revealed that many accelerators focus on digital startups enabling higher acceptance rates. In the conception stage, other financial resources providers such as impact business angels, government support, and impact investors were assessed as less prevalent than for non-digital and hybrid startups.

In the commercialization stage, the interviews revealed that corporate VC investors are less prevalent for digital than for hybrid startups. By contrast, VC investors in the commercialization stage are assessed as more prevalent for digital than for non-digital and hybrid startups. The interview participants argued that VC investors' preference for digital startups is linked to the low technological and market uncertainty of digital startups as well as the short and shallow "valley of death" that occurs due to low capital intensity and a shorter R&D time. This leads VC investors to perceive that digital startups achieve higher ROIs than non-digital and hybrid startups. For example, an investor noted: "*A typical good performing venture portfolio should achieve a 25% to 30% return [per year over the lifetime of the investment]. You can hit that when you invest in pure software companies*" (I5). The investors also revealed that path dependence of digital startups as investment targets drives their investment preferences. For example, one investor noted that "*Silicon Valley has over 25 years of VC investing experience in software companies*" (I4). Similarly, the founder and CEO of a non-digital startup claimed critically: "*Throughout most of the history, a lot of VC money was flowing to software. [...] There is a much bigger fantasy of wealth amongst the investors' minds*" (S3). VC investors have been most experienced with investing in digital startups, and thus, their due diligence competencies are often limited to digital startups. Relatedly, an investor elaborated: "*For VC firms that do not necessarily have access to technical experts who can do due diligence, it is easier to simply look for patterns across software startups*" (I4).

Social resource mobilization

The interviews revealed that alliances with research institutes in the conception stage are not relevant for digital startups because they neither require access to physical resources such as facilities and laboratories nor technical knowledge and skills of employees at the research institute.

Similar to non-digital and hybrid startups, incubators can be vital social resource providers for digital startups in the conception stage to access space, administrative support, and networking opportunities.

In the commercialization stage, corporate affiliations are valuable in terms of customer alliances. The interview participants revealed that many digital startups are selling to business customers that predominately include telecommunication and IT firms and utilities. These customer alliances are often facilitated by commercial VC investors: "*We introduce the customers to our [digital startups]. I make an introduction to connect them*" (I1).

The interviews also revealed that digital startups form alliances with other digital startups for value co-creation. All investors agreed that value co-creation alliances are most beneficial for digital startups as technical knowledge and skills in the software domain form a common skill and knowledge base. Digital startup alliances are often facilitated by VC investors. In this context, an investor told me: "*We have definitely done* *cross-pollination of our portfolio companies so that they were able to conduct business around each other*" (I2). However, another investor also pointed to competitive frictions when facilitating value co-creation between digital startups: "*There may be opportunities for collaboration, but you may run into more issues related to competition as well*" (I6).

Human resource mobilization

In the conception stage, digital startups require IT knowledge and skills. Overall, the interview participants assessed the availability of technical knowledge and skills for digital startups as higher than for non-digital and hybrid startups. They argued that IT knowledge and skills are not sector-specific and universally available. Relatedly, an investor argued: "*You do not need your backend developer to understand GHG emissions*" (I6). Such as in the case of non-digital and hybrid startups, the interview participants revealed that business skills and knowledge in the commercialization stage universally relate to collaboration and scaling.

Mobilization of other resources

Digital startups also need to mobilize other resources. In this regard, mobilizing technological resources requires digital startups to access (real-time) data and an IT infrastructure, including, for example, cloud storage and servers. The mobilization of manufacturing resources in the commercialization stage is not relevant because no physical product components are embedded in the product.

Exit

Digital startups typically have a short time to exit. This time is closely linked to a comparably short conception stage and better access to financial resources from VC investors in the commercialization stage, which enables digital startups to "*scale software very quickly*" (I2). Across the different mechanisms of liquidation events in the growth stage, acquisitions and IPOs are more prevalent than for non-digital and hybrid startups, emphasizing acquisitions over IPOs for digital startups: "*The median exit is going to be an acquisition, and it will likely be a software company*" (I4). According to the interview participants, acquirers are predominately those corporates that digital startups have formed prior customer alliances with, i.e., telecommunication and IT firms as well as utilities. The interview participants assessed SPACs as less prevalent for digital than for hybrid and non-digital startups.

4.6 Discussion and conclusion

4.6.1 Summary of the findings and theoretical contributions

This study aims to understand the resource mobilization and associated life cycle dynamics of non-digital, hybrid, and digital startups. I extend the established typology of non-digital and digital startup by introducing a third category of hybrid startups that, from a product-centric perspective, reflects the convergence of the two previous startup types. I derived a novel framework (see Table 4-2) that specifies the characteristics, resource mobilization approaches, and exit mechanisms for each startup type.

My findings reveal that *non-digital startups* face a longer and deeper "valley of death", which is mainly related to the comparably long time for R&D and high capital intensity in the conception stage as well as the high technological and market uncertainty, and additional scaling challenges in the commercialization stage. This leads VC investors to largely disregard non-digital startups for investment. A further problem for VC investors is that some lack the skills for conducting due diligence on non-digital startups. Although non-digital startups have potential support from a diverse set of financial resource providers in the conception stage, a severe financing gap occurs after the conception stage, due to the lack of timely follow-on investments from the private sector. Moreover, as regards social resources, corporates are vital partners for non-digital startups to set up development alliances, including non-recurring engineering. Mobilizing manufacturing resources is also essential for non-digital startups. The exit mechanism of non-digital startups incurs additional challenges. It reveals a longer time to exit and lower prevalence of acquisitions and IPOs.

Hybrid startups constitute an intermediate startup type between non-digital and digital startups. For hybrid startups, the role of corporate VC investment in the commercialization stage is pronounced. Corporate VC investors do not only provide financial resources but also resources such as IT infrastructure and manufacturing facilities. Therefore, corporate VC investors are essential for hybrid startups in the commercialization stage, and the same corporates can also act as acquirers in the growth stage.

Lastly, from a product-centric perspective, *digital startups* are at the opposite end of the spectrum from non-digital startups. Due to digital startups requiring less time for R&D, low capital intensity, low market and technology uncertainty, and less severe scaling challenges, digital startups face a shorter and shallower "valley of death". This makes digital startups more attractive to VC investors. Furthermore, while corporates are important partners for digital startups to form customer alliances, other digital startups can also act as partners for value co-creation in the commercialization stage. Overall, the exit mechanism of digital startups has certain advantages, including a shorter time to exit and a greater prevalence of acquisitions and IPOs. Regarding the carbon reduction potential, my findings indicate that products of non-digital cleantech startups have the highest potential for carbon reduction, followed by hybrid and digital cleantech startups. This study advances the theory on entrepreneurial resource mobilization and life cycle dynamics, as well as the digital and environmental entrepreneurship literature.

First, I contribute to the entrepreneurial resource mobilization and life cycle theory (Clough et al., 2019; Fisher et al., 2016). While resource mobilization approaches and life cycle dynamics have already been considered together (see section 4.2.1), the role of the startup type has not been considered in prior studies. It is relevant to consider the resource mobilization approaches and life cycle dynamics of non-digital, hybrid, and digital startups separately because their products bear fundamental technological differences, especially regarding the integration of IT (Kollmann, 2006; Lyytinen et al., 2016; Yoo et al., 2012). My findings reveal that the technological shift not only manifests in products, and, accordingly, the startup types, but it has consequences for the startups' approaches to resource mobilization. My findings provide evidence that resource mobilization approaches linked to life cycle dynamics differ based on the startup type. Specifically, I derived a novel framework (see Table 4-2) that specifies the characteristics, resource mobilization approaches, and exit mechanisms for each startup type. Overall, the results indicate that digital startups face less severe challenges in resource mobilization, followed by hybrid and non-digital startups. In particular, VC investors, who provide essential financial resources, are more inclined to invest in digital startups than in the other startup types. In this regard, prior research has already questioned the fit between VC investments and "deep tech", i.e., non-digital, startups (Gaddy et al., 2017). Furthermore, among the three startup types, digital startups reach the growth stage in the life cycle sooner. This resonates with the rapid scaling capabilities of digital startups along the life cycle (Huang, Henfridsson, Liu, & Newell, 2017).

Second, I contribute to the literature on digital entrepreneurship. In particular, I establish a stronger connection between digital entrepreneurship and digital innovation research. Taking a product-centric perspective, I link the startup types, i.e., non-digital, hybrid, and digital startups, to the product innovation types, i.e., non-digital, hybrid, and digital products (Kohli & Melville, 2019; Yoo et al., 2010). Thereby, I respond to recent calls not only to consider digitization as a context, but also to explore the fundamental assumption that digital products have distinct characteristics, which shape entrepreneurial processes and outcomes (Berger et al., 2021; Nambisan et al., 2019).

Furthermore, non-digital and digital startups have been compared in terms of business model evolution, strategic patterns, and entrepreneurial orientation (Kollmann et al., 2021; König et al., 2019). I enrich this stream of studies by providing comparative insights on the resource mobilization and life cycle dynamics of non-digital and digital startups. Additionally, I introduce a third category of hybrid startups that, from a product-centric perspective, lies between the two extreme categories of non-digital and digital startups. Hybrid startups develop and commercialize smart products. Those products contain both non-digital and digital components and have already been described in the information systems literature conceptually (Yoo et al., 2010; Yoo et al., 2012). By introducing the hybrid type, I transfer insights from the information systems literature to the growing field of digital entrepreneurship (Berger et al., 2021).

Third, the context of the qualitative study is the U.S. cleantech industry. The three peculiarities that distinguish cleantech startups from those in other high-tech sectors are hybrid value creation (Hoogendoorn et al., 2020; York et al., 2016), the double externality problem (Horbach et al., 2013; Rennings, 2000), and the sensitivity to politics (Cojoianu et al., 2020; Hegeman & Sørheim, 2021). These peculiarities were largely supported during my interviews. In addition, my interviews revealed that the startup type not only determines resource mobilization and life cycle dynamics but also the carbon reduction potential of the underlying cleantech product type. I show that startups leverage digital technologies to develop and commercialize digital products to tackle environmental sustainability (George, Merrill, & Schillebeeckx, 2021). Interestingly, my findings reveal that the carbon reduction potential of digital products is limited, because they tend to improve the efficiency of existing products or infrastructure. In contrast, the interviews revealed that the carbon reduction potential of non-digital products is extensive. In other words, I find that non-digital cleantech products have the highest carbon reduction potential, followed by hybrid and digital cleantech products. This result resonates with the conceptualization of cleantech startups as impact-focused ventures in the domain of environmental entrepreneurship (Vedula et al., 2022). To the best of my knowledge, the environmental impact of ventures has not been considered with the different types of startups. This paper provides a valuable addition to the debate of supporting ventures that strive to combat climate change.

4.6.2 Managerial implications

This study has important managerial implications for startups and VC investors. My findings suggest that *non-digital startups* should continue mobilizing financial resources from a variety of sources in the conception stage. When pitching to impact-driving financial resource providers, they should be prepared to present the carbon reduction potential of the non-digital product. Moreover, for non-digital startups, mobilizing large amounts of financial resources from VC investors is decisive in the commercialization stage. However, VC investors may still lack due diligence capabilities in evaluating the technical specifics of non-digital products. Therefore, VC investors should actively engage in networks to access the required capabilities. Moreover, non-digital startups should engage in R&D alliances with research institutes in the conception stage and development alliances with corporates in the commercialization stage, which can drive forward development endeavors and the usage of sales channels. *Hybrid startups* should focus on corporate VC investors as essential partners for mobilizing financial and other resources, such as manufacturing facilities and IT infrastructure. Similar to non-digital startups, they should also be prepared to present the carbon reduction potential of their products to impact business angels and impact investors. Concerning *digital startups*, VC investors should take on an active broker role to connect digital startups with corporates that can be potential customers and other digital startups for value co-creation purposes. In addition, digital startups themselves should actively seek these connections to corporates and other digital startups themselves. Regarding the high carbon reduction of non-digital cleantech startups, the policy implications in the next section focus on this startup type. Policy implications for hybrid and digital startups are also briefly described.

4.6.3 Policy implications

My findings have important implications for policymakers. There is a consensus that cleantech innovations are an important contributor to reaching net-zero emissions by 2050, where the private sector, and especially cleantech startups, play an essential role in developing and commercializing innovations (International Energy Agency, 2021; Sivaram & Norris, 2016; United Nations Framework Convention on Climate Change, 2015). Support from the public sector is further needed to bridge gaps in resource mobilization in the entrepreneurial life cycle.

For policymakers, it is important to acknowledge the carbon reduction potential of *non-digital startups* and specifically support this startup type. Although non-digital startups potentially have access to a diverse set of financial resource providers in the conception stage, they remain underfinanced. Therefore, grant volumes could be increased. Moreover, it would also be beneficial to establish a more flexible grant application process so that non-digital startups do not have to wait until there is a tender for the specific technology but could apply flexibly. Furthermore, lower administrative efforts for the grant application could free resources for other venture-related matters in the conception stage of non-digital startups.

The interviews also revealed that there is a significant funding gap between the conception and commercialization stages for non-digital startups and that governmental support drops off too early. Although it is a controversial topic whether to extend funding beyond the conception stage, governmental funding could be a valuable addition here. Indeed, pushing non-digital startups toward commercialization is essential because private sector investments largely fail to fund non-digital startups beyond the conception stage, and the societal benefit stemming from the commercialization of non-digital products is high. Government-funded programs could provide non-digital startups with vital access to financial resources beyond the conception stage, assist them to secure follow-on financing from the private sector, and further connect them with the primary private stakeholders.

Moreover, the interviews revealed that especially agnostic VC investors lack due diligence competencies for non-digital startups, which accounts for one reason that they disregard non-digital startups as investment targets. Government policy could be directed to connect non-digital startups and VC investors with research institutes, impact investors, and universities that can evaluate the technical specifics of the non-digital products. Initiating and empowering these alliances could help guide VC investors' due diligence decisions of non-digital startups by mitigating uncertainty related to the technical specifics. One suggestion is to establish a network of government-funded hubs as third-party organizations to orchestrate the ecosystem around non-digital cleantech startups and VC investors. A further way to incentivize VC investors to invest in non-digital startups could be to establish certification schemes for non-digital products.

Furthermore, the interviews have shown that access to manufacturing resources is essential for non-digital startups. Therefore, it could be helpful for non-digital startups to have a transparent overview of manufacturers in specific domains including first points of contact. Supported by government funding, a publicly accessible online database would be a vital tool.

Such a database could also be relevant for *hybrid startups*. Furthermore, regarding hybrid startups, the interview participants have stressed the role of corporate VC investors in mobilizing financial and other resources. Tax credits for corporate VC funds could help to incentivize these investments.

Lastly, deregulating the electricity market in more states could increase competition, motivating utilities to invest in digital cleantech products developed and commercialized by *digital startups* or acquire them directly.

4.6.4 Limitation and future research opportunities

Although the focus of the study was to investigate the mobilization of financial, social, human, and other resources across the life cycle of different startup types, the findings center on financial resources. On the one hand, this is related to the chosen interview participant category of investors that emphasized financial resource mobilization due to their occupation. On the other hand, startups and industry experts also covered financial resource mobilization extensively during my interviews. While this study indeed emphasizes financial resource mobilization compared with other types of resources (Clough et al., 2019), it also reflects the pronounced role of financial resources for startups to transit through the life cycle. Nevertheless, it would be helpful to conduct further interviews, for example, with participants from corporate VC investors, research institutes, and incubators, to understand the mobilization of other resource types in more detail.

Furthermore, the external validity of the results of this study may be limited. Although the research context of U.S. cleantech startups fits the research aim (see section 4.3), many findings are sector-specific. In particular, the carbon reduction potential and the involvement of impact-driven financial resource providers are detrimental for the cleantech industry. Therefore, results may be transferred to other sectors, such as food or agriculture technology, where the startup typology applies, and the environmental impact is an essential characteristic of the product. Beyond that, future research could compare entrepreneurial resource mobilization of climate-oriented sectors with other high-tech sectors such as fintech and biotechnology.

The findings of this study are based on interviews where the interview participants often elaborated on resource mobilization and life cycle dynamics retrospectively. This calls for further longitudinal studies, reflecting the unfolding of entrepreneurial resource mobilization and transiting through the life cycle over time. In particular, future research may conduct case studies by entering the field and collecting data over time. In this sense, it can be fruitful to develop a resource mobilization process model that takes the startup typology into consideration (Eisenhardt, 1989).

This work also provides promising avenues for further quantitative research. The findings of this study classify the environmental impact of products in terms of the carbon reduction potential generically as high, moderate, and low for non-digital, hybrid, and digital products. Although this classification derives from the interviews, various carbon reduction potentials of products could appear within one startup type. Thus, it would be interesting to quantitatively assess the carbon reduction potential of products and further investigate the causal relationship between the environmental impact and entrepreneurial outcomes on a startup level by using surveys or novel tools such as Crane[8].

After having explored the role of political ideology (see chapter 2) and product digitization in resource mobilization of cleantech startups (see chapter 3 and 4), I summarize the main findings and implications of this dissertation in the next and final chapter.

[8] https://www.cranetool.org, accessed on July 4, 2022

5 Conclusion and outlook

This dissertation focuses on the resource mobilization of cleantech startups and provides novel perspectives on the role of political ideology and product digitization. The dissertation comprises three studies. The first study investigates the effect of VC investors' political ideology on investment decision-making and the role of certain startup attributes to this end. The second and third study focus on the role of product digitization in entrepreneurial resource mobilization. While the second study analyzes the effects of product digitization and dependencies in startup/VC investor networks on venture growth, the third study generates an understanding of how non-digital, hybrid, and digital startups mobilize financial, social, human, and other resources along the life cycle.

The empirical context of this dissertation is the U.S. cleantech sector. When scrutinizing the role of political ideology in the first study, my co-authors and I added startups from the U.S. fintech sector to the sample to yield comparative results concerning VC investments between the ideologically neutral fintech sector and the liberal-leaning cleantech sector. Regarding the second and third study, the cleantech industry is appropriate for examining the role of product digitization as products with varying degrees of digitization are developed and commercialized by startups in this industry. Overall, the findings of the three studies contribute to the theory on entrepreneurial resource mobilization.

The results of the quantitative analyses in the *first study* demonstrate that the political ideology of VC investors shapes investment decisions. Specifically, my co-authors and I show that VC investors' conservatism lowers the likelihood of their investments in ventures. In addition, we identify that this effect is weaker when the ideology of the venture is conservative or if the venture operates in a conservative environment. Contrary to our predictions, no significant differences were found in the effect of VC investors' ideology between the fintech and cleantech sectors. In this study, we give emphasis to the significance of investors' characteristics, specifically their political ideology, and their interplay with venture characteristics. By focusing on political ideology, we provide novel evidence on the role of non-market logics – and not pure economic rationality – in entrepreneurial resource mobilization.

In the *second study,* my co-authors and I conduct quantitative analyses and show that product digitization and diversified startup dependence, which implies many direct ties with VC investors, are positively associated with venture growth. However, the growth effect is not significant for diversified VC investor dependence, indicating that

VC investors have many ties with other startups. Our research also demonstrates that the product digitization/growth effect accentuates when startup and VC investor dependencies are diversified vs. centralized. With this study, we identify the product digitization of startups as a novel dimension of the nature of products that shapes venture growth. In addition, we provide novel insights into resource dependence and the entrepreneurial performance of venture growth outcomes.

In the *third study,* I conduct a qualitative analysis and demonstrate that entrepreneurial resource mobilization patterns of financial, social, human, and other resources vary across the three startup types of non-digital, hybrid, and digital startups. In particular, my findings indicate that non-digital startups face severe challenges in mobilizing financial resources after the conception stage. Furthermore, my findings reveal that hybrid startups achieve benefits by forming alliances with corporate VC investors in the commercialization stage to mobilize financial and other resources. Among the three startup types, I find that digital startups are most attractive for VC investors and benefit from alliances with corporates and other digital startups in social resource mobilization in the commercialization stage. Regarding the environmental impact of the cleantech startups, my findings indicate that non-digital startups have the highest carbon reduction potential, followed by hybrid and non-digital startups from this sector. With this study, I show that the startup type determines entrepreneurial resource mobilization processes and outcomes, as well as the carbon reduction potential. By introducing the hybrid startup type as an intermediate category between non-digital and digital, I make a valuable addition to the non-digital/digital typology of startups.

The findings of the three studies also have *managerial implications* for both startups and VC investors. Regarding the first study, my findings imply that startups should pay attention to VC investors' political ideology to pre-assess their likelihood of receiving funding. They should also evaluate their own attributes in light of the investors' political ideology. At the same time, VC investors should recognize that their political ideology could bias investment decisions and that identity-based social categorization could lead conservative VC investors to preferably invest in conservative ventures or in those based in a conservative spatial environment. Such investment choices, however, do not reflect the quality of the venture. Concerning the second study, ventures should recognize that their degree of product digitization affects their ability to achieve a growth event through an acquisition or IPO. Startups with highly digitized products should particularly engage in diversified, vs. centralized, dependence compositions to mobilize financial and social resources. It might thus be fruitful for VC investors to occupy an active broker role to facilitate intra-portfolio collaborations between startups with highly digitized products. In the third study, the managerial implications are tailored to the three startup types of non-digital, hybrid, and digital startups. Non-digital startups should focus on mobilizing financial resources from a variety of actors in and after the conception stage. As VC investors often lack due diligence capabilities to evaluate the technical specifics of non-digital startups, VC investors should actively engage in networks to access the needed capabilities. Hybrid startups should focus on corporate VC investors as essential partners for mobilizing financial and other resources in the commercialization stage. Digital startups could benefit from having alliances with other digital startups and corporates in the commercialization stage. In addition to actively seeking such connections themselves, VC investors could assist in facilitating the needed connections.

In terms of the third study, I also derive *policy implications*. My findings indicate that non-digital startups especially require policy support. As grants are essential for non-digital startups in the early conception stage to gather financial resources, higher volumes of grants and a more flexible application process could be helpful. Furthermore, government-funded programs could be beneficial for non-digital startups in securing funding and receiving assistance in acquiring follow-on funding in the commercialization stage. Government-funded hubs could also be helpful in orchestrating an ecosystem around non-digital cleantech startups and connecting VC investors with research institutes, universities, and impact investors so that they can attain the required technical capabilities for conducting due diligence.

The *methodological implications* of this dissertation are related to the second study, where my co-authors and I construct a novel measure of product digitization. This keyword-based measure allows placing startups' products on a continuous scale. The product digitization measure is generic and applicable to industries other than cleantech and firm sizes other than that of startups to operationalize the degree of product digitization of firms.

Returning to the first sentence of this dissertation: "We are in the epoch of the Anthropocene", it is evident that human action is the dominating force affecting our climate system. In combating the severe, and often irreversible, consequences of climate change, cleantech startups and their innovations are part of the solution. By focusing on the cleantech sector as the empirical setting, I provide a deeper understanding of the mechanisms and processes associated with entrepreneurial resource mobilization. Yet, when it comes to innovations tackling climate change, there is potential to look beyond the energy-related cleantech sector.

Indeed, combating climate change has become a central aim in other sectors as well. For example, in the food technology sector, startups develop and commercialize vegan alternatives to meat to, among others, reduce GHG emissions associated with meat production processes. In this context, the U.S. startup Beyond Meat[9] pioneered the vegan meat alternatives market and was listed on the U.S. stock market in 2019. With a similar focus on providing plant-based chicken alternative products, the Singaporean startup Next Gen Foods[10] closed a 100 million USD Series A round in early 2022. In the agriculture technology sector, startups focus on limiting GHG emissions by decreasing transportation and moving the production closer to the consumption site. For example, the German startup Infarm[11] provides smart, vertical farming solutions that enable micro gardening. By the end of 2021, the startup raised 200 million USD in a Series D round. There are also startups in the forest technology sector that use data to analyze forest quality and provide a digital marketplace connecting forest landowners and stakeholders that want to offset their carbon emissions. An example is the U.S. startup NCX[12] that offers such a forest carbon marketplace and monitors the quality of forests by analyzing satellite images. This startup is VC-backed, among others, by the climate fund of Union Square Ventures. These examples show that startups in various sectors drive innovations to combat climate change. Due to the sectoral diversity of startups combatting climate change, expanding the definition of the traditional energy-related cleantech sector is necessary. Therefore, when studying resource mobilization of startups with an environmental focus, I suggest the expansion of the sectoral definition to include climate technologies, or *climatetech*, for short. This definition of climatetech shall be more holistic and comprise technology startups from various sectors such as food, agriculture, forest, and energy that develop and commercialize products to mitigate and adapt to climate change. I further encourage future work to broaden the geographical context beyond the U.S to study climatetech startups, for example, in Asia and Europe.

[9] https://www.beyondmeat.com, accessed on July 4, 2022
[10] https://www.nextgenfoods.sg, accessed on July 4, 2022
[11] https://www.infarm.com, accessed on July 4, 2022
[12] https://www.ncx.com, accessed on July 4, 2022

Appendix A

A-1 Results of the sensitivity analyses

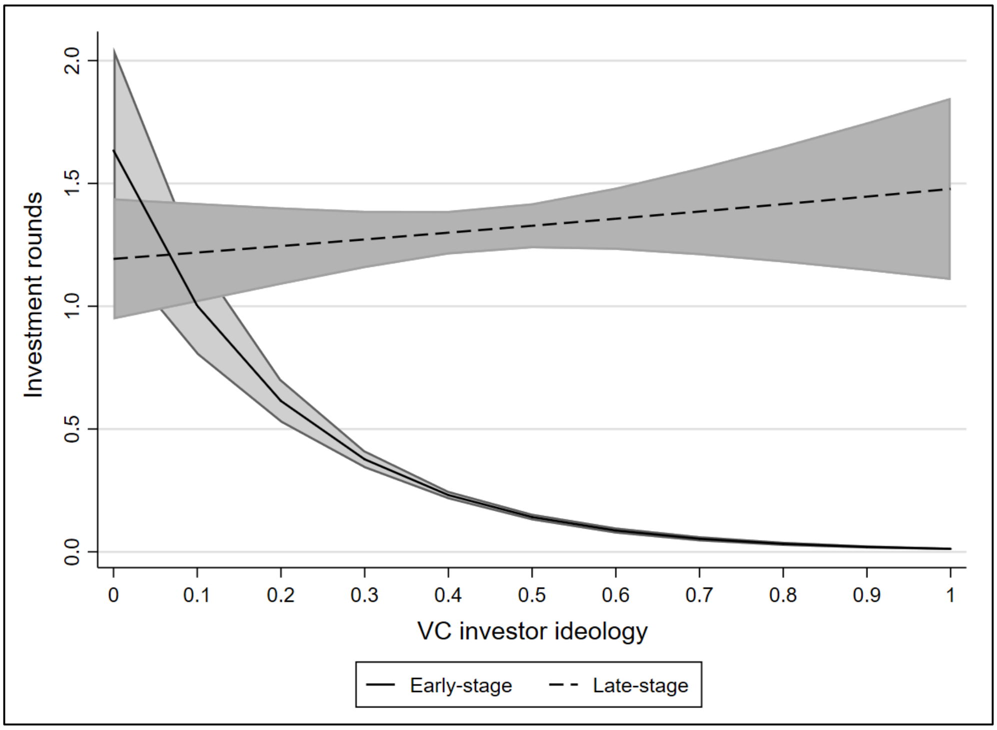


Figure A-1.1: Interaction effect: VC investor ideology x Investment stage

DV of Model 1: VC amount DV of Model 2: First investment round DV of Model 3: Investment rounds	**Model 1** Ordinary least square regression	**Model 2** Logit regression	**Model 3** Poisson regression (including patent citations for cleantech ventures)
VC investor ideology	-51.948***	-14.190***	-4.429***
	(0.000)	(0.000)	(0.000)
	[9.144]	[1.735]	[0.295]
Venture ideology	-10.959**	-0.323	-0.205
	(0.018)	(0.332)	(0.401)
	[4.622]	[0.334]	[0.244]
Pre-sample inv. round	3.797*	0.417***	0.016
	(0.052)	(0.006)	(0.911)
	[1.948]	[0.153]	[0.141]
Venture age	-0.36	-0.178***	-0.009
	(0.390)	(0.000)	(0.769)
	[0.419]	[0.034]	[0.031]
Sector	1.271	0.081	
	(0.363)	(0.533)	
	[1.396]	[0.131]	
Patent citations			0.000
			(0.110)
			[0.000]
Constant	39.718***	6.292***	1.149***
	(0.000)	(0.000)	(0.000)
	[4.754]	[0.790]	[0.172]
Location FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	3,459	3,696	2,048
R2	0.035		
Pseudo R2		0.186	0.121

Notes: P-values are displayed in parentheses and standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table A-1.1: Estimated coefficients of the ordinary least square regression of VC amount, logit regression of the first investment round, and Poisson regression of investment rounds including patent citations for cleantech ventures

DV: Investment rounds	**Model 1**	**Model 2**
	Poisson regression	Logit regression (Inflation)
VC investor ideology	-4.393***	
	(0.000)	
	[0.257]	
Venture ideology	-0.292	
	(0.139)	
	[0.198]	
Pre-sample inv. round	0.097	
	(0.251)	
	[0.085]	
Sector (fintech vs. cleantech)	0.176*	
	(0.051)	
	[0.090]	
Inflate: Venture age		1.089***
		(0.000)
		[0.149]
Location FE	YES	
Year FE	YES	
Observations	3,696	3,696
Prob. > Chi2	0.000	

Notes: P-values are displayed in parentheses and standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table A-1.2: Estimated coefficients of the zero-inflated Poisson regression of investment rounds

DV: Investment rounds	**Model 1**
	Instrumental variable Poisson regression
VC investor ideology	-0.569**
	(0.013)
	[0.229]
Venture ideology	-0.009
	(0.892)
	[0.069]
Pre-sample inv. round	0.062*
	(0.097)
	[0.037]
Sector (fintech vs. cleantech)	0.096***
	(0.000)
	[0.025]
Venture age	-0.007
	(0.358)
	[0.007]
Location FE	YES
Year FE	YES
Observations	841
Hansen's J Chi2 (1)	3.442 (p=0.064)

Notes: P-values are displayed in parentheses and standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table A-1.3: Estimated coefficients of the instrumental variable Poisson regression as endogeneity control of VC investor ideology

Appendix B

B-1 Overview of digital keywords and stemmed digital keywords

Number	Digital keyword	Stemmed digital keyword
1	access	access
2	alert	alert
3	algorithm	algorithm
4	analysis	analysi
5	analytics	analyt
6	anonym	anonym
7	app	app
8	artificial	artifici
9	blog	blog
10	bot	bot
11	broadcast	broadcast
12	buffer	buffer
13	bug	bug
14	button	button
15	cache	cach
16	class	class
17	click	click
18	cloud	cloud
19	code	code
20	communicate	commun
21	compute	comput
22	control	control
23	cookie	cooki
24	crawl	crawl
25	crawler	crawler
26	crowd	crowd
27	crowdsourcing	crowdsourc
28	crypt	crypt
29	cyber	cyber
30	data	data
31	database	databas
32	digital	digit
33	domain	domain
34	drone	drone
35	ecosystem	ecosystem
36	error	error
37	export	export
38	feed	feed
39	filter	filter
40	forum	forum
41	game	game
42	gamer	gamer
43	geek	geek
44	graph	graph
45	hack	hack
46	hacker	hacker
47	hashtag	hashtag
48	identify	identifi
49	identity	ident
50	import	import
51	index	index
52	information	inform
53	infrastructure	infrastructur
54	intelligence	intellig
55	interact	interact
56	interface	interfac
57	internet	internet
58	interpret	interpret
59	library	librari
60	link	link
61	memory	memori
62	meta	meta
63	model	model
64	narrowcast	narrowcast

Number	Digital keyword	Stemmed digital keyword
65	network	network
66	object	object
67	open	open
68	participation	particip
69	password	password
70	peer	peer
71	perl	perl
72	personalization	person
73	ping	ping
74	pixel	pixel
75	platform	platform
76	play	play
77	player	player
78	plug	plug
79	podcast	podcast
80	privacy	privaci
81	profile	profil
82	program	program
83	programmability	programm
84	protocol	protocol
85	proxy	proxi
86	real-time	real-tim
87	robot	robot
88	scrape	scrape
89	screen	screen
90	script	script
91	server	server
92	sharing	share
93	shelfware	shelfwar
94	signal	signal
95	simulation	simul
96	smart	smart
97	software	softwar
98	stream	stream
99	surveil	surveil
100	system	system
101	token	token
102	track	track
103	traffic	traffic
104	transcoding	transcod
105	transmission	transmiss
106	transpond	transpond
107	trigger	trigger
108	user	user
109	vector	vector
110	virus	viru
111	visualization	visual
112	web	web
113	widget	widget
114	wiki	wiki
115	wireless	wireless
116	zoom	zoom

B-2 Results of the sensitivity analyses

DV: Hazard of growth	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**
	Controls	Product digit.	Startup dep.	VC investor dep.	Product digit. # Startup dep.		Product digit. # VC investor dep.	
					Div. startup dep.	Cent. startup dep.	Div. VC investor dep.	Cent. VC investor dep.
Product digit.		3.980***			4.031**	2.520	5.152**	2.965
		(0.009)			(0.036)	(0.344)	(0.038)	(0.146)
		[2.094]			[2.677]	[2.461]	[4.078]	[2.219]
Div. startup dep.			1.624**					
			(0.017)					
			[0.329]					
Div. VC investor dep.				1.257				
				(0.230)				
				[0.240]				
Patent citations	1.056	1.061	1.042	1.054	1.041	1.054	1.065	1.049
	(0.188)	(0.150)	(0.329)	(0.206)	(0.435)	(0.454)	(0.275)	(0.441)
	[0.044]	[0.044]	[0.043]	[0.044]	[0.054]	[0.075]	[0.062]	[0.064]
Grant	0.701	0.762	0.719	0.700	0.865	0.608	0.966	0.578
	(0.224)	(0.361)	(0.264)	(0.224)	(0.718)	(0.308)	(0.935)	(0.239)
	[0.205]	[0.227]	[0.212]	[0.205]	[0.348]	[0.297]	[0.406]	[0.269]
Sector FE	YES	YES	YES	YES	YES	YES	YES	YES
Location FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	461	461	461	461	232	229	230	231
Growth events	107	107	107	107	67	40	55	52
LogLikelihood	-605.5	-603.0	-602.7	-604.9	-328.3	-196.4	-270.1	-257.7

Notes: P-values are displayed in parentheses and standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table B-2.1: Estimated hazard ratios of Cox proportional hazard models of growth events within 10 years after founding

DV: Hazard of growth	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**
	Controls	Product digit.	Startup dep.	VC investor dep.	Product digit. # Startup dep.		Product digit. # VC investor dep.	
					Div. startup dep.	Cent. startup dep.	Div. VC investor dep.	Cent. VC investor dep.
Product digit.		5.271***			7.074***	2.961	6.939**	3.102
		(0.003)			(0.010)	(0.251)	(0.016)	(0.179)
		[2.975]			[5.362]	[2.802]	[5.603]	[2.612]
Div. startup dep.			1.516**					
			(0.036)					
			[0.302]					
Div. VC investor dep.				1.355				
				(0.104)				
				[0.253]				
Patent citations	1.055	1.060	1.043	1.052	1.031	1.061	1.061	1.044
	(0.175)	(0.134)	(0.291)	(0.193)	(0.531)	(0.406)	(0.279)	(0.460)
	[0.041]	[0.041]	[0.041]	[0.041]	[0.051]	[0.075]	[0.058]	[0.060]
Grant	0.840	0.916	0.887	0.840	1.302	0.618	1.240	0.737
	(0.515)	(0.749)	(0.658)	(0.518)	(0.488)	(0.258)	(0.606)	(0.458)
	[0.225]	[0.250]	[0.240]	[0.226]	[0.495]	[0.263]	[0.517]	[0.303]
Sector FE	YES	YES	YES	YES	YES	YES	YES	YES
Location FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	403	403	403	403	207	196	203	200
Growth events	112	112	112	112	69	43	58	54
LogLikelihood	-608.5	-605.1	-606.3	-607.3	-324.1	-197.3	-269.5	-256.5

Notes: P-values are displayed in parentheses and standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table B-2.2: Estimated hazard ratios of Cox proportional hazard models of growth events within 14 years after founding of surviving startups

DV: Growth event	Model 1		Model 2		Model 3		Model 4	
	Controls		Product digit.		Startup dep.		VC investor dep.	
	β	AME	β	AME	β	AME	β	AME
Product digit.			1.949***	0.322***				
			(0.009)	(0.008)				
			[0.747]	[0.120]				
Div. startup dep.					0.476**	0.079**		
					(0.048)	(0.043)		
					[0.241]	[0.039]		
Div. VC investor dep.							0.289	0.048
							(0.231)	(0.228)
							[0.242]	[0.040]
Patent citations	0.100*	0.017*	0.108*	0.018*	0.088	0.015	0.096*	0.016*
	(0.073)	(0.068)	(0.056)	(0.051)	(0.115)	(0.111)	(0.085)	(0.080)
	[0.056]	[0.009]	[0.056]	[0.009]	[0.056]	[0.009]	[0.056]	[0.009]
Grant	-0.247	-0.040	-0.142	-0.023	-0.224	-0.036	-0.251	-0.040
	(0.471)	(0.452)	(0.681)	(0.674)	(0.518)	(0.502)	(0.461)	(0.442)
	[0.343]	[0.053]	[0.345]	[0.054]	[0.346]	[0.054]	[0.341]	[0.053]
Venture age	0.210***	0.035***	0.214***	0.035***	0.210***	0.035***	0.218***	0.036***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	[0.044]	[0.007]	[0.044]	[0.007]	[0.044]	[0.007]	[0.045]	[0.007]
Sector FE	YES	YES	YES	YES	YES	YES	YES	YES
Location FE	YES	YES	YES	YES	YES	YES	YES	YES
Intercept	-3.225***		-3.978***		-3.481***		-3.469***	
	(0.000)		(0.000)		(0.000)		(0.000)	
	[0.467]		[0.549]		[0.513]		[0.529]	
Observations	454		454		454		454	
Growth events	112		112		112		112	
LogLikelihood	-231.5		-228.3		-229.5		-230.8	
Chi2	49.10		54.95		47.91		48.62	
Prob. > Chi2	(0.000)		(0.000)		(0.000)		(0.000)	
Pseudo R2	0.087		0.100		0.095		0.090	

Notes: Numbers displayed in the estimation table report coefficients from the logit models (β) and AMEs. P-values are displayed in parentheses and standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1 *(table continues below)*

DV: Growth event	Model 5		Model 6		Model 7		Model 8	
	Product digit. # Startup dep.				Product digit. # VC investor dep.			
	Div. startup dep.		Cent. startup dep.		Div. VC investor dep.		Cent. VC investor dep.	
	β	AME	β	AME	β	AME	β	AME
Product digit.	2.434**	0.418**	1.196	0.179	2.866**	0.460***	1.041	0.171
	(0.019)	(0.015)	(0.301)	(0.299)	(0.012)	(0.009)	(0.312)	(0.310)
	[1.039]	[0.172]	[1.157]	[0.172]	[1.142]	[0.175]	[1.031]	[0.168]
Div. startup dep.								
Div. VC investor dep.								
Patent citations	0.038	0.006	0.161*	0.024*	0.115	0.018	0.105	0.017
	(0.632)	(0.632)	(0.070)	(0.063)	(0.158)	(0.150)	(0.207)	(0.200)
	[0.079]	[0.013]	[0.089]	[0.013]	[0.081]	[0.013]	[0.084]	[0.014]
Grant	0.013	0.002	-0.393	-0.055	0.085	0.014	-0.426	-0.065
	(0.978)	(0.978)	(0.465)	(0.427)	(0.863)	(0.865)	(0.410)	(0.369)
	[0.473]	[0.081]	[0.537]	[0.069]	[0.493]	[0.081]	[0.517]	[0.072]
Venture age	0.355***	0.061***	0.120**	0.018**	0.265***	0.043***	0.186***	0.031***
	(0.000)	(0.000)	(0.044)	(0.041)	(0.000)	(0.000)	(0.004)	(0.003)
	[0.079]	[0.012]	[0.060]	[0.009]	[0.064]	[0.010]	[0.065]	[0.010]
Sector FE	YES	YES	YES	YES	YES	YES	YES	YES
Location FE	YES	YES	YES	YES	YES	YES	YES	YES
Intercept	-5.122***		-3.276***		-4.743***		-3.602***	
	(0.000)		(0.000)		(0.000)		(0.000)	
	[0.945]		[0.775]		[0.812]		[0.822]	
Observations	229		213		225		229	
Growth events	68		43		58		54	
LogLikelihood	-117.9		-99.68		-110.0		-115.0	
Chi2	36.40		15.46		39.07		22.54	
Prob. > Chi2	(0.000)		(0.163)		(0.000)		(0.048)	
Pseudo R2	0.153		0.070		0.143		0.081	

Notes: Numbers displayed in the estimation table report coefficients from the logit models (β) and AMEs. P-values are displayed in parentheses and standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table B-2.3: Logit regressions of growth events within 14 years after founding

DV: Predicted hazard of growth	**Model 1**
	Product digit.
Predicted product digit.	3.194***
	(0.000)
	[0.496]
Patent citations	0.128***
	(0.000)
	[0.004]
Grant	-0.262***
	(0.000)
	[0.033]
Sector FE	YES
Location FE	YES
Intercept	0.620***
	(0.000)
	[0.176]
Observations	461
Growth events	112

Notes: P-values are displayed in parentheses and standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table B-2.4: Estimated coefficients of the two-stage least square regression as endogeneity control of product digitization

Bibliography

Adler, P. S., & Kwon, S.-W. (2002). Social capital: Prospects for a new concept. *Academy of Management Review*, *27*(1), 17-40.

Aiken, A. L., Ellis, J. A., & Kang, M. (2020). Do politicians "put their money where their mouth is?" Ideology and portfolio choice. *Management Science*, *66*(1), 376-396.

Ainsley, C. (2021). Decentralized central banks: Political ideology and the federal reserve system of regional banks. *Governance*, *34*(2), 277-294.

Allison, P. D. (2014). *Fixed effects regression methods for longitudinal data using SAS*. SAS Institute.

Alnahedh, S., & Alhashel, B. (2021). Political ideology in M&A. *Journal of Business Finance & Accounting*, *48*(9-10), 1711-1746.

Alvarez-Garrido, E., & Dushnitsky, G. (2016). Are entrepreneurial venture's innovation rates sensitive to investor complementary assets? Comparing biotech ventures backed by corporate and independent VCs. *Strategic Management Journal*, *37*(5), 819-834.

Amezcua, A. S., Grimes, M. G., Bradley, S. W., & Wiklund, J. (2013). Organizational sponsorship and founding environments: A contingency view on the survival of business-incubated firms, 1994-2007. *Academy of Management Journal*, *56*(6), 1628-1654.

Audretsch, D., Colombelli, A., Grilli, L., Minola, T., & Rasmussen, E. (2020). Innovative start-ups and policy initiatives. *Research Policy*, *49*(10), 104027.

Bajwa, S. S., Wang, X., Nguyen Duc, A., & Abrahamsson, P. (2017). "Failures" to be celebrated: An analysis of major pivots of software startups. *Empirical Software Engineering*, *22*(5), 2373-2408.

Baum, C. F., Schaffer, M. E., & Stillman, S. (2003). Instrumental variables and GMM: Estimation and testing. *The Stata Journal*, *3*(1), 1-31.

Baum, J. A., Calabrese, T., & Silverman, B. S. (2000). Don't go it alone: Alliance network composition and startups' performance in Canadian biotechnology. *Strategic Management Journal*, *21*(3), 267-294.

Baum, J. A., & Silverman, B. S. (2004). Picking winners or building them? Alliance, intellectual, and human capital as selection criteria in venture financing and performance of biotechnology startups. *Journal of Business Venturing*, *19*(3), 411-436.

Beckman, C., Eisenhardt, K., Kotha, S., Meyer, A., & Rajagopalan, N. (2012). Technology entrepreneurship. *Strategic Entrepreneurship Journal*, *6*(2), 89-93.

Beckman, C. M., & Burton, M. D. (2008). Founding the future: Path dependence in the evolution of top management teams from founding to IPO. *Organization Science*, *19*(1), 3-24.

Beckman, C. M., Burton, M. D., & O'Reilly, C. (2007). Early teams: The impact of team demography on VC financing and going public. *Journal of Business Venturing*, *22*(2), 147-173.

Bengtsson, O., & Hsu, D. H. (2015). Ethnic matching in the U.S. venture capital market. *Journal of Business Venturing*, *30*(2), 338-354.

Berger, E. S. C., Von Briel, F., Davidsson, P., & Kuckertz, A. (2021). Digital or not – The future of entrepreneurship and innovation. *Journal of Business Research*, *125*, 436-442.

Bergset, L. (2018). Green start-up finance – where do particular challenges lie? *International Journal of Entrepreneurial Behavior & Research*, *24*(2), 451-575.

Bharadwaj, A., El Sawy, O. A., Pavlou, P. A., & Venkatraman, N. (2013). Digital business strategy: Toward a next generation of insights. *MIS Quarterly, 37*(2), 471-482.

Blank, S., & Dorf, B. (2020). *The startup owner's manual: The step-by-step guide for building a great company*. John Wiley & Sons.

Blossfeld, H.-P., & Rohwer, G. (2002). *Techniques of event history modeling: New approaches to causal analysis.* (2nd ed.). Lawrence Erlbaum Associates.

Bonanno, G. A., & Jost, J. T. (2006). Conservative shift among high-exposure survivors of the September 11th terrorist attacks. *Basic and Applied Social Psychology*, *28*(4), 311-323.

Bonaparte, Y., Kumar, A., & Page, J. K. (2017). Political climate, optimism, and investment decisions. *Journal of Financial Markets*, *34*, 69-94.

Bonica, A. (2014). Mapping the ideological marketplace. *American Journal of Political Science*, *58*(2), 367-386.

Bosma, N., Van Praag, M., Thurik, R., & De Wit, G. (2004). The value of human and social capital investments for the business performance of startups. *Small Business Economics*, *23*(3), 227-236.

Brandes, U. (2016). Network positions. *Methodological Innovations*, *9*, 1-19.

Briscoe, F., Chin, M. K., & Hambrick, D. C. (2014). CEO ideology as an element of the corporate opportunity structure for social activists. *Academy of Management Journal*, *57*(6), 1786-1809.

Brooks, A. W., Huang, L., Kearney, S. W., & Murray, F. E. (2014). Investors prefer entrepreneurial ventures pitched by attractive men. *Proceedings of the National Academy of Sciences*, *111*(12), 4427-4431.

Brown, R. (2000). Social identity theory: Past achievements, current problems and future challenges. *European Journal of Social Psychology*, *30*(6), 745-778.

Brüderl, J., Preisendörfer, P., & Ziegler, R. (1992). Survival chances of newly founded business organizations. *American Sociological Review*, *57(*2), 227-242.

Brunswicker, S., & Schecter, A. (2019). Coherence or flexibility? The paradox of change for developers' digital innovation trajectory on open platforms. *Research Policy*, *48(*8), 103771.

Bruton, G. D., & Rubanik, Y. (2002). Resources of the firm, Russian high-technology startups, and firm growth. *Journal of Business Venturing*, *17*(6), 553-576.

Bumpus, A., & Comello, S. (2017). Emerging clean energy technology investment trends. *Nature Climate Change*, *7*(6), 382-385.

Caparos, S., Fortier-St-Pierre, S., Gosselin, J., Blanchette, I., & Brisson, B. (2015). The tree to the left, the forest to the right: Political attitude and perceptual bias. *Cognition*, *134*, 155-164.

Caporin, M., & Poli, F. (2017). Building news measures from textual data and an application to volatility forecasting. *Econometrics*, *5(*3), 35.

Carnahan, S., & Greenwood, B. N. (2018). Managers' political beliefs and gender inequality among subordinates: Does his ideology matter more than hers? *Administrative Science Quarterly*, *63*(2), 287-322.

Carney, D. R., Jost, J. T., Gosling, S. D., & Potter, J. (2008). The secret lives of liberals and conservatives: Personality profiles, interaction styles, and the things they leave behind. *Political Psychology, 29*(6), 807-840.

Carter, R. B., Strader, T. J., & Dark, F. H. (2012). The IPO window of opportunity for digital product and service firms. *Electronic Markets*, *22*(4), 255-266.

Cassar, G. (2006). Entrepreneur opportunity costs and intended venture growth. *Journal of Business Venturing*, *21*(5), 610-632.

Cavallo, A., Ghezzi, A., Dell'Era, C., & Pellizzoni, E. (2019). Fostering digital entrepreneurship from startup to scaleup: The role of venture capital funds and angel groups. *Technological Forecasting and Social Change*, *145*, 24-35.

CB Insights (2016, August 9). *Quick flips: The fastest $1B+ exits for VC-backed companies*. Retrieved July 4, 2022, from https://www.cbinsights.com/research/fastest-tech-exits

Chahine, S., & Zhang, Y. (2020). Change gears before speeding up: The roles of chief executive officer human capital and venture capitalist monitoring in chief executive officer change before initial public offering. *Strategic Management Journal*, *41*(9), 1653-1681.

Chandler, A. D. (1962). *Strategy and structure: Chapters in the history of the American enterprise*. MIT Press.

Chang, S. J. (2004). Venture capital financing, strategic alliances, and the initial public offerings of internet startups. *Journal of Business Venturing*, *19*(5), 721-741.

Chin, M. K., Hambrick, D. C., & Treviño, L. K. (2013). Political ideologies of CEOs: The influence of executives' values on corporate social responsibility. *Administrative Science Quarterly*, *58*(2), 197-232.

Chin, M. K., & Semadeni, M. (2017). CEO political ideologies and pay egalitarianism within top management teams. *Strategic Management Journal, 38*(8), 1608-1625.

Chow, D. Y. L., Louca, C., Petrou, A. P., & Procopiou, A. (2022). Marriage to the same kind: Organizational political ideology and mergers and acquisitions. *Organization Studies*, *43*(4), 521-546.

Christensen, D. M., Dhaliwal, D. S., Boivie, S., & Graffin, S. D. (2015). Top management conservatism and corporate risk strategies: Evidence from managers' personal political orientation and corporate tax avoidance. *Strategic Management Journal, 36*(12), 1918-1938.

Clough, D. R., Fang, T. P., Vissa, B., & Wu, A. (2019). Turning lead into gold: How do entrepreneurs mobilize resources to exploit opportunities?. *Academy of Management Annals*, *13*(1), 240-271.

Cojoianu, T. F., Clark, G. L., Hoepner, A. G., Veneri, P., & Wójcik, D. (2020). Entrepreneurs for a low carbon world: How environmental knowledge and policy shape the creation and financing of green start-ups. *Research Policy*, *49*(6), 103988.

Colombo, M. G., & Grilli, L. (2005). Founders' human capital and the growth of new technology-based firms: A competence-based view. *Research Policy*, *34*(6), 795-816.

Costa, P. T., & McCrae, R. R. (1992). The five-factor model of personality and its relevance to personality disorders. *Journal of Personality Disorders*, *6*(4), 343-359.

Cox Pahnke, E., McDonald, R., Wang, D., & Hallen, B. (2015). Exposed: Venture capital, competitor ties, and entrepreneurial innovation. *Academy of Management Journal*, *58*(5), 1334-1360.

Cruz, S. M. (2017). The relationships of political ideology and party affiliation with environmental concern: A meta-analysis. *Journal of Environmental Psychology*, *53*, 81-91.

Cumming, D., Henriques, I., & Sadorsky, P. (2016). 'Cleantech' venture capital around the world. *International Review of Financial Analysis*, *44*, 86-97.

Davila, A., Foster, G., & Gupta, M. (2003). Venture capital financing and the growth of startup firms. *Journal of Business Venturing*, *18*(6), 689-708.

De Clercq, D., Fried, V. H., Lehtonen, O., & Sapienza, H. J. (2006). An entrepreneur's guide to the venture capital galaxy. *Academy of Management Perspectives, 20*(3), 90-112.

DeCarolis, D. M., & Deeds, D. L. (1999). The impact of stocks and flows of organizational knowledge on firm performance: An empirical investigation of the biotechnology industry. *Strategic Management Journal*, *20*(10), 953-968.

Devine, C. J. (2015). Ideological social identity: Psychological attachment to ideological in-groups as a political phenomenon and a behavioral influence. *Political Behavior*, *37*(3), 509-535.

Di Silvestre, M. L., Favuzza, S., Sanseverino, E. R., & Zizzo, G. (2018). How decarbonization, digitalization and decentralization are changing key power infrastructures. *Renewable and Sustainable Energy Reviews, 93,* 483-498.

Doblinger, C., Surana, K., & Anadon, L. D. (2019). Governments as partners: The role of alliances in US cleantech startup innovation. *Research Policy*, *48*(6), 1458-1475.

Drover, W., Busenitz, L., Matusik, S., Townsend, D., Anglin, A., & Dushnitsky, G. (2017). A review and road map of entrepreneurial equity financing research: Venture capital, corporate venture capital, angel investment, crowdfunding, and accelerators. *Journal of Management, 43*(6), 1820-1853.

Dutta, S., & Folta, T. B. (2016). A comparison of the effect of angels and venture capitalists on innovation and value creation. *Journal of Business Venturing*, *31*(1), 39-54.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, *14*(4), 532-550.

El Sawy, O. A., & Pereira, F. (2013). *Business modelling in the dynamic digital space: An ecosystem approach*. Springer.

Elia, G., Margherita, A., & Passiante, G. (2020). Digital entrepreneurship ecosystem: How digital technologies and collective intelligence are reshaping the entrepreneurial process. *Technological Forecasting and Social Change*, *150*, 119791.

Ellis, C. (2013). Social context and economic biases in representation. *The Journal of Politics*, *75*(3), 773-786.

Ellis, C., & Stimson, J. A. (2012). *Ideology in America*. Cambridge University Press.

Fielding, K. S., & Hornsey, M. J. (2016). A social identity analysis of climate change and environmental attitudes and behaviors: Insights and opportunities. *Frontiers in Psychology*, *7*, 121.

Fisher, G., Kotha, S., & Lahiri, A. (2016). Changing with the times: An integrated view of identity, legitimacy, and new venture life cycles. *Academy of Management Review*, *41*(3), 383-409.

Francetic, A. (2019, August 29). *Artificial intelligence pushes 'commoditized' wind and solar power into the money*. Greentech Media. Retrieved July 4, 2022, from https://www.greentechmedia.com/articles/read/artificial-intelligence-pushes-commoditized-wind-and-solar-power-into-the-m

Frank, C., Sink, C., Mynatt, L., Rogers, R., & Rappazzo, A. (1996). Surviving the "valley of death": A comparative analysis. *The Journal of Technology Transfer*, *21*(1), 61-69.

Fu, Y., & Tietz, M. A. (2019). When do investors prefer copycats? Conditions influencing the evaluation of innovative and imitative ventures. *Strategic Entrepreneurship Journal*, *13*(4), 529-551.

Fuller, M. (2008). *Software studies: A lexicon*. MIT Press.

Gaddy, B. E., Sivaram, V., Jones, T. B., & Wayman, L. (2017). Venture capital and cleantech: The wrong model for energy innovation. *Energy Policy*, *102*, 385-395.

Gautier, A., & Lamesch, J. (2021). Mergers in the digital economy. *Information Economics and Policy*, *54*, 100890.

George, G., Merrill, R. K., & Schillebeeckx, S. J. D. (2021). Digital sustainability and entrepreneurship: How digital innovations are helping tackle climate change and sustainable development. *Entrepreneurship Theory and Practice*, *45*(5), 999-1027.

Ghosh, S., & Nanda, R. (2010). Venture capital investment in the clean energy sector. *Harvard Business School Entrepreneurial Management Working Paper*, 11-020.

Giarratana, M. S., & Fosfuri, A. (2007). Product strategies and survival in Schumpeterian environments: Evidence from the US security software industry. *Organization Studies*, *28*(6), 909-929.

Gift, K., & Gift, T. (2015). Does politics influence hiring? Evidence from a randomized experiment. *Political Behavior*, *37*(3), 653-675.

Gilbert, B. A., McDougall, P. P., & Audretsch, D. B. (2006). New venture growth: A review and extension. *Journal of Management*, *32*(6), 926-950.

Gimmon, E., & Levie, J. (2010). Founder's human capital, external investment, and the survival of new high-technology ventures. *Research Policy*, *39*(9), 1214-1226.

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2013). Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. *Organizational Research Methods*, *16*(1), 15-31.

Goldfarb, J. L., Buessing, M., & Kriner, D. L. (2016). Geographic proximity to coal plants and U.S. public support for extending the Production Tax Credit. *Energy Policy, 99*, 299-307.

Goldstein, A., Doblinger, C., Baker, E., & Anadón, L. D. (2020). Patenting and business outcomes for cleantech startups funded by the Advanced Research Projects Agency-Energy. *Nature Energy*, *5*(10), 803-810.

Gompers, P. A., & Lerner, J. (2001). *The money of invention: How venture capital creates new wealth*. Harvard Business School Press.

Graham, S. J., Merges, R. P., Samuelson, P., & Sichelman, T. (2009). High technology entrepreneurs and the patent system: Results of the 2008 Berkeley patent survey. *Berkeley Technology Law Journal*, *24*(4), 1255-1327.

Gromet, D. M., Kunreuther, H., & Larrick, R. P. (2013). Political ideology affects energy-efficiency attitudes and choices. *Proceedings of the National Academy of Sciences*, *110*(23), 9314-9319.

Gulati, R., & Higgins, M. C. (2003). Which ties matter when? The contingent effects of interorganizational partnerships on IPO success. *Strategic Management Journal*, *24*(2), 127-144.

Gulati, R., & Sytch, M. (2007). Dependence asymmetry and joint dependence in interorganizational relationships: Effects of embeddedness on a manufacturer's performance in procurement relationships. *Administrative Science Quarterly*, *52*(1), 32-69.

Guler, I. (2007). Throwing good money after bad? Political and institutional influences on sequential decision making in the venture capital industry. *Administrative Science Quarterly*, *52*(2), 248-285.

Gupta, A., & Briscoe, F. (2020). Organizational political ideology and corporate openness to social activism. *Administrative Science Quarterly*, *65*(2), 524-563.

Gupta, A., Briscoe, F., & Hambrick, D. C. (2017). Red, blue, and purple firms: Organizational political ideology and corporate social responsibility. *Strategic Management Journal*, *38*(5), 1018-1040.

Gupta, A., Briscoe, F., & Hambrick, D. C. (2018). Evenhandedness in resource allocation: Its relationship with CEO ideology, organizational discretion, and firm performance. *Academy of Management Journal*, *61*(5), 1848-1868.

Gupta, A., Fung, A., & Murphy, C. (2021). Out of character: CEO political ideology, peer influence, and adoption of CSR executive position by Fortune 500 firms. *Strategic Management Journal*, *42*(3), 529-557.

Gupta, A., Nadkarni, S., & Mariam, M. (2019). Dispositional sources of managerial discretion: CEO ideology, CEO personality, and firm strategies. *Administrative Science Quarterly, 64*(4), 855-893.

Gupta, A., & Wowak, A. J. (2017). The elephant (or donkey) in the boardroom: How board political ideology affects CEO pay. *Administrative Science Quarterly*, *62*(1), 1-30.

Guzman, J., & Stern, S. (2015). Where is Silicon Valley? *Science*, *347*(6222), 606-609.

Hall, B. H., Jaffe, A., & Trajtenberg, M. (2005). Market value and patent citations. *RAND Journal of Economics*, *36*(1), 16-38.

Hallen, B. L., Katila, R., & Rosenberger, J. D. (2014). How do social defenses work? A resource-dependence lens on technology ventures, venture capital investors, and corporate relationships. *Academy of Management Journal*, *57*(4), 1078-1101.

Hegde, D., & Tumlinson, J. (2014). Does social proximity enhance business partnerships? Theory and evidence from ethnicity's role in U.S. venture capital. *Management Science*, *60*(9), 2355-2380.

Hegeman, P. D., & Sørheim, R. (2021). Why do they do it? Corporate venture capital investments in cleantech startups. *Journal of Cleaner Production*, *294*, 126315.

Hertel-Fernandez, A. (2017). American employers as political machines. *The Journal of Politics*, *79*(1), 105-117.

Hewstone, M., Rubin, M., & Willis, H. (2002). Intergroup bias. *Annual Review of Psycholog*, *53*(1), 575-604.

Higgins, M. C., & Gulati, R. (2006). Stacking the deck: The effects of top management backgrounds on investor decisions. *Strategic Management Journal*, *27*(1), 1-25.

Hoang, H., & Antoncic, B. (2003). Network-based research in entrepreneurship: A critical review. *Journal of Business Venturing*, *18*(2), 165-187.

Hochberg, Y. V., & Fehder, D. C. (2015). Accelerators and ecosystems. *Science*, *348*(6240), 1202-1203.

Hochberg, Y. V., Ljungqvist, A., & Lu, Y. (2007). Whom you know matters: Venture capital networks and investment performance. *The Journal of Finance*, *62*(1), 251-301.

Hockerts, K., & Wüstenhagen, R. (2010). Greening Goliaths versus emerging Davids–Theorizing about the role of incumbents and new entrants in sustainable entrepreneurship. *Journal of Business Venturing* *25*(5), 481-492.

Hoehn-Weiss, M. N., & Karim, S. (2014). Unpacking functional alliance portfolios: How signals of viability affect young firms' outcomes. *Strategic Management Journal*, *35*(9), 1364-1385.

Hogg, M. A. (2014). From uncertainty to extremism: Social categorization and identity processes. *Current Directions in Psychological Science*, *23*(5), 338-342.

Hogg, M. A., & Terry, D. J. (2000). Social identity and self-categorization processes in organizational contexts. *Academy of Management Review*, *25*(1), 121-140.

Holtslag, M., Chevrollier, N., & Nijhof, A. (2021). Impact investing and sustainable market transformations: The role of venture capital funds. *Business Ethics, the Environment & Responsibility*, *30*(4), 522-537.

Hong, H., & Kostovetsky, L. (2012). Red and blue investing: Values and finance. *Journal of Financial Economics*, *103*(1), 1-19.

Hoogendoorn, B., Van der Zwan, P., & Thurik, R. (2020). Goal heterogeneity at start-up: Are greener start-ups more innovative?. *Research Policy*, *49*(10), 104061.

Horbach, J., Oltra, V., & Belin, J. (2013). Determinants and specificities of eco-innovations compared to other innovations – An econometric analysis for the French and German industry based on the community innovation survey. *Industry and Innovation*, *20*(6), 523-543.

Hornsey, M. J., Harris, E. A., Bain, P. G., & Fielding, K. S. (2016). Meta-analyses of the determinants and outcomes of belief in climate change. *Nature Climate Change*, *6*(6), 622-626.

Hosmer, D. W., Lemeshow, S., & May, S. (2008). *Applied survival analysis: Regression modeling of time-to-event data.* (2nd ed). Wiley-Interscience.

Howell, S. T. (2017). Financing innovation: Evidence from R&D grants. *American Economic Review*, *107*(4), 1136-1164.

Hsu, D. H. (2004). What do entrepreneurs pay for venture capital affiliation?. *The Journal of Finance*, *59*(4), 1805-1844.

Hsu, D. H. (2007). Experienced entrepreneurial founders, organizational capital, and venture capital funding. *Research Policy*, *36*(5), 722-741.

Hsu, D. H., & Ziedonis, R. H. (2013). Resources as dual sources of advantage: Implications for valuing entrepreneurial-firm patents. *Strategic Management Journal*, *34*(7), 761-781.

Huang, J. C., Henfridsson, O., Liu, M. J., & Newell, S. (2017). Growing on steroids: Rapidly scaling the user base of digital ventures through digital innovation. *MIS Quarterly*, *41*(1), 301-314.

Huang, L., & Knight, A. P. (2017). Resources and relationships in entrepreneurship: An exchange theory of the development and effects of the entrepreneur-investor relationship. *Academy of Management Review*, *42*(1), 80-102.

Hutton, I., Jiang, D., & Kumar, A. (2014). Corporate policies of Republican managers. *Journal of Financial and Quantitative Analysis*, *49*(5-6), 1279-1310.

Huyghebaert, N., & Van de Gucht, L. M. (2007). The determinants of financial structure: New insights from business start-ups. *European Financial Management*, *13*(1), 101-133.

Iacobucci, D., Posavac, S. S., Kardes, F. R., Schneider, M. J., & Popovich, D. L. (2015). Toward a more nuanced understanding of the statistical properties of a median split. *Journal of Consumer Psychology*, *25*(4), 652-665.

Intergovernmental Panel on Climate Change. (2022). *Climate change 2022: Mitigation of climate change*. Retrieved July 4, 2022, from https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_FinalDraft_FullReport.pdf

International Energy Agency. (2017). *Digitalization and energy*. Retrieved July 4, 2022, from https://iea.blob.core.windows.net/assets/b1e6600c-4e40-4d9c-809d-1d1724c763d5/DigitalizationandEnergy3.pdf

International Energy Agency. (2021). *Net zero by 2050: A roadmap for the global energy sector*. Retrieved July 4, 2022, from https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf

Islam, M., Fremeth, A., & Marcus, A. (2018). Signaling by early stage startups: US government research grants and venture capital funding. *Journal of Business Venturing*, *33*(1), 35-51.

Iyengar, S., Sood, G., & Lelkes, Y. (2012). Affect, not ideology: A social identity perspective on polarization. *Public Opinion Quarterly*, *76*(3), 405-431.

Jenkins-Smith, H. C., Ripberger, J. T., Silva, C. L., Carlson, D. E., Gupta, K., Carlson, N., ... & Dunlap, R. E. (2020). Partisan asymmetry in temporal stability of climate change beliefs. *Nature Climate Change*, *10*(4), 322-328.

Jiang, D., Kumar, A., & Law, K. K. (2016). Political contributions and analyst behavior. *Review of Accounting Studies*, *21*(1), 37-88.

Jost, J. T. (2006). The end of the end of ideology. *American Psychologist*, *61*(7), 651-670.

Jost, J. T., Glaser, J., Kruglanski, A. W., & Sulloway, F. J. (2003). Political conservatism as motivated social cognition. *Psychological Bulletin*, *129*(3), 339-375.

Jost, J. T., Napier, J. L., Thorisdottir, H., Gosling, S. D., Palfai, T. P., & Ostafin, B. (2007). Are needs to manage uncertainty and threat associated with political conservatism or ideological extremity?. *Personality and Social Psychology Bulletin*, *33*(7), 989-1007.

Jost, J. T., Nosek, B. A., & Gosling, S. D. (2008). Ideology: Its resurgence in social, personality, and political psychology. *Perspectives on Psychological Science*, *3*(2), 126-136.

Katila, R., Rosenberger, J. D., & Eisenhardt, K. M. (2008). Swimming with sharks: Technology ventures, defense mechanisms and corporate relationships. *Administrative Science Quarterly*, *53*(2), 295-332.

Kaustia, M., & Torstila, S. (2011). Stock market aversion? Political preferences and stock market participation. *Journal of Financial Economics*, *100*(1), 98-112.

Kazanjian, R. K. (1988). Relation of dominant problems to stages of growth in technology-based new ventures. *Academy of Management Journal, 31*(2), 257-279.

Kazanjian, R. K., & Drazin, R. (1989). An empirical test of a stage of growth progression model. *Management Science*, *35*(12), 1489-1503.

Kemper, J. A., Ballantine, P. W., & Hall, C. M. (2018). Global warming and sustainability: Understanding the beliefs of marketing faculty. *Journal of Public Affairs*, *18*(4), e1664.

Kindermann, B., Beutel, S., De Lomana, G. G., Strese, S., Bendig, D., & Brettel, M. (2021). Digital orientation: Conceptualization and operationalization of a new strategic orientation. *European Management Journal*, *39*(5), 645-657.

Koch, T., & Windsperger, J. (2017). Seeing through the network: Competitive advantage in the digital economy. *Journal of Organization Design*, *6*(1), 1-30.

Kohli, R., & Melville, N. P. (2019). Digital innovation: A review and synthesis. *Information Systems Journal*, *29*(1), 200-223.

Kollmann, T. (2006). What is e-entrepreneurship? Fundamentals of company founding in the net economy. *International Journal of Technology Management*, *33*(4), 322-340.

Kollmann, T., Stöckmann, C., Niemand, T., Hensellek, S., & De Cruppe, K. (2021). A configurational approach to entrepreneurial orientation and cooperation explaining product/service innovation in digital vs. non-digital startups. *Journal of Business Research*, *125*, 508-519.

König, M., Ungerer, C., Baltes, G., & Terzidis, O. (2019). Different patterns in the evolution of digital and non-digital ventures' business models. *Technological Forecasting and Social Change*, *146*, 844-852.

Kunda, Z., & Spencer, S. J. (2003). When do stereotypes come to mind and when do they color judgment? A goal-based theoretical framework for stereotype activation and application. *Psychological Bulletin*, *129*(4), 522-544.

Lanzolla, G., Lorenz, A., Miron-Spektor, E., Schilling, M., Solinas, G., & Tucci, C. L. (2020). Digital transformation: What is new if anything? Emerging patterns and management research. *Academy of Management Discoveries*, *6*(3), 341-350.

Layman, G. C., Carsey, T. M., & Horowitz, J. M. (2006). Party polarization in American politics. *Annual Review of Political Science*, *9*, 83-110.

Lee, C., Lee, K., & Pennings, J. M. (2001). Internal capabilities, external networks, and performance: A study on technology-based ventures. *Strategic Management Journal*, *22*(6-7), 615-640.

Levitin, T. E., & Miller, W. E. (1979). Ideological interpretations of presidential elections. *American Political Science Review*, *73*(3), 751-771.

Li, S., Shang, J., & Slaughter, S. A. (2010). Why do software firms fail? Capabilities, competitive actions, and firm survival in the software industry from 1995 to 2007. *Information Systems Research*, *21*(3), 631-654.

Lindsey, L. (2002). The venture capital keiretsu effect: An empirical analysis of strategic alliances among portfolio firms. *Stanford Institute for Economic Policy Research Working Pape*r.

Lyytinen, K., Yoo, Y., & Boland, R. J. (2016). Digital product innovation within four classes of innovation networks. *Information Systems Journal*, *26*(1), 47-75.

Mann, R. J., & Sager, T. W. (2007). Patents, venture capital, and software start-ups. *Research Policy*, *36*(2), 193-208.

Marlow, S., & Patton, D. (2005). All credit to men? Entrepreneurship, finance, and gender. *Entrepreneurship Theory and Practice*, *29*(6), 717-735.

Matusik, S. F., & Fitza, M. A. (2012). Diversification in the venture capital industry: Leveraging knowledge under uncertainty. *Strategic Management Journal*, *33*(4), 407-426.

Matusik, S. F., George, J. M., & Heeley, M. B. (2008). Values and judgment under uncertainty: Evidence from venture capitalist assessments of founders. *Strategic Entrepreneurship Journal*, *2*(2), 95-115.

Mayring, P. (2000). Qualitative content analysis. *Qualitative Social Research*, *1*(2), 34-56.

McCright, A. M., & Dunlap, R. E. (2011). The politicization of climate change and polarization in the American public’s views of global warming, 2001-2010. *The Sociological Quarterly*, *52*(2), 155-194.

McCrone, A. (2014, January 15). *Clean energy investment falls for the second year*. Bloomberg New Energy Finance. Retrieved July 4, 2022, from https://data.bloomberglp.com/bnef/sites/4/2014/01/BNEF_PR_2014-01-15_Investment_2013-corrected-final.pdf

McMichael, C. (2021, August 13). *State renewable portfolio standards and goals*. National Conference of State Legislatures. Retrieved July 4, 2022, from https://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx

Murnieks, C. Y., Haynie, J. M., Wiltbank, R. E., & Harting, T. (2011). 'I like how you think': Similarity as an interaction bias in the investor-entrepreneur dyad. *Journal of Management Studies*, *48*(7), 1533-1561.

Myers, M. D. (2009). *Qualitative research in business and management*. SAGE Publications.

Nadkarni, S., Pan, L., & Chen, T. (2019). Only timeline will tell: Temporal framing of competitive announcements and rivals' responses. *Academy of Management Journal*, *62*(1), 117-143.

Nambisan, S. (2017). Digital entrepreneurship: Toward a digital technology perspective of entrepreneurship. *Entrepreneurship Theory and Practice*, *41*(6), 1029-1055.

Nambisan, S., Wright, M., & Feldman, M. (2019). The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes. *Research Policy*, *48*(8), 103773.

Oaksford, M., Morris, F., Grainger, B., & Williams, J. M. G. (1996). Mood, reasoning, and central executive processes. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *22*(2), 476-492.

Olson-Hazboun, S. K., Howe, P. D., & Leiserowitz, A. (2018). The influence of extractive activities on public support for renewable energy policy. *Energy Policy*, *123*, 117-126.

Overall, J., & Wise, S. (2015). An s-curve model of the start-up life cycle through the lens of customer development. *The Journal of Private Equity*, *18*(2), 23-34.

Ozcan, P., & Eisenhardt, K. M. (2009). Origin of alliance portfolios: Entrepreneurs, network strategies, and firm performance. *Academy of Management Journal*, *52*(2), 246-279.

Park, U. D., Boeker, W., & Gomulya, D. (2020). Political ideology of the board and CEO dismissal following financial misconduct. *Strategic Management Journal*, *41*(1), 108-123.

Patton, M. Q. (2015). *Qualitative research & evaluation methods: Integrating theory and practice*. (4th ed.). SAGE Publications.

Peters, B. (2016). *Digital keywords: A vocabulary of information society and culture*. Princeton University Press.

Pfeffer, J., & Salancik, G. R. (1978). *The external control of organizations: A resource dependence perspective*. Harper & Row.

Plummer, L. A., Allison, T. H., & Connelly, B. L. (2016). Better together? Signaling interactions in new venture pursuit of initial external capital. *Academy of Management Journal*, *59*(5), 1585-1604.

Poole, K. T., & Rosenthal, H. (1984). The polarization of American politics. *The Journal of Politics*, *46*(4), 1061-1079.

Porter, M. E., & Heppelmann, J. E. (2014). How smart, connected products are transforming competition. *Harvard Business Review*, *92*(11), 64-88.

Price, E., Ottati, V., Wilson, C., & Kim, S. (2015). Open-minded cognition. *Personality and Social Psychology Bulletin*, *41*(11), 1488-1504.

Puri, M., & Zarutskie, R. (2012). On the life cycle dynamics of venture-capital-and non-venture-capital-financed firms. *The Journal of Finance*, *67*(6), 2247-2293.

Rennings, K. (2000). Redefining innovation—eco-innovation research and the contribution from ecological economics. *Ecological Economics*, *32*(2), 319-332.

Ries, E. (2011). *The lean startup: How today's entrepreneurs use continous innovation to create radically successful businesses*. Crown Business.

Robinson, W. T. (1990). Product innovation and start-up business market share performance. *Management Science*, *36*(10), 1279-1289.

Roche, M. P., Conti, A., & Rothaermel, F. T. (2020). Different founders, different venture outcomes: A comparative analysis of academic and non-academic startups. *Research Policy*, *49*(10), 104062.

Roth, P. L., Thatcher, J. B., Bobko, P., Matthews, K. D., Ellingson, J. E., & Goldberg, C. B. (2020). Political affiliation and employment screening decisions: The role of similarity and identification processes. *Journal of Applied Psychology*, *105*(5), 472.

Shane, S., & Stuart, T. (2002). Organizational endowments and the performance of university start-ups. *Management Science*, *48*(1), 154-170.

Sheldon, K. M., & Nichols, C. P. (2009). Comparing Democrats and Republicans on intrinsic and extrinsic values. *Journal of Applied Social Psychology*, *39*(3), 589-623.

Simons, T., & Ingram, P. (1997). Organization and ideology: Kibbutzim and hired labor, 1951-1965. *Administrative Science Quarterly*, *42*(4), 784-813.

Sivaram, V., & Norris, T. (2016). The clean energy revolution: Fighting climate change with innovation. *Foreign Affairs*, *95*(3), 147-156.

Sorenson, O., & Stuart, T. E. (2008). Bringing the context back in: Settings and the search for syndicate partners in venture capital investment networks. *Administrative Science Quarterly*, *53*(2), 266-294.

Stam, W., & Elfring, T. (2008). Entrepreneurial orientation and new venture performance: The moderating role of intra-and extraindustry social capital. *Academy of Management Journal*, *51*(1), 97-111.

Steffen, W., Crutzen, P. J., & McNeill, J. R. (2007). The Anthropocene: Are humans now overwhelming the great forces of nature. *AMBIO: A Journal of the Human Environment*, *36*(8), 614-621.

Steininger, D. M. (2019). Linking information systems and entrepreneurship: A review and agenda for IT-associated and digital entrepreneurship research. *Information Systems Journal*, *29*(2), 363-407.

Stern, N., & Valero, A. (2021). Innovation, growth and the transition to net-zero emissions. *Research Policy*, *50*(9), 104293.

Stinchcombe, A. L. (1965). Social structure and organizations. In J. G. March (Ed.), *Handbook of organizations* (pp. 142-193). Rand McNally.

Stock, J. H., & Watson, M. W. (2007). *Introduction to econometrics*. Addison-Wesley.

Stuart, T. E., Hoang, H., & Hybels, R. C. (1999). Interorganizational endorsements and the performance of entrepreneurial ventures. *Administrative Science Quarterly, 44*(2), 315-349.

Swigart, K. L., Anantharaman, A., Williamson, J. A., & Grandey, A. A. (2020). Working while liberal/conservative: A review of political ideology in organizations. *Journal of Management, 46*(6), 1063-1091.

Tedin, K. L. (1987). Political ideology and the vote. *Research in Micropolitics, 2*(1), 63-94.

Temple, J. (2020, November 30). *How VCs can avoid another bloodbath as the clean-tech boom 2.0 begins*. MIT Technology Review. Retrieved July 4, 2022, from https://www.technologyreview.com/2020/11/30/1012660/venture-capital-clean-tech-boom-biden

Tetlock, P. C., Saar-Tsechansky, M., & Macskassy, S. (2008). More than words: Quantifying language to measure firms' fundamentals. *The Journal of Finance, 63*(3), 1437-1467.

Tzabbar, D., & Margolis, J. (2017). Beyond the startup stage: The founding team's human capital, new venture's stage of life, founder-CEO duality, and breakthrough innovation. *Organization Science*, *28*(5), 857-872.

United Nations Framework Convention on Climate Change. (2015). *Paris Agreement*. Retrieved July 4, 2022, from http://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf

Van Lange, P. A., Bekkers, R., Chirumbolo, A., & Leone, L. (2012). Are conservatives less likely to be prosocial than liberals? From games to ideology, political preferences and voting. *European Journal of Personality, 26*(5), 461-473.

Vedula, S., Doblinger, C., Pacheco, D., York, J. G., Bacq, S., Russo, M. V., & Dean, T. J. (2022). Entrepreneurship for the public good: A review, critique, and path forward for social and environmental entrepreneurship research. *Academy of Management Annals*, *16*(1), 391-425.

Villanueva, J., Van de Ven, A. H., & Sapienza, H. J. (2012). Resource mobilization in entrepreneurial firms. *Journal of Business Venturing*, *27*(1), 19-30.

Wang, H., Wuebker, R. J., Han, S., & Ensley, M. D. (2012). Strategic alliances by venture capital backed firms: An empirical examination. *Small Business Economics*, *38*(2), 179-196.

Wasserman, D., & Flinn, A. (2017, April 7). *Introducing the 2017 Cook political report partisan voter index*. Cook Political Report. Retrieved July 4, 2022, from https://www.cookpolitical.com/introducing-2017-cook-political-report-partisan-voter-index

Williamson, T. (2008). Sprawl, spatial location, and politics: How ideological identification tracks the built environment. *American Politics Research, 36*(6), 903-933.

Wooldridge, J. M. (2020). *Introductory econometrics: A modern approach.* (7th ed.). Cengage Learning.

Wry, T., Cobb, J. A., & Aldrich, H. E. (2013). More than a metaphor: Assessing the historical legacy of resource dependence and its contemporary promise as a theory of environmental complexity. *Academy of Management Annals*, *7*(1), 441-488.

Yang, Q., Zimmerman, M., & Jiang, C. (2011). An empirical study of the impact of CEO characteristics on new firms' time to IPO. *Journal of Small Business Management*, *49*(2), 163-184.

Yoo, Y., Boland, R. J., Lyytinen, K., & Majchrzak, A. (2012). Organizing for innovation in the digitized world. *Organization Science*, *23*(5), 1398-1408.

Yoo, Y., Henfridsson, O., & Lyytinen, K. (2010). Research commentary – The new organizing logic of digital innovation: An agenda for information systems research. *Information Systems Research*, *21*(4), 724-735.

York, J. G., O'Neil, I., & Sarasvathy, S. D. (2016). Exploring environmental entrepreneurship: Identity coupling, venture goals, and stakeholder incentives. *Journal of Management Studies*, *53*(5), 695-737.

Zacharakis, A. L., & Shepherd, D. A. (2001). The nature of information and overconfidence on venture capitalists' decision making. *Journal of Business Venturing*, *16*(4), 311-332.

Zaheer, H., Breyer, Y., & Dumay, J. (2019). Digital entrepreneurship: An interdisciplinary structured literature review and research agenda. *Technological Forecasting and Social Change*, *148,* 119735.

Zahra, S. A., & Bogner, W. C. (2000). Technology strategy and software new ventures' performance: Exploring the moderating effect of the competitive environment. *Journal of Business Venturing*, *15*(2), 135-173.

Zettler, I., & Hilbig, B. E. (2010). Attitudes of the selfless: Explaining political orientation with altruism. *Personality and Individual Differences*, *48*(3), 338-342.

Zettler, I., Hilbig, B. E., & Haubrich, J. (2011). Altruism at the ballots: Predicting political attitudes and behavior. *Journal of Research in Personality*, *45*(1), 130-133.