Less Trust, More Truth: Affordances of Distributed Ledger Technologies for Decentralized Platform Ecosystems

DISSERTATION
of the University of St.Gallen,
School of Management,
Economics, Law, Social Sciences,
International Affairs and Computer Science,
to obtain the title of
Doctor of Philosophy in Management

submitted by

Kilian David Schmück

from

Germany

Approved on the application of

Prof. Dr. Oliver Gassmann
and
Prof. Dr. Elgar Fleisch

Dissertation no. 5197

Difo-Druck GmbH, Untersiemau 2022

The University of St.Gallen, School of Management, Economics, Law, Social Sciences, International Affairs and Computer Science, hereby consents to the printing of the present dissertation, without hereby expressing any opinion on the views herein expressed.

St.Gallen, October 29, 2021

The President:

Prof. Dr. Bernhard Ehrenzeller

Acknowledgments

The doctoral journey has been an exceptional endeavor, characterized by manifold experiences and impressions. I perceive it as a privilege that allowed me to grow both as a researcher as well as personally. Challenging my comfort zone and advancing my academic and personal boundaries in a fundamentally disruptive yet sheltered environment was an integral part of my experience. This dissertation is one of the main tangible outcomes of this path as a doctoral student, my time at the *Institute of Technology Management* of the *University of St.Gallen (ITEM-HSG)*, and my research stint as a visiting scholar at the Information Systems department at the *Boston University Questrom School of Business.* I want to take this opportunity to express my gratitude to the people who have been central during this journey.

I want to thank my supervisor, Prof. Dr. Oliver Gassmann, for his constant support throughout my doctoral journey, especially for backing my dissertation topic on blockchain and decentralized platform ecosystems, which was still a relatively novel matter four years ago. He also did not hesitate to support my practice projects and several other ideas and initiatives I had during the last years, most notably the *St.Gallen Blockchain Roundtable*, the DLT Think Tank, as well as some research expeditions. The freedom given to me was the cornerstone for continuously learning, developing, and succeeding throughout my academic and personal endeavors. Moreover, Oliver never shied away from any academic or project-related discussions—not even when these took place on a Friday evening, in the middle of the hallway, when he was just trying to get home. I will keep in mind his sometimes very apt sayings such as "*lieber Stärken stärken, als Schwächen verbessern,*" "*man ordnet seine Research Findings oft in Schwarz und Weiß, aber die Realität und die Managerial Implications sind dann oft Grau,*" or "*beim Laufen wachsen einem Muskeln.*" Furthermore, I would like to thank Prof. Dr. Elgar Fleisch for taking over the co-supervision. His clarity and profound expertise substantially contributed to reflecting my findings for robustness. Finally, I would like to express my gratitude to Prof. Dr. Marshall Van Alstyne for hosting me at the *Boston University Questrom School of Business.* He revealed a seemingly endless abundance of anchoring theoretical harbors to my research concepts or ideas. Our frequent brown bag lunches, which provided great occasions for him to introduce me to the local restaurants, invariably tended to test and extend the limits of my cognitive capabilities. Nevertheless, these discussions significantly contributed to refining the theoretical framework of my thesis. I greatly appreciate the inspiration and knowledge I was able to absorb, his excellent and caring hospitality, and all the helpful words even beyond our scientific exchanges. His conviction to always use the stairs to the sixth floor—and never the elevator—will remain an encouragement to me.

My dissertation topic has received incomparable support from *Siemens* throughout my doctoral journey, allowing me to devote my full attention to decentralized platform ecosystems and their auxiliary topics, such as DLTs/blockchain technologies, web3 business models, platform governance, and platform externalities. In particular, I wish to thank Prof. Dr. Monika Sturm and Bernd Rosauer, who initiated this research cooperation with me and promoted the research with full endorsement by providing in-depth insights, facilitating all required networking, or serving as lively and sophisticated sparring partners. Also, I am grateful to Carolin Rubner, who took over and even extended our research cooperation. Thanks to her venturesome support, we reflected the research findings into several business units within *Siemens* and established the research cooperation with Marshall Van Alstyne. Carolin's intuition and networking skills were vital in bringing our research cooperation to a genuinely well-rounded integration into the *Siemens* organization. Furthermore, I am very grateful to Frank Konopka for his support of connecting my research to research endeavors in the field of digital health and for his valuable reflections on my dissertation.

Furthermore, I highly appreciate the support I received from Ursula Elsässer, Sonja Baumgartner, Elisabeth Vetsch, and Jörg Klaus whenever project matters called for it. Special appreciation is also in order for the IT department of the *University of St.Gallen*, which was a constant companion during my time in St. Gallen; sometimes with competent and constructive support, sometimes with lucky punches in appearing to be of constructive support, and sometimes with deliberate diversionary maneuvers, leaving me with no choice but to investigate and resolve my IT struggles by myself—granting me with the satisfaction of feeling like a true problem solver.

I am grateful to my co-authors, co-researchers, and, more generally, the people I had the chance to collaborate with within my research. This includes several team members of the *Institute of Technology Management*, other departments, my former interns and thesis students, and adjacent organizations. Besides countless discussions that have served as a rich source of inspiration, many lively memories have collectively made the past years an exhilarating adventure. In this regard, I want to express the following thanks:

To the *ITEM-HSG*: My special thanks go to Dr. Thomas Möllers, who took me under his wings during my first academic steps as a doctoral student and who has been a close friend ever since. Many thanks for the joint trips to dizzying heights in Aachen, night hikes in Heidelberg, less-than-successful pre-Christmas "Kiki's Knalla Balla" explorations, Berlin vibes, or scooter rides on Koh Lanta. Dr. Maximilian Böger, for the joint struggles with cold project acquisitions, working group designs, morning sports sessions, "Oleg & Bolek's" house hunting, as well as subsequent neighborly hassles. Dr. Florian Huber, for his general positivity and for generously housing "Oleg & Bolek" after their neighborly dispute eventually escalated. His Christmas pastries, however, led to even more intensive sports sessions for "Oleg & Bolek". Barbara Bencsik, for being my sudden office mate, for her patience with my initial irritation about having to share my office again, our subsequent profound friendship, and her near-daily composed phone calls with the IT department, which provided me with an appreciation for her serenity. Dr. Charlotte Lekkas, for being such a vivid companion throughout our time at the institute and even during occasional political discussions, as well as her invaluable reviews of my academic work. Dr. Henrik Wesemann, for sharing his academic experiences and providing me with the frankest research reviews, as well as for his balancing, positive presence at the institute. Moreover, and it goes without saying that I genuinely admire his exquisite taste in fashion—which admittedly left us looking alike quite regularly. Dr. Roman Sauer, for his pertinent advice and his conscientious introduction to the institute, when I started my journey in St. Gallen. Also, thanks for spontaneously housing me in Stuttgart or Munich, whenever required, and for subsequently joining forces in tasting Bavarian or Swabian specialties. His forethought in connecting me with Anette, little Gabriel, and Dr. Simon Büchler also provided me with the delightful opportunity to meet them high up in the sky between Zurich and Boston. Beyond helping me navigate the cumbersome procedures of the *TSA*, I want to thank them for their warmth, generosity, and the many beautiful evenings we shared in Boston. Prof. Dr. Naomi Häfner for the many culinary excursions with Alex, her continuous support within our Emerging Technologies Lab, and the exciting excursion to the Matterhorn I was allowed to partake in.

Furthermore, I am very grateful to Dr. Christoph Meister for his ongoing project support and our vigorous discussions. With his Swiss charm, he always created a relaxed, cheerful, and inspiring atmosphere. I am incredibly grateful to Prof. Dr. Christoph Wecht for paving my way from *Volkswagen* to the *University of St. Gallen* four years ago. I benefited considerably from experiencing his ability to spark ideas and create added value by connecting people. He has also given an old and rusty *Lada Niva* a new (retirement) home in Austria, where it can go out for a run, shielded from the prying eyes of overeager *TÜV* inspectors by dense forest. Thanks to Peter Brugger for his empathic manner of incidentally including me in the—at least to me—unpredictable and unexpected joint jogging forest run with the *Adidas* team in Oregon, right after I had indulged in an extensive breakfast. Thanks, too, for subsequently exploring fantastic craft breweries in Portland. I thank Georg von der Ropp for his delicate way of providing me with book recommendations and our thoughtful collaboration in preparing a memorable study trip to Tel Aviv and Jerusalem, where we finally and somehow ended up attending a gala dinner with the prime minister.

To my former interns: I am grateful to Nicolas Gilgen, in whom I found a fiery and challenging sparring partner in advancing my research in platform governance. In doing so, he also did not hesitate to spontaneously join the location switch to Berlin in order to experience the prosperous blockchain ecosystem there; and for his excellent support in co-authoring several articles and book chapters—with more to come. Johannes Türk, who brought some delicate technological reflections to my research and who willingly and confidently presented these reflections to our project partners. Additionally, he did not hesitate to explore the Swiss Alps with me—never with the slightest protest about our hiking speed, the slope of the selected hiking routes, or the weather conditions that we were confronted with. Luca Heer, for his excellent support and his diligence even in the most profound abysses of hydrogen proof-of-origin regulation, for which he managed to develop a temporary—and perhaps driven by necessity—passion. Leopold Crecelius, for his motivated, energetic, and independent support for the *St.Gallen Blockchain Roundtable*, with no effort too great to ensure the event's success. I also thank Anna Bünter for her prudent, sensitive, and committed measures for the *St.Gallen Blockchain Roundtable* as well as her excellent taste in wine, enriching its Apéro lineup. So too, Norbert Grimm, for his unconditional and diligent commitment to supporting my research work.

This work was supported by a multitude of partners in practice, who continuously contributed their greatest dedication and commitment. I therefore express my appreciation and gratitude to the following persons in alphabetical order: Afri Schoedon, Ana Trbovich, Andreas Kind, Bastian Widenmayer, Bernd Rosauer, Björn Wagner, Carl-Philipp Sassenrath, Carolin Rubner, Christian Geiger, Christian Heise, Christian Sander, Christopher Burgahn, David Bosswell, Dietrich Sümmermann, Emanuele Parlato, Fabian Biegel, Fabian Kraft, Frank Konopka, Hakan Yildiz, Hans Kespohl, Harry Behrens, Heiko Musa, Helge Michael, Henning Höhnert, Hermann Bach, Hubert Tardieu, Hubertus Breier, Jan Pechstein, Jens Kaatze, Jürgen Schmelting, Karl-Thomas Neumann, Kerstin Eismann, Lukas Groebke, Luka Müller, Mario Brandenburg, Marquart Franz, Mathew Chittazhathu, Matthias Felder, Matthias Manger, Micha Roon, Michael F. Spitz, Michael Leipold, Monika Sturm, Moritz Kaminski, Nik Scharmann, Peter Busch, Ramin Ghafari, Roman Schnider, Simon Karrenberg, Simon Seiter, Steffen Erath, Thomas Hahn, Thorsten Lampe, Thorsten Müller, Timo Mühlhausen, Torben Pörtner, Vitus Ammann, Volker Seith, Werner Folkendt, and Wolfgang Korosec, among others.

During my time in St. Gallen, I was blessed to make new friendships, which enriched my life in many facets. I am incredibly grateful for them, and I look forward to maintaining these friendships beyond my doctoral journey: Dr. Maximilian Dexheimer for his loyal company, for the excessive *Freeletics* sessions, garrulous jogging laps through the Peter & Paul wildlife park, awful stair runs, and the agonizing bitter *Apple Watch* competitions, which thankfully found an abrupt ending through our beloved girlfriends' courageous interventions, and—it goes without saying—the imperative demands of our dissertations. Moreover, thanks, for one, for the intense political and philosophical discussions that brought me closer to his beloved Stoicism, ultimately leaving me as a convinced Stoic myself, and, for another, for the occasional crypto stakes, in which he was always "very bullish." Prof. Dr. Erwin Hettich, who soon eagerly joined the jogging laps but demonstrated a more reflected attitude when it came to *Freeletics* or our crypto stakes, thus providing the necessary counterweight to our overly keen fixations. With his discipline, calmness, and drive, he represents such an exemplary and inspiring way of combining family life, constructing a house, and being an outstanding researcher, especially when it comes to case studies. Dominik Hofstetter, who crossed my path already in St. Gallen, and who proved to be such a diligent, athletic, and debating companion and true friend in Boston, where he inspired and enriched my time abroad. Many thanks for persuading me to join the *CrossFit* community, which, however, also "unfortunately" and unforeseeably implied exhausting, near-daily workouts at the beautiful and welcoming *Commonwealth CrossFit* box in Somerville. Moreover, he accompanied me during our weekends, either at the *Harvard Law Library*, the beloved atrium on the 6th floor of the *Boston University Questrom School of Business* or at the *MIT* laboratories (under the "strictest" of supervision by Dr. Sebastian Ahling to whom I would also like to express my gratitude). Camillo Visini, for being a true friend, who proceeded to become such a remarkable all-rounder, always helping me out with all kinds of technical matters; be it editing videos, setting up *LaTeX* templates, performing quantitative cluster analyses, or arranging fantastic wine tastings of his beloved "Piggy" wine. He remains a phenomenon to both Dexi and me when it comes to *Apple Watch* competitions, where his hour-long morning walks made him an unbeatable opponent. Alex Hunter, for his continuous and excellent communication of financial updates from Wall Street, and who could furthermore prepare every cocktail (or even ski trip accounting sheet) with meticulous accuracy, nearing perfection. Magnus Schückes, for his at times silent, and other times more audible patience for my stubbornness to tear down any conceptual artifacts once they were erected—even though these teardowns were highly necessary. Moreover, his creative ability to balance our paper developments through political disputes was always a welcome delight. Thank you for the methodological accuracy and teaching me the art of qualitative research throughout our intense paper developments, which will hopefully be followed by a few more. Dr. Maximilian Richter, for sharing discussions on future mobility and our common Aachen nostalgia. I eagerly await embarking on our joint book project, *"Engineers First: The Stupidity of Engineers,"* which will someday soon revolutionize the world of future engineering students. Eduard Müller, for the numerous social evenings, the occasional chess game, or the 4-star cuisine, which revealed to me the secret of French cuisine: a sneaking piece of butter in every dish!

Ultimately, my doctoral journey and this dissertation are the outcomes of exchanges and discussions with people that have made my time in St. Gallen and Boston genuinely remarkable. These have shaped my journey in many ways, and I thank you all for accompanying me during different stages. Most notably and in alphabetical order: Alexander Illichmann, Anna Mader, Anette Büchler, Dr. Bernhard Lingens, Carmen Sprus, Casper Rogalla, Christopher Baumann, Dr. Daniel Moser, Elias Barth, Ennio Limbach, Erik Mewe, Fabian Schäfer, Prof. Dr. Felix Wortmann, Ferdinand Deitermann, Dr. Jan-Niklas Kramer, Dr. Jonas Böhm, Dr. Lea Jablowski, Lucas Miehé, Dr. Lukas Neumann, Julius Schilling, Julius Schubarth, Jurij Besednjak, Katina Ahling, Marco-Martin Woerz, Prof. Dr. Martin Bader, Prof. Dr. Maximilian Palmié, Olson Pook, Dr. Peter Tinschert, Raffael Spescha, Dr. Raphael Bömmelburg, Dr. Sebastian Ahling, Severin Kranz, Dr. Simon Büchler, Sven Jung, and Prof. Dr. Tobias Gutmann.

Further, I am incredibly grateful to all my friends whose fruitful company I enjoyed even before my doctoral journey. They continuously provided me with inspiration and drive for what I have accomplished and for all that lies ahead.

From my *Volkswagen* time: Dr. Jan Benedikt Stolze was an exceptional mentor to me during my time at *Volkswagen*. Since then, he has been an inspiration, primarily due to his determination coupled with his calmness and confidence in its execution. It was Jan Benedikt's honest and supportive words that drove me to St. Gallen. He has become a constant companion and friend to me. Philip Meier, whose involvement from *Volkswagen*'s side in the *ITEM-HSG*'s working group on platform economy, put me into contact with St. Gallen in the first place. His networking ability and drive for platforms and entrepreneurship are true inspirations. Dr. Steffen Heinrich, whose consistency and commitment to entrepreneurship provided me with the necessary enthusiasm that inspired me to pursue similar endeavors. Thanks also for the precise and outstanding advice on what lies ahead of me now. Dr. Peter Mirwald, whose sarcastic repartee in rhetorical duels both challenged and amused me. Dr. Lars Gehrke, for inspiring me with his discipline and drive. Lars encouraged me to set foot on the path to a Ph.D. in the first place (even though the initial plan was to do it at *Volkswagen*).

From my time in Aachen: Dr. Lasse Härtel, for his loyal friendship over many years and his sincere, joyful character, the fantastic experiences, and the incredible honor to be your best man! Björn Wagner, who so incredibly convincingly encouraged me to go "all-in" on blockchain as my dissertation topic and for continuously inspiring me to think and act outside the box. I genuinely appreciate his support, especially whenever I was endeavoring in data gathering from the blockchain community. Ruben Conrad, for his sarcastically sober analyses, as well as his incredible loyalty and consistency since day one. Daniel Mock, for his winning personality that always manages to bring us all together once in a while; for being an incredible housemate in Aachen and his genuine friendship.

From my Detroit time: Alexandre Domarco, for his exhilarating mind, friendship, and peculiar humor, which scores with occasional clumsiness in putting a foot in his mouth. Dr. Gregor Schmid-Szybisty, for his enthusiasm, incredible endurance, and advice on entrepreneurship. He also demonstrated an excellent sense for throwing a fantastic farewell party just before I was leaving for Boston.

From my time in Heidelberg: Many thanks for the beautiful childhood and the many experiences we gathered. This goes to all my Heidelberg people. Additionally, many thanks to Dr. Maximilian Kiemle for the legal support and considerations within my dissertation. The same holds true for Patrick Kalina, who also accommodated me in Munich at times. Dr. Mara Thomas, for her incredible inspiration through her academic career and the shared passion for dogs. Kai Shen, for years of friendship and his occasional vocal performances that make you feel young again. Gabriel Venzago, for his profound, lasting friendship and for always dragging me to any classical concerts, theater plays, operettas or operas.

Furthermore, I am deeply and genuinely grateful for the love and support I have received from my family. First, I want to express my sincere gratitude to my mother for all I am today and for all you have done for me! Times have not always been easy; however, all these memories and experiences allowed me to become exactly the person I want to be for myself and others. I value and marvel at the intuition and intelligence you possess to comprehend the slightest personal, social, or societal tensions. You have paved my first paths already from day one. For your care and selflessness, I will always be thankful! Second, I want to thank my father for everything he could share with me during his lifetime. I learned the art of chess from you, which instilled in me a requisite sense of strategic awareness. Likewise, you instilled in us a sense of justice and passionately preached that we approached others and our lives with greater empathy. Third, I owe enormous appreciation to my siblings Johannes, Ariane, and Julia for their unconditional support and the many similarities we share. Johannes, you are a splendid brother, always there for me, listening and supporting with the most considerable empathy. Keep going with your journey; you are becoming a wonderful personality. Ariane, you are the anchor point and balancing force for all of us. I am glad to have you around and hope you stay as you are. Julia, I marvel at your enormous stamina, how you have combined family, studies, and job. I henceforth hope you find more time for yourself. I am more than happy to have you all in my life. Fourth, I express tremendous heartfelt gratitude to the next generation: Lotta, Anton, Kalle, and to all the wonderful beings still to come: Your presence constantly allows reflection on the essential things and serves as the glue for the older generations whenever they lose sight or fail in understanding each other. Fifth, I thank Jack for his composure, affection, and commitment to any family matters (also be it to indulge some IPA together) and Sven, who added an admirable passion for wildlife photography, creativity, and contribution to the family. Sixth, I thank the entire Polyakov family, for whose support I am incredibly grateful; for providing me with a Swiss home, their warmth, and family inclusion, as well as sharing their proud family dog Boba for weekend stayovers once in a while.

Last but not least, I want to express my deepest gratitude and appreciation to one very particular person, Uliana Polyakova. Uliana, you have been my closest companion since we met; you have always supported me with your serenity, cheerfulness, and various, at times even abstruse, ideas. You never fail to ground me and to cheer me. You have allowed me to grow under your umbrella of support and comfort. And yet, perhaps the most crucial aspect is how proactive and versatile you are in making me laugh and enriching my life with profound joy: Sometimes, you do so by deliberately trying to be fun with your unmistakably unique gags, hoping to attract buzz around you. But in all honesty, my dearest, I must admit that it is not your jokes themselves that cause that desired buzz; instead, it is the secondhand embarrassment of observing your unfortunate attempt of being jolly. This, coupled with the awkward situation that follows, induces in me pure joy and deep gratitude for you (and your humor). Most of the time, however, it is your personality that is so contagiously heartening and sparkling. Regardless of what you do, how you look, how you think, how you talk, how you move, how you smell, how you sing, how you sleep, how you concentrate, how you stressfully manage your video calls with your new headphones on (then talking way too loud, underestimating their noise-canceling functionality), how you smile, how you look at me and how your soul embraces mine: simply all your facets thrill me and repeatedly infuse an innate affection that makes my life so light. It is your complete soul, cleverness, and beauty that constantly and consistently matches so precisely my emotional core and flow, which allows our relationship to feel so effortless, making me long for so many more shared moments and joy. Joy for a concerted journey that requires us to share our happiness with a bunch of little creatures, being living images of the love we share. Uliana, your personality captivates me so quietly and unobtrusively. You radiate a calm and balance becoming such a delightful partner to me. Your empathy and patience allow you to process the most complex world of ideas, leaving me full of admiration. I revel in your sharp and open-minded reflections and sensory perceptions. Your innermost character is a daily gift to me. You have enriched my life in so many facets, allowing me to grow so consistently and, most importantly, created such a constructive and pleasant vibe that I am eager to enjoy for the rest of my life to grow even further. Together with you, I want to create a fruitful launchpad for all the little rascals that will someday arrive and flourish under our shared umbrella.

Perhaps, as you read these lines, you may already sense where I am going with this. Not least since Marshall—whom I had just previously filled in on my plans—was already so illustrious and chipper about it the other day when the three of us had lunch together. All the while, this poor Kilian lingered in a stressed and overwhelmed manner, rashly and clumsily denying what had just unfolded, while at the next moment clutching at a straw, philosophizing aloud about the very first platform externality topic that popped into his spinning head, hoping for an effective distraction. Fortunately, you were only joyously delighted by my temporary inability to cope. You could not have understood how much candor sat in his words. Little did you know that Marshall had already guided me in choosing the right place to get the one thing needed. And which somehow unsurprisingly ended up with the most transparent and efficient way to source such a thing: a platform-based “stone pit,” where I could leverage the given transparency to immerse myself in the most intertwining depths of rock science close to obtaining my second Ph.D. there. Uliana, I love you more than anything! So, if anything has worked out as I have planned it, you should be smiling, perhaps teary-eyed. At the same time, I should be kneeling before you, out of sight, hidden by the printed dissertation (“that I asked you to read for any printing flaws”), holding a ring toward you, hoping to place it on your left ring finger. Uliana, will you do me the honor of becoming my wife?

Boston, December 2021 Kilian Schmück

Executive Summary

The internet and information technologies have accelerated platform business models associated with distinct economic advantages. By exploiting network effects and information asymmetries, winner-take-all marketplaces and monopolistic market structures developed. However, the advent of novel digital technologies, such as distributed ledger technologies (DLTs), carries broad implications for new ways of platform orchestration with the ability to challenge our understanding of platform ecosystems, particularly concerning disintermediation effects and a reconfiguration of governance and incentive alignments. I explore how the inherent and unique affordances of DLTs affect and allow for novel business model patterns in platform ecosystems. Along with incentive mechanisms and governance configurations, I investigate DLT business model characteristics, directions, and alignments of value creation and value capture. Through a mixed methods study design, I first develop a taxonomy of DLT business model dimensions and second cluster new kinds and DLT-exploiting configurations of platform ecosystems into associated business model archetypes. This allows me to construct a theoretical model of how restricting or loosening DLT affordances influence these ecosystem configurations and the interplay between the platform's core and periphery. I outline novel design choices for platform configurations that predominantly strive for data sovereignty. My findings reveal how the extent to which DLT affordances are integrated into the platform governance design—and thus how the integrity of the technology generates information symmetry and platform disintermediation—impacts and even replaces digital trust with what I call *digital truth*. The integrity of governance inherent in technology and not a platform sponsor allows for new and decentralized platform ecosystem design choices, where decentralized governance becomes a fundamental element. As such, I examine DLT governance mechanisms, considering its integrity, network robustness, and the successful coordination of network intersubjectivity when enforcing consensus. Finally, I explore the orchestrated initiation of decentralized platform ecosystems through coopetition models, in which decentralized governance is exploited to solve game-theoretic challenges when seeking the macro-economically efficient state of competitivity among the coopetition partners. This thesis seeks to shed light on managing platform externalities, thereby enabling platform

configurations in which negative externalities are effectively internalized while preserving or even promoting positive externalities where the novel value in multi-party models is created through optimized and fostered data-sharing. Thus, DLT affordances allow for *digital truth* and information symmetry in platform ecosystems, progressing towards autonomous and dynamic networks of networks.

Kurzdarstellung

Das Internet und andere Informationstechnologien haben zu einer Beschleunigung von Plattform-Geschäftsmodellen geführt, womit signifikante Wettbewerbsvorteile einhergehen. Netzwerkeffekte und Informationsasymmetrien haben "Winner-take-all"-Marktplätze ermöglicht und somit zu monopolistischen Marktstrukturen geführt. Neue digitale Technologien wie Distributed-Ledger-Technologies (DLTs) umfassen dabei neue Ansätze für Plattform-Orchestrierung und bergen das Potenzial, unser heutiges Bewusstsein und Wissen über Plattform-Ökosysteme neu zu definieren – insbesondere im Hinblick auf Disintermediationseffekte und neue Governance- und Anreizmechanismen. Ich untersuche in meiner Dissertation, wie ein inhärenter Angebotscharakter (oder eine Affordanz) der DLTs neuartige Geschäftsmodellmuster in Plattform-Ökosystemen schaffen kann. Einhergehend mit Anreizmechanismen und Governance-Konfigurationen untersuche ich Geschäftsmodellmuster, sowie Stoßrichtungen und Anordnungen von Value Creation und Value Capture. Mithilfe eines Mixed-Methods Forschungs-Designs entwickle ich zunächst eine Taxonomie über DLT Geschäftsmodelldimensionen und ordne anschließend neue und DLT-ummantelnde Konfigurationen von Plattform-Ökosystemen in entsprechende Geschäftsmodell-Archetypen ein. Dies ermöglicht die Identifizierung eines theoretischen Modells darüber, wie Beschränkungen oder Erweiterungen der DLT-Affordanzen die Ökosystemkonfigurationen und das Zusammenspiel zwischen Plattformkern und seiner Peripherie beeinflussen. Ich identifiziere Gestaltungsoptionen von Plattformkonfigurationen, die in erster Linie auf Datensouveränität abzielen. Meine Ergebnisse zeigen auf, wie das Verhältnis mit welchem DLTs – und somit auch deren Integrität als Technologie – in die Plattform-Governance integriert werden, Informations-Symmetry, Plattform-Disintermediation und das digitale Vertrauen beeinflussen und sogar durch etwas ersetzen, was ich digitale Wahrheit nenne. Durch Schaffung von Governance-Integrität, die von der Technologie und nicht von einem Plattformsponsor herrührt, können neue und dezentralisierte Gestaltungsmöglichkeiten des Plattform-Ökosystems gewählt werden, bei denen die dezentrale Governance das kritisches Element wird. Ich untersuche DLT-Governance-Mechanismen und berücksichtige dabei deren Integrität, die Folgen auf Netzwerk-Stabilität und die Wirksamkeit der Konsensdurchsetzung bei Berücksichtigung der Intersubjektivitäts-

Koordinierung. Zum Schluss untersuche ich die orchestrierte Initiierung dezentraler Plattform-Ökosysteme durch Coopetitions-Modelle, bei denen die dezentrale Governance genutzt wird, um spieltheoretische Herausforderungen bei der Suche nach einem makroökonomisch effizienten Wettbewerbszustand zwischen den Coopetitionspartnern zu lösen. Dies strebt ein Verständnis über das Management von Plattform-Externalitäten und Plattformkonfigurationen an, in denen negative Externalitäten effektiv internalisiert werden, während positive Externalitäten erhalten oder sogar gefördert werden. Hiermit soll neuer Wert in Mehrparteienmodellen durch optimierten und geförderten Datenaustausch geschaffen werden. DLT-Affordanzen ermöglichen somit die Schaffung einer digitalen Wahrheit und Informationssymmetrie in Plattform-Ökosystemen, wodurch der Weg zu autonomen und dynamischen Netzwerken geebnet werden kann.

Contents

List of Figures

List of Tables

List of Abbreviations

B2B	Business to business
B2B2C	Business to business to (end) customer/user
B2C	Business to (end) customer/user
BCH	Bitcoin Cash
*BEP*2	Binance Chain Evolution Proposal 2
BES	Business ecosystem
BIP	Bitcoin Improvement Proposal
BSV	Bitcoin SV
BTC	Bitcoin
BTCB	Bitcoin BEP2
BTG	Bitcoin Gold
CEO	Chief executive officer
*CO*2	Carbon dioxide
CTO	Chief technology officer
DAO	Decentralized autonomous organization
DApp	Decentralized application
DLT	Distributed ledger technology
DOGE	Dogecoin
DOT	Polkadot
EIP	Ethereum Improvement Proposal
EoT	Economy of Things
ETC	Ethereum Classic
ETH	Ether/ Ethereum
EV	Electric vehicle
GMT	Greenwich Mean Time
ICO	Initial coin offering
ID	Identity

IoT	Internet of Things
IP	Intellectual property
KYC	Know-your-customer
LTC	Litecoin
MASF	Miner Activated Soft Fork
MB	Megabyte
ML	Machine learning
OSS	Open-source software
*P*2*P*	Peer-to-peer
PEP	Python Enhancement Proposal
PoA	Proof of Authority
PoS	Proof of Stake
PoW	Proof of Work
PSP	Polkadot Standards Proposal
RPOW	Reusable Proof of Work
SegWit	Segregated Witness
*SegWit*2*x*	Segregated Witness 2x
*SHA*256	Secure Hash Algorithm 256
SSI	Self-Sovereign Identity
SV	Satoshi Version
TGE	Token generation event
UASF	User Activated Soft Fork
*Web*1	Web 1.0; refers to protocols and networks that emphasize publisher-created content, where users only can read
*Web*2	Web 2.0; refers to protocols and networks that emphasize user-generated content, where the network control relies with single authorities
*Web*3	Web 3.0; refers to protocols and networks that emphasize user-generated content, with simultaneously providing users with network control rights and integrating revenue and incentivizazion structures
WTA	Winner-take-all

1. Introduction

1.1 Research Motivation

Rapid developments in digital technologies have transformed how firms interact within as well as across organizational boundaries (Amit & Han, 2017; Ciarli et al., 2021; Massa et al., 2017), especially when leveraged through platform business models (Casadesus-Masanell & Zhu, 2013; G. Parker et al., 2016).

Accelerated by network effects, platform business models have created advantageous boundary-spanning ecosystems, augmenting their ability to co-create and aggregate value into common bundles as well as deliver and capture value for their stakeholders (Bhargava, 2021; G. Parker et al., 2017). As a result of their ability to accomplish digital orchestration of information while simultaneously reducing transaction costs, platform business models have become omnipresent in practice and research (Cusumano et al., 2019; Kretschmer et al., 2020). Yet, antitrust concerns regarding platforms' tendencies toward winner-take-all marketplaces and monopolistic market structures (Eisenmann et al., 2011; Gawer, 2020) have led to an increasing focus on balancing platform designs (Boudreau, 2010; G. Parker & Van Alstyne, 2018), especially regardings data protection and data sovereignty in sensitive business settings. Some authors advocate for regulatory interventions explicitly through formalized ex-ante frameworks (G. Parker et al., 2020). The emergence of digital technologies, where platform governance occurs at the data level (Vergne, 2020), offers an intriguing avenue to address these concerns. In particular, distributed ledger technologies (DLTs), such as blockchain, promise data regulation in a technology-inherent way. When integrated into platform ecosystems, their affordances can have implications for platform control and associated business models, allowing for balanced reconfigurations of value creation and value capture mechanisms, thereby providing new alternatives for platform optimization that go beyond cost-efficiency approaches in centralized platform ecosystems.

Almost twenty years after Amit and Zott's (2001) seminal work on value creation drivers in e-businesses, I seek to shed new light on platform business models driven by new kinds of digital technologies by examining the growing DLT ecosystem. I regard DLTs as a digital protocol accompanied by unique features and affordances—defined as the action opportunities offered by an object in relation to a user (Autio et al., 2018; Zammuto et al., 2007)—such as transparency, data sovereignty, automated step-by-step contracts, and tokenization. These create new capacities for regulating, controlling, and orchestrating the digital era at a data level (Vergne, 2020). Up to this point, the internet has largely dominated the discussion regarding technology and business models, yet its inherent technological affordances are limited to the transfer of information (web1 and web2) (Amit & Zott, 2001; Amit & Han, 2017). DLT features fundamentally differ from those of the internet, also allowing for the transfer of value or ownership (web3) (Böhme et al., 2015; Natarajan et al., 2017). Therefore, the affordances of DLTs both challenge extant industry templates and potentially advance and expand our understanding of platform business models and business model configurations writ large (Autio et al., 2018; Nambisan et al., 2019). Despite the increasing impact of digital technologies (Steininger, 2019; von Briel et al., 2018) and the nascent and growing stream of literature on DLTs (Chen et al., 2020; Cheng et al., 2019; Lumineau et al., 2020; Schmeiss et al., 2019), the influence on platform literature and business model design has gone largely unexplored. In light of the well-established links between platform ecosystems, business models, and the emergence of new digital technologies, I ask the following research question: *"How are decentralized platform ecosystems designed to internalize negative platform externalities while simultaneously foster positive platform externalities"*

1.2 Overview of Studies and Contributions

Building on a mixed method study in that I identify DLT business model dimensions and corresponding business model archetypes through a total of 171 interviews and a survey of 126 DLT ventures, I construct a theoretical model illustrating how restricting or loosening DLT affordances can influence platform business models, platform governance, and the interplay between a platform's core and its periphery. More specifically, I find that the integration of DLTs in platform ecosystems leads to increased transaction transparency and information symmetry, thereby impacting or even replacing the digital trust in a platform sponsor with *digital truth* inherent in the technology. However, it also increases coordination costs and limits a platform-based business model's economic advantage as lock-in effects diminish and ex-ante predictions of the emerging value capture mechanisms are impeded. Value capture becomes subject to the platform's emerging and dynamic governance models and thus relies on platform participants narrowing platform control. I present two distinct types and design choices of platform ecosystems with associated business model archetypes. These types differ in their degree of DLT integration (including whether they incorporate tokens) and thus in the extent to which they incorporate *digital truth*, with implications for value creation, value capture, and platform control. When fully integrated, *digital truth* can allow for self-sustaining platform ecosystems where aforementioned concepts are wrapped and incentivized by DLT-native tokens, establishing new kinds of token and platform economics. These new types of platform ecosystem configurations involve decentralized governance, where the integrity of governance no longer rests with a single central platform sponsor but is inherently embedded in the technology through *digital truth*. The integrity of DLTs can be transmitted into platform ecosystems if carefully integrated. Platform governance, and decentralized governance in particular, thus gain relevance and significance in successfully coordinating the platform network and the intersubjectivity of its requirements. Building on the two decentralized types of platform ecosystems, I construct an inductive study of each in order to explore the managing of platform externalities through decentralized governance mechanisms. First, I elevate on decentralized governance, in which I analyze the capabilities of the respective DLT governance models of *Bitcoin*, *Ethereum*, and *Polkadot*. While DLT protocols are technically evolving through open-source software development processes in a decentralized manner contributed from the DLT community, at the same time, socio-technical intersubjective demands may encounter this technical evolution, necessitating consensus. If, however, the interests of the DLT network and its community are very diverse, this can lead to controversy. In such a case, DLT governance must maintain integrity to steer the network toward robustness and consensus. To this end, I conducted 18 qualitative interviews with contributors, donors, complementors, and users of the three DLT protocols and examined the formalized and implemented governance structures of the respective DLT protocols. I find evidence that the integration of heterogeneous and socio-technical network demands also impacts the relevance for more sophisticated DLT governance models, as heterogeneous socio-technical network demands necessitate sensitivity to its intersubjectivity. Thus, a network may only expand as fast as the sophistication of its decentralized governance allows; otherwise, the integrity of decentralized governance is at risk. Second, through 69 qualitative interviews, I explore the game-theoretic challenges that arise when decentralized governance is used to initiate a decentralized platform ecosystem based on a coopetition approach. The long-term goal of this must be a competitive composition of the network to create macro-economic efficiency. This is a prerequisite for the successful creation of positive platform externalities that are at least equally valuable as to centralized platform ecosystems. Such initiatives mainly help incumbents of existing markets to gain a competitive advantage over digital platform business models by leveraging their non-digital core business and enabling data sharing in a B2B multi-party context.

My findings enable me to make several contributions. I add to the literature on platform ecosystems by providing evidence to de Reuver, Sørensen, and Basole's (2018) hypothesis that new types of "platformization" are emerging due to DLTs. These platform types differ based on their deployment of DLTs with implications for their associated business models. Decentralized platforms use the DLT affordances (such as data sovereignty and information symmetry) to create *digital truth*, which allows for the disintermediated execution of these platform's core functionalities (Gu & Zhu, 2021; Iansiti & Lakhani, 2017). In concert with data portability and interoperability, these overcome negative platform externalities such as lock-in effects for platform users. Therefore, DLTs lead to power balance within platform ecosystems, and with appropriate governance models, allow for more democratization in platform ecosystems. I shed light on platform control mechanisms (G. Parker & Van Alstyne, 2018), which by default and through decentralized governance structures and *digital truth*, gravitate towards maximal platform openness in value creation and value capture. In some instances, this leads to increased diffusion of boundaries between the affiliated business models with innovation spillovers where the bundling of individual incentive and value capture mechanisms is managed through an explicitly formalized native platform governance model. Hence, my findings relate to Chen et al. (2020) by providing insights about the business model and platform configurations when decentralized governance structures are implemented. This resonates with recent policy attempts, especially in Europe, to create a secure and federated data infrastructure (e.g., *GAIA-X).* I further contribute to the business model literature by classifying real-world manifestations of platform business models in the era of digital technologies and DLTs to uncover technology-specific attributes and value drivers (Massa et al., 2017; Zott et al., 2011). My findings illustrate the need for a stronger emphasis on digital technology affordances in conceptualizing business models and reveal how they both enable novel mechanisms of value creation and balance monopolistic market structures in platform ecosystems (Autio et al., 2018). I thereby provide a more nuanced view of the role that digital technologies (and DLTs in particular) play in forming business models and ecosystems. Furthermore, my findings shed light on how DLT affordances support managing platform externalities to make the necessary condition of the Coase theorem (Coase, 1960) attainable. Through information symmetry, negative platform externalities can be internalized; furthermore, through a successfully exploited integrity of decentralized governance, positive platform externalities can be preserved, or even promoted as a result of created data sovereignty and regulated data access for third parties, as innovation can potentially be attained through fostered third-party complementarities.

1.3 Thesis Outline

This thesis is composed of five sections. This introductory chapter serves to illustrate the motivation and relevance of this thesis. It also includes a summary of the expected findings and contributions. Section 2 lays the theoretical foundation underlying the elaboration of the results. First, I review the literature on business models and business model innovation, as the interrelation of new technologies and business models is a fundamental understanding of this thesis. Second, I present the current state of the literature on platform ecosystems, business models, and platform governance as interdependencies between DLT business models and platform ecosystems become apparent with implications for their coordination and alignment. Finally, I introduce technical and socio-technical backgrounds on the *Bitcoin*, *Ethereum*, and *Polkadot* blockchains as well as DLT affordances. The methodological design of this thesis, including data sampling, collection, and analysis, is described in chapter 3. This includes a mixed method design for the development of the findings 4.1 to 4.3 and inductive methods for findings 4.4 and 4.5. The findings are depicted in section 4. First, I present the dimensions, characteristics, and variables of DLT business models. Second, I present DLT business model archetypes identified through cluster analysis. Third, I conceptualize a theoretical model for describing different platform configurations and design choices that envelop decentralized governance to varying extents. Fourth, I address DLT governance and identify features for its integrity to internalize negative platform externalities. Fifth, I present the coopetition initiation process for shared platform ecosystems from an incumbents' perspective, elaborating on a novel value brought by data sovereignty, data interoperability, and data portability. In section 5, I draw the findings into a theoretical, empirical, and practical context and show their contributions. I also present key managerial implications and outline the limitations of my thesis.

2. Literature Review

In this section, I lay the theoretical foundation and discuss the literature on business models and the impact of new technologies on business model innovation. In my thesis, I examine the impact of DLT affordances on business models and their orchestration through platform ecosystems. I will also discuss the existing platform and platform business model literature. Finally, I address the technological developments of DLTs, their history, and their technology affordances.

2.1 Business Models and Business Model Innovation

The concept of the business model has received considerable attention in the management literature for most parts triggered by the advent of the internet and information technologies, both of which have been shown to enable new ways of doing business and to transform industries (Chesbrough & Rosenbloom, 2002; Massa et al., 2017; Zott et al., 2011). A business model can be described as a holistic picture of how a firm creates, delivers and captures value for its stakeholders through a system of interrelated activities (Teece, 2010; Zott & Amit, 2010). Hence, a business model is inextricably linked to the nature of the firm as it explains the logic by which a firm operates (Massa et al., 2017), while also being influenced by its cognitive capabilities (Frankenberger & Sauer, 2019). A common conceptualization distinguishes between four components that jointly constitute a business model: the value proposition (the value that is proposed to fulfill a customer need), a mechanism for value creation (the activities necessary to provide the value), a mechanism for value capture (how revenues are generated), and a relationship model (how to target customers) (Gassmann et al., 2014; Wirtz et al., 2016).

Several academic strands originated during the last decade with regard to business models (Massa et al., 2017; Zott et al., 2011) and business model innovation (Foss & Saebi, 2017). One perspective has embodied a static approach of business models and focused on constructing taxonomies and archetypes that help scholars in understanding the roles that business models play in linking resources, organizational structure and value delivery (Baden-Fuller & Haefliger, 2013; Baden-Fuller & Morgan, 2010; Demil & Lecocq, 2010; Frankenberger et al., 2014). The influence of technology on business models is a profound element of this stream of literature.

Technological innovations and business models are fundamentally interlinked as the economic value of a technology only materializes through an appropriate business model (Chesbrough & Rosenbloom, 2002; Lehoux et al., 2014; Teece, 2010). The business model, by acting as a market device and mediator, needs to be aligned to the value network in order to unleash the value inherent in the technology (Björkdahl, 2009). The business model design hence "determines the nature of complementarity between business models and technology and the paths to monetization" (Baden-Fuller & Haefliger, 2013, p. 422). Novel technologies often require fundamentally new ways to appropriate value from new features and characteristics of the technology (Baden-Fuller & Haefliger, 2013; Johnson et al., 2008). As such, the choice of a business model determines the ability of a firm to create competitive advantage from technology developments (McDonald & Eisenhardt, 2020).

2.2 Platform Ecosystems and Platform Governance

Due to their economic advantages, it is not surprising that digital markets and platform business models—enabled by information technology—have become the center of many today's business environments (Cusumano et al., 2019). These platforms channel information and facilitate transactions across distinct groups, thereby fostering business ecosystems and webs of interdependencies to emerge and pursue joint value propositions (Adner, 2017; Lingens et al., 2020; Shipilov & Gawer, 2020), while at the same time leading to complex relationships among platform ecosystem designs that orchestrate associated business models and organizational structures (Cennamo & Santaló, 2019; Constantinides et al., 2018).

The associated platform architecture is crucial for digital and platform business models and their value creation (De Reuver et al., 2018). The structure of platform ecosystems typically consists of a stable core (i.e., the platform itself) and a dynamic periphery (i.e., an organically growing ecosystem based on the platform) (Baldwin & Woodard, 2009; Baldwin & Clark, 2000; Jacobides et al., 2018; Kretschmer et al., 2020). Platform ecosystems create economic structures and dependencies between formerly independent organizations (Adner, 2017; Kretschmer et al., 2020), combining resources from platform sponsors and third-party providers to promote innovation (Cennamo & Santaló, 2019; Jacobides et al., 2018; Nambisan et al., 2018; Panico & Cennamo, 2020; Rietveld et al., 2019). They can be conceptualized as meta-organizations (Ciborra, 1996; Gawer, 2014) in charge of microeconomies (G. Parker & Van Alstyne, 2018) that resemble intertwined social or economic value propositions and business models (Adner, 2017; Gulati et al., 2012; Kapoor, 2018). As an enacted digital infrastructure, intermediary, and orchestrator of the platform ecosystem, digital platforms moderate communication, interactions, and innovations for both economic transactions and social activities (Constantinides et al., 2018; McIntyre & Srinivasan, 2017). The success of platform ecosystems is underpinned by digital trust stemming from the platform architecture and the platform sponsor, which facilitates transactions and channels information, enabling mutually unfamiliar stakeholders to rely on the network to accredit and effectively carry out transactions (Gu & Zhu, 2021; Kretschmer et al., 2020).

In their integrative framework that combines economic and engineering platform perspectives, Cusumano et al. (2019) differentiate between transaction and innovation platform characteristics. Transaction platforms mediate different user groups and facilitate multi-sided marketplaces (Boudreau & Hagiu, 2009). The platform's value grows as the user groups or their participants expand (Eisenmann et al., 2006; Evans, 2003), and as a result of the mediation of different user groups, so-called network effects or positive platform externalities arise (Katz & Shapiro, 1985; Shapiro & Varian, 1998). A network is conceptualized as interconnected nodes (Borgatti et al., 2009), where a node is represented by both an individual or collective party such as an organization (Kane et al., 2014). Direct network effects emerge when a user's benefit from a network participation depends on the number of other network users from the same side and with whom they can interact (Eisenmann et al., 2006; Katz & Shapiro, 1985). Indirect network effects occur when value is added to the network from a different side of a network and where both sides subsequently and mutually benefit from each other (Boudreau & Jeppesen, 2015; Evans, 2003; Hagiu & Wright, 2015; Rochet & Tirole, 2003). Fostered by direct and indirect network effects, these positively affect the value of a platform, leading to a growing return of scale and winner-take-all (WTA) dynamics (Eisenmann et al., 2006; Katz & Shapiro, 1994; Shapiro & Varian, 1998). Since the single mediation of network effects fosters information asymmetries in favor of the platform sponsor (G. Parker & Van Alstyne, 2014), a centralized ownership of the platform also leads to negative platform externalities such as lock-in effects, which ultimately result in concentrated or monopolistic market structures in favor of the platform sponsor (Cutolo et al., 2021; Gawer, 2020; Zhu & Iansiti, 2012). Innovation platforms are different in that they are purely technical artifacts, with the platform itself being an extensible, code-based core that provides the core functionalities (de Reuver et al., 2018). The periphery consists of complementary modules that target user-specific needs (Boudreau, 2012; Tiwana & Konsynski, 2010), primarily provided by third parties (though the platform sponsor may provide complementary modules as well) (Cenamor & Frishammar, 2021; Thomes, 2015; Zhu & Liu, 2018). The governance embedded in platforms regulates the balance of power between complementary third-party interaction and platform-owned actions (Darking et al., 2008; Wareham et al., 2014). Tiwana, Konsynski, and Bush (2010, p. 679) define platform governance as “who makes what decisions about a platform.” The balancing act of governance is to manage sufficient control over the platform in order to preserve integrity while allowing sufficient openness for innovation by third parties. The Goldilocks governance problem describes striking a balance between (a) decision rights partitioning, (b) control, and (c) proprietary versus shared ownership, while maintaining just the right proportions (Tiwana et al., 2010).

2.3 Distributed Ledger Technologies and DLT Affordances

In this section, I first provide some historical details and consideration of the motives and technological developments of *Bitcoin*, *Ethereum*, and *Polkadot*. I elaborate on this part slightly more generously, as the historical developments and technical modules presented significantly affect the DLT governance findins discussed in chapter 4.4 and are required for their analysis. DLT governance often tends not to follow a clear strategic decision due to its decentralized design and open access based upon open-source software development processes. Thus, to understand their complex mechanisms, detailed understanding of the *Bitcoin*, *Ethereum* and *Polkadot* motives is required. Second, I present the DLT affordances that arise when deploying DLTs in a platform context.

2.3.1 Background and Motives for *Bitcoin*, *Ethereum*, and *Polkadot*

Bitcoin: A Peer-To-Peer Electronic Cash System

The motive for the creation of *Bitcoin* has a strong ideological background among the so-called *cypherpunks*, who sought a monetary system that would operate in a decentralized manner without state-owned and thus transaction-controlling financial institutions—hence solving privacy concerns of the digitalization and the internet. The *cypherpunks* acted in an open-source development approach, decentrally organized through forums and email lists (Popper, 2015). The central problem statement was the creation of an electronic, decentralized, peer-to-peer payment system, as central financial institutions had lost their organic governance bind by decoupling money from physical assets—such as gold—and had become politically driven, lacking their integrity (Schär & Berentsen, 2020). The birth of *Bitcoin* in 2008 could not have been more aptly timed, arriving during the world financial crisis beginning in 2007. On August 18, 2008, the domain *bitcoin.org* was registered by an anonymous party[1]. The link to the *Bitcoin* whitepaper titled "*Bitcoin: A Peer-to-Peer Electronic Cash System"* was distributed by email on November 11, 2008, by the pseudonym Satoshi Nakamoto (Nakamoto, 2008; Popper, 2015). The first block, the Genesis block, was mined on January 3, 2009, at 19:15 GMT+1. The first mined 50 BTC (the *bitcoin*-native coin) consigned without processing any transaction to the address 1A1zP1eP5QGefi2DMPTfTL5SLmv7DivfNa[2]. Included in this block was the message *"The Times 03/Jan/2009 Chancellor on brink of second bailout for banks,"* the front-page headline of the British *The Times*—a reference to

---

[1] https://bitcoin.org/en/posts/ten-year-anniversary

[2] https://www.blockchain.com/btc/block/000000000019d6689c085ae165831e934ff763ae46a2a6c172b3f1b60a8ce26f

the worsening financial conditions of the global economic crisis (Centieiro, 2021). *Bitcoin*'s monetary policy is defined by a mathematical formula, with a scheduled convergence to 21 millions BTC, making BTC a finite asset (Böhme et al., 2015), thus earning *Bitcoin* the name Digital Gold.

However, Satoshi Nakamoto did not create *Bitcoin* from scratch—*Bitcoin* is a recombination of pre-existing technology components (Popper, 2015; Schär & Berentsen, 2020). In 1983, David Chaum created *eCash*, which allowed a payment function to be linked directly to computers, enabling micro-transactions at an efficient price while solving the double-spent problem (Panurach, 1996). However, *eCash* was operated by a central and controlling company named *DigiCash*. This constellation was understood among the *cypherpunks* to be a "Trojan horse" (Popper, 2015). In the end, *eCash* failed due to trust issues towards enterprise cooperation on the part of David Chaum, these days also the CEO of *DigiCash*. *"As a cryptographer, you must assume the whole world is trying to rip you off. A certain amount of paranoia is part of the job"* (Ian Grigg, 1999). Today, the concept behind *eCash* has been mainly adopted by *PayPal*.

With *HashCash*, the Proof-of-Work (PoW) consensus mechanism was conceived in 1997 by the *cypherpunk* Adam Back. PoW is a cryptographic system where actors within a network must solve a computational problem and in which verification of the solution is relatively straightforward. In this way, a consensus on the global data state within the distributed database is eventually generated. One potential application for *HashCash* was to prevent spam emails, making mass sending of emails of little economic value at unprofitable cost (Back, 2002).

In 1998, Wei Dai published a proposal for *B-money*, an anonymous, decentralized money system that was already very similar to today's *Bitcoin* and which already incorporated a PoW consensus mechanism. More specifically, Wei Dai proposed actually two protocols: *"The first one is impractical, because it makes heavy use of a synchronous and unjammable anonymous broadcast channel. However, it will motivate the second, more practical protocol"* (Dai, 1998). In both protocols, anonymity about the sender and the receiver was enabled, and transactions were traceable only through their public keys. The first protocol described was very similar to today's *Ethereum*: Besides the anonymized transfer of money it also includes effecting, conclusion, and enforcement of contracts. The second protocol—the simpler and more feasible variant—was already quite similar to today's *Bitcoin* (Dai, 1998).

> *"A community is defined by the cooperation of its participants. And efficient cooperation requires a medium of exchange (money) and a way to enforce contracts."* (Wei Dai, 1998)

In 2004, the *cypherpunk* Hal Finney, one of Satoshi Nakamoto's first supporters, developed *Reusable Proof-of-Work (RPOW)*, an adaptation of Backs's PoW which allowed for multiple uses of tokens. Thus, a token that had been mined with significant computing power could be reused if an authentic (digital) resource would guarantee it. This also enabled transfers of tokens independently of a PoW execution (Finney, 2004). *RPOW* was the only system implemented until 2009, albeit without real economic gain. Hal Finney, though, would later become particularly relevant in shaping *Bitcoin* (Popper, 2015). In 2005, Nick Szabo developed *BitGold*, the direct ancestor of *Bitcoin.* In principle, both systems are almost identical, but instead of a blockchain, *BitGold* refers to a public string that continuously adds data (Szabo, 2005). The system is decentralized and based on most of the *Bitcoin* concepts, although *BitGold* was never implemented.

On January 9, 2009, version 0.1 of the *Bitcoin* software became public and thus open source, allowing for first transactions[3]. The very first network transaction took place three days later, in which Satoshi Nakamoto sent 10 BTC to Hal Finney (Peterson, 2014). Hal Finney had been the first one of the *cypherpunks* reacting to Satoshi Nakamoto's email containing the *Bitcoin* whitepaper and who subsequently devoted himself constructively to its further development (Popper, 2015). He also became the second user after Satoshi Nakamoto, active as a miner with his personal computer. Initializing *Bitcoin* was very centrally accomplished by Satoshi Nakamoto and Hal Finney as sparring partners in between the publication of the white paper and the implementation of the network. Eventually,

---

[3] https://satoshi.nakamotoinstitute.org/code/

other *cypherpunks* such as Gavin Andreesen became aware of the project, adding feedback or contributing to the development (Popper, 2015). Satoshi Nakamoto himself worked on the source code of *Bitcoin* until 2010, but then increasingly handed over further development to the *Bitcoin* network. On April 23, 2011, he finally stepped back for good by writing his last message: *"I've moved on to other things. It's in good hands with Gavin (Andreessen) and everyone"* (Popper, 2015, p. 159). This left a vacuum of legitimacy with the *Bitcoin* community wondering who may be behind the pseudonym, Satoshi Nakamoto. However, Satoshi Nakamoto's centralized mining efforts during the very first days of *Bitcoin* have left him with a fortune of approximately 1 million BTC in his wallets, which would presently place him as one of the wealthiest "person" in the world. However, the money was never withdrawn, that is considered as one success factor and reason for *Bitcoin*'s integrity: (1) *Bitcoin* was allowed to take the time required to thrive without inflating user expectations or attracting premature attention from media or regulators. (2) The project truly achieves decentralization both in operation and governance, as there is no central legitimacy in place after Satoshi Nakamoto's retraction, and *Bitcoin* assets are relatively distributed (apart from the enormous amounts on Satoshi Nakamoto's wallets). Hence, the *Bitcoin* protocol and the *Bitcoin* network was allowed to grow organically while establishing trust and robustness (Popper, 2015).

> *"Trust is Bitcoin's barrier to success. I don't think there is anything we can do to speed up the process of getting people to trust that Bitcoin is solid; it takes time to build trust."* (Gavin Andreesen) (Popper, 2015, p. 127)

Nevertheless, what is currently understood or thought to be understood regarding Satoshi Nakamoto indicates that he is presumably not native Japanese. His surname was never placed at the beginning of his name, as it would be customary in Japan. In addition, his spelling has always been British, along with using British words such as *"bloody"* (Popper, 2015). It is speculated that Hal Finney or Nick Szabo could have been behind the pseudonym—or even a collective. In addition, numerous individuals such as Craig Wright claimed to be Satoshi Nakamoto (The Guardian, 2021). It is also speculated that Elon Musk or even intelligence agencies could be behind all of this (Popper, 2015). The hubbub and speculation surrounding the identity of Satoshi Nakamoto also reveals the strength of *Bitcoin* and the complete anonymity of both the users and the creator, which protects against outside influence and allows disruptive innovation to flourish in one of the most sensitive infrastructural areas of societies: the monetary system.

***Ethereum*: A Next Generation Smart Contract and Decentralized Application Platform**

When proposing *B-Money*, Wei Dai already referred to two protocols, one for the effective implementation of financial transactions and another that could also execute contracts of various types linked to executed financial transactions (Dai, 1998). The former includes the functionalities of *Bitcoin* and serves as a motivation for the second protocol, which is more complex and challenging to create. Vitalik Buterin, the founder of *Ethereum* and CEO of the *Ethereum Foundation*, published the *Ethereum* whitepaper *"A Next-Generation Smart Contract and Decentralized Application Platform"* in 2014, that extended the functionalities of *Bitcoin* through so-called smart contracts to enable applications on top of DLT networks and to create the infrastructural basis for it (Buterin, 2014). Smart contracts are if-then relationships written in code and concerted upon in an ex-ante manner by the decentralized network, which automatically execute a computer program when the ex-ante defined state is reached (Christidis & Devetsikiotis, 2016). For instance, if it is ex-ante specified that a program will be executed once a specific public key X receives an amount Y, the program subsequently could generate the authorization for a particular action Z. Since this smart contract is shared with the entire and decentralized network, accurate execution is monitored and implemented by all the network participants. Thus, the technology becomes a kind of trustee that enables even trustless network participants to mutually agree and comply with the ex-ante defined terms. In the strict sense, this digital trust encompasses a more transparently implemented *digital truth* within the DLT network and its protocol where all the network conditions become transparent to all network participants. Based on the internet protocol, the transfer of information became feasible via a decentralized network. *Bitcoin* had established a protocol that enabled the transfer of ownership adjacent to it (Natarajan et al., 2017). *Ethereum* was the first to allow these two achievements in one single protocol, integrated and linked through smart contracts—enabling novel and diverse applications in a decentralized manner.

> *"I first sort of rediscovered Bitcoin in 2013. And it wasn't long after that I came to the conclusion that for it to survive, it needed to decentralize not just the basic currency itself but also things such as the exchanges since the infrastructure, at the time, was entirely centralized."* (Gavin Wood, 2019)

While *Bitcoin* became the first DLT protocol to be developed and implemented without much media or social attention when initiated, *Ethereum* had slightly different preconditions. The blockchain technology was already well-known in the tech-savvy community. Thus, there was already a development community in place. These circumstances allowed for a much more efficient and deliberate way to promote and guide the development and establishment of *Ethereum*. Vitalik Buterin was the driving force and visionary behind it. Prior to publishing the *Ethereum* white paper in 2013, he spent nearly half a year traveling the world, meeting with *Bitcoin* developers to identify opportunities for improvement (Locke, 2021). Eventually, he embraced the idea of smart contracts that had originally already beein advocated by Nick Szabo (Szabo, 1996), being *"self-executing scripts that reside on the blockchain—integrate these concepts and allow for proper, distributed, heavily automated workflows"* (Christidis & Devetsikiotis, 2016, p. 2292). The aggregation of smart contracts allows for the establishment of self-executing and dedicated network functions, so-called decentralized applications (*DApps*). When *DApps* are added with a self-regulatory governance, this allow for Decentralized Autonomous Organizations (DAOs) (Hassan & De Filippi, 2021; Singh & Kim, 2019). DAOs are the most complex aggregation of smart contracts, allowing for resolving the principal-agent dilemma (Shermin, 2017).

To effectively implement *Ethereum*, the *Ethereum Foundation* was established on June 7, 2014, as a non-profit and earmarked legal entity based in Zug, Switzerland. In addition to Vitalik Buterin, its founding partners included Dr. Gavin Wood, Joseph Lubin, and Charles Hoskinson, among others (Hamacher, 2020). The technical implementation of *Ethereum* was published in 2014 through the yellow paper by Gavin Wood, the CTO of the *Ethereum*

Foundation at that time, published on July 11, 2014 (Wood, 2014). The Initial Coin Offering (ICO) ended on August 30, 2014, raising a total of $16m[4] (Ethereum Foundation, 2014). Users participated by contributing *Bitcoin*, with a declining exchange ratio starting at 2000 Ether (ETH) for one *Bitcoin* (BTC) (Ethereum Foundation, 2014). Since there was no interoperability between the *Bitcoin* and *Ethereum* protocol present, the change from BTC to ETH and subsequent ETH allocation depended on the trust given to the legal entity and the earmarking of the *Ethereum Foundation*. The funding provided by the ICO was subsequently managed by the *Ethereum Foundation* to build up and incentivize the required open-source ecosystem as well as to advance *Ethereum*'s development and its community education.

***Polkadot*: A Heterogeneous, Interoperable Multi-Chain Framework**

The isolated embedding of *Ethereum* with other DLTs, however, ultimately led to the motivation for *Polkadot*. The CTO of the *Ethereum Foundation*, Gavin Wood, published the *Polkadot* white paper *"Polkadot: Vision for a Heterogeneous Multi-Chain Framework"* in 2016, which aimed for interoperability among multiple DLT (web3) networks (Wood, 2016).

> *"But fast forward to like March, April 2014, and it became clear that Ethereum was going to suffer from a similar sort of problem in that you can decentralize the very core of the protocol you want, but if you don't have decentralized infrastructure surrounding it, then it's not going to fulfill the overarching purpose."*
> (Gavin Wood, 2019)

A multi-chain was developed to connect and link distinct and prior disconnected DLTs, thus creating interoperability and fostering application efficiencies (Wood, 2016). Gavin Wood's vision is also based on the assumption that in the end, there will not be one dominant network but rather a multitude of networks capable of interacting with each other.

Polkadot provides such a framework, consisting of a native main network (layer-1)—the relay chain—and several layer-2 networks on top—so-called parachains. For interoperability

---

[4] https://icodrops.com/ethereum/

with non-native *Polkadot* networks, so-called bridges are implemented. Hence, *Polkadot* is a sharded network that allows for both layer-1 and layer-2 networks (Burdges et al., 2020). *Polkadot*'s ICO was launched in 2017 by its dedicated *Web3 Foundation* and raised the equivalent of $144m[5] in funding. With *Substrate*[6], *Parity Technologies*, a for-profit development entity, created a modular software toolkit that allows *Polkadot*'s network to assemble its own parachains. With the *Kusama*[7] network, a separate and upstream test network is in place. This becomes necessary as *Polkadot* incorporates a web3-based on-chain governance model that allows *Polkadot* governance's integrity to be independent of any central control, requiring the governance implementation to be tested in advance for robustness.

2.3.2 DLT Affordances

Distributed ledger technologies (such as blockchain) constitute a novel digital infrastructure. DLTs enable a new form of technology-inherent digital trust—what I refer to as *digital truth*—through decentralized and transparent monitoring of transactions, automated and smart contracts, and sophisticated consensus mechanisms allowing for disintermediated transfer of digital ownership (Buterin, 2014; Natarajan et al., 2017; Wood, 2014). At their core, DLT protocols comprise a distributed network operation for the architecture of databases in which consensus about the state of the database can be reached in permissioned (require permission to join and participate) as well as permissionless (require no permission to join and interact) settings (Nakamoto, 2008). While I refrain from explaining the technical details of DLTs in the following, I point out some of its unique affordances that redefine relationships among actors, objects, and entities:

1. *Decentralization and data sovereignty.* DLTs mandate a decentralized consensus, which implies that participating actors in the system agree on a single description of a global state of the data set (Wood, 2016). DLTs, therefore, need to incentivize responsible

---

[5] https://icodrops.com/polkadot/

[6] https://www.substrate.io/

[7] https://kusama.network/

and rigorous data entry among a community of actors and simultaneously ensure that the majority of actors agree on a single state. This is usually enacted through carefully designed consensus mechanisms such as Proof-of-Work (PoW) or Proof-of-Stake (PoS) (Biais et al., 2019). Thus, it allows for facilitating transactions through a decentralized peer-to-peer network, where data control and sovereignty are anchored with the data or resident (web3).

2. *Automation and transactional transparency.* As mentioned, the advent of the DLT protocol *Ethereum* paved the way for smart contracts. These are programs that automatically execute a digital contract once its object of agreement occurs (Buterin, 2014). These smart contracts allow automated execution of transactions within preemptively defined and immutable terms and conditions. A smart contract automates the transfer of digital ownership based on the state of the distributed ledger (Wood, 2014), allowing self-enforcing execution and creating transactional transparency while bypassing human actors as a source of unpredictability.

3. *Network alignment and tokenization.* Tokens and cryptocurrencies are inherent in public permissionless DLT applications and are typically used as an incentive mechanism for facilitating rigorous data entry (Narayanan et al., 2016). Tokenization refers to the implementation of digital proxies that represent a previously amorphous unit of natural capital and essentially disciplines actors in the DLT network to operate properly. Moreover, DLT-native tokens serve for aligning the network, either through incentivizing the consensus finding of the distributed network (Nakamoto, 2008) and/or as a voting tool when implemented as inherent functionality of the DLT protocol (Wood, 2016).

4. *Disintermediation and information symmetry.* As transactions are recorded on a distributed ledger, all states of transactions are visible to all actors (dependent on the DLT and network settings) and immutable at all times, which also reduces the involvement of centralized institutions (Nakamoto, 2008), thereby ensuring that a network cannot be monopolized. Moreover, the principal-agent problem is to be solved. Con-

trol is shared among independent actors, resulting in data sovereignty and a decrease of dependencies (Gu & Zhu, 2021; Iansiti & Lakhani, 2017). Since transactions can be viewed and verified by all actors, information symmetry is established throughout the network, allowing for novel openness mechanisms (Cong & He, 2019), where each participant and third party can capture value and create innovation.

In summary, whereas before actors had to place digital trust in the platform intermediary (or platform sponsor), DLTs affordances enable trust to be transformed into a repository of *digital truth*.

The implications stemming from these affordances are far-reaching and have significant consequences for economic and organizational theory (Lumineau et al., 2020). Schückes and Gutmann (2020) find evidence that the design of a venture's organizational arrangements often reflects the extent to which the underlying DLT is integrated. Given the unique consequences of adopting DLTs and their implementation, underpinning the set of digital technologies with novel business and operating models promises considerable payoffs, making them increasingly relevant across different streams of the literature and stimulating new ways of thinking about how to create value (George et al., 2020; Nambisan, 2017). This makes the development of new theorizing around a digital technology perspective pressing (Nambisan et al., 2019), especially considering the heavy reliance of the current literature on the incongruent affordances of the internet.

2.4 Synthesis and Research Gap

Vergne (2020) introduces a framework distinguishing between machine learning (ML) platforms (described in this thesis as centralized platform ecosystems) and blockchain platforms (resulting in decentralized platform ecosystems, when evolved). The difference between both also lies in how their platform governance is designed, which can be configured in terms of coordinated communication (centralized vs. decentralized) and decision-making (distributed vs. concentrated). Accordingly, ML platforms are centralized in their coordinated communication. They create a data gravity and process these enormous amounts of data into information using distributed decision-making algorithms, resulting in information asymmetry in the platform ecosystem and promoting monopolistic market structures within the centralized platform ecosystem. In contrast, blockchain platforms are also distributed in terms of decision-making but have decentralized coordinated communication. Thus, they create decentralized data access, allowing for information symmetry and fostering multiple innovation streams (Iansiti & Lakhani, 2017). Consequently, value creation in ML platforms is obtained by transforming data into information through ML algorithms. For blockchain platforms, value is additionally and correspondingly expected through decentralized coordinated communication, allowing for new means of innovation by leveraged third-party complementarities. In this regard, I understand and define blockchain and DLTs as protocols that embrace network effects to allow for automated and disintermediated orchestration of digital information and ownership transactions.

In my thesis[8], I strive to shed light on decentralized governance mechanisms , exploring their implications when integrated into the platform context. I seek to delineate their configurations to elaborate the value of DLTs and their technology affordances subsequently. An essential role of platform governance is to create integrity within a platform's network (Tiwana et al., 2010), which in the case of centralized platforms, is provided by digital trust in the central platform sponsor. As a result, it has been inevitable that platform governance included a minimum level of centralization, constraining innovation through third-party complementarities, necessitating careful management between opening and closing platform access (G. Parker & Van Alstyne, 2018). Yet, DLT affordances allow for digital integrity inherent in the technology—something I call *digital truth.* Therefore, the question arises surrounding how this sort of integrity in governance can be decentralized in different platform configurations, identifying implications and characteristics for platform design. As a result of the created information symmetry and the integrity of the technology, the occurrence of monopolistic market structures can thus be avoided by ex-ante frameworks (G. Parker et al., 2020), acting at a data level and automatically enforced within the platform transactions.

---

[8] Parts of this thesis have been presented at *AoM2021* and have been submitted to a scientific journal with my co-authors Magnus Schückes, Thomas Möllers, Tobias Gutmann, and Oliver Gassmann. They contributed substantially with their reviews, edits, changes, and feedbacks. I hereby declare that most of the content of the following chapters has been written by myself.

Finally, I also aim to determine managerial implications arising for the platform network, including related activities and incentives to enable decentralized platform ecosystems to evolve in the direction of self-regulating, autonomous, and a dynamic network of networks. A critical element in this process is maintaining the same capabilities that digital trust has created in centralized platform ecosystems with *digital truth* and thus by the integrity of the technology. Therefore, it is essential to establish at least an equal value with positive platform externalities to successfully transition to more decentralization and balance in the platform ecosystem while even creating a new competitive advantage through fostered third-party complementarities. It must strive to ensure that the platform network is enabled to proactively share its data seeking for exploitation, despite the increasing decentralization of coordination communications and the internalization of negative platform externalities. Therefore, even under decentralized governance with integrity created by *digital truth*, data gravities need to emerge so that derived information can generate at least the same value outputs as centralized governed platform ecosystems and thereby establish a competitive advantage. In this thesis, I seek to answer the research question:

> *Q: "How are decentralized platform ecosystems designed to internalize negative platform externalities while simultaneously foster positive platform externalities?"*

I aim to shed light on platform externalities and present mechanisms capable of addressing the Coase Theorem (Coase, 1960). I consider DLTs the requisite technology to provide affordances that enable platform ecosystems to meet the Coase Theorem's conditions through decentralized platform governance and the resulting information symmetry. Based on the above-stated research gap, I formulated five sub-research questions. These sub-research questions contribute to a consistent conclusion to the main research question, allowing for theoretical, empirical, and practical contributions.

Based on the theoretical foundation of business models and the widely accepted interrelation of technology affordances and business model innovation, I examine the emergence of new business model characteristics related to the technology affordances of DLTs. In this context, I raise the following first sub-research question:

> *Q1: "How do DLT affordances translate into business model dimensions, variables, and characteristics?"*

Based on Amit and Zott's (2001) seminal work, I further examine what platform-specific accomplishments are attributed to platform ecosystems when DLTs are integrated into their design. The internet has spawned digital marketplaces with a competitive advantage for platform business models through the automated transfer of information (web1 and web2). These competitive advantages are largely credited to positive platform externalities. DLTs incorporate post-internet significant opportunities, with far-reaching implications on platform ecosystem configurations. Disintermediation in the platform context is anticipated due to technology-inherent and automatable transfer of ownership (web3) (Gu & Zhu, 2021; Iansiti & Lakhani, 2017). Taking a closer look at the corresponding implications, I pose the following sub-research question:

> *Q2: "How are DLT business model patterns and archetypes classified and how are DLT affordances integrated into decentralized configurations of platform ecosystems?"*

Decentralized configurations in platform ecosystems can thus be created as a result of decentralized governance. I will elaborate on the respective distinctions to be made based on the strength of the decentralized governance, clarifying the form by which the required integrity of platform governance is composed. Thus, the question emerges to what degree digital trust (with a requisite central authority in the platform ecosystem) or even *digital truth* (with autonomization effects in the platform ecosystem) can be achieved. For this, I define the third sub-research question:

> *Q3: "How do DLT affordances impact configurations and design choices in decentralized platform ecosystems with implications to their coordination through decentralized platform governance mechanisms?"*

Building on Vergne's (2020) framework, I will discuss requirements for a decentralized governance model to enable the internalization of negative platform externalities through information symmetry. A corresponding requirement is integrity created by DLT affordances, allowing positive platform externalities to be preserved simultaneously. In this context, I formulate the fourth sub-research question:

> *Q4: "What are decentralized governance characteristics to allow for a balanced management of distinct platform network requirements and coordination of platform externalities?"*

Keeping the practical context in mind, I explore initiatives of incumbents striving to integrate decentralized governance mechanisms and developing shared platform ecosystems that leverage prevailing business models and create new competitive advantage by integrating DLT affordances. Herein, I address game-theoretic considerations of such coopetition approaches (Ritala & Hurmelinna-Laukkanen, 2009) and derive managerial implications. For this, I address the fifth sub-research question:

> *Q5: "How can DLT affordances and decentralized governance mechanisms be exploited to initiate and foster the growth of platform ecosystems where game-theoretic challenges are successfully managed in coopetition models?"*

3. Methodology

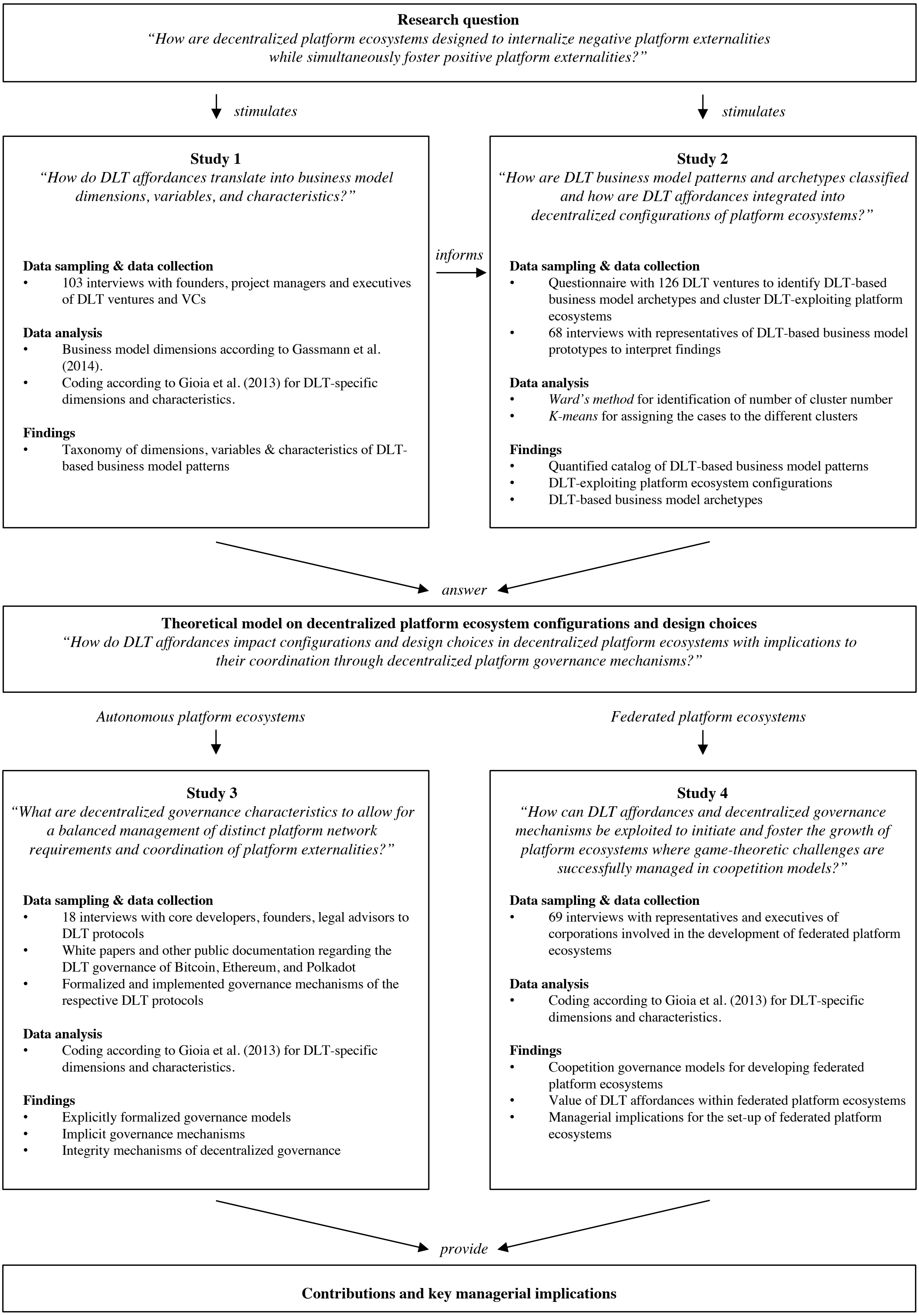
This section presents the methodological design of my thesis together with data sampling, data collection, and data analysis.

3.1 Research Design

In order to answer my research question, *"How are decentralized platform ecosystems designed to internalize negative platform externalities while simultaneously foster positive platform externalities?"*, I have chosen a mixed method research approach, followed by two inductive studies, which is illustrated in Figure 3.1. Accounting for my research design, my research question is subsequently broken down into five sub-research questions.

In study 1, I adopted a qualitative approach with the goal of exploring relevant and DLT-specific business model dimensions, variables, and characteristics. I conducted 103 semi-structured interviews with executives or founders of DLT ventures as well as executives and project managers of corporations and venture capital firms dealing with or exploiting DLTs. Following a structured and rigorous methodology for analyzing my data as established by Gioia, Corley, and Hamilton (2013), I inductively uncover DLT-specific business model dimensions, their variables, and their characteristics, with the aim to answer the sub-research question of *"How do DLT affordances translate into business model dimensions, variables, and characteristics?"*

In study 2, I employed a quantitative approach to validate the dimensions and characteristics from study 1 through a questionnaire with executives of 126 DLT ventures, resulting in a quantified catalog of DLT business model patterns. Based on these findings, I consequently performed a cluster analysis using unsupervised machine learning algorithms to distinguish between types (Ketchen & Shook, 1996; Punj & Stewart, 1983; Short et al., 2008). I applied *Ward*'s method and *k-means* consecutively and in tandem to determine and validate the number of clusters and allocate the 126 cases respectively (see Block et al.,



Research question

"How are decentralized platform ecosystems designed to internalize negative platform externalities while simultaneously foster positive platform externalities?"

Study 1

"How do DLT affordances translate into business model dimensions, variables, and characteristics?"

Data sampling & data collection
- 103 interviews with founders, project managers and executives of DLT ventures and VCs

Data analysis
- Business model dimensions according to Gassmann et al. (2014).
- Coding according to Gioia et al. (2013) for DLT-specific dimensions and characteristics.

Findings
- Taxonomy of dimensions, variables & characteristics of DLT-based business model patterns

Study 2

"How are DLT business model patterns and archetypes classified and how are DLT affordances integrated into decentralized configurations of platform ecosystems?"

Data sampling & data collection
- Questionnaire with 126 DLT ventures to identify DLT-based business model archetypes and cluster DLT-exploiting platform ecosystems
- 68 interviews with representatives of DLT-based business model prototypes to interpret findings

Data analysis
- *Ward's method* for identification of number of cluster number
- *K-means* for assigning the cases to the different clusters

Findings
- Quantified catalog of DLT-based business model patterns
- DLT-exploiting platform ecosystem configurations
- DLT-based business model archetypes

Theoretical model on decentralized platform ecosystem configurations and design choices

"How do DLT affordances impact configurations and design choices in decentralized platform ecosystems with implications to their coordination through decentralized platform governance mechanisms?"

Study 3

"What are decentralized governance characteristics to allow for a balanced management of distinct platform network requirements and coordination of platform externalities?"

Data sampling & data collection
- 18 interviews with core developers, founders, legal advisors to DLT protocols
- White papers and other public documentation regarding the DLT governance of Bitcoin, Ethereum, and Polkadot
- Formalized and implemented governance mechanisms of the respective DLT protocols

Data analysis
- Coding according to Gioia et al. (2013) for DLT-specific dimensions and characteristics.

Findings
- Explicitly formalized governance models
- Implicit governance mechanisms
- Integrity mechanisms of decentralized governance

Study 4

"How can DLT affordances and decentralized governance mechanisms be exploited to initiate and foster the growth of platform ecosystems where game-theoretic challenges are successfully managed in coopetition models?"

Data sampling & data collection
- 69 interviews with representatives and executives of corporations involved in the development of federated platform ecosystems

Data analysis
- Coding according to Gioia et al. (2013) for DLT-specific dimensions and characteristics.

Findings
- Coopetition governance models for developing federated platform ecosystems
- Value of DLT affordances within federated platform ecosystems
- Managerial implications for the set-up of federated platform ecosystems

Contributions and key managerial implications

Figure 3.1: Research design

2015; Ketchen and Shook, 1996; Leask and Parker, 2007). The resulting clusters serve as DLT business model archetypes. To interpret the four emergent archetypes, I conducted 68 semi-structured interviews with representatives of firms performing DLT business models that prototypically mirror the four identified archetypes. A subsequent comparative analysis leads to my theoretical and practical contributions. Accordingly, with study 2, I elaborate on a second sub-research question: *"How are DLT business model patterns and archetypes classified and how are DLT affordances integrated into decentralized configurations of platform ecosystems?"*

The theoretical model regarding decentralized platform ecosystem configurations and design choices that I draw upon from the first two studies subsequently answers the research question: *"How do DLT affordances impact configurations and design choices in decentralized platform ecosystems with implications to their coordination through decentralized platform governance mechanisms?"*

Based on the findings from studies 1 and 2, I identified two types of decentralized configurations in platform ecosystems, which I use as the basis for studies 3 and 4. In study 3, I apply an inductive research design to analyze the decentralized governance structures of *autonomous platform ecosystems*. I conducted 18 semi-structured interviews with core developers, founders, legal advisors of and to *Bitcoin*, *Ethereum*, and *Polkadot*, along with associated and connected DLT networks. I enriched those data by sparring secondary data and data directly drawn from the respective DLT protocols into the finding's development process. Again, I follow a structured and rigorous methodology for analyzing my data as established by Gioia et al. (2013) and uncover integrity mechanisms of decentralized governance, with the aim to answer the sub-research question: *"What are decentralized governance characteristics to successfully allow for a balanced management of distinct platform network requirements and coordination of platform externalities?"*

In study 4, I examine the initiation mechanisms of *federated platform ecosystems*. I conducted 69 interviews with executives and managers of corporations that have initiated or are in the process of initiating *federated platform ecosystems*. Again, I use the methodology of Gioia et al. (2013) for the data analysis and identify managerial implications and requirements for decentralized governance in supporting such a coopetition approach allowing for maximum competitiveness. Here, I address the sub-research question: *"How can DLT affordances and decentralized governance mechanisms be exploited to initiate and foster the growth of platform ecosystems where game-theoretic challenges are successfully managed in coopetition models?"*

3.2 Data Sampling and Data Collection

The following interview data for this thesis were collected over a period of 3.5 years[9]; however, I separate the data in the following and assign them to the respective studies, as these represent the thematic focus and developments within the thesis. Likewise, studies 1 and 2 contain a mixed method approach, which makes a separation of data sampling and data collection necessary.

3.2.1 Study 1

I used theoretical sampling to identify a diverse set of DLT ventures, which include startups, corporate spin-offs, joint ventures, and non-profit ventures (Yin, 2003). These ventures (1) had to be presently operating and offering services in the field of DLTs; (2) were clearly identified as an independent and separate organizational unit; (3) disclosed sufficient information in order to evaluate my sampling criteria and contact them (e.g., firms operating in 'stealth mode' were not taken into consideration). Using these criteria, I leveraged both *crunchbase.com* and industry-specific databases such as *ICObench.com*, which are increasingly used in DLT-related entrepreneurship studies (Bellavitis et al., 2020; Cumming et al., 2019; Momtaz, 2020), as starting points to identify relevant ventures. I further reached out to a multitude of European corporations that are particularly involved in digital technologies and data-based business models. I relied on exploratory semi-structured interviews as my

---

[9] Nicolas Gilgen, Luca Heer, Severin Kranz, Leopold Crecelius, Ennio Limbach, Christopher Baumann, Matthias Reichl, Gabriel Fässler, Marco Wörtz, Alexander Illichmann, Julius Schubarth, and Raffael Spescha supported the data collection of semi-structured interviews under the supervision of the author of this dissertation. The interview guideline and its subsequent adaptations were developed by the author of this dissertation. The students could use the interview material for their Bachelor's or Master's theses.

primary data source, through which I was able to reap the benefits of acquiring an emic understanding of the business models and their components from the interviewees themselves (Kvale & Brinkmann, 2009). Following Gassmann et al. (2014), I structured the interviews around the common conceptualization of a business model consisting of a customer relationship model, a value proposition, mechanisms for value creation, and mechanisms for value capture. Therefore, the interview guide was able to generate a common language for describing business models while remaining flexible, especially with regard to focusing on DLT-induced components of the business model. The guide was initially tested with four pilot interviews and continuously adapted to reflect emerging themes and insights. Between December 2017 and March 2018, I conducted a total of 103 interviews with founders, executives, and project managers of DLT ventures as well as experts such as angel and venture capital investors active in the field. The interviews ranged from 15 to 121 minutes and took an average of 39 minutes. Upon completion, most interviews were transcribed within twenty-four hours, resulting in 1633 pages of double-spaced text. To reduce the risk of interviewer bias and maximize replication logic, I established a common research orientation and research protocol.

3.2.2 Study 2

Building upon study 1, the second step of my mixed method research design aimed at validating my initial data structure by developing a catalog of DLT business model configurations as well as identifying respective archetypes. To generate the catalog, I sampled DLT ventures by leveraging the *crunchbase.com* database. I identified the 1000 highest ranked ventures using the keywords “blockchain,” “distributed ledger technologies,” and “DLT” respectively. I filtered out ventures which I considered to be insufficiently related to distributed ledger technologies or for which I could not find sufficient secondary information and then used the same three selection criteria as employed in study 1. The resulting sample represented ventures from various industries, market segments, and regions. I sent a survey consisting of multiple-choice questions based on my data structure to each of the remaining 558 ventures aimed at identifying configurations of business models. I received 126 completed responses representing a response rate of 23 percent, which is above a typically reported response rate for surveys that are mailed to executives (e.g., Hannen et al., 2019; Patel et al., 2013). My sample has a global distribution with a concentration in Europe (57.89%), North America (25.44%), and Asia (11.40%). 15.79% of the ventures in my sample are located in Switzerland due to its early regulatory treatment regarding DLT-native tokens. The ventures in the sample received an average funding amount of $65m, with the funding types ranging among ICOs, grants, seed money, series A-C, and corporate rounds. 95% of the ventures operate for-profit. As a control mechanism, I tested for response bias by conducting a t-test in which I compared respondents to nonrespondents. Because of the nature of ventures in my sample, I designated the total funding amount as a predictor. I extracted funding statistics from the *crunchbase.com* database. This comparison revealed that the total funding amount did not emerge as a significant predictor ($t = 1.681$, $df = 71$, $p\text{-}value = 0.097$) of inclusion in my final sample (coded "1" for respondent), indicating that ventures included in my sample are unlikely to differ systematically from ventures that did not respond. In Figure 4.2, I present a catalog of DLT-specific business model patterns. The catalog is based on the DLT business model dimensions, variables, and characteristics from study 1 and supplemented by the corresponding quantified information gleaned through the questionnaire.

3.2.3 Study 3

For the deep-dive into DLT governance, I chose *Bitcoin*, *Ethereum*, and *Polkadot* and their governance models as a sampling representatives. All three protocols exhibit strong performance indicators in user adoption, developer base (Shen et al., 2021), and market capitalization[10]. Additionally, they show vital significance concerning distinct governance model mechanisms. Moreover, their governance's successive developments and the legitimacy of their key drivers allow for an evolutionary reflection of DLT governance. The identification of relevant core developers was made via *GitHub*. Since all three projects use open-source software, their contribution is transparently and consistently logged via the *GitHub*

---

[10] https://coinmarketcap.com/

database. This enabled me to subsequently contact relevant core developers via crypto conferences or *Twitter*. The governance of each's DLT protocol is publicly accessible and logged in detail. Their foundation's wikis and on-chain documentation are used for this purpose. Furthermore, project management descriptions and contribution guidelines on *GitHub* were considered parts of detailed documentation. Finally, formalized and DLT protocol-specific governance changes can be reviewed via the protocol's own *GitHub* projects and their proposals (BIP, EIP). The interviews were conducted between May 2019 and November 2020, resulting in 1016 minutes of recording, lasting between 23 and 97 minutes with an average length of 56 minutes and 416 pages of double-space transcript.

3.2.4 Study 4

The sampling for the study stems from the *GAIA-X* initiative, *IDunion*, and two consortium projects, one for hydrogen certification and the other in the production context. A total of 69 semi-structured interviews were conducted with an average length of 51 minutes, ranging from 29 to 72 minutes, and containing 1456 pages of double-spaced text transcripts. The interviews were conducted between November 2019 and August 2021, ensuring that the projects were intentionally recorded intermittently over a more extended period of time to include evolution cycles in the respective consortium projects.

3.3 Data Analyis

Studies 1, 3, and 4 involve qualitative data and are analyzed accordingly using qualitative research methods. Study 2, on the other hand, involves quantitative data analysis. The applied methods are presented below.

3.3.1 Qualitative Data

I analyzed my qualitative data according to the methods by Gioia et al. (2013), thereby building on established procedures for inductive research aimed at theory building (Glaser & Strauss, 2017). To ensure intercoder reliability and guard against individual biases, the data were coded by two additional researchers individually and the codes were subsequently compared to settle on a final interpretation (Lofland & Lofland, 1971). Overall, I iterated between the developing model and the data until I achieved a viable set of first-order codes, second-order themes, and aggregated dimensions. I stopped when I reached theoretical saturation (Glaser & Strauss, 2017). For the sake of clarity, I present my analysis, using study 1 as an example, in three sequential steps that are captured in my data structure shown in Figure 4.1.

Step 1: Initial data coding. In order to uncover, name, and develop concepts, I began to identify first-order codes by "open coding" (Corbin & Strauss, 2014) the data regarding the *'Who?'*, *'What?'*, *'How?'* and *'Why?'* of business model design choices (Gassmann et al., 2014). Each researcher independently coded the data by breaking it down into distinct chunks. I then compared and refined my categorization schemes to assess reliability. Following Corley and Gioia (2004), each chunk consisted of a sentence or paragraph conveying a coherent point about my research focus (Weber, 1990). These statements were labeled and subsequently categorized into mutually exclusive and collectively exhaustive first-order codes, which constitute in the findings of study 1 the DLT-specific business model characteristics (Gioia et al., 2013).

Step 2: Second-order themes. I built upon these first-order codes and reassembled the fractured data with the goal of detecting conceptual patterns and similarities. Moving from the initial open coding to axial coding (Corbin & Strauss, 2014), I identified linkages and themes within the first-order codes to derive second-order themes, which constitute within the findings of study 1 the DLT-specific business model variables (Gioia et al., 2013).

Step 3: Theory induction through aggregation. I formed aggregated dimensions by raising the level of abstraction and linking the various second-order themes (Gioia et al., 2013) that emerged from the data to construct in study 1 the data structure depicting the building blocks of DLT business models. I focused on DLT-induced or novel business model components and derived nine main aggregated dimensions that describe business model configurations. Those aggregated dimensions (which are DLT-specific business model dimensions in study 2), in conjunction with the second-order themes (DLT-specific business model variables) and first-order concepts (DLT-specific business model characteristics), serve as the constitutive elements of my taxonomy that reflect the basic components of a business model: (1) target customer, (2) value proposition, (3) value creation, and (4) value capture. During this process, I spent considerable time discussing and interpreting the data. I also discussed my emerging data structure with colleagues from academia who were previously not involved in the coding process to ensure the reliability of the coding (Guba & Lincoln, 1994). For the interviews I used in study 3, the data were also coded according to Gioia et al. (2013), to ensure rigor in the analysis. These data were additionally triangulated with archival data, such as the *GitHub* code repositories, the project wikis, and recent documentation such as white papers issued by the founders and contributors of the three analyzed projects. The qualitative interviews in studies 2, 3, and 4 were also coded according to Gioia et al. (2013); however, they were additionally supplemented by a cross-case analysis (Eisenhardt & Graebner, 2007) to extract the corresponding mechanisms of the coopetition approaches.

3.3.2 Quantitative Data

In study 2, I conducted a cluster analysis to determine distinct DLT business model archetypes. Clustering is a widely used method in management studies (Ketchen & Shook, 1996; Leask & Parker, 2007; Leung et al., 2017; Punj & Stewart, 1983; Short et al., 2008). One of the challenges lies in identifying cases with similar organizational configurations that display individual and mutually multidimensional characteristics (Meyer et al., 1993; Miller & Mintzberg, 1983). Organizational configurations, typologies (Miles et al., 1978), taxonomies (Meyer et al., 1993), or archetypes (Miller & Friesen, 1978) can be researched based on generic information about data on an aggregated level of individual observations (Aggarwal & Zhai, 2012). The goal of such an analysis is to identify clusters that exhibit a high degree of heterogeneity between clusters and at the same time a high degree of homogeneity within the cluster (Ketchen & Shook, 1996). Ketchen and Shook (1996) recommend a two-step cluster analysis approach combining hierarchical and non-hierarchical methods. The former serves to determine the number of clusters, while the latter is subsequently employed to assign the cases to the identified clusters. I employed two machine learning algorithms. I first used *Ward*'s method, a widely accepted and frequently applied hierarchical algorithm of agglomerative clustering that produces clusters of roughly equal size (Leask & Parker, 2007). Effective identification of the number of clusters is achieved by visualization using a dendrogram (Figure 3.2). Two clusters with a Euclidean distance of 13.10 were identified. Among each of those classes, two further clusters were found with Euclidean distances of 8.40 and 9.27.

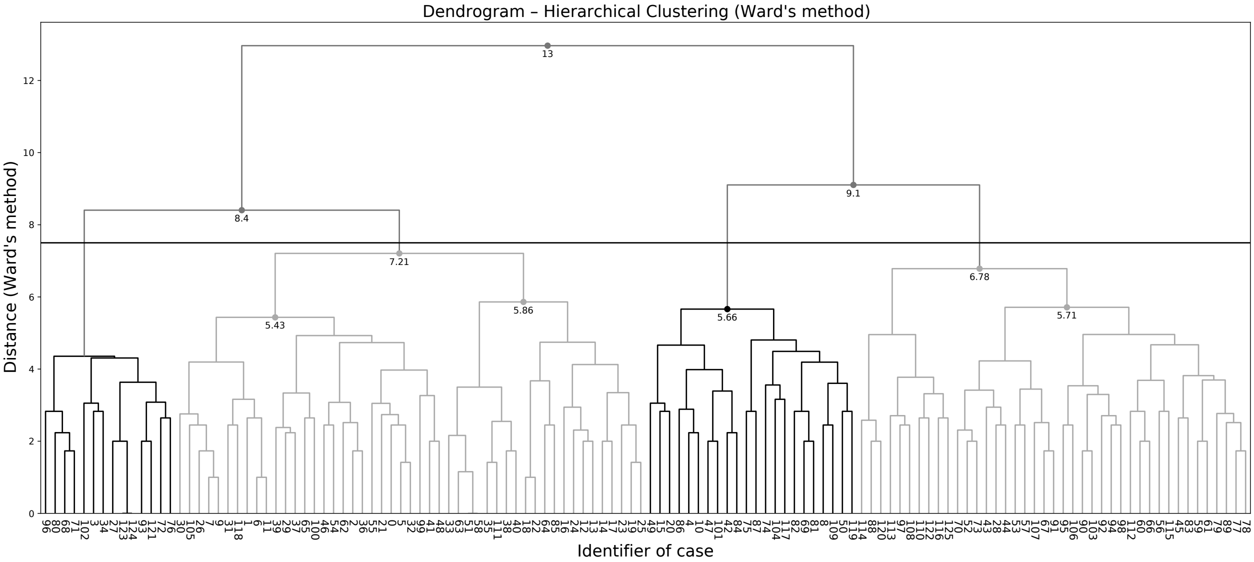


Figure 3.2: Dendrogram—*Ward*'s method

I subsequently used *k-means* as a non-hierarchical clustering algorithm (Figure 3.3). The *k-means* algorithm partitions the data set accordingly and allocates the data among the clusters (Goodfellow et al., 2016). Any potential influence of outliers is compensated through the iterative character of *k-means* (Ketchen & Shook, 1996). Using *k-means*, I first assigned my data set to the first two parent clusters to draw a first overall classification (k=2). Subsequent clustering into four child clusters (k=4) still reveals a relatively large heterogeneity between the child clusters, with sufficient homogeneity within these child clusters. The assigned cases for each child cluster reflect a concentration profile in the catalog, while the individual cases represent prototypes that collectively define the business model archetypes.

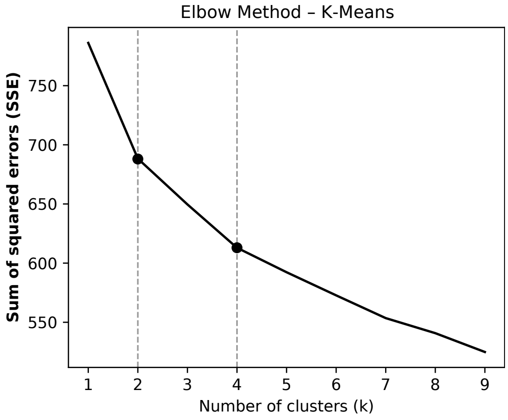


Figure 3.3: Elbow method—*K-means*

To help interpret the identified business model archetypes, I conducted additional 68 interviews with representatives (e.g., founders, executives) of prototypical ventures between November 2018 and February 2021, so qualitative data is added. In contrast to the qualitative data collection from study 1, I took a deep dive into the prototypes' respective business models in these interviews, not only trying to understand the single business model components but their interrelations with each other, allowing me to identify two DLT-exploiting, decentralized platform ecosystems (parent clusters) with two archetypes (child clusters) within each. The interviews ranged from 29 to 79 minutes and lasted an average of 49 minutes, resulting in an additional 1362 pages of double-spaced text.

4. Findings

4.1 DLT Business Model Dimensions, Variables, and Characteristics

In this section, I present the analysis of my findings from study 1. My analysis reveals a multi-layered taxonomy (Figure 4.1) which includes idiosyncratic characteristics of DLT business models structured along the main variables and dimensions relevant for the description of a firm's business model. I present the taxonomy (including its different dimensions, variables, and corresponding characteristics) by moving from the holistic business model configuration to its constitutive elements. For the sake of brevity, I focus on particularly noteworthy technological and DLT-enabled aspects and their interplay.

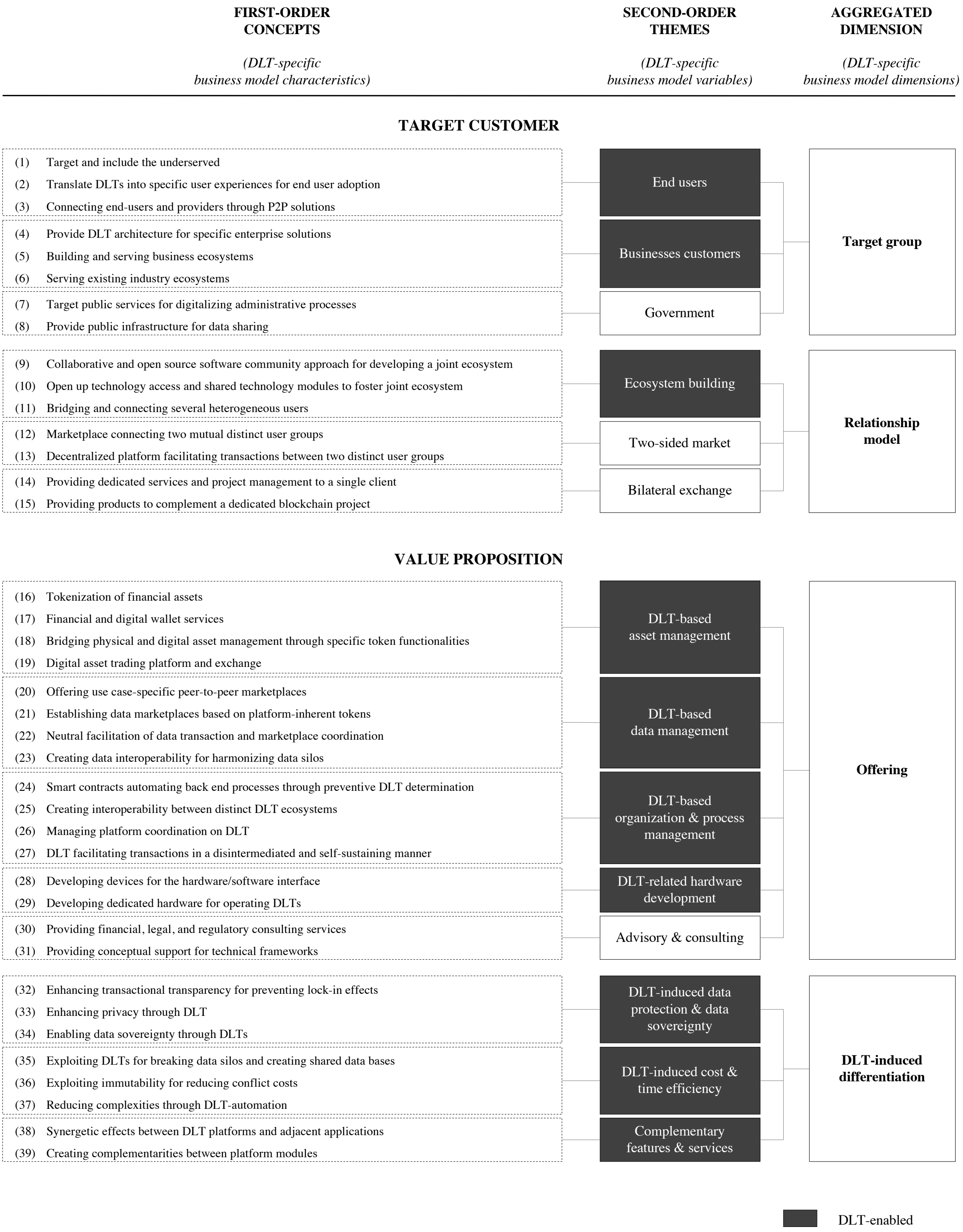
4.1.1 Targeting Manifold and Heterogeneous Customers Through P2P Marketplaces

Ventures with DLT business models largely target *"underserved"* end users that have not yet had access to basic commodities or are not satisfied by current product or service standards and penetrate a *"forgotten"* or unpopular segment of the market:

> *"The core mission of Libra is about financial inclusion: Bringing digital payment solutions to the unbanked people around the world, and thus allowing them to send, receive, and spend their money, enabling a more inclusive global financial system."* (Libra)

These firms leverage peer-to-peer (P2P) platform solutions and focus on a user base that was previously considered unappealing to incumbent firms, thereby filling an institutional void in their industry.

> *"What we are trying to do is bring power to areas that are not connected to the grid. We then use blockchain technologies to provide the end user with a*



FIRST-ORDER CONCEPTS *(DLT-specific business model characteristics)*	SECOND-ORDER THEMES *(DLT-specific business model variables)*	AGGREGATED DIMENSION *(DLT-specific business model dimensions)*
TARGET CUSTOMER		
(1) Target and include the underserved (2) Translate DLTs into specific user experiences for end user adoption (3) Connecting end-users and providers through P2P solutions	■ End users	**Target group**
(4) Provide DLT architecture for specific enterprise solutions (5) Building and serving business ecosystems (6) Serving existing industry ecosystems	■ Businesses customers	
(7) Target public services for digitalizing administrative processes (8) Provide public infrastructure for data sharing	Government	
(9) Collaborative and open source software community approach for developing a joint ecosystem (10) Open up technology access and shared technology modules to foster joint ecosystem (11) Bridging and connecting several heterogeneous users	■ Ecosystem building	**Relationship model**
(12) Marketplace connecting two mutual distinct user groups (13) Decentralized platform facilitating transactions between two distinct user groups	Two-sided market	
(14) Providing dedicated services and project management to a single client (15) Providing products to complement a dedicated blockchain project	Bilateral exchange	
VALUE PROPOSITION		
(16) Tokenization of financial assets (17) Financial and digital wallet services (18) Bridging physical and digital asset management through specific token functionalities (19) Digital asset trading platform and exchange	■ DLT-based asset management	**Offering**
(20) Offering use case-specific peer-to-peer marketplaces (21) Establishing data marketplaces based on platform-inherent tokens (22) Neutral facilitation of data transaction and marketplace coordination (23) Creating data interoperability for harmonizing data silos	■ DLT-based data management	
(24) Smart contracts automating back end processes through preventive DLT determination (25) Creating interoperability between distinct DLT ecosystems (26) Managing platform coordination on DLT (27) DLT facilitating transactions in a disintermediated and self-sustaining manner	■ DLT-based organization & process management	
(28) Developing devices for the hardware/software interface (29) Developing dedicated hardware for operating DLTs	■ DLT-related hardware development	
(30) Providing financial, legal, and regulatory consulting services (31) Providing conceptual support for technical frameworks	Advisory & consulting	
(32) Enhancing transactional transparency for preventing lock-in effects (33) Enhancing privacy through DLT (34) Enabling data sovereignty through DLTs	■ DLT-induced data protection & data sovereignty	**DLT-induced differentiation**
(35) Exploiting DLTs for breaking data silos and creating shared data bases (36) Exploiting immutability for reducing conflict costs (37) Reducing complexities through DLT-automation	■ DLT-induced cost & time efficiency	
(38) Synergetic effects between DLT platforms and adjacent applications (39) Creating complementarities between platform modules	■ Complementary features & services	

■ DLT-enabled

Figure 4.1: Data structure: Aggregate dimensions, variables, and characteristics of DLT business models

FIRST-ORDER CONCEPTS *(DLT-specific business model characteristics)*	**SECOND-ORDER THEMES** *(DLT-specific business model variables)*	**AGGREGATED DIMENSION** *(DLT-specific business model dimensions)*
VALUE CREATION		
(40) Venturing team with a specific industry background (41) Spin-off or project from incumbent with deep industry expertise	Specific industry knowledge	**Knowledge allocation**
(42) Venturing team with a dedicated DLT expertise (43) Venture is based on a scientific DLT research (44) Venturing organization is exploiting previously conducted DLT R&D	■ Sophisticated DLT expertise	
(45) Venture is leveraging its network into the DLT and start-up community (46) Venture is leveraging its access to specific industry networks	Business network	
(47) Directly building on top of prevailing DLT protocols (48) Building on top of prevailing DLT protocols but adapting features to own needs (49) Forking an existing DLT protocols for own needs	■ Leveraging prevailing DLT developments	**DLT development**
(50) In-house development to initiate new DLT protocol (51) In-house contributions for curating prevailing DLT protocol (52) In-house development of complementary DLT modules	■ Contributing to DLT protocols or modules	
(53) Providing services without using a technological layer (54) Developing hardware for DLT deployment	No DLT developments	
(55) Token enables and realizes coordination and governance of decentralized networks (56) Token model and consensus mechanisms provide network and incentive alignment (57) Token integration and distribution creates network robustness	■ Token has inherent network functionality	**Token integration**
(58) Token integration is omitted due to existing regulatory and jurisdictional restrictions (59) Token integration is omitted due to insurmountable business model and corporate culture tensions (60) Token integration is omitted due to data control and data protection concerns	Business requirements lead to token omission	
VALUE CAPTURE		
(61) Token sale kickstarts DLT development & fosters community adoption (62) Token is adopted into future business model (63) Token adoption through the network increases token valuation and incentivizes for DLT curation	■ Token distribution	**Adoption mechanism**
(64) Community is highly involved in development roadmap and adoption through token incentives (65) Open Source Software contributions create vivid engagement of DLT community	Community engagement	
(66) Using social media marketing channels (67) Create digital buzz through online advertisements	Online marketing	
(68) Partner with renowned institutions and corporations to launch DLT initiative (69) Leverage own reputation and network to foster business model adoption	Leveraging reputation	
(70) Client recommendations increase business model adoption (71) Engaging in high-visibility projects to obtain organic referrals	Referrals	
(72) Charge a commission fee for usage of module or application (73) Transaction fee is leveraged for compensating DLT validators and operators	■ Commission/Transaction fees	**Revenue generation**
(74) Charging fees for dedicated hardware usage (75) Charging fees for software unit usage	Pay-per-use	
(76) Charging cyclical subscription fees for membership (77) Charging technology licensing fees for proprietary DLT services or modules	Subscription model	
(78) Charging one-off payments and project-based renumeration	One-off payments	
(79) Asking user base for donations and voluntary payments to keep DLT service alive (80) Attracting developer and contributors to volunteer in DLT ventures (81) Receiving government or foundation grants	Donation	

■ DLT-enabled

Figure 4.1: (con't) Data structure: Aggregate dimensions, variables, and characteristics of DLT business models

> *credit score and a kind of track record, which I would call for simplicity's sake a financial identity."* (Bitlumens)

DLT business models also enable some ventures to reap the benefits of particular DLT components governing cross-business-ecosystems, such as establishing *digital truth* through immutable traceability and transactional transparency across industries and organizations:

> *"People have lost trust in the food supply chain due to transparency gaps and data silos within the ecosystem. (...) Many of the food incumbents are very aware of this shift and want to find technologies that solve that problem through interoperability across data silos in a sustainable way."* (Ambrosus)

Thus, end users (B2C) are included in the value chain by solving business-to-business (B2B) data sharing obstacles, thereby fostering B2B2C or P2P approaches through the transparency induced by DLTs. A significant portion of DLT ventures leverage DLT features to create two-sided markets or ecosystem models through which they facilitate exchange and transactions by eliminating the *"trust problem for true sharing"* (Arcade City). Accordingly, B2B firms are largely focused on designing and providing a DLT infrastructure that lays the groundwork for enterprise solutions and unifying ecosystems that at their core bind multiple heterogeneous stakeholder groups. A plethora of firms provide third parties with access to their technological layers and extend joint DLT platforms through complementary modules, thereby profiting from a multiplicity and complexity of interactions. As one respondent explained,

> *"We build protocol-level solutions that allow others to easily plug their system into [our product] and leverage our infrastructure. By making use of the augmented information layer, we envision that attaching data to individual transactions or public key identities would finally become easy. We want to enable developers to use our blockchain by creating new applications on top of our architecture."* (Herdius W)

This open-source software development and open innovation approach is accompanied by a community model featuring core and third-party developers who work on or leverage a horizontal technological layer with generic applications.

4.1.2 Providing Novel Offerings in Asset Management and Advancing Data Management

DLT ventures' value propositions focus extensively on DLT-induced functionalities and features such as combining data sovereignty and transactional transparency with tokenization. Firms focusing on DLT-based asset management deploy the DLT-inherent affordance of digital ownership transfer across the platform network to provide ownership-specific offerings without mediating intermediaries or platform companies. These offerings leverage creating liquidity through tokenization of financial assets or establishing digital asset trading and exchange platforms:

> *"Square Room aims to advance the tokenization of real estate. In this way, it will become possible for everyone to invest in shares of real estate even with smaller amounts. From a holistic market perspective, this creates much more liquidity and efficiency in the real estate sector."* (Sqroom)

The distinguishing feature of DLT-based asset management lies in DLT-induced cost and time efficiencies as a result of establishing digital marketplaces for orchestrating digital asset ownership—using the DLT affordances for automated and fine-grained tracking, accounting, and bundling of micro-transactions. By comparison, DLT-based data management differs from DLT-based asset management in its focus on exploiting DLT affordances in the handling and orchestrating of data. DLTs can disintermediate the internet's ability to transfer information, automating platform functionalities for data transfer while ensuring *digital truth* and providing information symmetry across platform ecosystems. Consequently, DLTs foster the creation of application-specific P2P marketplaces based on data sovereignty:

> *"Arcade City is really a platform for building social trust, empowering people to offer an economical service that's accepted or not accepted peer-to-peer in a trustworthy and accountable way."* (Arcade City)

Consequently, neutral facilitation of data transactions and marketplace coordination is enacted in a DLT-inherent way, democratizing the platform economy and reducing monopolistic market structures in platform ecosystems by reducing lock-in effects for any single entity:

> *"The competitive advantage that we see is that Winding Tree is the first neutral 'piece' to go in the middle of the travel ecosystem to facilitate communication, facilitate bookings, facilitate governance, and facilitate all of that, which today is completely gridlocked."* (Winding Tree)

Since data management is based on transactional transparency and consistent data interoperability, employing DLTs allows for data silos to be broken while harmonizing heterogeneous and distinct data sources. DLT-based organization and process management offerings correspond primarily to platform operation and the network layer of platform ecosystems, where DLT-inherent features are leveraged, and the platform transactions are effectively executed. For example, platform transaction automation is established by providing smart contracts that are automatically executed in a decentralized fashion according to the fulfillment of preventively defined conditions:

> *"It operates in a fully transparent and known formula and executes automatically as soon as the necessary conditions are met. At Bancor, this happens each time someone wants to buy a token. The smart contracts that we have developed then issue these accordingly."* (Bancor Foundation)

The open and explicitly formalized boundaries and conditions under which transactions occur without an orchestrated curation are based on *digital truth.* As a result of data complementarity, common consensus mechanisms, and mutually compatible designs of DLT modules through open-source software development approaches, data and asset handling is processed more efficiently since redundancies are disincentivized:

> *"A major driver for Polkadot is the belief that instead of there being a single blockchain, there will be different technologies for different purposes. However,*

> *both permissioned and permissionless ledgers should be able to coexist somehow under the same roof. Among those, communication and transaction in trustless environments have to be carried out without the necessity of an intermediary. It is about interoperability and shared finalization mechanisms."* (Web3 Foundation)

By eliminating the orchestrating intermediary or platform sponsor from the platform ecosystem, DLT-based organization and process management provide a democratized way for coordination through governance models that create a technology-inherent tool that neutrally and autonomously organize and steer the platform network towards a consensus:

> *"Bitcoin is about operating a peer-to-peer network for financial transactions that is self-sustaining and backed by complex consensus mechanisms to prevent double-spending."* (ChaincodeLabs)

4.1.3 Creating a Token Model for Self-Sustaining Platform Coordination or Technology Adoption

Enabled by DLT affordances, multiple firms leverage a DLT-native token in order to create self-sustaining coordination mechanisms within their ecosystems. These tokens are further supposed to incentivize the usage and promotion of joint, neutral, and DLT-based platform ecosystems, thereby kickstarting community and network effects through their adoption: *"For some kinds of networks, you really need that coin. There is no other option. How will you start a decentralized business without the ICO?"* (Decent). Community involvement and spreading the word are perceived as two sides of the same coin in which ventures are expected to constantly interact with the development community. In turn, the community is contributing value creation through an open-source software development approach, which is crucial in order to create trust in the technology:

> *"The reason for selecting the open-source software approach and why it is so attached to blockchain technology is the ability to put more trust in a piece of open-source software than in a piece of proprietary software."* (Linux Foundation)

When leveraged and incentivized through open access to the core of the platform, this approach allows for accelerated sequential and open innovation with multitude innovation spillovers. At the same time, the associated platform business models cannot claim intellectual property (IP) and platform control, which prevents the leverage of licensing and platform lock-in effects for value capture purposes. For these models, tokens serve as a novel and required incentive mechanism undergirding such approaches, where *"the tokens are very powerful in creating and setting incentives, especially when network effects have to be fostered—at the value creation as well as the value capture side"* (Linux Foundation). In such cases, a token serves as a multi-purpose instrument that can entail a financial, technical, or governing function beyond the business model, allowing for network and incentive alignment across stakeholders as well as robustness:

> *"In addition to their financial incentives and with on-chain governance, tokens may also include inherent control rights for their native protocol and its network coordination. However, prior to the ICO, the development of the protocol and any technical or governance specifications therein is centrally orchestrated by the foundation following the foundation's purpose. The tokens themselves do not exist until the genesis block of a chain is proposed and accepted by the network. This first block contains the distribution of the tokens from the ICO. The tokens and the control rights are, thus, distributed through the network and handed over to the community, with the on-chain governance model henceforth forming the core for explicitly formalized decision-making. Here, the broad distribution of tokens becomes essential as it contributes to the robustness of the network."* (Tezos Foundation)

But in other instances, where stakeholders simultaneously operate and leverage an associated core business model through the shared platform ecosystem, the additional incentive of a token would be disadvantageous:

> *"And other types of networks do not necessarily need that [token] incentive, because those incentives exist already in other ways, where network effects have already been established."* (Linux Foundation)

There are also regulatory and jurisdictional reasons for omitting tokens within DLT networks:

> *"The energy market is highly regulated. So, for example, a token integration with decentralized control rights is challenging as it must comply with local regulations and could disrupt existing systems. This makes it more challenging and sometimes slower for us to exploit the technology's potential to its full extent."* (Siemens Energy)

Sometimes a token integration can also create tensions within the incumbent business model or the corporate culture, which leads to excluding a DLT-native token into the network:

> *"Is the token considered a digital asset? Or a currency? Or a utility? How do we need to treat the token in fiscal terms? How can we manage token utilization from a corporate perspective without compromising our compliance and reputation? Of course, all these matters can be resolved if required and desired in the organization. But it is currently not requested to reconcile this with the current business models and the derived requirements of our operational businesses."* (Siemens)

Moreover, a lack of prior experience regarding control rights appears to augment corporate and legal risks, causing reservations on token exploitation:

> *"The decentralized approach with tokens is still new territory for us, and therefore it is currently imperative for us to first observe and understand how this works. Therefore, and currently, the preferred way is to use decentralized approaches that do not involve an active token integration with their inherent governance features: In this way, we can implement access and control rights or data and resource management—such as data sharing and data protection—without exposing the company to entrepreneurial, operational, and legal risks."* (Siemens)

4.1.4 Capturing Value Through Efficient Transaction Fees With Fair and Joint Revenue Streams

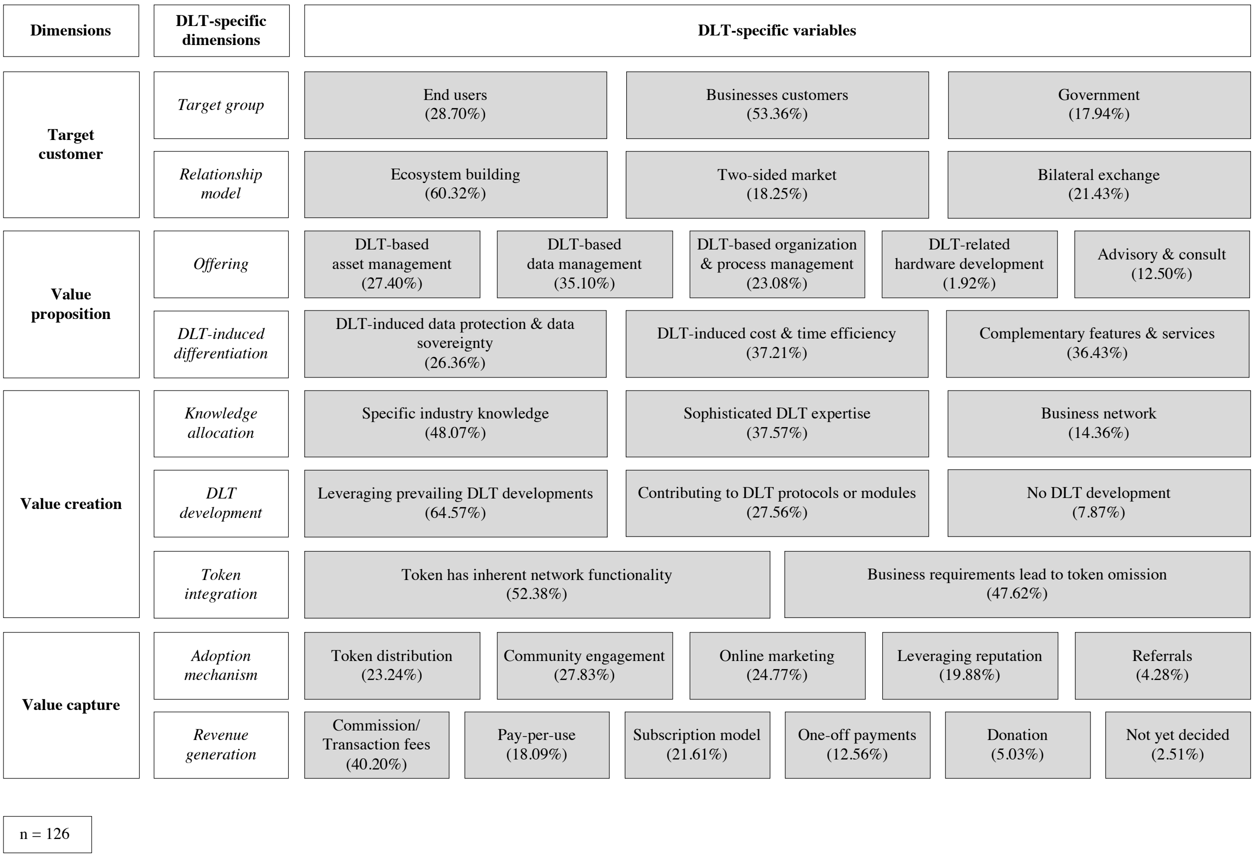
Except for firms that are leveraging bilateral relationships, most DLT-enabled business models capture value through commission or transaction fees as a continuous revenue generation mechanism: *"Our blockchain collects small fees like most other online platforms. This is done automatically by the blockchain. So, we make money by taking a percentage of the value transferred by the users"* (Peerplay). Since the integration of DLTs into platform ecosystems reduces lock-in effects for single entities and promotes data portability, the transaction fees tend to reflect efficient market prices that align with the cost of self-sustainability, which are often *"relatively negligible compared to traditional platforms"* (SOMA). The token can play a crucial role by serving as the sole value capture mechanism, while transaction costs are shared across the entire value-creating ecosystem:

> *"All partners have joint performance-based revenue-sharing models that we have aligned and mutually committed to whenever we consider the shared infrastructure."* (Swisscom)

4.2 DLT Business Model Configurations and Archetypes

In study 2, I quantified the identified DLT business model dimensions, characteristics, and variables through a survey of 126 DLT ventures. Figure 4.2 presents the catalog of DLT business model patterns resulting from this survey.

Subsequently, and through cluster analysis, I identified four child clusters (business model archetypes) that are grouped within two parent clusters (decentralized platform ecosystem configurations). Within the first parent cluster, which I call *federated platform ecosystems*, I found two child clusters: (1) the *platform consortium* and (2) *DLT as a service.* The second parent cluster, what I call *autonomous platform ecosystems*, includes two child clusters: (3) *DLT ecosystems* and (4) *decentralized applications (DApps).* In the following, I elaborate on each cluster to further describe the decisive business model characteristics of each.



Dimensions	DLT-specific dimensions	DLT-specific variables
Target customer	*Target group*	End users (28.70%) Businesses customers (53.36%) Government (17.94%)
	Relationship model	Ecosystem building (60.32%) Two-sided market (18.25%) Bilateral exchange (21.43%)
Value proposition	*Offering*	DLT-based asset management (27.40%) DLT-based data management (35.10%) DLT-based organization & process management (23.08%) DLT-related hardware development (1.92%) Advisory & consult (12.50%)
	DLT-induced differentiation	DLT-induced data protection & data sovereignty (26.36%) DLT-induced cost & time efficiency (37.21%) Complementary features & services (36.43%)
Value creation	*Knowledge allocation*	Specific industry knowledge (48.07%) Sophisticated DLT expertise (37.57%) Business network (14.36%)
	DLT development	Leveraging prevailing DLT developments (64.57%) Contributing to DLT protocols or modules (27.56%) No DLT development (7.87%)
	Token integration	Token has inherent network functionality (52.38%) Business requirements lead to token omission (47.62%)
Value capture	*Adoption mechanism*	Token distribution (23.24%) Community engagement (27.83%) Online marketing (24.77%) Leveraging reputation (19.88%) Referrals (4.28%)
	Revenue generation	Commission/ Transaction fees (40.20%) Pay-per-use (18.09%) Subscription model (21.61%) One-off payments (12.56%) Donation (5.03%) Not yet decided (2.51%)

n = 126

Figure 4.2: DLT business model patterns: A catalog

4.2.1 Parent Cluster 1: *Federated Platform Ecosystems*

The *federated platform ecosystem* class comprises two business model archetypes: (1) a *platform consortium* and (2) *DLT as a service.* A jointly shared digital marketplace, network layer, and governance model are at the core of the *platform consortium*, which is shaped and operated by incumbents of an existing market and initiated either by a single orchestrator or by a consortium initiative. In this business model archetype, the DLT affordances are deployed in service of the prevailing business models of the market incumbents, and the cluster is characterized by a demand-pull initiation (referring to an adjustment of technology affordances to market conditions). A DLT-native token is omitted due to regulatory hurdles, insurmountable business model tensions, and a desire to keep control rights over the platform ecosystem. Nor are tokens required to incentivize participation; adoption occurs instead by leveraging the existing reputation of the market incumbents of the *platform consortium*. By establishing the joint platform ecosystem with a digital marketplace layered on top of it, the prevailing business models of the market incumbents are leveraged while existing network effects of each stakeholder can be united and jointly exploited. The *DLT as a service* archetype is designed to support the required open-source technology frameworks (such as a DLT protocol) on which the platform ecosystem is based. By jointly maintaining the *federated platform ecosystem* through a coopetition approach, especially within the *platform consortium*, negative platform externalities such as monopolistic market structures are dissolved while benefiting from the positive externalities of a digital marketplace to leverage the existing non-platform business models.

Child Cluster/ Business Model Archetype 1: ***Platform Consortium***

The *platform consortium* represents a business ecosystem (BES) of incumbents that jointly build and operate a platform ecosystem to address a joint value proposition to serve a specific customer or market need. It is considered a demand-pull initiative, which draws on the brand reputation of incumbent firms. The DLT provides transparency and data sovereignty among the BES partners and within the platform ecosystem to avoid information asymmetry. To achieve this goal, it builds on an existing technology infrastructure that does not integrate a DLT-native token, predominantly to avoid regulatory and legal repercussions that could harm the participants' brand reputation.

> *"We are a listed company with a shareholder structure with governance requirements that we must meet. Thus, a token integration may not infringe the interests of our shareholders in a legal sense. This sometimes restricts us from leveraging technology potentials."* (Siemens)

The *platform consortium* deliberately deploys private-permissioned DLT protocols, as they allow limited, selected, and controlled network access, thereby reflecting the business model logic and corporate culture of the incumbents. This allows the network to operate with consensus mechanisms that are pragmatically limited to the core incumbents, which positively impacts transaction performance. The *platform consortium* is initiated and built either by an authorized orchestrator in the form of a consortium or by both. In all such cases, a separate legal entity manages the control mechanisms for the platform ecosystem.

Revenue generation is achieved through transaction fees; however, often, these serve largely to just cover the operating costs. The *platform consortium*'s goal is to strengthen the core business of the participants by benefiting from a platform ecosystem, but without suffering from information asymmetry in favor of a single platform sponsor:

> *"We have a common unifying goal consisting of two streams, where the technology is needed as an infrastructure for that purpose: First, as a defensive element against the threat of single corporate-managed identity systems and the gang of hyperscalers—centralized and monopolistic platform ecosystems that impose a negative long-term lock-in for us. Second, as an offensive element with innovation opportunities, especially for the asset-driven industries and Europe: decentralized data and identity management resolve the current hurdles of several industries to share data, thus, boosting innovation. These two streams are the motivation to build the network and the consortium together: to use the common, decentralized, and democratic platform for each partner's existing business models and to enable innovation."* (Bosch)

Prototypes address industry-specific and cross-business marketplaces. For instance, the *IDunion* consortium has launched a joint digital identity management platform to provide internet of things (IoT) devices, corporate entities, and natural persons with a self-sovereign identity (SSI) that is mutually compatible, allowing frictionless communication and validation with and between digitized agents. The consortium is subsidized by the German government whose incumbent members (which include the *Main Incubator/Commerzbank*, *TU Berlin*, *Deutsche Telekom*, *Bosch*, *DB Systel*, and *Siemens*, among others) jointly create the value proposition in coopetition mode:

> *"We all have the same problem: how to get the current customers digitally onboarded in the most efficient way and at the lowest possible cost. Here, the coopetition approach is a perfect solution. We share the joint costs and the resources in setting up the network; we create and share network effects and then operate the network to strengthen each of our core businesses through the joint identity solution."* (DB Systel)

Child Cluster/ Business Model Archetype 2: *DLT as a Service*

The second and related business model archetype within the *federated platform ecosystem* is *DLT as a service.* This archetype complements the *platform consortium* by providing the necessary DLT expertise and customized DLT infrastructure and architecture through open-source technology frameworks.

> *"IBM wanted its blockchain module Fabric to be widely adopted, and thus housed it as a code in a non-profit organization—the Hyperledger Foundation—where it is provided with some legitimacy and where enterprises have a certain level of comfort with it."* (Linux Foundation)

Subsequently, conceptual consulting and infrastructural development services are offered through open-source business models by the prototypes of this archetype, and in return, they receive a service fee.

> *"If Hyperledger Fabric becomes then the new standard for how you run a private-permissioned blockchain network, and enterprises are looking for support in setting up those networks, IBM would be a compelling choice to go to: They can legitimately say, 'We created Fabric in the beginning, we are Fabric experts, we know more about Fabric than anyone else: Come to us, and we will help you.' Open-source business models are about trying to establish something that is widely adopted in the standard, and you are subsequently going to benefit from it."* (Linux Foundation)

Hence, prototypes of the *DLT as a service* archetype include blockchain specific development and consulting companies such as *IBM*, as well as non-profit foundations to foster the technology framework adoption such as the *Hyperledger Foundation*, which embrace several DLT frameworks and components:

> *"What Hyperledger does is it brings the enterprises together and helps them with the PR and marketing as well as legal infrastructure to work with an open-source community and open-source frameworks, as well as the blockchain in general."* (Hyperledger Foundation)

4.2.2 Parent Cluster 2: *Autonomous Platform Ecosystems*

The *autonomous platform ecosystem* comprises two business model archetypes: A (3) *DLT ecosystem* and manifold (4) *DApps.* As with the *federated platform ecosystem*, the core of this class is a governance model and the network layer, but this time aligned and designed to depend on a native open-source software innovation platform that exploits DLT affordances to their fullest extent. Since the *DLT ecosystem* is fully decentralized in its ownership and control rights, the DLT-native tokens wrap different core functionalities and serve as a coordination and incentivization instrument within and across the platform ecosystem while allowing for self-sustaining platform governance. The token value subsequently fosters token adoption and generates network effects.

> *"The future will bring summated, decentralized, autonomous networks, which belong to no individual authority, governed and developed in a decentralized way; these open, very fluid, dynamic ecosystems will then organically grow. Such growth and the value generated are then reflected by the token value. And by holding tokens, the network values are shared with the network and all its individuals."* (Parity Technologies)

DApps address end-consumer and business needs with technologically harmonized and standardized transaction platforms connected to the *DLT ecosystem*, which together create the *autonomous platform ecosystem.* While the *DLT ecosystem* primarily focuses on in-house DLT developments to contribute to DLT protocols or modules in an open-source software manner, *DApps* leverage these developments to establish user-specific value propositions. Governance models emerge through a technology-push initiation—when technology affordances cause market changes (Di Stefano et al., 2012)—driven by technological affordances in data sovereignty, interoperability, and transparency, creating information symmetry and *digital truth* throughout the whole platform ecosystem. *Autonomous platform ecosystems* can be considered democratized at the data level, which avoids costly lock-in effects for participants.

Child Cluster/ Business Model Archetype 3: *DLT Ecosystems*

The core of the *DLT ecosystem* is a public, permissionless DLT protocol such as *Bitcoin*, *Ethereum*, *Tezos*[11], or *Polkadot*, which serves as a focal and common platform core. They are initiated through a DLT-native token sale or ICO, which serves as a crowdfunded financing vehicle to fund an independent entity, typically a dedicated non-profit foundation. This entity subsequently organizes the initial governance model as well as the launch of the associated DLT protocol. With the distribution of the DLT-native token to the network, the maintenance, development, and coordination function of the entity becomes distributed to the network, allowing third parties to connect and enabling their core competencies to be made available for the common good. A consensus-aligned DLT protocol leads to greater network adoption with an accompanying greater token demand, which increases the value of the tokens. The tokens subsequently serve as a voting and incentivization mechanism within the emerging *DLT ecosystem.* The governance model of the DLT protocol addresses the network's coordination of development strategies and sets the boundaries, while the DLT-native tokens and their value provide the incentives as well as the means for implementing the governance throughout the network. The DLT protocol-inherent on-chain governance model (sometimes accompanied by off-chain governing mechanisms) is then the basis for self-governing the network, where third parties can openly connect their business models, thus forming a decentralized, publicly available, and self-regulating *DLT ecosystem.* Governance models vary considerably depending on their application extent: the *Bitcoin* protocol permits only financial transactions relying on limited governance adaption potentials, whereas *Ethereum* was created to enable industrial applications through smart contracts, requiring a broader governance adaption. In order to reduce the risk of network forking, others like *Polkadot* and *Tezos* include sophisticated on-chain governance mechanisms that also combine economic and quasi-parliamentary aspects in network voting exploiting the DLT-native tokens as a voting tool.

---

[11] *Tezos* was created in 2017 by the *Tezos Foundation* located in Zug, Switzerland, for deploying smart contracts on top of its protocol and network. Its ICO raised $232m in *Bitcoin* and *Ethereum*, being one of the most extensive ICOs at the time. Like *Polkadot*, *Tezos* also comprises an on-chain governance model.

> *“With Polkadot, you need to create a proposal, add some code that enables this upgrade, put it in on the governance platform on Polkadot, and see if people vote for that with their coins in time. It’s transparent. You can see what’s going on; you can see the direction of the network—where it’s going—before it’s even making those upgrades.”* (Web3 Foundation)

I categorize the different types of actors supporting the *DLT ecosystem* into four distinct roles: *initiators*, *curators*, *modulators*, and *validators*. *Initiators* create the initial technical and conceptual developments of an associated DLT protocol and its governance models as well as launch the token distribution and network adoption. For instance, the *initiator* of the *Bitcoin* protocol and its ecosystem is known under the pseudonym Satoshi Nakamoto, whereas the *Ethereum Foundation* is the *initiator* of the *Ethereum* protocol, the *Tezos Foundation* for *Tezos*, and the *Web3 Foundation* for *Polkadot*. *Curators* are development and implementation actors who further develop, optimize, or adapt DLT protocols to specific network purposes (and thus operate within the network and its sensitive network effects). Independent organizations such as *Parity Technologies* (*curator* of *Ethereum* and *Polkadot*) or *Bitcore* (*curator* of *Bitcoin*) engage through for-profit open-source software business models in the curated activities (though the non-profit foundations can themselves also act):

> *“Parity Technologies was initially founded to develop and contribute additional implementations for Ethereum, which provided more advancement and innovation for the ecosystem. We independently contribute advancements for the protocol as well as complementary features and modules, such as the Parity Wallet or messaging implementations, but also for Bitcoin and specifically Polkadot.”* (Parity Technologies)

Hence, *curators* may also contribute to other roles, such as contributing DLT-overlapping and technology agnostic software modules, which would comprise a modulating activity. These *modulators* supplement the DLT protocols with additional complementing modules, such as the mentioned wallets, DLT clients, or other network functionalities (and that do not require or influence the network effects of the respective *DLT ecosystem*). But also, more specific functionalities or industry-specific adaptions and forks are added: for example, the *Bancor* protocol is based on *Ethereum* and aims to balance token liquidity shortages, and the *Energy Web Foundation* has launched a dedicated blockchain (the *Energy Web Chain*) tailored for energy applications exploiting some *Ethereum* functionalities. Finally, *validators* are effectively operating the transaction execution of DLT networks and DLT modules. Since the network and its node operation is being decentralized through DLT integration, consensus mechanisms such as Proof-of-Work (PoW), Proof-of-Stake (PoS), or Proof-of-Authority (PoA) represent the integrated function to reach an agreement throughout the network on the collective and harmonized state of the data set. Summarizing:

> *"The Polkadot ecosystem has different actors; there are exchanges and DApps; there are service providers; there are developers. They are all a different kind of actor. They are all DOT-holders, and that's what you see transparently on-chain. But they may be incentivized in different ways, and that's what you don't see on-chain. But it all comes down to them using their DOTs for participating in the governance, which means that you require DOTs in coordinating Polkadot."*
> (Web3 Foundation)

Child Cluster/ Business Model Archetype 4: ***DApps***

In the end, the *DLT ecosystem* serves as the basis and data infrastructure for various *DApps* that grow on top of it and fulfill specific end-customer needs. These *DApps* must be interoperably linked to its related *DLT ecosystem*, as it inclusively addresses end-consumers and businesses largely through value proposition-specific two-sided markets, thereby establishing transaction platforms while simultaneously executing the required transactions on the infrastructure of its *DLT ecosystem.* For example, *Share&Charge* utilizes the *Energy Web Chain* to adapt *Ethereum* to its own energy application—namely arranging EV charging between mobility service provider and charging point operators by deploying the *Open Charging Network* and novel offerings of DLT-based data management:

> *"We are focusing on the challenge of how to use decentralized approaches for solving the roaming issue, the lack of interoperability between charging station*

> *operators and mobility providers."* (Share&Charge Foundation)

However, this means that *DApps* cannot profit from collected data as it belongs to the data originator; they only profit from a countable and associated service creation. The revenue models of *DApps* are implicated by the fact that transactions are transparent and accessible to all parties, preventing information asymmetry in favor of a single party. Like traditional transaction platforms, transaction fees are still charged; however, due to the non-existent lock-in effects caused by information symmetry, these fees are significantly lower and are thought to better reflect efficient market prices. From a business model perspective, this means that value capture is highly linked to value creation without the interference of market power or platform monopolies. For example, *Arcade City* provides mobility services and tries to break *Uber*'s market power by internalizing the negative externalities of lock-in effects through data sovereignty via its *DApp* that leverages the DLT affordances of *Ethereum*:

> *"We address real ride-sharing, peer-to-peer without a central entity. So, there are no credit card fees, and there are no centralized policies. Arcade City aims to reinvent the sharing economy by combining the power of blockchain technology, open-source development, platform 'cooperativism,' and a decentralized 'swarm' organizational model open to everyone."* (Arcade City)

In some cases, when a *DApp* is conceptualized as a decentralized autonomous organization (DAO), it also issues a *DApp*-native token through a token generation event (TGE). This also allows for the crowdfunding mechanisms to incentivize the initial developments, with the token subsequently serving as the governing element of a DAO.

Figure A.1 in the Appendix summarizes the key characteristics I found through study 1 by aligning them to the four DLT business model archetypes I identified through study 2.

4.3 Decentralized Platform Ecosystems and Novel Configuration Choices

Based on my findings from studies 1 and 2, I derive a theoretical model which captures DLT affordances and their implications on platform ecosystems and associated business models—

as well as their inherent characteristics—by illustrating the relations and interdependencies between distinct actors (Figure 4.3). In study 1, I identified DLT-induced business model dimensions that are directly tied and derived from DLT affordances. DLTs provide data sovereignty for the effective data owner or resident and can create information symmetry through transactional transparency for all network participants. As a result, DLT business models create unique value offerings enabled by inherent technological characteristics. While these characteristics create a more pronounced effect for value propositions of ventures, DLTs also offer opportunities for value creation and value capture. These affordances bring considerable implications for platform ecosystems, through which I identified DLT business model archetypes via a cluster analysis in study 2. By establishing information symmetry, negative platform externalities such as lock-in effects can diminish, which creates a stronger array of ecosystem contributors and allows for more balanced power structures within platform ecosystems. Since a platform ecosystem thus becomes democratized, corresponding democratic and decentralized platform governance becomes essential.

In decentralized platform ecosystems, the characteristic features of innovation platforms and transaction platforms are coupled to form a coherent and integrated platform ecosystem where the selection of complementary modules influences its network effects, creating a crucial demand for consistent and aligned platform governance. Moreover, *platform consortia* and *DLT ecosystems* also both employ relationship and governance models that at their core bind a network of different and heterogeneous stakeholder groups together. This offers a compelling reason for DLT utilization, creating *digital truth* when cross-organization processes are implemented. Even in trustless environments, immutable traceability and transactional transparency generate compliance with common rules:

> *"It has become apparent that various industry players see value and benefit in the technology applying it in an environment where there are cross-business processes. In this case, some processes need to be mapped in a trustworthy manner, which blockchain technology inherently enables. These processes are then envisioned, defined, and implemented in such a way they create common rules. The technology then enforces the rules and guarantees that no party can act outside of those rules.*

(...) And the economic value of the technology is immutable traceability." (Parity Technologies)

For securely orchestrating data complexities with manifold and heterogeneous agents, the network layer (together with an associated governance model) is the anchor for decentralized platform ecosystems (*federated* or *autonomous*), harmonizing the innovation and transaction platform aspects of the platform in one common integrated platform ecosystem. Yet, the extent to which DLT affordances are integrated into a platform ecosystem determines how the platform ecosystem is structured (with respect to the governance model and the allocation of access and control rights to DLTs).

In *federated platform ecosystems*, DLT affordances are constrained to the use of private DLT protocols by core incumbents for the purpose of steering its orientation towards fostering the associated business models. Decentralized governance of the platform ecosystem is enacted indirectly by personal coordination through a consortium-controlled legal entity. These platform ecosystems are typically formed by a demand-pull initiation by incumbents of existing markets and industries, whose goal is to jointly exploit the advantages of platform ecosystems and positive externalities, thereby creating digital marketplaces for their prevailing platform-independent or complementary core business models. The incumbents attempt to free themselves from prevailing centralized platform ecosystems and overcome corresponding negative platform externalities (such as lock-in effects) that pose a threat to their existing business models. DLT-native tokens are omitted due to regulatory reasons as well as the requirements of the incumbent's business models. Furthermore, the DLT-native token's inherent technological value is not required since the platform ecosystem is governed without technology-inherent tools (such as coin voting), and incentives for network effect are created independent of tokens. Indirect platform governance allows for selectively consigning control rights to the consortia partners, thereby retaining authority over the platform ecosystem and leveraged business models. The incumbents' prevailing reputation provides the required digital trust to the platform periphery for an effective platform operation while ensuring *digital truth* for the core incumbents.

"At IDunion, we are planning to establish the legal entity of a European cooper-

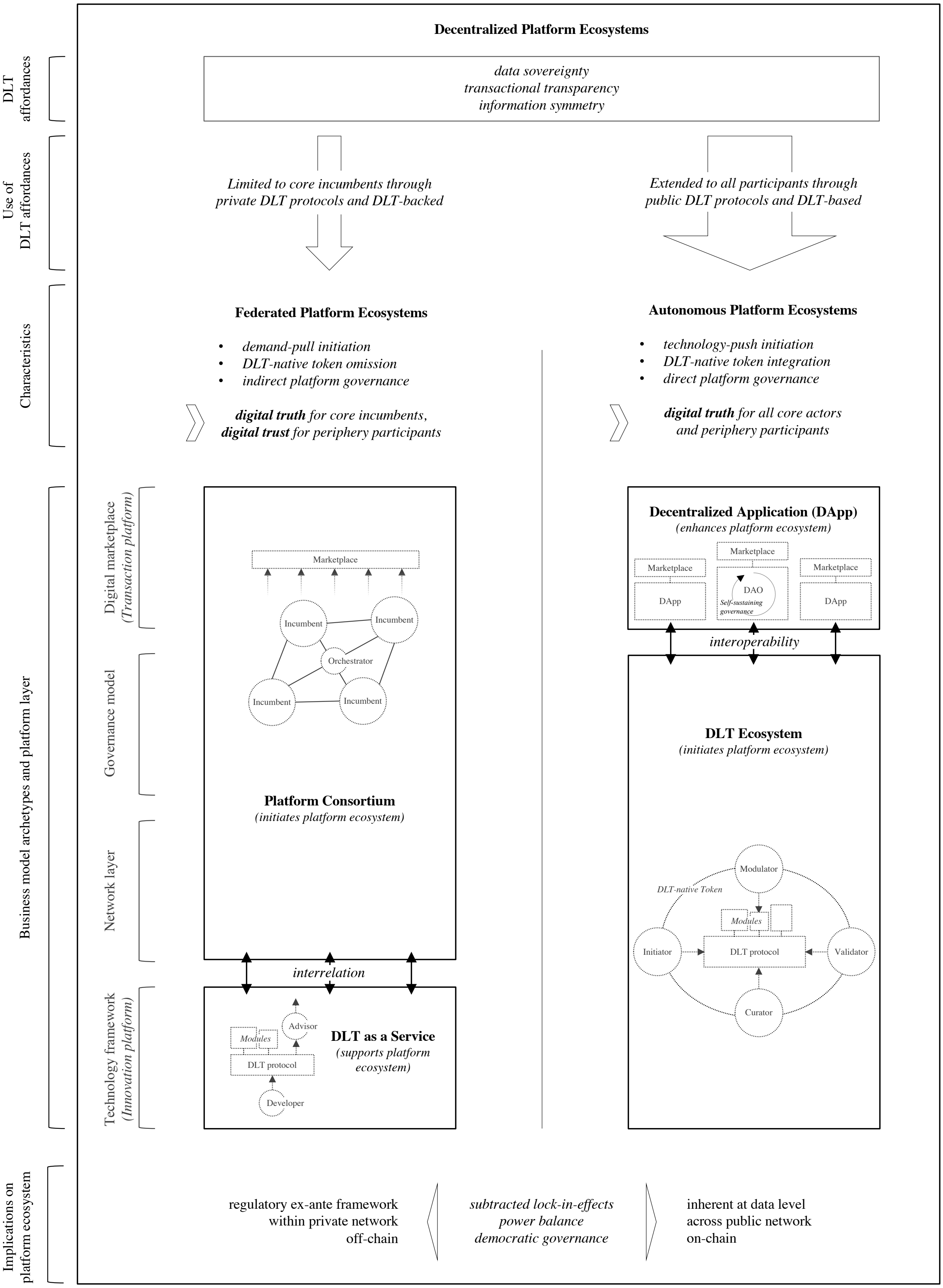


Figure 4.3: Theoretical model of DLT affordances and implications on platform ecosystems

> *ative, the IDunion S.C.E.*[12]*, in which all consortium members are represented. There, we are planning to have the so-called Supervisory Board, which consists of an uneven number of board members who are elected by the members of the consortium. The Supervisory Board then generally decides about strategic decisions for the consortium. The role of the Supervisory Board in the legal structure of IDunion S.C.E. is mirrored into the technical structure of the IDunion network through the role of the Trustees. The Trustees are then legally bound to translate and implement the decisions of the Supervisory Board of the consortium into the platform network. This means that IDunion is not governed by 'code is law'; instead, the legal governance structures of IDunion S.C.E. are preeminent. In the end, these structures determine what the technical governance structure looks like. And if the legal governance changes, the technical governance is adapted accordingly."* (Helge Michael, Head of IDunion consortium, Main Incubator)

Within *federated platform ecosystems*, the *platform consortium* establishes a transaction platform aiming for positive externalities while simultaneously operating the network jointly through decentralized but controlled node maintenance. Hence, the *platform consortium* is located at the application, the governance, and the network layer. However, its initiation is supported by *DLT as a service* providers that generate the underlying infrastructure, consisting of a required, customized, and private DLT protocol. Dependent on the technical demands, the required functionalities are assembled utilizing complementary software modules. Thus, the infrastructure provided corresponds to an innovation platform. The business model of the *DLT as a service* comprises conceptual and technical development and advisory activities on the value creation side and is hence strongly interrelated to the eventual *platform consortium.*

In contrast, I refer to *autonomous platform ecosystems* when DLT affordances are in-

---

[12] Societas Cooperativa Europaea (S.C.E): The legal form of the European Cooperative Society was created to eliminate the need for the establishment of subsidiaries in each Member State of the European Union in which they operate and to allow cooperatives to freely transfer their registered office and head office from one Member State to another while retaining their legal identity and not having to register or dissolve legal entities.

tegrated to their fullest extent into platform ecosystems through public DLT protocols, resulting in associated business models that are driven by new ventures and have a disruptive character. In this case, the disintermediated platform ecosystem is self-regulating and requires democratic platform governance anchored directly in the DLT protocol (on-chain). With *autonomous platform ecosystems* there is a public network that every participant can access, write, and read given the respective governance model. Access and control rights as well as incentive mechanisms are formalized in an explicit and technology-inherent way. Enabled through the crowdfunding of the token sale, sustainable and long-term oriented development activities are incentivized, allowing *autonomous platform ecosystems* to originate from a technology-push initiation. Thus, the token provides a coordination and incentivization functionality within the platform ecosystem—for value creation as well as value capture mechanisms and especially for open-source contributions. Often, additional and heterogeneous incentive mechanisms are accumulated, such as leveraging core business or gaining reputation. However, the DLT-native token allows for explicitly formalizing incentive mechanisms within the platform ecosystem, even though these may be distinctive in their antecedents.

> *"As an investor, we co-sponsored our corporate spin-out Share&Charge and would have received tokens as an incentive. (...) Moreover, the ICO and the tokens were expected to increase network effects, also increasing the token value. That was our bet! Unfortunately, we lost the bet: Due to the crypto winter and its negative momentum, the ICO was not realized. Thereby, we also lost the associated incentive for making internal IP open source available. However, we had already released too much corporate energy internally, why we were looking for a decent solution. The non-profit and earmarked foundation was helpful there. Thus, we could write off our IP and, perhaps, promote our core business in the future."* (Innogy)

The DLT affordances are exploited across the entire network, consistently and inherent in the technology, thus providing full transparency, information symmetry, and establishing *digital truth* across the *autonomous platform ecosystem.* Due to the full use of DLT affordances, negative externalities are entirely and sustainably eliminated at a data level. The *DLT ecosystem* comprises the subordinated business model actors of the *initiator*, the *curator*, the *modulator*, and the *validator*. Together these provide all required activities for setting up a platform ecosystem, being initiation, conception, and development of the initial DLT protocol and its governance model as well as the contribution of technological advancements, network curation, complementing features and modules, network operation, and consensus generation. Hence, the *DLT ecosystem* is the starting point for evolving the *autonomous platform ecosystem* and is located at the infrastructure, the network and the network layer, since the operation of the network is tightly coupled with the DLT protocol specifications, its governance model, and its DLT-native token incentivization. Technologically interoperable *DApps* couple with the *DLT ecosystem* and provide an end-customer specific value proposition with dedicated digital marketplaces while exploiting the technological functionalities of the *DLT ecosystem*. Accordingly, *DApps* similarly exploit positive platform externalities, such as transparency and reduced transaction costs while averting lock-in effects. However, this also leads to more competition, which drives the amount of commission fees towards efficient market prices.

In both cases, DLT affordances are being used to democratize platform ecosystems. In doing so, two distinct approaches are employed. The extent of DLT affordances (including DLT-native tokens) divides decentralized platform ecosystems into two "idealistic" camps, which assign different meanings, functions, and implications to the technology. On the one hand, *federated platform ecosystems* leverage only parts of DLT affordances for a democratized coordination within the business ecosystem to strengthen its associated business models—and are DLT-backed. Coordination and incentivization are achieved through analog and conventional means within the *platform consortium*. On the other hand, *autonomous platform ecosystems* fully leverage DLT affordances and encapsulate the DLT-native token as the essential and central vehicle to accomplish the digital and public ecosystem coordination and incentivization—and are DLT-based. However, both approaches incorporate digital marketplaces aiming for positive platform externalities, and DLT affordances are utilized in both cases for dissolving negative externalities as well as for aligning the platform ecosystem governance towards democratized configurations. As Gavin Wood, former CTO of the *Ethereum Foundation* and founder of *Polkadot*, stated in 2017 during a *Parity Technologies* coding retreat:

> *"So, we already have technologies such as Bitcoin and Ethereum, which are able to, in some sense, disintermediate many of the middlemen, many of the institutions and authorities, and remove the need for much of the trust in society. But what we currently have is a patchwork of, if you like, independent and isolated legal systems of the internet. And this is problematic because it creates many different groups who, although they share the same vision, have a misalignment in how they wish to achieve it. Creating borders where borders don't need to be there. We have this great new technology that is allowing us to automate one of the sorts of very fundamental aspects of an economy, which is trust."* (Gavin Wood, 2020)

Hence, DLT affordances transform the kind of trust the platform economy relies upon into *digital truth*, with fundamental implications for value creation and value capture within platform ecosystems along with disintermediation effects.

Figure 4.4 represents the optimization and design choices provided by DLTs for decentralized platform ecosystems in contrast to prevailing centralized platform ecosystems enabled by the internet. By facilitating the transfer of information, centralized platform ecosystems leverage monopolistic market structures to create cost efficiencies across the platform ecosystem. The transfer of ownership is controlled by the platform ecosystem's platform sponsor, which in turn generates the desired cost efficiencies when orchestrating transactions. Digital trust in the platform ecosystem is hence a precondition.

In contrast, *autonomous platform ecosystems* accept platform efficiency disadvantages to optimize for data sovereignty. Both the transfer of information and the transfer of ownership are processed decentrally by employing DLT affordances, thereby establishing *digital truth* across the entire network. Due to the high degree of decentralization dictated by sophisticated and democratized platform governance, disintermediation is achieved, leading to increased coordination efforts within the platform ecosystem. The DLT-backed *federated*

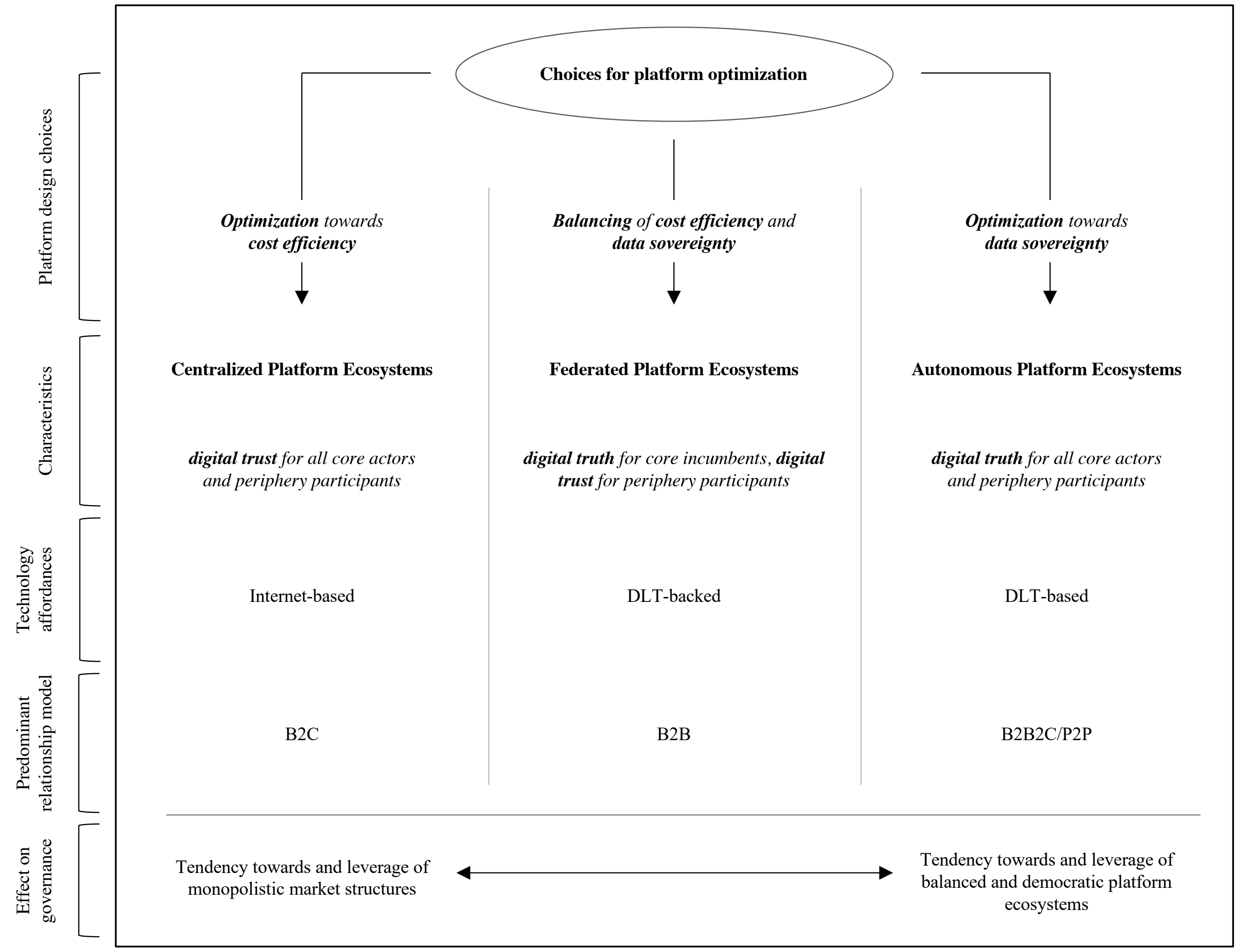
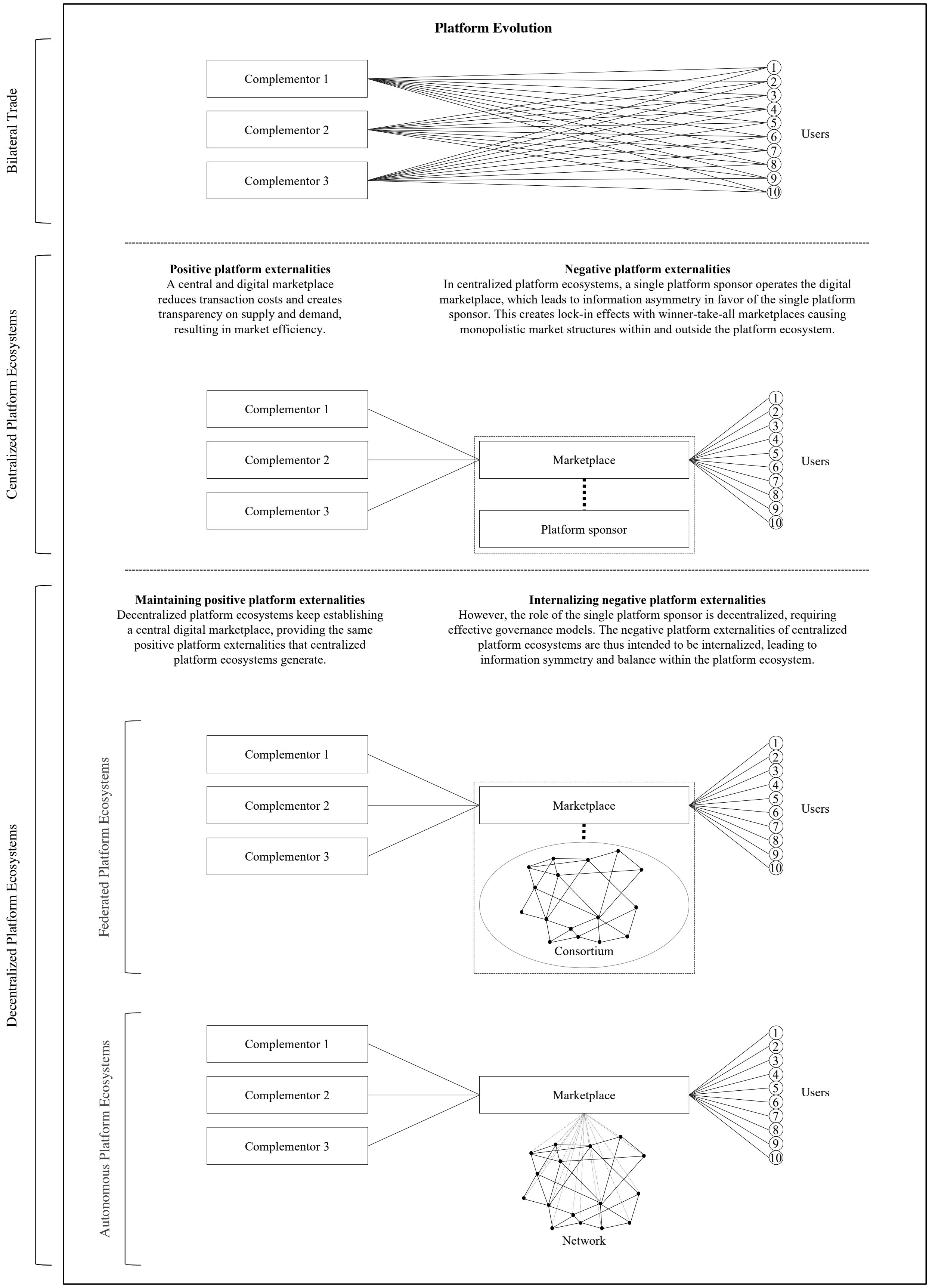


Figure 4.4: Platform optimization design choices

platform ecosystems attempt to balance both cost efficiency and data sovereignty. *Digital truth* is established within the operating *platform consortium*, whereas digital trust must be present for external parties to execute transactions effectively.

In Figure 4.5, I illustrate the platform economy's evolutionary stages: Starting from (1) an inefficient bilateral trade between *complementors* and *users* to (2) multilateral, orchestrating centralized platform ecosystems by establishing positive platform externalities through a central marketplace. Through the integration of DLTs into platform ecosystems, (3) decentralized platform ecosystems are emerging. These aim for internalizing the occurring negative platform externalities of (2) centralized platform ecosystems by harmonizing and balancing the whole platform ecosystem.

As discussed in section 2.2, centralized platform ecosystems create a competitive advantage by establishing central and digital marketplaces. These marketplaces exploit the



Positive platform externalities
A central and digital marketplace reduces transaction costs and creates transparency on supply and demand, resulting in market efficiency.

Negative platform externalities
In centralized platform ecosystems, a single platform sponsor operates the digital marketplace, which leads to information asymmetry in favor of the single platform sponsor. This creates lock-in effects with winner-take-all marketplaces causing monopolistic market structures within and outside the platform ecosystem.

Maintaining positive platform externalities
Decentralized platform ecosystems keep establishing a central digital marketplace, providing the same positive platform externalities that centralized platform ecosystems generate.

Internalizing negative platform externalities
However, the role of the single platform sponsor is decentralized, requiring effective governance models. The negative platform externalities of centralized platform ecosystems are thus intended to be internalized, leading to information symmetry and balance within the platform ecosystem.

Figure 4.5: Platform evolution

affordances of the internet and provide transparency on supply and demand of *complementors* and *users*—thus, significantly reducing transaction costs. As the internet inherently only provides digital transfer of information (web2), facilitating the digital transfer of ownership (web3) requires an additional vehicle to effectively enact transactions and provide the requisite digital trust. Thus, these two functions, (1) transfer of ownership and (2) creation of the digital trust, cannot be implemented technology-inherent on an internet basis but require the so-called platform sponsor in the form of an analog and legally managed company. For example, suppose a *user X* wants to buy a pair of shoes via *Amazon Marketplace*. In that case, the *user* can search for and configure a corresponding pair of shoes on the digital marketplace *Amazon Marketplace* online and express interest in buying such a pair. On the other side of the market, *complementor Y* offers the corresponding pair of shoes and expresses its interest in selling those. For the effective transaction—shoes for money—the transfer of ownership (payment via credit card or *PayPal*) as well as digital trust (trusting the transaction will be executed as well as trust in *Amazon*'s KYC) is required but cannot be provided by the affordances of the internet technology itself, which is why *Amazon* as an escrow agent plays a crucial role. In conclusion, positive platform externalities occur due to the central and digital marketplace, namely transaction cost reduction and transparency on supply and demand. However, since the digital trust and transfer of ownership can only be provided by the central platform sponsor operating the marketplace, lock-in effects occur in the form of information asymmetry favoring the platform sponsor, and once the marketplace scales to a winner-take-all marketplace, this also results in monopolistic market structures within and outside the centralized platform ecosystem. DLT affordances, which enable the technology-inherent and automated transfer of ownership in platform ecosystems, are thus creating novel kinds of platform configurations that are in line with web3 demands.

4.4 *Autonomous Platform Ecosystems* and Their Governance Integrity

In this chapter, I will first elaborate on platform governance and present its relevance. Second, I will provide an overview of the DLT governance of *Bitcoin*, *Ethereum*, and *Polkadot*, highlighting specifications and providing an evaluation.

4.4.1 Platform Governance to Align Decentralized Platform Ecosystems

Decentralized platform ecosystems endeavor to overcome lock-in effects imposed by the platform sponsor, thus internalizing the negative platform externalities while at the same time retaining the positive externalities of platforms. With *federated platform ecosystems*, centralized access for the operating entity (*platform consortium*) is still retained. However, the operator's role is indirectly democratized through the consortium-based operation and its bylaws. As a consequence, the operation and control of the marketplace can still be organized centrally in order to efficiently build up positive platform externalities in an orchestrated way while at the same time avoiding monopolistic market structures. The transfer of ownership is still executed by a legal entity (the *platform consortium*) instead of fully surrendered to the DLTs and their integrity, meaning that digital trust in the consortium parties remains essential. While transactions and the transfer of ownership are backed simultaneously by DLTs, these transactions can be overwritten or trumped ex-post by the consortium's authority. As such, the DLT-inherent transfer of ownership is designed more for automated management of the consortium and its steady-state operation, providing complexity reduction for the multi-party coordination and as an evidential layer for a possible consortium intervention.

In *autonomous platform ecosystems*, any lock-in is resolved through a full DLT integration and replaced with optional but neat access to support the marketplace operation. Digital trust is no longer feasible, as there is no single authority providing orientation; instead, DLT-inherent *digital truth* is established by the integrity of the technology. Thus, the transfer of ownership is based solely on DLTs, irreversibly, without any superior authority being able to interfere. Partial and temporary control from network participants is organized by a sophisticated, directly regulating, and decentralized platform governance model.

With decentralized platform ecosystems, the governance model becomes crucial. The more decentralized a platform ecosystem becomes, the more sophisticated the underlying platform governance model must be developed. Similar to politics: If a government is trans-

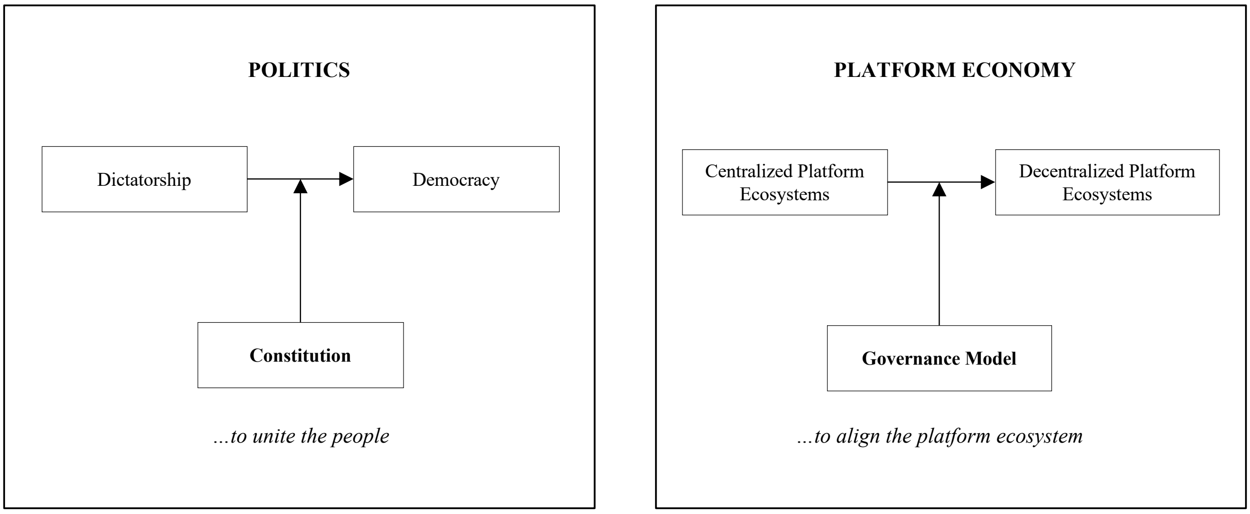


Figure 4.6: Analogy to politics: Governance model to align a decentralized platform ecosystem

formed from a dictatorship into a democracy, the constitution serves as the initial building block for determining the rules of decision-making in the decentralized context. Likewise, when a platform ecosystem becomes decentralized, the authority of decision-making disappears with the disappearance of the central authority of the platform sponsor. This gap needs to be addressed by an initial and effective governance model (see Figure 4.6). The *autonomous platform ecosystems* represent an extreme form since all authority is transferred to the network, similar to direct democracy. The decision-making power is transmitted directly to each citizen, thus giving full sovereignty and full responsibility. Therefore, direct democracies and *autonomous platform ecosystems* are susceptible systems, which at all times require fully functional governance and integrity of the decision-making processes.

As previously described in chapter 4.2, *autonomous platform ecosystems* are initiated by employing an initial DLT governance model, which allows the DLT protocol to be developed, built, and implemented in a decentralized manner by the DLT community. However, the initiation of the DLT governance itself and, therefore, the very spark of the platform ecosystem initiation still requires a central starting point. In the case of *autonomous platform ecosystems*, this is usually enacted and supported by a dedicated non-profit foundation, where the decentralization of the DLT network is stipulated immutably in its bylaws. Hence, transferring the platform control to the DLT network is ex-ante being defined and subsequently realized by distributing the DLT-native tokens to the DLT network. Thus, the DLT governance becomes the only governing authority in the network.

Using the analogy to politics once again: *federated platform ecosystems* can be compared to an indirect democracy in which certain deputies are elected who can then assume authority and thus act in a more pragmatic and self-reliant manner. However, these deputies must be trusted to a certain extent, making indirect democracies more efficient than direct democracies. Hence, digital trust is a component in platform ecosystems, allowing a platform ecosystem to be more efficient than solely *digital truth*-based platform ecosystems. Consequently, this phenomenon constitutes a crucial motivation for establishing *federated platform ecosystems*, especially in B2B contexts, when a certain level of underlying trust among the network participants is already prevalent. In such a case, a balance between digital trust and *digital truth* in the platform governance model entails significant efficiency improvements while still effectively internalizing negative platform externalities. Moreover, it also provides the ability to overrule governance-established decisions in the case of failure, for example, if the platform governance should decide incorrectly and in an undesirable way for the network. This is precisely the risk with *autonomous platform ecosystems*; they are zero-fault tolerant. With sole authority granted to a decentralized governance model implemented in a network, all network participants are tied to its jurisdiction and are forced to trust its robustness against sabotage or failure. Thus, trust is required even if the governance model itself is based on *digital truth.* The challenge arises since the network participants are also counting on their future robustness while not being able to anticipate future influencing factors, forcing them to trust. Truth is a function only of being able to take past or present actions into account but unable to consider future actions. That's where *digital truth* is limited, requiring additional components of digital trust. And since trust, in turn, is a function of time, *autonomous platform ecosystems* are expected to undergo only a gradual adoption. However, the longer a respective DLT governance can prove its robustness in integrity, the more adoption it will experience, which in turn will influence a pricing valuation of the respective DLT-native tokens due to higher token demand (apart from the purely speculative pricing valuation of meme coins, such as *Dogecoin* or *Shiba Inu*, etc.). The current high valuation of BTC is, therefore, very much related to the fact that the BTC network in and of itself has not had any negative incidents to report since 2009—up to the time of this work—which confirmed trust in the *Bitcoin* governance model and subsequently positively impacted user adoption.

4.4.2 Distinguishing Between Codified Governance and Governing the Codified Governance

In this chapter, I showcase a deep dive into the governance models of *Bitcoin*, *Ethereum*, and *Polkadot* in order to introduce a decisive distinction when considering governance models: one governance mechanism being technical and what I call *codified governance*; and one governance mechanism being socio-technical and what I call *governing the codified governance* model (see Figure 4.7). Thus, I will discuss the technical and socio-technical developments of *Bitcoin*, *Ethereum*, and *Polkadot*. Focus is placed particularly on the decentralized governance models that ensure the self-regulation of the blockchain protocols when ownership, maintenance, and operation are decentralized. As previously discussed, the purpose of decentralized governance is to coordinate decentralized platform ecosystems in their progression and its alignment of incentive mechanisms of the heterogeneous stakeholders so that agreement is reached in the decision-making process while the network stays robust. Under DLT robustness, I define a state where the risks for centralization or forking the DLT network can be nearly eliminated. Only if DLT networks are robust, the required trust and reliability can be established to provide the demanded integrity for building up applications on top of *DLT ecosystems*.

When considering the *Bitcoin*, *Ethereum*, and *Polkadot* governance models, three generations of DLT governance can be identified. *Bitcoin* has implemented a first generation DLT governance. This first generation incorporates an explicitly formalized codified governance, which contains the ex-ante defined rules of network use, recorded and enforced through the DLT protocol. Due to information symmetry within the network, each agent must comply with the codified governance. It is simply impossible to move outside of codified governance since a misstep would be recognized immediately by all network participants and thus not

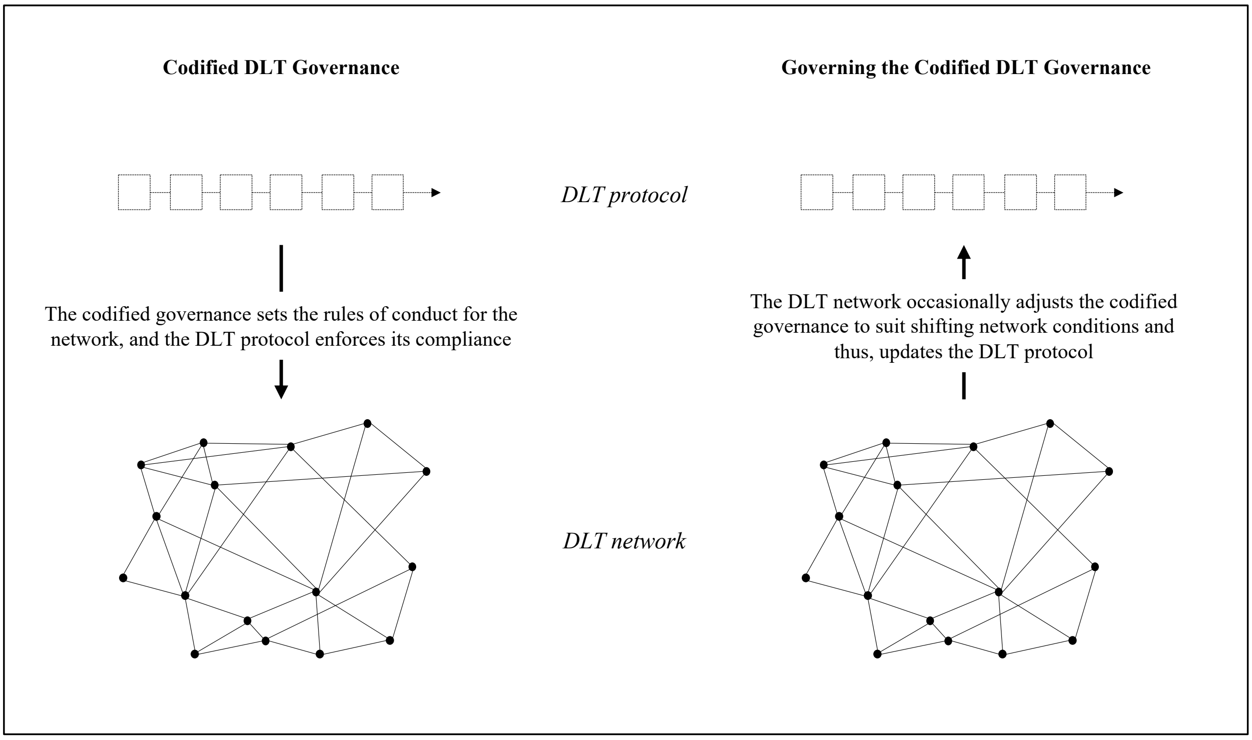


Figure 4.7: DLT governance and governing the DLT governance

receive an effective majority and permission. To move outside of codified governance would automatically mean exclusion from the network. For example, if a network user were to generate a block with claims of an executed transaction but did not calculate the hash function of this block first, the user would not receive a supporting majority from the network according to the Proof-of-Work consensus mechanism. Instead, the network would approve the miner who had actually and verifiably calculated the hash function of the corresponding block first. The individual miner with the contrary claim would effectively be forced to conform to the network's will—otherwise, the transactions he claimed in his block would not be accepted by the network and, therefore, would be invalid and worthless.

The second generation of DLT governance includes codified governance together with an additional governance mechanism that enables the DLT network to adjust the codified governance implemented in the DLT protocol—the governing the codified governance mechanism. This is required if shifting circumstances require an adjustment in order to guarantee continued robustness. *Ethereum* has implemented this second generation decentralized governance as smart contracts enabled industrial applications on top of it by deploying *DApps* or

Generation **Representative**	**1st generation** *Bitcoin*	**2nd generation** *Ethereum*	**3rd generation** *Polkadot, Tezos*
Codified Governance specifications *(maintaining the steady state)*	explicitly formalized; on-chain & web3-based	explicitly formalized; on-chain & web3-based	explicitly formalized; on-chain & web3-based
Governing the Codified Governance specifications *(amending the governance to shifting external conditions)*	unfeasible, ruthlessly minimized to soft forks	intended, with implicitly evolving governance mechanisms; off-chain & web2-based	intended, with explicitly formalized governance processes; on-chain & web3-based

Table 4.1: Decentralized governance generations

DAOs. Robust codified governance is a critical condition for this purpose, as centralization or forking of the DLT network are not accepted. For this purpose, governing the codified governance provides the governance model with a learning capability that can compensate for potentially arising sources of mistrust, corresponding to effective risk mitigation and stronger robustness. However, the prerequisite is that the governance model also experiences a certain level of exposure to be able to identify these sources of mistrust. That said, the exposure may only reach a level where the resilience of the codified governance is not exceeded.

While *Ethereum*'s governing the codified governance mechanism is only implicitly formalized (off-chain)—thus, allowing for higher flexibility, the third generation of DLT governance also formalizes governing the codified governance mechanism explicitly into the DLT protocol (on-chain). A representative of third generation DLT governance models is *Polkadot* or *Tezos*. Table 4.1 summarizes the specifications on DLT governance and its generations.

In the following, I briefly describe the background and characteristics of each DLT governance model, as well as unique events that allow for an evaluation of their robustness and integrity.

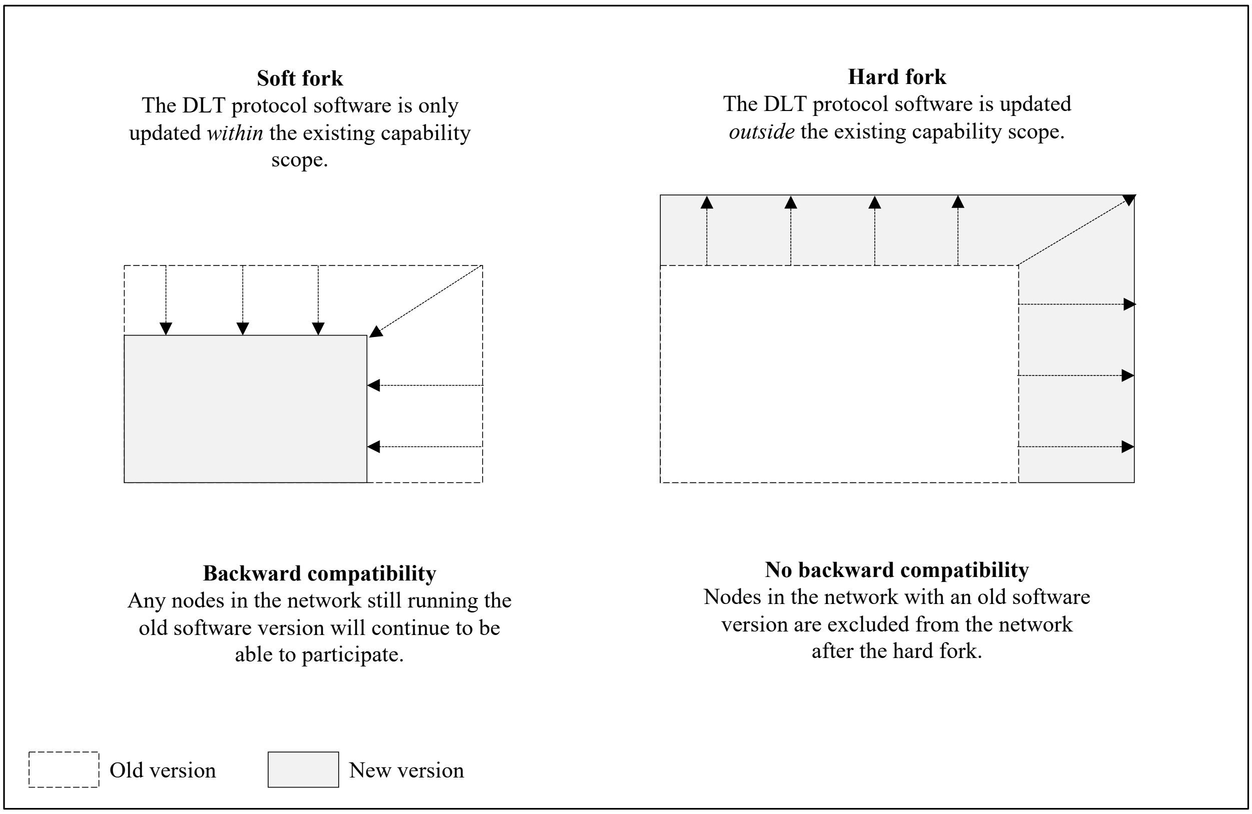
4.4.3 *Bitcoin*: 1st Generation DLT Governance

Bitcoin's codified governance basically resembles a mathematical equation. The significant parts of the governance are ex-ante defined and immutable. It is, for instance, determined that *Bitcoin* is implementing a Proof-of-Work consensus mechanism for committing the decentralized network to a centralized global data state. The access rights are regulated using private keys, while SHA-256 is used as the cryptographic hash function. It is precisely defined how much BTC a miner receives for a created block, as well as the blocks which will be subject to halving and the time at which no further BTC will be mined, thereby ensuring *Bitcoin* achieves its maximum number of 21 million BTC. To date, the *Bitcoin* governance has demonstrated strong robustness and has never been hacked. There literally have been no compensatory events that could challenge the robustness of the BTC protocol and the BTC network. While there have been events of hacking or fraud, such as in the case of *Mt.Gox*[13], this has never involved the BTC network itself but rather centralized interface providers. Although there is a theoretical risk of 51% attacks if, for example, mining pools take over more than 50% of the nodes in a coordinated manner—thus creating centralism, these risks have been successfully averted to date, and the BTC network has proven its resilience, which confirms the integrity of its governance.

This does not mean that *Bitcoin*'s codified governance cannot be adapted at all—it can, but only by means of a soft fork mechanism. In this context, modification of the DLT protocol implies that a software update is implemented, which is then available to the network nodes to update the new software version. This is precisely where the distinction between a soft fork and a hard fork becomes essential (see Figure 4.8). In a soft fork, the old state of a DLT protocol can only be updated within its pre-existing functionality scope. The underlying rationale lies in what is known as backward compatibility, i.e., in the case of a soft fork, nodes that have not completed the update can still continue to participate in the network since the new updates are within the pre-existing functionality scope. *Bitcoin* has firmly anchored this backward compatibility and consequently only allows software updates through a soft fork in its codified governance, which excludes a significant effective performance increase of the network. Therefore, *Bitcoin* will also always be based on Proof-of-Work, as a modification of the consensus mechanism is not feasible on the basis of a soft fork. Still, as a DLT protocol, *Bitcoin* is not particularly practicable, as the high energy consumption to run the network

---

[13] Mt.Gox was a *Bitcoin* exchange, from which 850,000 BTC were stolen in 2014.



Soft fork
The DLT protocol software is only updated *within* the existing capability scope.

Hard fork
The DLT protocol software is updated *outside* the existing capability scope.

Backward compatibility
Any nodes in the network still running the old software version will continue to be able to participate.

No backward compatibility
Nodes in the network with an old software version are excluded from the network after the hard fork.

Figure 4.8: Outline of the soft fork and hard fork mechanisms

(through Proof-of-Work) and the low performance (7 transactions per second) remain in place. However, in terms of governance, *Bitcoin* comprises a robust DLT governance.

Since *Bitcoin* is open-source software, it is also curated accordingly through open-source development processes. In this sense, the *Bitcoin* network is curated through the use of soft forks. The procedures for this are maintained on *GitHub* via the so-called *Bitcoin Improvement Proposals* (BIP). However, *Bitcoin* initially adopted the process for developing soft forks from *Python* and its *Python Enhancement Proposals* (PEP). Using BIPs, proposals for *Bitcoin* improvement can thus be submitted, which are subsequently technically evaluated by the network through forums and eventually implemented. Since soft fork updates, due to backward compatibility, do not force network participants to update a node, a consensus on software updates by the network is not necessarily required, avoiding significant disagreements among network participants. However, the situation is different with hard forks, as backward compatibility would no longer be provided, and node operators are forced to update their nodes if they choose to be part of the network. Nevertheless, performing a hard fork is always an option, albeit with the clear prerequisite that the original *Bitcoin* network will not endorse it. And since *Bitcoin* is open source and the forking function on *GitHub* generally does not distinguish between a soft fork and a hard fork, the source code of *Bitcoin* can be copied with a single mouse click and subsequently be modified in the scope of a hard fork. It is merely a matter of how the network will respond to such a move, deciding if the hard fork will be of relevance and thus supported by a critical mass of the network in order to be recognized as a valid hard fork, but creating an additional *Bitcoin* network. After all, that decisively distinguishes *Python* from *Bitcoin*: the network effects that *Bitcoin*, unlike *Python*, is based and dependent on. While a fork has a purely positive impact on the *Python* programming language, leading to more innovation, a hard fork has a significantly negative effect on *Bitcoin* since network effects are diminished as the network is being divided (see Figure 4.9).

This means that, whether deliberately or not, the hard fork serves as an effective yet undesirable governance mechanism for *Bitcoin*, for instance, if parts of the *Bitcoin* network were to feel obliged to fork out in order to achieve a higher level of performance.

Figure 4.10 illustrates the soft and hard forks that have already been conducted at *Bitcoin*. Apart from the original *Bitcoin* (BTC), several concurrent networks have emerged by now, such as *Bitcoin Cash* (BCH), *Bitcoin BEP2* (BTCB), *Bitcoin SV* (BSV), *Bitcoin Gold* (BTG), *Litecoin* (LTC), as well as *Dogecoin* (DOGE), which again is a hard fork of *Litecoin*. A hard fork becomes particularly sensitive when the network's expectations deviate significantly, as is evident in the case of the User Activated Soft Fork (UASF) with BIP148[14].

> *"The fact that the implicit governance is vague isn't great; that makes it kind of hard. The UASF is a perfect example of when it went outside the explicit governance model. And it went with a lot of things that many people disapproved of."* (Bitcoin Core Developer)

To address *Bitcoin*'s scaling issues, a camp of *Bitcoin* network users and contributors formed to increase *Bitcoin*'s performance by modifying the way a block is signed (to be more

---

[14] https://github.com/bitcoin/bips/blob/master/bip-0148.mediawiki

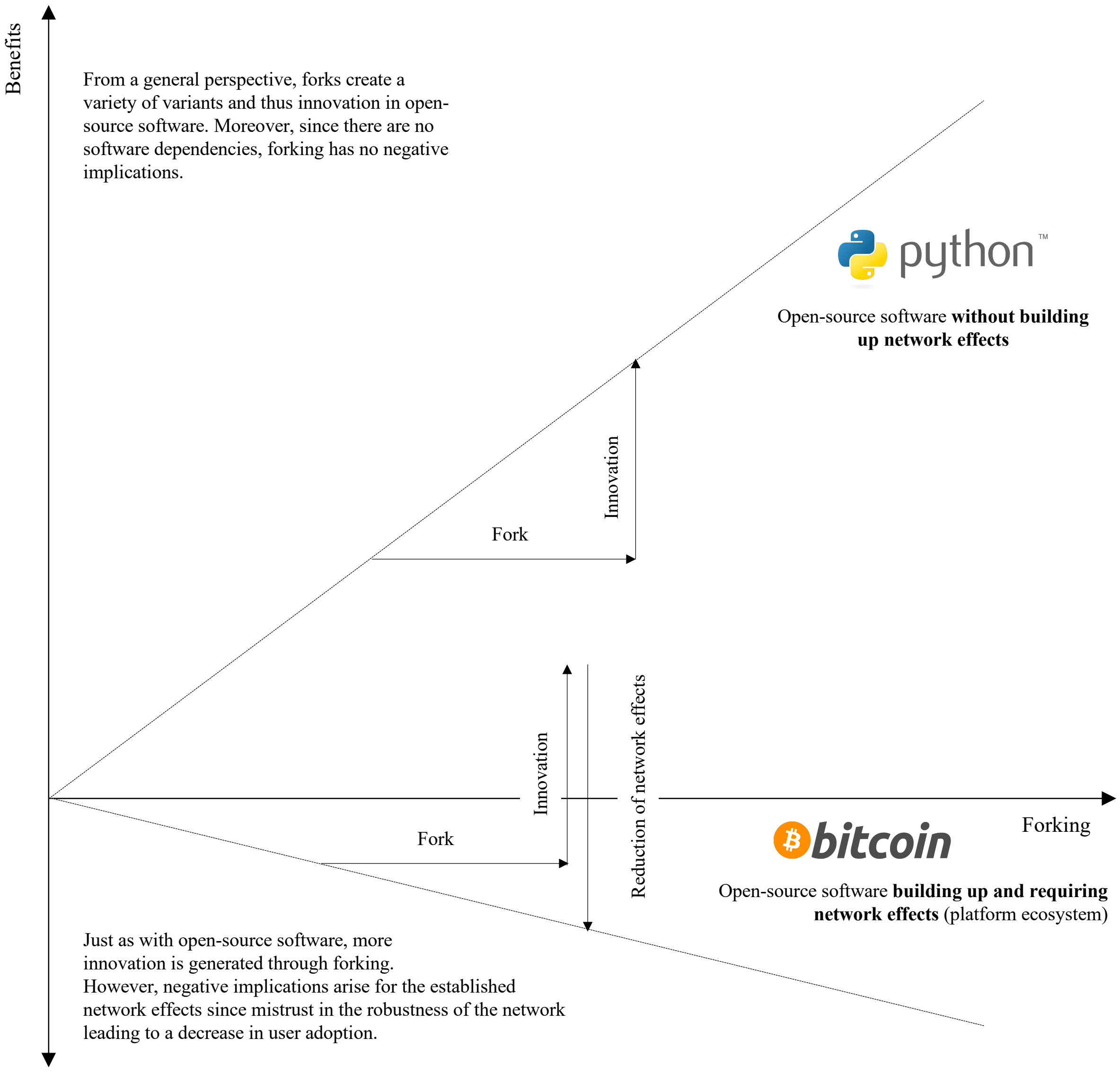


Figure 4.9: Forking impacts on *Python* and *Bitcoin*

efficient) and using the freed-up space for adding transactions to the block. This proposal is also known as Segregated Witness (SegWit). The theoretical block size would have increased to 4MB, however, based on a soft fork with backward compatibility. Thus, miners would have been able to decide for themselves whether to use the update allowing for additional transactions to be validated. On the other hand, another camp—led by the mining giant *Bitmain*—intended to use the opportunity to push through a hard fork to fundamentally

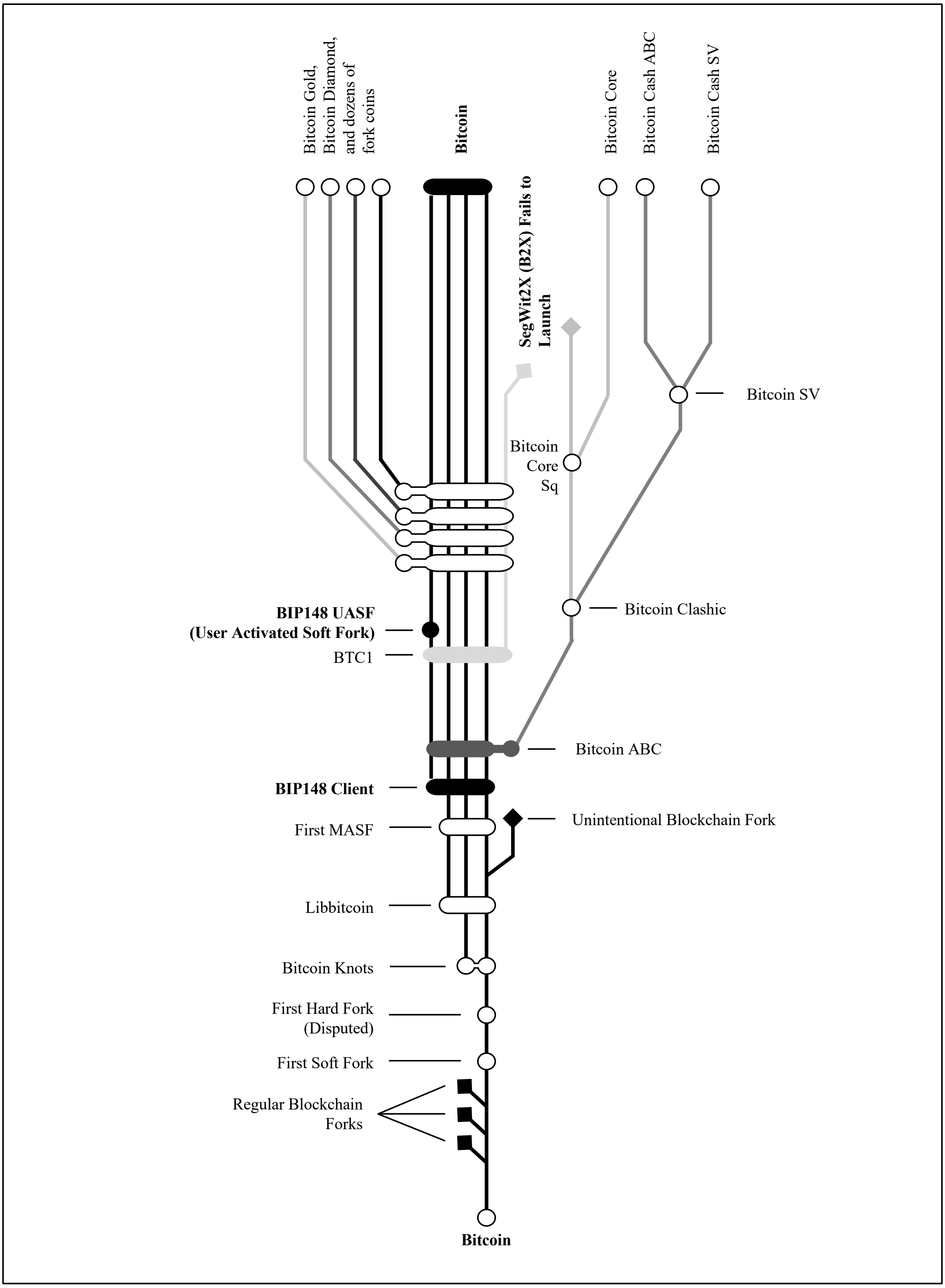


Figure 4.10: A map of *Bitcoin* forks based on Viens (2019)

double the SegWit-enabled block size even further from 4MB to 8MB[15]. Doing so would have increased *Bitcoin*'s scalability significantly but at the risk of causing about twice as many transactions to lie unvalidated in a block every 10 minutes. This counter-act is known as SegWit2x. The motivation behind SegWit2x may be of a commercial nature, as the miners, including *Bitmain*, could expect twice as much revenue from transaction fees. In the end, the UASF with SegWit succeeded, which means to be accepted by most miners while not forcing everyone to update their nodes. On the other hand, the SegWit2x hard fork ultimately failed due to lack of acceptance and was consequently not implemented. However, this event highlights the importance of formalized governing the codified governance.

> *"So I would say that the whole SegWit2x episode to me was very encouraging in terms of governance vulnerability, I think if there was a real governance vulnerability in Bitcoin, that's when it would have been more or less discovered because you had powerful businesses, businesses with very deep pockets and a lot of money and developers that they had recruited and a whole lot of a community trying to co-op the consensus and it didn't work."* (Bitcoin Core Developer)

Nevertheless, an evident strength of *Bitcoin* is the very formalized rationale of not allowing any hard forks, thus, protecting *Bitcoin*'s core network in its existence. Regardless of *Bitcoin*'s performance drawbacks, the charm of *Bitcoin* governance lies in its radical minimization to code without further outside influence. In 2018, Nick Szabo tweeted on that subject:

> *"Blockchain governance generally comes in only three varieties: (1) Lord of the Flies, (2) lawyers, or (3) ruthlessly minimized. (...) It has to be ruthless, otherwise, the children or the lawyers will win."* (Nick Szabo, @NickSzabo4)[16]

---

[15] https://blog.bitmain.com/en/uahf-contingency-plan-uasf-bip148/

[16] https://twitter.com/NickSzabo4/status/1009996445280169985

4.4.4 *Ethereum*: 2^{nd} Generation DLT Governance

The introduction of smart contracts in *Ethereum* significantly changed the self-understanding of the protocol compared to the self-understanding of *Bitcoin.* Through smart contracts and thus the decentralized, automatic execution of programs across the network pursuant to ex-ante defined conditions, *DApps* could be implemented, which encase various value propositions. *Ethereum* thus enabled the execution of a wide range of applications, whereas *Bitcoin* comprises only a single application: decentralized payment. In other words, *Bitcoin* comprises one single application with its own DLT network, its own DLT protocol explicitly created for this purpose, and its own codified DLT governance. *Ethereum*, on the other hand, is a DLT protocol with a single codified DLT governance but with a wide range of diverse applications that impose various and heterogeneous requirements on the network. Vitalik Buterin described the comparison to *Bitcoin* as follows:

> *"A pocket calculator does one thing, and it does one thing well, but really, people want to do all these other things. And if you have a smartphone, then you have a pocket calculator as an app. (...) So basically, taking that same kind of idea of increasing the power of the system by making it more general purpose and applying it to blockchains."* (Vitalik Buterin) (Locke, 2021)

However, this plethora of decentralized applications still demands a shared and unified codified governance to ensure interoperability across the network, raising demands for a more adaptive *Ethereum* governance and necessitating the need for a governing the codified governance function. Implementing a "*ruthlessly minimized*" DLT governance, such as with *Bitcoin*, is therefore simply not feasible in *Ethereum*, which faces significantly greater socio-technological demands in its network.

> *"Ethereum, on the other hand, as part of its vision, community, and road map, requires hard forks over time to evolve the network and adapt the network to the users and the needs of the network. And the matter with hard forks is that you always have the chance to create a network split because if you do not upgrade,*

> *you will be on a different chain than those who did the upgrade. And this requires much more coordination—social coordination."* (Polkadot governance engineer)

In operational terms, amendments to *Ethereum* are litigated via *GitHub* through *Ethereum Improvement Proposals* (EIP) similar to *Bitcoin*. Unlike *Bitcoin*, however, the *Ethereum* network consists of two crucial authorities of central legitimacy, which play a significant role in governing the codified governance: first, the *Ethereum Foundation*, and second, Vitalik Buterin. However, governing the codified governance is thus only implicitly formalized while relying on their legitimacy and integrity. History demonstrated that this is a pragmatic and agile approach when it comes to purely technical and thus objective discussions. For discussions of a socio-technical nature and where a consensus of intersubjectivity is at stake, *Ethereum*'s governing the codified governance mechanisms is insufficient. A very seminal incident to express this lack in governance is the *the DAO* hack. *The DAO* was a decentralized autonomous organization aimed at creating a decentrally managed investment fund, where the community itself invests and makes decisions about the investments through a democratic process and without any decentralized authority (Jentzsch, 2016). Also, *the DAO* was the first representative of a decentralized autonomous organization (DAO), at its core being a *decentralized application (DApp)*, additionally self-managing and implemented on top of *Ethereum*. *The DAO* was kicked off on April 30, 2016, by the launch of its token sale, which continued for 28 days, bringing *the DAO* to launch on May 28, 2016, along with decentralizing its future coordination. The TGE of *the DAO* tied 11,994,260.89 Ether (ETH) through smart contracts, which represented 14% of the total ETH supply. Given the price of ETH at the time, *the DAO* TGE raised the equivalent of $150m. Shortly after, vulnerabilities in *the DAO* code were revealed and communicated by the community, which *Slock.it*—who had implemented *the DAO*——intended to remediate. Furthermore, the tied ETH was stored in one single public address of the network. As early as June 17, 2016, approximately one-third of all tied ETH was stolen using a so-called child-DAO. An unknown user deployed a copy of *the DAO* and had initiated a successive drain of the tied ETH, exploiting the vulnerability in *the DAO* code and thus hacking the system. However, the child-DAO that had been implemented for this purpose possessed exactly the same code as the parent-DAO, which had just carried out the 28-day TGE. Therefore, the drained money had to be stored for additional 28 days also in the child-DAO according to the rules of the TGE, providing the *Ethereum* and *the DAO* community with some time to discuss how to handle the incident. Since the transaction itself was a regularly executed transaction, it was transparent to everyone where the money had been gone and where it was currently stored.

> *"So, there are a few things to explain about this; the first thing is that the problem isn't with Ethereum itself, but the problem is with one of these applications, with one of these smart contracts. So, the smart contracts are not built into Ethereum. Ethereum exists, sort of on a lower level. And these software [smart contact] run on a higher level. So, it's like saying, well, this website is broken, and it's not saying the same thing as the Internet is broken. So Ethereum is like the Internet; it just sorts of works, but yes, one of the websites, as it were, that sits on Ethereum, broke. This website was called the DAO."* (Gavin Wood) (Dutch Blockchain Conference, 2016)

The community was given 28 days to decide how to treat the apparent robbery, although it was carried out legitimately.

> *"Well, the signatures that were done are digital signatures, not any other kinds of signatures. And what did these digital signatures mean? Well, you have to view it in the wider context of the system that they were submitted to, which is a very well-defined smart contract execution system that will not easily be intervened with except by the consensus of the community. It will execute the contract, the code blindly. And so, in some sense, the signatures give authority to the flaw and, therefore, to the attack."* (Gavin Wood) (Dutch Blockchain Conference, 2016)

The DAO hack subsequently led to immense debates. If DLTs are a ledger whose content is defined in a decentralized way by the majority of nodes and their votes, *the DAO* hack could be reversed if the majority of nodes agreed to it, meaning more than 51% of the nodes. The *Ethereum* community would have had to agree on a hard fork that would rewind the data state to the one that existed before *the DAO* hack. In other words, it would be done by jumping back in time. However, it would simultaneously undermine *Ethereum*'s codified governance and violate the most fundamental principles of DLTs and *Ethereum*, namely, the immutability of the data state. Such a hard fork would be a kind of betrayal of *Ethereum* and its codified governance, massively undermining its integrity. After all, the problem was not with *Ethereum* per se—*Ethereum* had very effectively executed what was defined ex-ante through *the DAO* smart contracts. As such, why reset the entire *Ethereum* data set just because a single application on top had implemented a flawed smart contract? After all, *the DAO* investors knew about their risks and thus should have to accept losing money.

> *"Lost coins only make everyone else's coins worth slightly more. Think of it as a donation to everyone."* (Satoshi Nakamoto)

From a principled point of view, *Ethereum*'s codified governance clearly indicated how to proceed. However, since almost 14% of the total ETH supply was affected by *the DAO* hack, this also raised governing and economic implications for *Ethereum*. The bundling and outflow of such significant amounts of ETH supply were threatening the robustness of the *Ethereum* network as the risk of centralization increased. It was also reflected in the *Ethereum* valuation with a 25% drop of the ETH price. Thus, the *Ethereum* community found itself in a dilemma, which eventually was decided through a simple coin voting of the ETH-holders, managed and carried out by the *Ethereum Foundation*. Before the expiration of the 28-day window, the voting was enacted, resulting in an 89% majority in favor of a hard fork to unwind *the DAO* hack. The other 11% voted for a version of the network that prioritized principled retention, legitimating *the DAO* hack. This version is now known as *Ethereum Classic* (ETC). At the same time, the much more dominant *Ethereum* (ETH) in the proper sense has violated the principle of immutability and thus the integrity of its governance model.

> *"Well, this is the thing: so Ethereum is fundamentally a consensus network, which means right and wrong is determined by the will of the people, by the consensus that the people behind it decide. So now, in this instance, people really do have a decision; they can say, 'well honestly, this contract had a hook, it*

> *had a flaw, but it was nonetheless well-defined, and the attacker they did drain against people's expectations, but those expectations were flawed just as the code was flawed and the attacker is in some sense utilizing what was fair'. So, there is an argument to be made for the fact that this system is executing correctly. Now, of course, there's also the argument that is: 'well, hold on, expectations, wide expectations, were that this contract was going to do this; and it doesn't do that and so you know I expect that it will be altered to what I thought it was going to do'."* (Gavin Wood) (Dutch Blockchain Conference, 2016)

One year later, on November 6, 2017, another incident occurred involving the Parity Multi-Signature Wallets. Multi-signature wallets are designed especially for businesses seeking to manage DLT wallet access through multiple private keys rather than a single private key in order to increase security through presumably shared use within their own organizational structures. A *GitHub* user named "devops199" exploited a buggy code, or rather a missing initialization of the library managing the multi-signatures, to finally initialize it and declare himself as the sole owner of the library. Subsequently, he erased the library, which also irreversibly deactivated access for the user to their wallets. As such, "devops199" had not stolen any funds but instead had frozen 587 Parity Multi-Signature Wallets worth 513,774.16 ETH (Parity Technologies, 2017), the equivalent of roughly $150m back then. The *Web3 Foundation* was especially affected, as it had just raised $145m through an ICO for its *Polkadot* project. It is estimated that almost 60% of this funding got frozen.

> *"The multi-sig used by the Web3 Foundation to accept contributions for Polkadot was one of those affected, putting the ETH in it beyond access. (...) The affected multi-sig wallet does not contain all of the Web3 Foundation's funds; our ability to build Polkadot as planned and to the original timetable has not been affected."* (Web3 Foundation, 2017)

On the part of *Parity Technologies*, Afri Schoedon submitted a proposal to restore the frozen funds with the EIP999, which once again led to off-chain and web2[17]-based governing the codified governance debates about its pros and cons. Again, this demonstrated the vulnerability of *Ethereum*'s governing the codified governance mechanisms, namely when dealing with an intersubjective, socio-technical discourse, which is not of a purely technical, objective nature. The process for advancing the *Ethereum* protocol, and thus the codified governance, is in place at *Ethereum* using the EIPs. The EIP process itself is explicitly formalized in the EIP1 on *GitHub*. Besides submitting the EIPs on *GitHub*, *Ethereum*'s governing the codified governance mechanism involves a subsequent discussion among core developers via video calls. Initially, these calls were held among the *Ethereum* core developers, a handful of people who also knew each other on a personal level and who majorly originated from the *Ethereum Foundation*. As the network grew and new contributors such as *Parity Technologies* and more core developers joined, the EIPs were discussed and evaluated through the so-called *Ethereum Magician Calls* and *Ethereum Magician forums*[18]. Nevertheless, only technical and objective matters of *Ethereum* can be effectively discussed and agreed upon without requiring a formalized voting mechanism.

> *"In the Magician Calls, there is no voting as a matter of principle. There is always the rule of rough consensus and running code; that means a proposal is considered as accepted if no one says, 'only over my dead body.' However, the proposals that are presented must be technically flawless, and all points of criticism must be addressed. Subsequently, it is literally asked around if someone is against this proposal. If someone is against it, then someone must also argue why, and then it becomes iterative. But, if at some point, no one objects, then the proposal is recorded as accepted—But of course, the whole matter only applies to technical aspects, so assuming it's not controversial."* (Afri Schoedon, Ethereum core developer with Parity Technologies)

---

[17] refers to protocols and networks that emphasize user-generated content, but where the network control and digital ownership relies with single authorities. Thus, network votes cannot be transparently tracked and retraced or implemented with explicitly formalized automated voting mechanisms.

[18] https://eth.wiki/en/governance/governance-compendium

Representative voting would necessitate an explicitly formalized governing the codified governance mechanism, which would be web3[19]-based and run on-chain to prove the corresponding compliance and integrity of the voting. If such compliance is proven, socio-technical, intersubjective governance matters can be effectively brought to a consensus. However, this does not exist with *Ethereum*, meaning that for intersubjective and thus controversial issues, a kind of ground noise exists outside of the formalized governance processes. Therefore, although the technical governing the codified governance processes are explicitly addressed by the EIP1, these processes are only technical in nature and are not capable of handling the controversial and intersubjective community debates. Correspondingly, in the aftermath of the Parity Multi-Signature Wallet incident, vague and unrepresentative decision-making mechanisms emerged, which relied on the mentioned EIP999 as a technical basis. The *Ethereum Magician Calls* sought to address the EIP999. However, the core developers failed to gain the required authority since it was not a technical matter but rather a socio-technical one. In the end, a non-representative, non-formalized, and diffused coin voting decided the outcome.

> *"There were no technical objections; technically, it was accepted. But no one dared to confirm this during that call explicitly. It was pretty clear that this was not something that could be discussed technically. That has to be discussed on other levels. And then we had this coin vote, which turned out to be negative. From then on, it was basically a done deal, although the coin vote was very small, had very few participants, and only lasted about one day. Participation was also challenging, especially for the less tech-savvy users and therefore for a large portion of the community. That's how it happened, though, with the result that the coins were not released. Thereafter, it was tough to argue against this momentum the coin vote had created."* (Afri Schoedon, Ethereum core developer with Parity Technologies)

---

[19] refers to protocols and networks that emphasize user-generated content. Additionally, users are provided with network control rights and data ownership. Thus, network-implemented and protocol-inherent voting mechanisms can be processed, where its compliance is tracked and retraced by the web3 network itself.

In this way, the community rejected EIP999, which aimed to restore the frozen funds. For the second time, though, it became clear that *Ethereum* suffers a flaw in governing the codified governance: *Ethereum* aims to address socio-technical influences by integrating smart contracts. Nevertheless, it does not possess an explicitly formalized governing the codified governance mechanism to effectively handle the emerging socio-technical governance demands. An implicitly formalized coin voting scheme is unable to bridge this gap, as it does not represent a fair and goal-oriented model. It does not consider the respective role constraints and incentives of the actors. It is solely decided by the number of available coins preferring the actors who possess large numbers of coins.

> *"Coin holder voting is basically this idea that if a decision needs to be made within some system that has coins, then each of the owners or controllers of those coins will have some voice in this decision, and the amount of voice that they have will generally be proportional to the amounts of coins that they have, so one coin equals sort of one vote, so to speak."* (Gavin Wood, 2019)

Currently, the *Ethereum Foundation* is transforming *Ethereum* into its former research project called *Ethereum 2.0*. This comprises the transition from Proof-of-Work to Proof-of-Stake, which resembles a kind of "open-heart surgery". The *Beacon chain* launched on December 01, 2020, which runs in parallel to *Ethereum 1.0* and implements Proof-of-Stake. On April 15, 2021, the *Berlin upgrade* that included four EIPs became effective in modifying transaction types on *Ethereum*. With the *London upgrade*, *Ethereum* got a new fee structure on August 05, 2021, to minimize the incentive for Proof-of-Work and thus to encourage Proof-of-Stake. The *Beacon chain* is to subsequently receive so-called "sync committees" with the *Altair upgrade*. The *Shanghai upgrade* is intended to prepare *Ethereum* for merging with the *Beacon chain*, allowing the merge between the *Beacon chain* and *Ethereum* to occur afterward, thus running *Ethereum* entirely on Proof-of-Stake (Ethereum Foundation, 2021). After that, *Ethereum* will become a sharded blockchain protocol like *Polkadot* (in *Polkadot* terminology, a parachain), establishing sharded chains. However, it is expected that one significant difference will remain to *Polkadot*: the governing the codified governance function. *Ethereum* further intends to preserve this web2-based and off-chain, while *Polkadot* has implemented this governance mechanism on-chain and web3-based, thus representing the third generation DLT governance (Web3 Foundation, 2021).

4.4.5 ***Polkadot*: 3$^{\text{rd}}$ Generation DLT Governance**

As stated above, *Polkadot* is a sharded blockchain protocol, allowing the scaling problems to be solved. Sharding is the decoupling of subsets of transactions from the main network, enabling validation partially over the sharded network. In contrast, only aggregated states are validated from the main network. This makes it possible to create a separate network for a particular application or even application categories, each of which requires its own network configurations and consequently its own codified governance. In *Polkadot* terminology, the main network is called the relay chain (layer-1), and the sharded networks are called parachains (layer-2). Between the relay chain and the parachains, interoperability is required to always be maintained while at the same time allowing for a variety of diverse network configurations. This applies to the execution of transactions but also their respective governance models. This interoperability is furthermore to be guaranteed to non-*Polkadot* DLT networks, which is implemented via so-called bridges. In other words, what smart contracts were for *Ethereum*, for *Polkadot*, this is interoperability.

> *"Polkadot is, in many respects, the biggest bet in this ecosystem against chain maximalism. Even if there were one perfect chain, I don't think it would stay perfect for very long. I would try to convince people that it's really not such a good plan to be so focused on backing one winner above all others."* (Gavin Wood, 2020)

The underlying vision of *Polkadot* is that there will not be "*one chain to rule them all*" but instead a complementary coexistence of multiple chains, each providing its own strengths for applications or application categories. However, among these multiple chains, *Polkadot* is supposed to break down boundaries and allow for a wide variety of transactions. Before founding *Polkadot*, Gavin Wood formerly served as the CTO for the *Ethereum Foundation*, whose founding members started to fall apart:

> *"To be honest, I always wondered how these guys must have met. They were truly the best minds of that time. From a technical point of view, they were really fantastic, but the meetings with them—that wasn't easy! I sometimes had to leave the meeting and said, 'Look, you guys come to an agreement first, and I'll come back as soon as it gets legally relevant.' They all felt very connected to the Ethereum Foundation and the protocol itself, but apart from that, they all went their separate ways thereafter. And in the end, only Vitalik remained in the foundation. But this does not mean that they have turned their backs on him. And I mean, the reason why they're not together is also due to their individual ambitions to do something themselves. They all took the Ethereum project as a stepping stone."* (Luka Müller, former legal advisor to the Ethereum Foundation) [translated]

Charles Hoskinson left the *Ethereum Foundation* already in 2014, as he was pushing to transform the non-profit *Ethereum Foundation* into a commercial, for-profit entity, causing intense disputes among the founding members[20]. In the aftermath, he founded *Cardano*. Joseph Lubin, who agreed with Charles Hoskinson's opinion to turn *Ethereum* into a commercial product, founded *ConsenSys* in 2014, which aims to build *Ethereum*-based applications that are somewhat on the business side of DLTs.

> *"Joe Lubin is the commercial guy. He basically said, 'That is good! Perfect, that is very nice that we have a protocol now with the possibility to set up verticals with applications on top of it.'—That's where he also got very strong with his firm ConsenSys—that's Joe Lubin! Gavin, on the other hand, quite rightly thought a little further down the road. And with Polkadot, he basically stated, 'look, we're always going to have different protocols, that means we still require interoperability.' And so, he stayed at the infrastructure level and continued to pursue the infrastructure side of DLT governance."* (Luka Müller, former legal

---

[20] https://www.forbes.com/sites/angelauyeung/2018/02/07/charles-hoskinson-ethereum-iohk-blockchain-crypto-cryptocurrency/?sh=1e93a2787c15

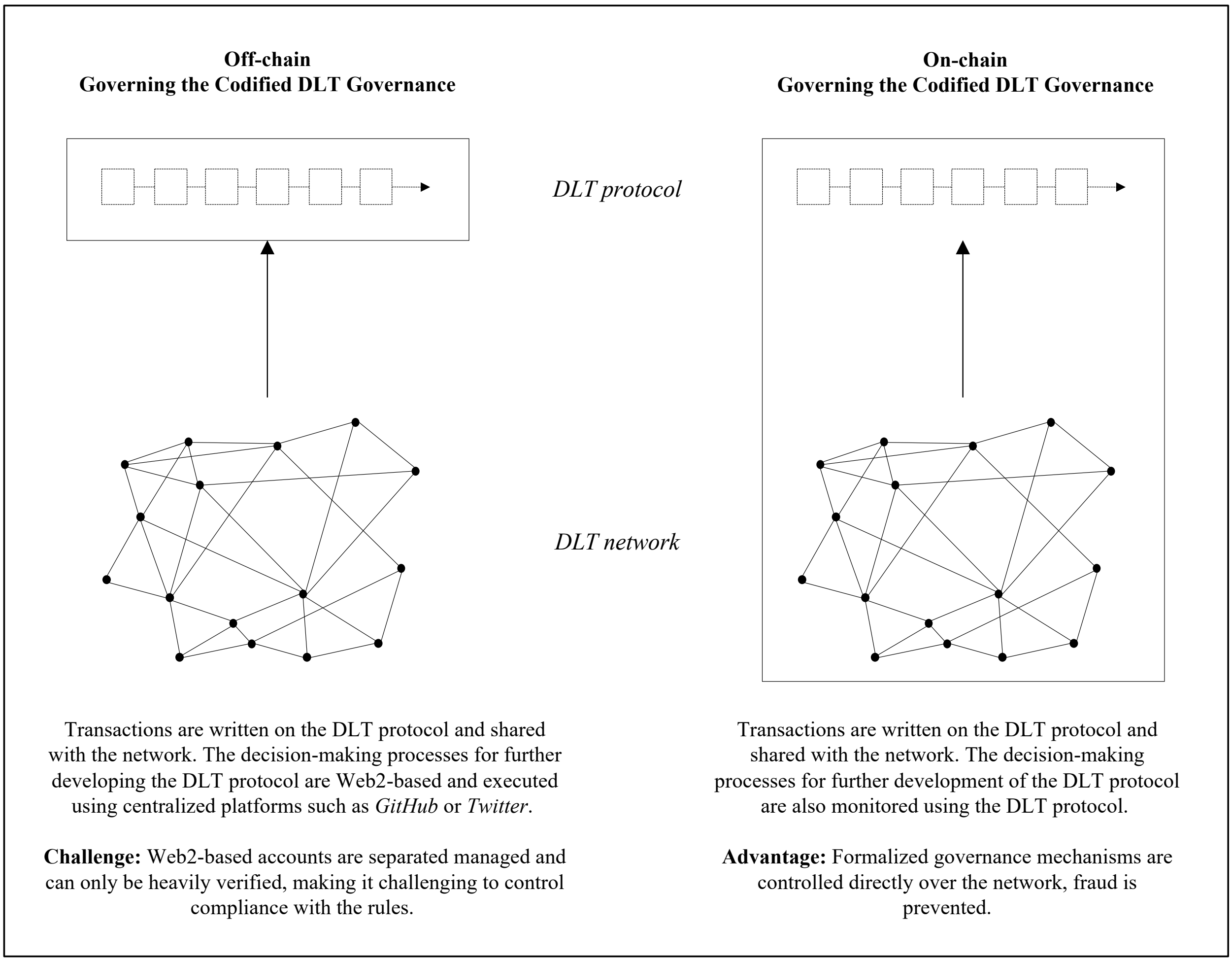
> advisor to the Ethereum Foundation) [translated]

After leaving the *Ethereum Foundation*, Gavin Wood first co-founded *Ethcore* (now *Parity Technologies*) for an *Ethereum Foundation*-independent contribution to *Ethereum*, and eventually started building *Polkadot* in 2017 through the *Web3 Foundation* together with *Parity Technologies* which ultimately launched live in August 2020.

> *"There was a general idea back in 2014, when we were starting Ethereum, that Ethereum 2.0 should be being under development by late 2016. And here we were sitting around in autumn of 2016, and there was absolutely no indication that there was going to be any development, significant at least, on Ethereum 2.0 for some time. So really, we wanted to push forward with that one way or another. Let's embark on something that we think will be complementary to Ethereum 2.0, a system in parallel that can fulfill things that probably Ethereum 2.0 is going to be less than optimal fulfilling. And ideally, that will interoperate with Ethereum 2.0 a well."* (Gavin Wood, 2020)

A fundamental shift at *Polkadot* was also the comprehensive, consistently implemented, explicitly formalized, on-chain governance model, which encompasses both codified governance and governing the codified governance through sophisticated voting mechanisms as well as a more scalable nominated Proof-of-Stake consensus mechanism. Since the simple coin voting mechanism *Ethereum* deployed is ineffective to bridge objective technical with intersubjective socio-technical expectations, *Polkadot*'s vision was to implement a more sophisticated voting scheme that would also address socio-technical, intersubjective governance concerns.

The essential distinction from off-chain governance is depicted in Figure 4.11. Both the codified governance, which is defined by the DLT protocol itself, and the agents of the DLT network are anchored on-chain in the DLT protocol. This has the decisive advantage that it is ex-ante specified who is authorized to vote on intersubjective governance matters and which exact procedures are to be used for governing the codified governance as well as to enforce the decision-making of the DLT network on socio-technical as well as purely



Transactions are written on the DLT protocol and shared with the network. The decision-making processes for further developing the DLT protocol are Web2-based and executed using centralized platforms such as *GitHub* or *Twitter*.

Challenge: Web2-based accounts are separated managed and can only be heavily verified, making it challenging to control compliance with the rules.

Transactions are written on the DLT protocol and shared with the network. The decision-making processes for further development of the DLT protocol are also monitored using the DLT protocol.

Advantage: Formalized governance mechanisms are controlled directly over the network, fraud is prevented.

Figure 4.11: Off-chain and on-chain governance

technical matters. Technical proposals may still be submitted using *GitHub*, referred to as *Polkadot Standards Proposals* (PSPs). However, *"A Polkadot Standards Proposal (PSP) describes standards for the Polkadot ecosystem. The Polkadot Standards Proposal GitHub is a community-based initiative. PSP process is not supposed to be a substitute for Polkadot governance process and is meant to focus only on commonly agreed usage patterns rather than protocol adjustments"* (w3f GitHub repository)[21]. All effective *Polkadot* governance has thus disappeared from web2-based coordination tools, as complete tracking of governance compliance can only be accomplished by directly linking suggested proposals to the governing the codified governance mechanisms through a web3-based, on-chain scheme. Access to

---

[21] https://github.com/w3f/PSPs

governance is thus only possible when employing the *Polkadot* public addresses. The *Polkadot* on-chain governance model includes a so-called council, in which deputies are nominated by the *Polkadot* network. Furthermore, it contains different *"on-chain voting mechanisms such as referenda with adaptive super-majority thresholds and batch approval voting. All changes to the protocol must be agreed upon by stake-weighted referenda."*[22] The proposals can be submitted by public users as well as proposed by the council. So, there are both public referenda and council referenda. For public proposals, a minimum number of coins coupled to the proposals has to be provided. Subsequently, coins are also used for voting, which will be locked in a specific period to prevent sabotage. This ensures that votes are only made by those who have "skin in the game" and therefore do not vote destructively. The longer the coins are locked, the more weight the vote receives. However, the minimum time of locking lasts 28 days. Ballots are decided by majorities. There are two types of majorities: super-majorities and simple majorities. Public referenda require a super-majority for a proposal to be accepted. However, only a simple majority is required to accept a proposal for council referenda, but a super-majority is needed to reject a proposal. More details are publicly available and may change continuously. I will therefore refrain from further technical explanations. In essence, I merely intend to illustrate the complexity required to grasp and implement intersubjective, socio-technical voting effectively. A sophisticated governance model is thus a fundamental component of *Polkadot* and is essential for its success. Interoperability is not just a technical aspect but rather a socio-technological performance indicator that can only be established through an effective governance model.

Besides *Polkadot* itself, two associated and essential components of the *Polkadot* project are necessary to mention: *Kusama* and *Substrate*. After all, on-chain governance also poses a risk. If on-chain governance is implemented incorrectly, there is no way to revoke such a binding to a flawed decision. *The DAO* hack, in tandem with its violation of codified *Ethereum* governance, had shown that the principle of "code is law" was capable of being overturned in the face of doubt, as the code was ultimately intended to serve people, 89% of

---

[22] https://wiki.polkadot.network/docs/learn-governance

whom recognized that this was misconduct. With *Polkadot*'s on-chain governance, however, this is no longer so easily accomplished. The principle of "code is law" is in effect, which means that the code has to be tested beforehand to ensure consistency. This circumstance called for a test network to be implemented upstream of *Polkadot*'s launch, which is known as the *Kusama* network.

> *"Kusama is a network built as a risk-taking, fast-moving 'canary in the coal mine' for its cousin Polkadot. It's a living platform built for change agents to take back control, spark innovation and disrupt the status quo. Kusama is a scalable network of specialized blockchains built using Substrate and nearly the same codebase as Polkadot. The network is an experimental development environment for teams who want to move fast and innovate on Kusama, or prepare for deployment on Polkadot."* (Kusama.network)[23]

Since *Polkadot* also actively promotes the multiplicity of parachains, *Parity Technologies* has provided *Substrate* a kind of modular assembly kit to deploy customized blockchains. It provides all the core components for assembling dedicated blockchains, including native interoperability with *Polkadot* and its parachains.

4.4.6 The Integrity of Governance Is the Key to Digital Trust in Decentralized Networks

When comparing and evaluating the governance models of *Bitcoin*, *Ethereum*, and *Polkadot*, it is also essential to take their ambitions into account. In other words, the more limited the technical capabilities of a DLT network are, the less sophisticated the associated governance model for enforcing compliance must be. If the governing network demands are purely technical, purely technical codified governance is sufficient. However, if the network requirements become more controversial due to more complexity and higher application demands, a more sophisticated governing the codified governance mechanism is required to enforce intersubjective, socio-technical decision-making, and its compliance.

---

[23] https://kusama.network/

> *"I think the big benefit to on-chain governance is the speed of decision-making. I've been involved in Bitcoin for a long time, and I was quite involved in the whole debate around increasing the block size, and that was just an enormously frustrating thing. And in the end, was it the right thing to do or not to do it? Who knows? But, definitely, it seemed enormously inefficient. If you just looked at the amount of time that went into all of these debates and all of the hours. There is an enormous amount of economic value that was wasted there."* (Bitcoin core developer)

Bitcoin is a pure transaction platform and comprises only one single application—decentralized financial transactions while solving the double-spent problem. A single DLT protocol with its proprietary DLT network is implemented for this sole purpose. The codified governance anchored in the *Bitcoin* protocol has effectively supported transacting this single application until today. Although there have been some *Bitcoin* forks, these were provoked by *Bitcoin*'s rigid codified governance with its firm posture on maintaining backward compatibility, not allowing for any scaling or performance improvements. Hard forks are an accepted governance mechanism for disruptive DLT protocol modifications, subsequently determined by whether network effects are established or not. Given this consideration, the *Bitcoin* network, with its rather simplistic application claims and its straightforward governance model, has, however, been able to prove compliance and integrity of its governance while proving that the application and its governance are aligned. Although *Bitcoin* is entirely unsuitable for an industrial application beyond *Bitcoin* payments, decentralized applications are technically not possible nor intended.

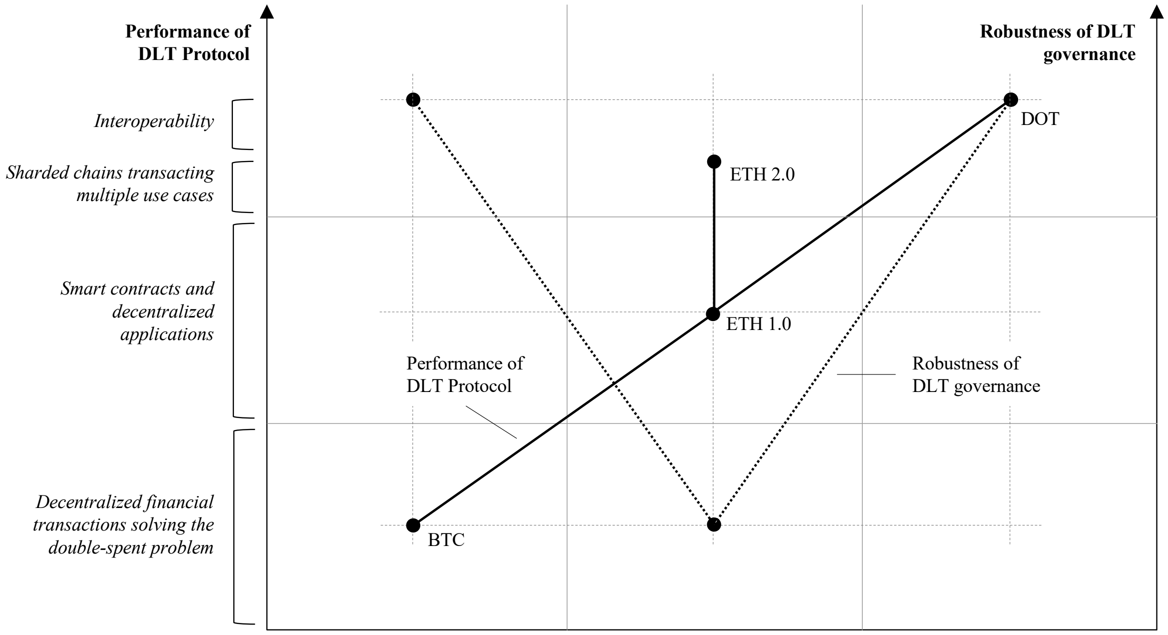
Ethereum, on the other hand, also raised its aspirations in terms of a more challenging network management following the introduction of smart contracts. *Ethereum* explicitly intended to address industrial applications, which also enhances the expectations for the integrity of *Ethereum*'s governance. The intersubjectivity integrated by the industrial applications concerning decision-making, extending beyond a purely technical-objective evaluation of proposals, calls for an effective and fair voting tool. However, this is not inherent in the *Ethereum* governance framework. Governing the codified governance mechanisms are primarily carried out by core developers and are web2-based, which is provoking controversial debates outside of these formalized governance structures. Coin voting has become a significant mechanism for reflecting and integrating those offside debates into the governance process; however, coin voting does not provide a reasonable basis for resentment throughout the network; thus it does not effectively prohibit forks. Furthermore, *the DAO* hack caused a striking violation of *Ethereum*'s principles and its codified governance, thus squandering trust in *Ethereum*'s governance integrity.

Polkadot advanced the claim of socio-technical, intersubjective network management by providing interoperability. Nevertheless, the interoperability requirement and the creation of different parachains, i.e., heterogeneous sub-networks, also necessitated an effective and explicit formalized, on-chain governing the codified governance mechanism. Therefore, in *Polkadot*, the entire governance model is and had to be elevated from a web2-based to a web3-based basis to encompass all governance processes on one consistent and harmonized network. Furthermore, sophisticated and properly established voting mechanisms—fine-grained and traceable—allow for sounding the intersubjectivity of a heterogeneous network.

Figure 4.12 plots the DLT governance classification of *Bitcoin*, *Ethereum*, and *Polkadot* according to these rationales. In addition to the formalized governance mechanisms mentioned, I want to highlight one remaining element of DLT governance: legitimacy, which serves as a heuristic function. DLT networks transform digital trust into *digital truth*. However, ultimately, DLT networks are utilized by human beings who tend to evaluate with heuristics on a trust basis, which feeds into the DLT governance structures in the form of reputation and legitimacy. The tech-savvy, complex governance creates the need for heuristics in human agents. Thus, legitimacy has a crucial influence despite all the formalization of governance since human beings cast their votes. And when their individual voting sovereignty is overwhelmed, they let themselves be guided by reputation, which gives legitimacy to central entities such as the umbrella foundations (*Ethereum Foundation*, *Web3 Foundation*) or outstanding individuals such as Satoshi Nakamoto, Vitalik Buterin, or Gavin Wood.

This is also where the naming of a legal entity gains importance and influence, e.g.,

DLT Protocol Performance and DLT Governance Robustness indicators of *Bitcoin*, *Ethereum*, and *Polkadot*



	bitcoin		Polkadot.
Network configuration	*One chain one use case, one governance model*	*One chain multiple use cases multiple governance streams*	Multi-chain multiple use cases one joint governance model
Platform framework	*Transaction platform*	*Innovation platform* + *Transaction platform*	Integrated platform
Governance configuration	*Explicitly formalized on-chain codified governance* *Explicitly formalized, off-chain governing the codified governance for technical proposals*	*Explicitly formalized on-chain codified governance* *Explicitly formalized, off-chain governing the codified governance for technical proposals.* *Implicit evolving off-chain governing the codified governance mechanisms for intersubjective, socio-technical matters.*	*Explicitly formalized on-chain codified governance* *Explicitly formalized, on-chain governing the codified governance for technical proposals as well as for intersubjective, socio-technical matters.*

Figure 4.12: Evaluation of DLT governance integrity

whether the foundation shares the same name as the associated DLT network (*Ethereum Foundation* and *Ethereum*) or not (*Web3 Foundation* and *Polkadot*). The same mechanism applies to the legitimacy of natural persons, which can be advantageous when fostering network adoption, but also create risk at the same time since all legitimacy has been provided to one concentrated authority. For instance, what happens to the network if this person should resign or pass away at some point in the future? This presents opportunities for applications that provide analyzing heuristic functions, so voting sovereignty is not being overwhelmed in the first place. Likewise, this void is likely to be closed as soon as the machine economy becomes a reality and *autonomous platform ecosystems* are exploited by machines with corresponding and inherent and data-driven decision-making functions, directly integrated with their edge computing devices, thereby minimizing the implicit governing mechanism of heuristics and legitimacy.

> *"We don't see any governance coordination between Bitcoin Cash and Bitcoin anymore; we don't see any governance coordination between Ethereum Classic and Ethereum anymore. So, that's like a failure of governance in some ways. But, in other ways, it allows people not to be locked in."* (Parity Technologies)

Therefore, the integrity of governance is the nexus that converts multiple nodes into a network; it is the social contract, the ex-ante defined collective bond, which authorizes interdependencies with other network participants and allows for the associated implications. The integrity of governance creates acceptance to harmonize and interrelate individual with collective needs. Thus, lock-in effects are also beneficial for the network, as they generate cohesion and therefore are required to occur. Nevertheless, a lock-in effect must not be static and centrally allocated but must be dynamically and distributed along with the network, ensuring that all network participants benefit. Consequently, also decentralized platform ecosystems are not free of lock-in effects; these lock-in effects create specific network effects and cause positive platform externalities.

However, balance and dynamism determine whether to create a sustainable platform ecosystem that creates positive lock-in effects for positive platform externalities while avoiding negative lock-in effects for negative platform externalities due to platform balance and data sovereignty. Decentralized governance models may provide this kind of platform governance integrity. They can become sensitive to the intersubjectivity of the network to establish dynamic ecosystems based upon networking the network effects.

4.5 Initiating *Federated Platform Ecosystems* to Solve Game-Theoretic Challenges in Digital and Multi-Party Coopetition Models

This chapter will first elaborate on game-theoretic challenges that may emerge in coopetition approaches, such as when initiating *federated platform ecosystems*, and how these can be mitigated by a diligent compilation of the consortium participants. Second, I will introduce a framework that derives from the findings of the previous chapters a contrasting classification of roles, activities, and incentive mechanisms within *federated platform ecosystems.* Third, I will provide an overview of applications where *federated platform ecosystems* are reasonably deployed. There, I will showcase how a digital identity management, energy certification, and an application in the industrial context can be fostered by selectively backing some processes with DLTs.

4.5.1 The Composition of a *Platform Consortium* Significantly Influences the Governability of a *Federated Platform Ecosystem*

As discussed in chapter 4.2, *federated platform ecosystems* are initiated in a B2B context by incumbents of pre-existing markets to leverage each company's prevailing and typically asset-heavy core business. As such, it is essential that each partner avoids thinking in terms of value capture mechanisms driven by profit and growth to justify their participation in *federated platform ecosystems* but instead engage in incentive mechanisms that serve as compensation for their contributed activities. Conversely, this implies that a *federated platform ecosystem* is not conceived as a profit-oriented concept and instead is intended to leverage each partner's core business model cost-neutrally. Therefore, any economic evaluation should remain with each individual company based on their core business model. This allows for a collaborative atmosphere within the *federated platform ecosystem*, minimizing game-theoretic challenges inherent in such a coopetition approach. It is worth noting that the goal is to jointly mitigate existing cost structures of each party's prevailing business model and not to generate novel business in a jointly manner. Otherwise, the coopetition approach would become too competitive, requiring much more sophisticated platform governance, rendering the coopetition mode less efficient. Thus, the *federated platform ecosystem* is intended to create a shared digital environment within which *digital truth* prevails, providing data sovereignty, data interoperability, and data portability among the participants. This reduces, in particular, the digital cost structure of each individual by jointly building up positive platform externalities while avoiding monopolistic market structures. The negative platform externalities are internalized through the jointly sponsored *platform consortium* with its inherent consortium governance. For the positive platform externalities, it is essential that network effects are accumulated by the pre-existing customer base of the consortium members. Thereby, if network effects become accumulated efficiently, *federated platform ecosystems* can outperform centralized platform ecosystems effectively. However, solving game-theoretic challenges becomes crucial for this purpose. The more complementary the *platform consortium* and its roles are assembled, the lower these game-theoretic challenges become. The framework depicted in Figure 4.13 is intended to serve as a guideline for the complimentary composition, in which the roles are aligned through activities and incentive structures.

The platform governance within *federated platform ecosystems* is intentionally kept simplistic in the beginning to allow for a more pragmatic and straightforward approach when establishing positive platform externalities. Conversely, this means that game-theoretic challenges within the *platform consortium* need to be minimized, notably in the beginning, until the platform governance has evolved to a more sophisticated state. The more sophisticated the platform governance, the more effective the game-theoretic challenges within the platform ecosystem are permitted. Moreover, the more competitive the composition of *platform consortium* participants is, the greater the game-theoretical challenges; however, in turn, the more efficient the macro-economic state of the digital marketplace. Thus, the long-term objective of a *federated platform ecosystem* should always be to evolve towards a more competitive structure of participants. Although the platform governance grows only gradually and thereby also becomes more sophisticated, the composition of the participants should not exceed the development of the platform governance. A growing and more sophisticated platform governance is thus a prerequisite for the orderly growth of the platform network. The underlying reason for this is the concept of coopetition, which represents the balancing act between cooperation and competition among the participants and is derived from game theory. This is essentially the balancing act between the *Stag Hunt* and the *Prisoner's Dilemma* when considering the underlying game-theoretical concepts.

In the *Stag Hunt*, a rational agent is incentivized to cooperate as this promises a greater benefit to everyone rather than each acting individually. For example, two hunters can either go hunting individually and shoot a rabbit or join forces and hunt a stag together. Half a stag promises more meat than a whole rabbit, so a rational-thinking hunter will opt to join forces with another hunter. However, let's assume, during the pursuit of the stag, a hiker is accidentally shot, without knowing which of the two hunters did it. Therefore, both hunters are temporarily taken into custody by a policeman in order to clarify the situation. For this purpose, both hunters are each put in a prison cell and interrogated about the circumstances of the case. The ex-ante communicated precept is that if hunter A incriminates hunter B while hunter B remains silent, hunter B receives three years detention while hunter A is released, and vice versa. If both hunters remain silent, both hunters get a one-year sentence. If, on the other hand, both hunters incriminate each other, both hunters are given two years' imprisonment (Rapoport et al., 1965). Under such competitive circumstances, a rational-thinking hunter, and thus rational agent, should incriminate the other hunter instead of taking the risk of three years' imprisonment.

An effective governance scheme would have considered the possible scenario of a competitive situation ex-ante. The hunters' bullets would have been numbered, and a forensic identification system would be in place, allowing the case to be clarified without causing the unpleasant situation of the *Prisoner's Dilemma*. This explains why effective governance, including for competitive positions within the *federated platform ecosystem*, must be in place before the platform network becomes competitive in the first place. Thus, the following applies when initiating *federated platform ecosystems* for selecting the *platform consortium*'s partners:

1. as complementary as possible, ensuring that the platform governance is not overburdened already at the outset and thus becomes less robust, resulting in a negative impact on the consortium
2. as few partners as possible, allowing the *federated platform ecosystem* to be built straightforwardly and efficiently, without creating excessive coordinating tasks, which in turn would require more sophisticated governance
3. as the largest partners possible, to address a market share that is as large as possible right from the beginning, to efficiently create established network effects and positive platform externalities.

4.5.2 Introducing a Framework to Guide *Federated Platform Ecosystems* in Their Growing

This chapter presents a framework (see Figure 4.13) to define roles, activities, and incentives in decentralized platform ecosystems. This especially aims to assist in initiating *federated platform ecosystems*, as they are not organically growing from a governance model like *autonomous platform ecosystems*; instead, they are orchestrated by a *platform consortium* according to ex-ante defined roles, activities, and incentives rather in the manner of a business ecosystem. For describing and assigning the *platform consortium*'s participants and their roles accordingly, an appropriate framework is required. This framework consists of four platform layers and five distinct roles, derived from the *autonomous platform ecosystems* in study 2. All of these are required for the decentralized operation of platform ecosystems, such as in the case of *federated platform ecosystems.* In the following, I will concentrate on describing the framework for setting up a *federated platform ecosystem* and its required roles. The collective goal of these roles is to create a trusted environment for multi-party data sharing, where DLT affordances are exploited to integrate *digital truth* and the integrity of decentralized governance into the platform context.

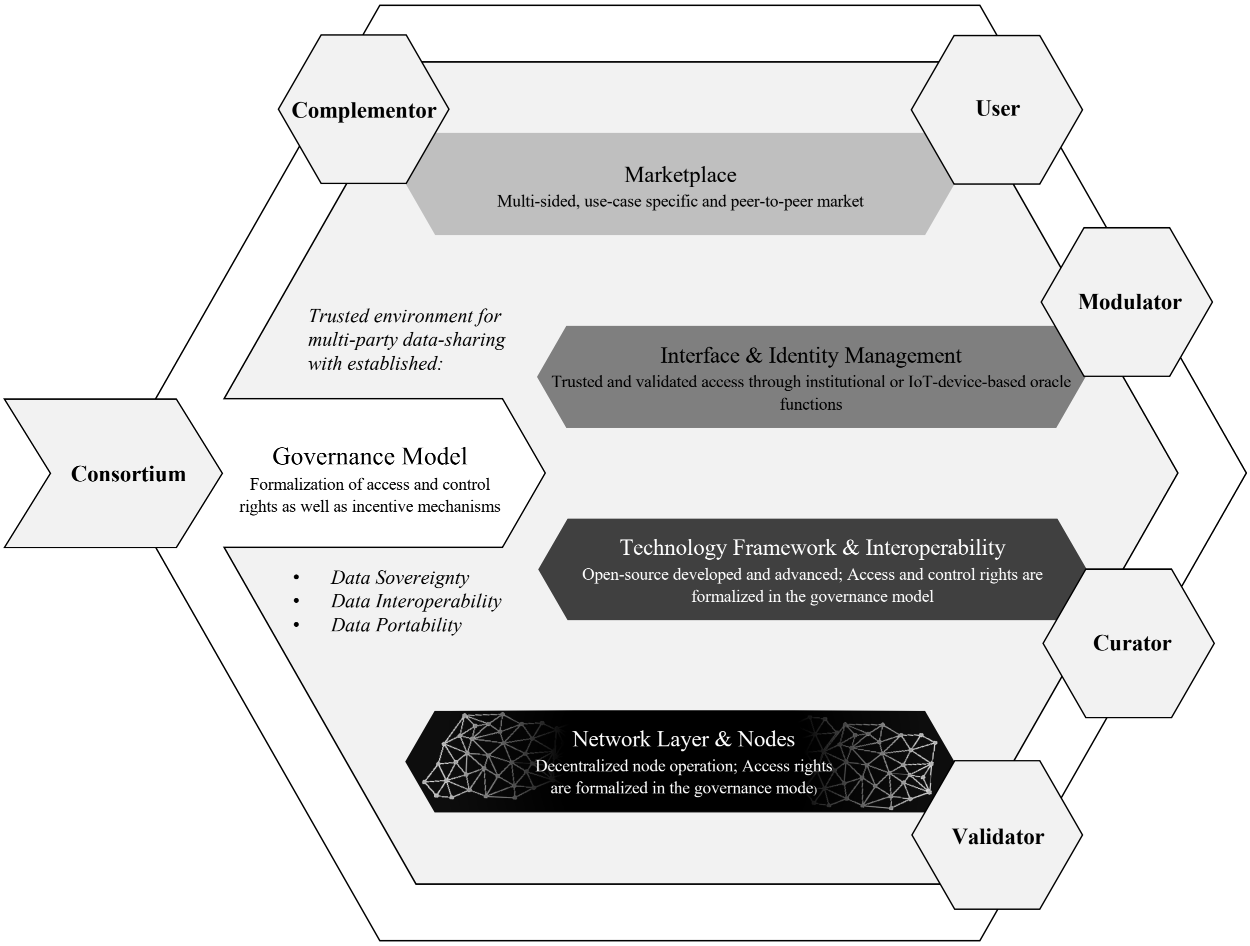


Figure 4.13: A framework to guide and align the establishment of *federated platform ecosystems*

The layer structure spans a digital marketplace between *users* and *complementors*, creating an efficient and transparent multi-sided market that offers a specific value proposition to *users* and *complementors.* As this marketplace is rooted upon a trusted environment that must build digital trust outwards, the interfaces to outwards must be secured from mistrust sources, although it is decentralized. This safeguarding is facilitated by the interface and identity management layer through institutionalized or IoT device-based oracle functions. *Modulators* provide these to verify the single source of truth. As the marketplace aims to evolve from a pure transaction platform into an integrated platform, that also contains an innovation platform and thus continues to develop and remain dynamic in the software component, *curators* are required to provide complementary or new technology frameworks and modules that are simultaneously designed to be interoperable with one another. The decentralized operation of the entire *federated platform ecosystem* and the execution of transactions is maintained in the network layer based on a decentralized node operation and is DLT-backed by *validators*. The governance model enforces the integration of its layers and the coordination of contributed activities into incentive mechanisms. However, in contrast to the *autonomous platform ecosystems*, this is determined by the consortium governance and subsequently monitored by DLTs to ensure compliance.

4.5.3 Increasing Informative Values Through Data Interoperability and Cross-Sector Information Harmonization: Showcased by the Example of Energy Certification

Federated platform ecosystems demonstrate their relevance, for instance, in the energy context, particularly in supporting the decentralized and automated tracking of energy certificates to provide information on the history of energy provision. Especially higher demands in reducing carbon dioxide footprints strive to create transparency and high-resolution when guaranteeing a decarbonized energy provision. The energy transition to decarbonization and decentralization is a substantial task for society and the economy. Effective measurability of carbon dioxide (CO2) footprints and a subsequent incentivization of decarbonization initiatives are essential for successfully harmonizing ecological goals with an economical implementation. Thereby, carbon dioxide certificates become a trusted "currency" to be of effective means in incentivizing a behavioral change of society and economy that is based on market principles while solving game-theoretic challenges. However, this eventually requires a trustworthy environment where information on relevant energy attributes is compiled from existing certification schemes of specific energy sources. Thus, a harmonized data score can be created based on heterogeneous data and information pools, enabling the aggregation of reliable information to generate effective CO2 certificates. This additional informative value, arising from the automated harmonization of complex data structures, is necessary for CO2 certificates to be accepted as a kind of "decarbonization currency." A *federated platform ecosystem* can provide this kind of infrastructure where seamless and cross-sector coupling transfer of energy attributes is fostered through data interoperability.

In such heterogeneous constructs, the affordances of DLTs create the integrative work required to establish an accepted CO2 certificate standard which is derived from different certification schemes. Through the interoperability capabilities of a *federated platform ecosystem*, the high informative value of the different and specific certification schemes remains—through consistent and automated pass-through of energy attributes via smart contracts and tokenization of such attributes—to then aggregate a harmonized CO2 certificate, which maintains the same trusted, informative value. Furthermore, the functionality of the centralized trustee can be decentralized, digitized, and automated, creating corresponding efficiencies as the complexity of the certification system increases. A decentralized certification system becomes particularly relevant as energy provision likewise is becoming increasingly decentralized. The transition from a centralized energy provision with a central energy management system to a decentralized energy provision through a multitude of smaller energy assets will require a decentralized and sensitive energy management system, including a corresponding certification system. This subsequently also allows for a linking of sovereign-acting IoT devices wrapped by the decentralized energy assets. With such a stage, moving from the Internet of Things (IoT) to the Economy of Things (EoT) becomes feasible, a state where things are enabled to act autonomously as economic agents. The ex-ante defined agitation spaces of these EoT agents require a neutral trust layer, which is provided and governed through DLTs and smart contracts. Trusted oracle functions containing a decentralized, digital, and trusted identity are also needed, together with the wrapping EoT device, ensuring that a trusted interface is available to provide a single source of truth to the trusted environment of the *federated platform ecosystem*.

4.5.4 Creating Data Sovereignty for Legal, Natural, and Electronic Persons Through Self-Sovereign Identities: Demonstrated by *IDunion*

To secure the interfaces in *federated platform ecosystems* in a trusted way, so-called oracle functions are required to enable a single source of truth. In the context of industrial B2B applications, a verifiable credentials management system is often chosen for this purpose, allowing the issuance, the management, and the verification of all types of identities and credentials for legal, natural, and electronic persons (for instance, EoT agents such as autonomous vehicles or autonomously economizing industrial robots). This way, institutional or economic authorities, called issuers, digitally sign a corresponding credential upon request of a sovereign agent, called holders. Equipped with this identity, a holder can then present and prove the newly issued credential to a verifier upon prior request. Thus, the verifier is being confirmed with a specific credential without necessarily being provided with all credential details. The processes in-between are tracked on a DLT-based verifiable data registry, providing digital trust between the issuer and the verifier. This decentralized manner of providing trust without losing any data sovereignty is called self-sovereign identities (SSI), a technology framework that comprises various software modules, including DLTs. In the case of *IDunion* (already presented in chapter 4.2.1), these are the components *Hyperledger Indy* (providing client functionalities), supported by *Hyperledger Aries* (providing interoperability features), and *Hyperledger Ursa* (a shared cryptographic library). The DLT protocol *Hyperledger Fabric* backs the decentralized network. The nodes are operated via a private network by the members of the *IDunion* network, including *MainIncubator*, *Bosch*, *Commerzbank*, *Siemens*, *DB Systel*, *Bundesdruckerei*, *Deutsche Telekom*, *Deutsche Post*, *the State of North Rhine-Westphalia*, and the *City of Cologne*. A consortium agreement controls the governance of the *federated platform ecosystem* through a legal entity, which is nevertheless duplicated onto the DLT protocol to enforce compliance within its technical network. Coordination on amendments is done indirectly within the consortium. However, the design of the *federated platform ecosystem* allows the identity harmonization of hybrid issuance either via central and pre-existing authorities, such as the ID card issued by the *Bundesdruckerei* in Germany or via decentralized integration directly in cars or traffic lights by *Bosch* or *Siemens*. Likewise, in addition to the classic identities, financial accounts such as central bank accounts on the part of the banks (*Deutsche Bank*, *Commerzbank*) or decentralized wallets on the part of *Bosch* or *Siemens* can be integrated into the SSI system representing an oracle function to third parties or coupled *federated platform ecosystems*.

4.5.5 Allowing for Data Reciprocities Through Trusted Data Usage and Data Portability: Showcased by the Example of Production as a Service

The competitive advantages generated by positive platform externalities which is offered by platform ecosystems and their digital marketplaces involve platform users to establish digital trust for the platform ecosystem. In the B2C context, digital trust has been quickly established since the value of transactions is usually kept relatively low, allowing this digital trust to be slowly tested by the users over time and eventually to be established after cumulating positive experiences. On the other hand, in the B2B context, this situation is somewhat more complicated since transactions have a significantly higher value and businesses tend not to rely on trust that is only revealed ex-post of such a valuable transaction. Instead, companies tend to require an ex-ante provided *digital truth*, thus being aware prior to executing transactions of how data will be used within and by the platform ecosystem. In a nutshell, the average end user simply will not read the terms and conditions of a platform ecosystem; instead, they will believe it to be compliant and will agree to it. In contrast, business users have a dedicated legal department for such purposes, who will read the terms and conditions very diligently and, if in doubt, tend to reject them. As such, transparency and compliance regarding data usage within a B2B platform ecosystem are prerequisites for adoption in a B2B multi-party context. Internalizing negative platform externalities is precisely the value proposition provided by decentralized platform ecosystems. *Federated platform ecosystems* are the lowest entry point for companies to engage in decentralized platform ecosystems, as they allow for specific control mechanisms to be in place, which in turn positively affect the perceived level of trust of a given corporation. Enterprises, especially in the industrial context, aim to share data—like production data—to receive dynamic and data-based services in return, such as tailored insurance or predictive maintenance. Thus, data silos need to be breached in order to benefit from positive platform externalities. Effective data reciprocity and being able to control data usage on the side of the reciprocity partner is the first and most controlled step towards escaping data silos.

> *"But it is subject to a prior pulling behavior caused by the reciprocity of the use*

> *case itself. If companies were shown concrete use cases and the resulting added value, such as cost savings or increased efficiency, they would immediately be willing to share their machine data with the respective manufacturer. However, in many cases, the major challenge is that the explicit value of such data in a given use case within the reciprocity can hardly be evaluated beforehand."* (former Bystronic)

In other words, data are not released until the counterparty's value proposition has already been determined ex-ante. As a result, this is a matter of bilateral trade that has solely been implemented in a digital context without creating the desired positive platform externalities, such as reducing transaction costs by providing transparency on supply and demand. The risk arises that the so-called hyperscalers such as *Amazon*'s *AWS*, *Microsoft Azure*, or *Google Cloud* will leverage their established economies of scale and become the central provider of multilateral digital marketplaces in the B2B multi-party context while not taking too much care to internalize negative platform externalities. Politically-driven initiatives such as *GAIA-X* (initiated by the German and French governments to create a European and Federated Data Infrastructure) or *Catena-X* attempt to precisely counter this scenario. At the same time, however, they can be understood as politically driven and protectionist, which renders these initiatives subject to global political forces. Thus, competitive decentralized platform ecosystems that are self-sustaining and politically independent while promising the value proposition of internalizing negative platform externalities and simultaneously establishing positive platform externalities are required. While acting as political buy-in, *GAIA-X* and *Catena-X* create the much-needed legal umbrella for coopetition approaches for such an establishment; they also induce the needed attention within complex corporate-organizational structures and provide government-driven investments fostering innovative activities. However, it is essential that the political buy-in does not lead to distraction and statism. Instead, it should be seen as a room of innovation being created, from which various decentralized platform ecosystems and associated technology modules can sprout. A crucial takeaway is that data reciprocities within specific applications should not mistakenly be understood as a digital marketplace providing positive platform externalities. In fact, it should be seen as bilateral trade (see Figure 4.5), acting as the starting point for upcoming digital marketplaces. Existing data reciprocities basically reflect an existing supply and demand of data looking for data exploitation. Orchestration in a multi-party context, where data is not provided in response to a pull request through effective data reciprocity but is provided ex-ante through a push behavior into the data space seeking for data exploitation, will create significant value in an industrial context.

> *"Open source means: 'I give data freely, but I also get data back.' And I think the sum of what you get back is greater than the one part you give out, in many use cases."* (Fraunhofer ISST)

However, this still requires *digital truth* mechanisms, which are currently explored and implemented by *autonomous platform ecosystems.* Thus, it is safe to assume that incumbents will try to avoid centralized platform ecosystems as the infrastructural basis in a B2B multi-party context, while gradually shifting from *federated platform ecosystems* to *autonomous platform ecosystems*—presumably in an imperceptible way—and thus towards dynamic and autonomous networks of networks.

> *"In my view, decentralized platform ecosystems are the only alternative to centralized platform ecosystems. It will be enormously challenging and short-term oriented to ban digital marketplaces and essentially say: 'Amazon and Uber, that's all cruel; they have to be restricted and expelled.' In such a way, we would only isolate ourselves; we simply have to allow digital marketplaces; because people want them because they bring positive benefits. But there is an alternative design choice: open marketplaces, operated by decentralized networks, which configure and self-govern themselves, based on blockchain technology."* (Dr. Karl-Thomas Neumann, former CEO of Opel)

5. Discussion

My mixed methods study identifies DLT business model dimensions, variables, and characteristics based on DLT affordances, while subsequently establishing a taxonomy of DLT business model patterns as well as DLT business model archetypes and decentralized platform ecosystem configurations and characteristics. The extent to which DLT affordances are incorporated in establishing DLT business models is a significant fork in the road that leads ventures down a distinct path of business model design with implications on platform ecosystems and the operating layer. I distinguish between two types of decentralized platform ecosystems, *federated* and *autonomous platform ecosystems*, and present evolutionary stages and design choices of platform ecosystems. My inductive study on DLT governance within *autonomous platform ecosystems* differentiates between codified governance and governing the codified governance mechanisms, where I identify that thoughtful integration of a DLT protocol's ambition to solve game-theoretic challenges within a DLT network must be harmonized and explicitly formalized into a consistent DLT governance design, addressing both governance mechanisms. With my inductive study on *federated platform ecosystems*, I explore the opportunities and managerial implications of a smooth DLT affordance integration into platform ecosystem designs, which internalizes negative platform externalities and fosters positive platform externalities. When successfully, this allows for data-sharing in a B2B multi-party context. These findings have several theoretical and practical implications and give rise to ample future research opportunities.

5.1 Theoretical and Empirical Contributions

I contribute to the literature on platform business models, business models in general, platform ecosystems, and distributed ledger technologies in several ways. Based on my knowledge, I am the first to investigate the implications of DLTs on platform business models and associated platform ecosystems. Through my inductive classification of real-world manifestations of business models in the era of digital technologies and DLTs, I uncover technology-specific attributes and sources of value creation as well as value capture. These stand in stark contrast to the discussion of value drivers in the internet era that has dominated the business model literature ever since Amit and Zott's (2001) notable analysis of e-businesses and suggest a new way to design and optimize platform ecosystems for data sovereignty and information symmetry over cost efficiency and control. These findings are novel to the literature on platform ecosystems in the sense that my model offers distinct pathways organizations can choose in designing their platform business model through technology alone. My analysis calls for a stronger emphasis on (digital) technology affordances in conceptualizing business models and asks how far new digital technologies not only enable novel mechanisms of value creation but also dictate or limit potential business and organizing activities within platform ecosystems (Autio et al., 2018). This is especially true for DLT business models that incorporate a native token in which the lines between value creation and value capture become increasingly fuzzy, calling for managers to engage in open systems thinking and new business model metrics.

As with the literature on platform business models, I also advance and challenge extant sources of value creation and platform externalities and provide more fine-grained distinctions: on the marketplace side, positive externalities lead to transparency in supply and demand as well as lower transaction costs. However, from a platform periphery's perspective, platforms create negative externalities such as lock-in effects, which have led to quasi-monopolistic market structures in favor of dominant platform sponsors (Eisenmann et al., 2011; Gawer, 2020; Zhu & Liu, 2018). Recently, regulators' privacy and antitrust concerns indicated a growing need for regulatory intervention to ensure a positive alignment of platform sponsors' and ecosystem participants' interests (Srinivasan, 2018). However, effective regulation of externalities requires an ex-ante framework (G. Parker et al., 2020). I show how decentralized platform ecosystems can overcome negative platform externalities at the data level for a sustainable platform ecosystem alignment (Vergne, 2020) and compensate for negative externalities of platform ecosystems through its technology-inherent characteristics—characteristics that circumvent the concerns that led to the argument for an ex-ante framework in the first place. These findings call for further investigations into the potential of decentralized platform ecosystems to overcome conflicts in centralized platform ecosystems and their life cycles (Kretschmer et al., 2020).

Moreover, my findings stress the need to increasingly incorporate open-source thinking when designing and managing platform business models through digital technologies when combined with alternative platform governance structures. As in the case of decentralized platform ecosystems, open-source software development approaches, where IP is shared with the community, have become the new standard. Additionally, sequential and open innovation along with innovation spillovers lead to accelerated value creation dynamics with implications for IP rights and platform control (G. Parker & Van Alstyne, 2018). The role of the platform sponsor, as an intermediary, decreases while platform ecosystems are democratized through incentive mechanisms that align not only heterogeneous stakeholders but also respond to business model requirements in redistributing value creation and value capture when lock-in effects are eliminated. DLT-native tokens play a crucial role in this regard as they unlock open-source software contributions that lead to rapid platform innovation and optimal growth orchestration of a platform sponsor (Lian & Van Ryzin, 2021) without requiring oversight (G. Parker & Van Alstyne, 2018). My findings add to the existing literature that increasingly focuses on the integration of tokens and the distinction between a tokenless and a tokenized economy (Cong et al., 2020) and contribute empirical and theoretical insights on their use for information aggregation (information symmetry), coordination (on- and off-chain platform governance), and financing (incentivization tools and mechanisms for initiating, operating and enhancing *autonomous platform ecosystems*) new types of self-sustaining platform ecosystems that are based on decentralized governance structures (Chen et al., 2020).

I have identified data sovereignty, transactional transparency, and information symmetry as crucial DLT affordances in decentralized platform ecosystems. These, in effect, create technology-inherent *digital truth*, which allows for a disintermediated execution of a platform ecosystem's core functionalities (Gu & Zhu, 2021), and in concert with data interoperability and portability, overcome lock-in effects of intermediaries. Therefore, DLTs provide a power balancing within platform ecosystems and, with appropriate governance models, can lead to a democratization of the platform economy.

Finally, I contribute to the literature of distributed ledger technologies by providing classification and evaluation of DLT governance. Using its attributes, I provide causality related to decentralized governance (Chen et al., 2020), considering both explicitly formalized governance mechanisms, which are often part of academic studies (Lumineau et al., 2020) and implicitly emerging governance mechanisms. I consider the implicitly emerging governance mechanisms especially significant within decentralized governance, as these are upstream and controversially discussed off-chain dissonances that are the driving force for hard forks, the most critical explicit governance mechanism, with substantial negative implications for digital trust and network effects of the respective DLT network. Furthermore, I present evidence that decentralized governance must consistently incorporate explicit-formalized governance mechanisms that reflect the respective DLT protocol's own ambition of being able to successfully manage the emergent intersubjectivities of its DLT network.

5.2 Managerial Implications

Besides the theoretical and empirical contribution, I capture in the following the key management implications derived from my findings, aiming for a practical contribution.

The platform design choices described in chapter 4.3 allow for a goal-oriented configuration of platform ecosystems according to an organization's objectives. If cost-efficiency and economies of scale are desired, and the organization does not possess any data-generating devices on its own, centralized platform ecosystems are a desirable choice since such ecosystems are solely dedicated to efficient data orchestration without providing specific opportunities for a pull-through business involving any hardware resources. However, if the organization's core business originates from an asset-heavy background, and the core business is to be promoted by a platform ecosystem while protecting the sovereignty of its data-generating hardware devices and its data points, decentralized platform ecosystems are a suitable choice. If pre-existing customer bases can be contributed to generating network effects, a *federated platform ecosystem* is recommended. The same applies if the core business operates in a highly regulated context, as the indirect platform governance by the *platform consortium* preserves sufficient control mechanisms for the individual enterprises, which can guarantee customer fulfillment and conformity with existing regulations. At the same time, however, this is also an obligation to contribute the established customer base as a mass to the achievement of network effects. Should that be impossible, the DLT-native token can serve as an incentive for creating network effects, which, then, also requires greater decentralization of control rights towards an autonomization of the platform ecosystem—thus causing the appropriate choice to be made in favor of *autonomous platform ecosystems.* Subsequently, the DLT-native token and its coordinating value within platform ecosystems may lead to network effects due to its extrinsic value serving as an incentive mechanism for customer adoption. In addition, the following logic applies: In a B2C context, the network tends to expect a more extraordinary user experience over data sovereignty, something more easily guaranteed by a more centralized control structure of a platform ecosystem. However, in a B2B context, the adoption of platform ecosystems is the opposite; data sovereignty is often a non-negotiable condition for participation and the provision of proprietary data, while user experience tends to be of secondary importance.

Decentralized platform ecosystems are either DLT-based (*autonomous platform ecosystems*) or only DLT-backed (*federated platform ecosystems*), whereby DLT affordances will inherently affect the efficiency and robustness of the platform ecosystem. DLTs tend to have fewer technological concerns but rather organizational challenges due to their decentralized nature. The more decentralized a DLT protocol is designed, and the more heterogeneous the associated DLT network is, the more significant the organizational obstacles posed by consensus building of intersubjectivity with increased game-theoretic challenges. Consequently, it is imperative to incorporate the evaluation of governance models into the technology assessment process. Governance models are integrated for managing these complexities as efficiently as possible, and thus as automatically as possible. *Autonomous platform ecosystems* demonstrate considerable promises with this respect as the most recent developments are becoming more and more mature (see chapter 4.4). Therefore, when initiating *federated* *platform ecosystems*, an orientation toward *autonomous platform ecosystems* should be intended allowing for successively integrating new governance opportunities.

Decentralized platform ecosystems serve their purpose by preventing negative platform externalities such as lock-in effects for a single platform sponsor; thus, preventing monopolistic market structures. Integrating DLT affordances creates information symmetry within the platform ecosystem, granting each platform participant sovereignty of its proprietary data. At the same time, positive platform externalities such as reducing transaction costs are to be maintained to create market efficiency to leverage the core business of each platform participant. Conversely, this implies that the expectations of each platform participant call for a realistic adjustment, accordingly. Exponential growth and disproportionately high margins, as with central platform sponsors, are thus excluded and should not be expected. Central platform sponsors seek to actively tolerate information asymmetries within the platform ecosystem, providing them with a lock-in effect. Through network effects of the digital marketplace, fostered by the positive platform externalities, winner-take-all marketplaces emerge, giving the platform sponsor a monopoly situation within the platform ecosystem and allowing it to exploit this position for disproportionate margins. Consequently, if this is to be effectively prevented by decentralizing the platform ecosystem, expectations for "exponential growth," "10x," and so on cannot arise. Therefore, thinking in terms of platform business models will not result in a satisfactory evaluation. Instead, thinking in incentive mechanisms is preferable, promoting one's core business, and thus rationalizing involvement in decentralized platform ecosystems. It is also important to mention in this context that centralized platform ecosystems usually do not allow for a "fast follower" strategy due to the nature of network effects; instead predominantly allowing only "pioneers" to exist (G. Parker et al., 2020). Hence, and for instance, if there is already a centralized mobility platform ecosystem like *Uber* existent in a market that additionally has already built up network effects successfully, and thus entails a pioneering and dominating position, it will be challenging for non-digital organizations like *Volkswagen* to catch up only by being able to contribute an economy of scale that is asset-driven. In such a comparison, the economies of scale will favor *Uber* with the significantly more efficient network effects over an economy of scale based on a large vehicle fleet. However, suppose such network effects can be effectively pooled with additional mobility providers through a decentralized platform ecosystem. In that case, *Uber*'s network effects can be surpassed, and the monopolistic market structure can be broken. Hence, the core business of such mobility providers can be leveraged, however, implying that this is the only expected outcome. In such a context, where centralized platform monopolies prevail, the maxim "less is more" needs to be applied. Once the lock-in effect of a central platform sponsor has been overcome and information symmetry has been established, *Volkswagen* will again be able to use its economies of scale with its vehicle fleet to become a major complementor within the decentralized platform ecosystem.

The digital era and platform ecosystems have created a paradigm shift to set corporate strategies based on infinite games, where the players and the rules of the game are constantly changing or unknown and where the goal of the game is not deterministic. However, hardware-driven companies tend to think in terms of finite games, with clearly defined rules, players, and a deterministic goal of the game. A data-driven digital environment has different directions, and hardware-driven companies should anchor this in their expectations and the derived corporate strategy.

Once an incumbent chooses to develop a *federated platform ecosystem*, this is typically achieved with or without the support of a central orchestrator but by using a consortium structure with a single legal entity that indirectly incorporates the platform governance. At this point, three composition criteria for the consortium should be considered (see chapter 4.5). First, the consortium should consist of incumbent participants selected as complementary among each other as possible. This allows for a straightforward and efficient approach in building the platform ecosystem, which is particularly valuable in the early stages when the consortium governance is still fragile. The long-term goal for the platform ecosystem should be a competitive environment of platform participants, as this leads to macroeconomic efficiencies. However, this also poses significant game-theoretic challenges, which necessitate sophisticated platform governance. As this is initially designed relatively simple for the purpose of complexity reduction and efficiencies' sake with *federated platform* *ecosystems*, a complementary setup is recommended. Second, for the same reason, the number of consortium participants should be kept to a minimum when starting. Having too many participants will lead to increased complexities. Since *federated platform ecosystems* and the initiating consortium must primarily cope with organizational tasks at the beginning, too many stakeholders would lead to excessive coordination overhead, which would slow down the initiation efforts. Managing the coordination of a complex network is to be reduced by a shared governance model. Therefore, this must evolve steadily and become more advanced and automated as the platform participants grow. Third, only consortium participants should be chosen who guarantee the fastest possible way in generating network effects. Since *federated platform ecosystems* generate network effects by pooling and accumulating the existing customer base of the consortium participants, these should comprise a substantial market share in the target market.

In general, *federated platform ecosystems* require fewer coordinating tasks and less governance if the digital marketplace primarily addresses the optimizing of the cost structure of pre-existing markets, where the market shares are already defined and in place, instead of conquering new markets. This is related to the coopetition model, which originates from game theory. Suppose a pre-existing market share, defined by each participant's core business, is only jointly optimized to be more efficient but is not shifted or newly defined. In that case, a complementary and thus cooperative situation is emerging (*Stag Hunt*, cf. chapter 4.5.1). If, on the other hand, a new market is to be entered, the market shares of the respective consortium participants must first be staked out and negotiated, which leads to competitive behaviors, which in turn requires effective and sophisticated platform governance (*Prisoner's Dilemma*, cf. chapter 4.5.1).

Furthermore, politically driven initiatives such as *GAIA-X* support the development of *federated platform ecosystems*. The political buy-in creates a legal framework for trusted collaboration without antitrust concerns; it attracts the appropriate attention within the management of the stakeholder organizations; it allows for financial seed funding provided by the government. However, it is important to stress that it must not lead to statism and a protectionist attitude. This would cause the *federated platform ecosystem* to lose its independence and become subject to political dictates. Instead, a self-regulating and competitive platform structure is required, transcending the bilateral arrangement of reciprocities, targeting a multi-party context, and establishing a trusted environment that allows for data sharing without constraints. For this purpose, digital trust is required, which is conditioned by a robust governance model.

Finally, DLT affordances provide benefits independently of a platform governance context. DLTs can efficiently regulate even large data complexities according to ex-ante defined policies, assuming DLTs the capacity of enforcement of compliance within the digital space. Thus, micro-tracking of complex data streams at economically viable conditions becomes viable. Suppose these opportunities are systemically integrated into digital processes. In such a case, process compliance can be enforced digitally and automatically, thereby ensuring micro-tracking to entail micro-enforcement, which can ultimately be exploited for micro-incentives—for example, to overcome game-theoretical challenges in the decarbonization context and successfully manage climate change. Instead of selective waivers that induce societal and global inequity, systemic incentives are provided by high-resolution tracking and enforcing of environmental standards tied directly to CO2 emissions. Thus. their informative value can then be used as the basis for CO2 certificates, promoting sustainability innovations and achieving global adoption. Global challenges that require a cooperative mode in game theory also require globally effective tracking and incentive mechanisms that enable such a constructive engagement. Isolated activities lead to globally competitive behaviors, which collectively constitute destructiveness.

5.3 Conclusion and Limitations

Remaining true to the spirit of mixed method research, I explored four distinct DLT business model archetypes, which bundle into two decentralized platform ecosystem classes. I use the findings to better inform the literature within platform ecosystems and business models. I believe this to be the start rather than the end. My findings raise questions concerning meta-organizational classifications and features such as authority, incentives, and coordination mechanisms (Kretschmer et al., 2020). Future researchers could address the precise mechanisms of how authority is being established. In particular, authority through legitimacy within *autonomous platform ecosystems* is rarely studied in terms of its mechanisms and robustness. In addition, the incentivizing mechanisms of the two decentralized platform ecosystem classes have significant implications for their coupled existing business models. For example, leveraging core business models through a shared platform offered by the *federated platform ecosystem* poses game-theoretic challenges embedded in the coopetition mode (Nalebuff & Brandenburger, 1997; Ritala & Hurmelinna-Laukkanen, 2009). Related issues involve the ratio between collaborative value creation and individual value capture—specifically, what proportions are economically viable for each organization to allow the business ecosystem to be pragmatically developed in a goal-oriented manner. With *autonomous platform ecosystems*, questions arise regarding the DLT-native tokens' internal value. What kinds and value trajectories of tokens enable sustainable incentivization of all actors within the platform ecosystem? Equally relevant is the regulatory aspect of tokens, as amendments to regulation can have a significant impact on incentivization mechanisms for value creation, especially for open-source software contributions. This entire subject of tokenomics requires further research to design incentive mechanisms according to its objectives effectively.

Finally, I have introduced a new kind of platform ecosystem in this dissertation: decentralized platform ecosystems. The democratic approach of these platform ecosystems is anchored in their governance model. Both the "analog" and indirect governance of the *federated platform ecosystem*, as well as the "digital" and direct governance of the *autonomous platform ecosystem*, need to be designed in a balanced, robust, and purposeful manner. Future research should address the conditions of decentralized platform ecosystems and the corresponding design of the governance models to ensure their long-term success. This will help address theoretical concepts, such as the Coase Theorem (Coase, 1960), which could effectively be implemented with DLTs to strengthen positive externalities and dissolve negative externalities.

References

Adner, R. (2017). Ecosystem as structure: An actionable construct for strategy. *Journal of Management*, *43*(1), 39–58. https://doi.org/10.1177/0149206316678451

Aggarwal, C. C., & Zhai, C. (2012). *Mining text data*. Springer Science & Business Media. https://doi.org/10.1007/978-1-4614-3223-4

Amit, R., & Zott, C. (2001). Value creation in e-business. *Strategic Management Journal*, *22*(6-7), 493–520. https://doi.org/10.1002/smj.187

Amit, R., & Han, X. (2017). Value creation through novel resource configurations in a digitally enabled world. *Strategic Entrepreneurship Journal*, *11*(3), 228–242. https://doi.org/10.1002/sej.1256

Autio, E., Nambisan, S., Thomas, L. D. W., & Wright, M. (2018). Digital affordances, spatial affordances, and the genesis of entrepreneurial ecosystems. *Strategic Entrepreneurship Journal*, *12*(1), 72–95. https://doi.org/10.1002/sej.1266

Back, A. (2002). Hashcash - a denial of service counter-measure. http://www.hashcash.org/papers/hashcash.pdf

Baden-Fuller, C., & Haefliger, S. (2013). Business models and technological innovation. *Long Range Planning*, *46*(6), 419–426. https://doi.org/10.1016/j.lrp.2013.08.023

Baden-Fuller, C., & Morgan, M. S. (2010). Business models as models. *Long Range Planning*, *43*(2), 156–171. https://doi.org/10.1016/j.lrp.2010.02.005

Baldwin, C. Y., & Woodard, C. J. (2009). The architecture of platforms: A unified view. In A. Gawer (Ed.), *Platforms, markets and innovation*. Edward Elgar.

Baldwin, C. Y., & Clark, K. B. (2000). *Design rules: The power of modularity*. MIT Press.

Bellavitis, C., Cumming, D. J., & Vanacker, T. R. (2020). Ban, boom, and echo! Entrepreneurship and initial coin offerings. *Entrepreneurship Theory and Practice*. https://doi.org/10.2139/ssrn.3608978

Bhargava, H. K. (2021). Bundling for flexibility and variety: An economic model for multiproducer value aggregation. *Management Science*, *67*(4), 2365–2380. https://doi.org/10.1287/mnsc.2020.3662

Biais, B., Bisiere, C., Bouvard, M., & Casamatta, C. (2019). The blockchain folk theorem. *The Review of Financial Studies*, *32*(5), 1662–1715. https://doi.org/10.1093/rfs/hhy095

Björkdahl, J. (2009). Technology cross-fertilization and the business model: The case of integrating ICTs in mechanical engineering products. *Research Policy*, *38*(9), 1468–1477. https://doi.org/10.1016/j.respol.2009.07.006

Block, J. H., Fisch, C. O., Hahn, A., & Sandner, P. G. (2015). Why do SMEs file trademarks? Insights from firms in innovative industries. *Research Policy*, *44*(10), 1915–1930. https://doi.org/10.1016/j.respol.2015.06.007

Böhme, R., Christin, N., Edelman, B., & Moore, T. (2015). Bitcoin: Economics, technology, and governance. *The Journal of Economic Perspectives*, *29*(2), 213–238. https://doi.org/10.1257/jep.29.2.213

Borgatti, S. P., Mehra, A., Brass, D. J., & Labianca, G. (2009). Network analysis in the social sciences. *Science*, *323*(5916), 892–895. https://doi.org/10.1126/science.1165821

Boudreau, K. J. (2010). Open platform strategies and innovation: Granting access vs. devolving control. *Management Science*, *56*(10), 1849–1872. https://doi.org/10.1287/mnsc.1100.1215

Boudreau, K. J. (2012). Let a thousand flowers bloom? An early look at large numbers of software app developers and patterns of innovation. *Organization Science*, *23*(5), 1409–1427. https://doi.org/10.1287/orsc.1110.0678

Boudreau, K. J., & Hagiu, A. (2009). Platform rules: Multi-sided platforms as regulators. In A. Gawer (Ed.), *Platforms, markets and innovation* (pp. 163–191). Edward Elgar.

Boudreau, K. J., & Jeppesen, L. B. (2015). Unpaid crowd complementors: The platform network effect mirage. *Strategic Management Journal*, *36*(12), 1761–1777. https://doi.org/10.1002/smj.2324

Burdges, J., Cevallos, A., Czaban, P., Habermeier, R., Hosseini, S., Lama, F., Alper, H. K., Luo, X., Shirazi, F., Stewart, A., & Wood, G. (2020). Overview of Polkadot and its design considerations. *arXiv*arXiv 2005.13456.

Buterin, V. (2014). A next-generation smart contract and decentralized application platform. https://ethereum.org/en/whitepaper/

Casadesus-Masanell, R., & Zhu, F. (2013). Business model innovation and competitive imitation: The case of sponsor-based business models. *Strategic Management Journal*, *34*(4), 464–482. https://doi.org/10.1002/smj.2022

Cenamor, J., & Frishammar, J. (2021). Openness in platform ecosystems: Innovation strategies for complementary products. *Research Policy*, *50*(1), 104148. https://doi.org/10.1016/j.respol.2020.104148

Cennamo, C., & Santaló, J. (2019). Generativity tension and value creation in platform ecosystems. *Organization Science*, *30*(3), 617–641. https://doi.org/10.1287/orsc.2018.1270

Centieiro, H. (2021). Decoding Bitcoin's first block coinbase transaction. Retrieved December 10, 2021, from https://medium.com/geekculture/decoding-bitcoins-first-block-coinbase-transaction-aeefe87ceec0

Chen, Y., Pereira, I., & Patel, P. C. (2020). Decentralized governance of digital platforms. *Journal of Management*, *47*(5), 1305–1337. https://doi.org/10.1177/0149206320916755

Cheng, S. F., De Franco, G., Jiang, H., & Lin, P. (2019). Riding the blockchain mania: Public firms' speculative 8-K disclosures. *Management Science*, *65*(12), 5901–5913. https://doi.org/10.1287/mnsc.2019.3357

Chesbrough, H., & Rosenbloom, R. S. (2002). The role of the business model in capturing value from innovation: Evidence from xerox corporation's technology spin-off companies. *Industrial and Corporate Change*, *11*(3), 529–555. https://doi.org/10.1093/icc/11.3.529

Christidis, K., & Devetsikiotis, M. (2016). Blockchains and smart contracts for the internet of things. *IEEE Access*, *4*, 2292–2303. https://doi.org/10.1109/ACCESS.2016.2566339

Ciarli, T., Kenney, M., Massini, S., & Piscitello, L. (2021). Digital technologies, innovation, and skills: Emerging trajectories and challenges. *Research Policy*, *50*(7), 104289. https://doi.org/10.1016/j.respol.2021.104289

Ciborra, C. U. (1996). The platform organization: Recombining strategies, structures, and surprises. *Organization Science*, *7*(2), 103–118. https://doi.org/10.1287/orsc.7.2.103

Coase, R. H. (1960). The problem of social cost. In *Classic papers in natural resource economics* (pp. 87–137). Palgrave Macmillan, London.

Cong, L. W., & He, Z. (2019). Blockchain disruption and smart contracts. *The Review of Financial Studies*, *32*(5), 1754–1797. https://doi.org/10.1093/rfs/hhz007

Cong, L. W., Li, Y., & Wang, N. (2020). Tokenomics: Dynamic adoption and valuation. *The Review of Financial Studies*, *34*(3), 1105–1155. https://doi.org/10.1093/rfs/hhaa089

Constantinides, P., Henfridsson, O., & Parker, G. G. (2018). Introduction—Platforms and infrastructures in the digital age. *Information Systems Research*, *29*(2), 381–400. https://doi.org/10.1287/isre.2018.0794

Corbin, J., & Strauss, A. (2014). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. SAGE Publications.

Corley, K. G., & Gioia, D. A. (2004). Identity ambiguity and change in the wake of a corporate spin-off. *Administrative Science Quarterly*, *49*(2), 173–208. https://doi.org/10.2307/4131471

Cumming, D., Meoli, M., & Vismara, S. (2019). Investors' choices between cash and voting rights: Evidence from dual-class equity crowdfunding. *Research Policy*, *48*(8), 103740. https://doi.org/10.1016/j.respol.2019.01.014

Cusumano, M. A., Gawer, A., & Yoffie, D. B. (2019). *The business of platforms: Strategy in the age of digital competition, innovation, and power*. Harper Business.

Cutolo, D., Hargadon, A., & Kenney, M. (2021). Competing on platforms. *MIT Sloan Management Review*, *62*(3), 22–30.

Dai, W. (1998). B-money. http://www.weidai.com/bmoney.txt

Darking, M., Whitley, E. A., & Dini, P. (2008). Governing diversity in the digital ecosystem. *Communications of the ACM*, *51*(10), 137–140. https://doi.org/10.1145/1400181.1400211

Demil, B., & Lecocq, X. (2010). Business model evolution: In search of dynamic consistency. *Long Range Planning*, *43*(2), 227–246. https://doi.org/10.1016/j.lrp.2010.02.004

de Reuver, M., Sørensen, C., & Basole, R. (2018). The digital platform: A research agenda. *Journal of Information Technology*, *33*(2), 124–135. https://doi.org/10.1057/s41265-016-0033-3

Di Stefano, G., Gambardella, A., & Verona, G. (2012). Technology push and demand pull perspectives in innovation studies: Current findings and future research directions. *Research Policy*, *41*(8), 1283–1295. https://doi.org/10.1016/j.respol.2012.03.021

Dutch Blockchain Conference. (2016). Gavin Wood on how $60m hack of DAO happened and what to do next. Retrieved December 10, 2021, from https://youtu.be/JzCGRtGyxvY

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal*, *50*(1), 25–32. https://doi.org/10.5465/amj.2007.24160888

Eisenmann, T., Parker, G., & Van Alstyne, M. (2011). Platform envelopment. *Strategic Management Journal*, *32*(12), 1270–1285. https://doi.org/10.1002/smj.935

Eisenmann, T., Parker, G., & Van Alstyne, M. W. (2006). Strategies for two-sided markets. *Harvard Business Review*, *84*(10), 92.

Ethereum Foundation. (2014). What is the Ether sale? Retrieved December 10, 2021, from https://web.archive.org/web/20140804235628/https://www.ethereum.org/

Ethereum Foundation. (2021). Upgrading Ethereum to radical new heights. Retrieved December 10, 2021, from https://ethereum.org/en/eth2/

Evans, D. S. (2003). Some empirical aspects of multi-sided platform industries. *Review of Network Economics*, *2*(3). https://doi.org/10.2202/1446-9022.1026

Finney, H. (2004). RPOW - reusable proofs of work. Retrieved December 10, 2021, from https://cryptome.org/rpow.htm

Foss, N. J., & Saebi, T. (2017). Fifteen years of research on business model innovation: How far have we come, and where should we go? *Journal of Management*, *43*(1), 200–227. https://doi.org/10.1177/0149206316675927

Frankenberger, K., & Sauer, R. (2019). Cognitive antecedents of business models: Exploring the link between attention and business model design over time. *Long Range Planning*, *52*(3), 283–304. https://doi.org/10.1016/j.lrp.2018.05.001

Frankenberger, K., Weiblen, T., & Gassmann, O. (2014). The antecedents of open business models: An exploratory study of incumbent firms. *R&D Management*, *44*(2), 173–188. https://doi.org/10.1111/radm.12040

Gassmann, O., Frankenberger, K., & Csik, M. (2014). *The business model navigator: 55 models that will revolutionise your business*. Pearson UK.

Gawer, A. (2014). Bridging differing perspectives on technological platforms: Toward an integrative framework. *Research Policy*, *43*(7), 1239–1249. https://doi.org/10.1016/j.respol.2014.03.006

Gawer, A. (2020). Digital platforms' boundaries: The interplay of firm scope, platform sides, and digital interfaces. *Long Range Planning*. https://doi.org/10.1016/j.lrp.2020.102045

George, G., Merrill, R. K., & Schillebeeckx, S. J. D. (2020). Digital sustainability and entrepreneurship: How digital innovations are helping tackle climate change and sustainable development. *Entrepreneurship Theory and Practice*. https://doi.org/10.1177/1042258719899425

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. https://doi.org/10.1177/1094428112452151

Glaser, B. G., & Strauss, A. L. (2017). *Discovery of grounded theory: Strategies for qualitative research*. Routledge. https://doi.org/10.4324/9780203793206

Goodfellow, I., Bengio, Y., Courville, A., & Bengio, Y. (2016). *Deep learning*. MIT press Cambridge.

Grigg, I. (1999). How digicash blew everything. Retrieved December 10, 2021, from https://cryptome.org/jya/digicrash.htm

Gu, G., & Zhu, F. (2021). Trust and disintermediation: Evidence from an online freelance marketplace. *Management Science*, *67*(2), 794–807. https://doi.org/10.1287/mnsc.2020.3583

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. *Handbook of Qualitative Research*, *2*(163-194), 105.

Gulati, R., Puranam, P., & Tushman, M. (2012). Meta-organization design: Rethinking design in interorganizational and community contexts. *Strategic Management Journal*, *33*(6), 571–586. https://doi.org/10.1002/smj.1975

Hagiu, A., & Wright, J. (2015). Multi-sided platforms. *International Journal of Industrial Organization*, *43*, 162–174. https://doi.org/10.1016/j.ijindorg.2015.03.003

Hamacher, A. (2020). Who are Ethereum's co-founders and where are they now? Retrieved December 10, 2021, from https://decrypt.co/36641/who-are-ethereums-co-founders-and-where-are-they-now

Hannen, J., Antons, D., Piller, F., Salge, T. O., Coltman, T., & Devinney, T. M. (2019). Containing the Not-Invented-Here syndrome in external knowledge absorption and open innovation: The role of indirect countermeasures. *Research Policy*, *48*(9), 103822. https://doi.org/10.1016/j.respol.2019.103822

Hassan, S., & De Filippi, P. (2021). Decentralized autonomous organization. *Internet Policy Review*, *10*(2), 1–10. https://doi.org/10.14763/2021.2.1556

Iansiti, M., & Lakhani, K. R. (2017). The truth about blockchain. *Harvard Business Review*, *95*(1), 118–127.

Jacobides, M. G., Cennamo, C., & Gawer, A. (2018). Towards a theory of ecosystems. *Strategic Management Journal*, *39*(8), 2255–2276. https://doi.org/10.1002/smj.2904

Jentzsch, C. (2016). Decentralized autonomous organization to automate governance. https://lawofthelevel.lexblogplatformthree.com/wp-content/uploads/sites/187/2017/07/WhitePaper-1.pdf

Johnson, M. W., Christensen, C. M., & Kagermann, H. (2008). Reinventing your business model. *Harvard Business Review*, *86*(12), 57–68.

Kane, G. C., Alavi, M., Labianca, G., & Borgatti, S. P. (2014). What's different about social media networks? A framework and research agenda. *MIS Quarterly*, *38*(1), 274–304. https://doi.org/10.25300/misq/2014/38.1.13

Kapoor, R. (2018). Ecosystems: Broadening the locus of value creation. *Journal of Organization Design*, *7*(1), 12. https://doi.org/10.1186/s41469-018-0035-4

Katz, M. L., & Shapiro, C. (1985). Network externalities, competition, and compatibility. *American Economic Review*, *75*(3), 424–440.

Katz, M. L., & Shapiro, C. (1994). Systems competition and network effects. *Journal of Economic Perspectives*, *8*(2), 93–115. https://doi.org/10.1257/jep.8.2.93

Ketchen, D. J., & Shook, C. L. (1996). The application of cluster analysis in strategic management research: An analysis and critique. *Strategic Management Journal*, *17*(6), 441–458. https://doi.org/10.1002/(SICI)1097-0266(199606)17:6<441::AID-SMJ819>3.0.CO;2-G

Kretschmer, T., Leiponen, A., Schilling, M., & Vasudeva, G. (2020). Platform ecosystems as meta-organizations: Implications for platform strategies. *Strategic Management Journal*. https://doi.org/10.1002/smj.3250

Kvale, S., & Brinkmann, S. (2009). *Interviews: Learning the craft of qualitative research interviewing*. SAGE.

Leask, G., & Parker, D. (2007). Strategic groups, competitive groups and performance within the U.K. pharmaceutical industry: Improving our understanding of the competitive process. *Strategic Management Journal*, *28*(7), 723–745. https://doi.org/10.1002/smj.603

Lehoux, P., Daudelin, G., Williams-Jones, B., Denis, J.-L., & Longo, C. (2014). How do business model and health technology design influence each other? insights from a longitudinal case study of three academic spin-offs. *Research Policy*, *43*(6), 1025–1038. https://doi.org/10.1016/j.respol.2014.02.001

Leung, A. C. M., Agarwal, A., Konana, P., & Kumar, A. (2017). Network analysis of search dynamics: The case of stock habitats. *Management Science*, *63*(8), 2667–2687. https://doi.org/10.1287/mnsc.2016.2470

Lian, Z., & Van Ryzin, G. (2021). Optimal growth in two-sided markets. *Management Science*. https://doi.org/10.1287/mnsc.2020.3832

Lingens, B., Miehé, L., & Gassmann, O. (2020). The ecosystem blueprint: How firms shape the design of an ecosystem according to the surrounding conditions. *Long Range Planning*, *54*(2). https://doi.org/10.1016/j.lrp.2020.102043

Locke, T. (2021). Ethereum co-founder on why he got into crypto: Empower the little guy, 'screw' the big guy — 'they already have enough money'. Retrieved December 10, 2021, from https://www.cnbc.com/2021/05/18/why-ethereum-founder-vitalik-buterin-got-into-crypto-bitcoin.html

Lofland, J., & Lofland, L. H. (1971). *Analyzing social settings*. Wadsworth Publishing Company.

Lumineau, F., Wang, W., & Schilke, O. (2020). Blockchain governance—a new way of organizing collaborations? *Organization Science*, *32*(2), 500–521. https://doi.org/10.1287/orsc.2020.1379

Massa, L., Tucci, C. L., & Afuah, A. (2017). A critical assessment of business model research. *Academy of Management Annals*, *11*(1), 73–104. https://doi.org/10.5465/annals.2014.0072

McDonald, R. M., & Eisenhardt, K. M. (2020). Parallel play: Startups, nascent markets, and effective business-model design. *Administrative Science Quarterly*, *65*(2), 483–523. https://doi.org/10.1177/0001839219852349

McIntyre, D. P., & Srinivasan, A. (2017). Networks, platforms, and strategy: Emerging views and next steps. *Strategic Management Journal*, *38*(1), 141–160. https://doi.org/10.1002/smj.2596

Meyer, A. D., Tsui, A. S., & Hinings, C. R. (1993). Configurational approaches to organizational analysis. *Academy of Management Journal*, *36*(6), 1175–1195. https://doi.org/10.5465/256809

Miles, R. E., Snow, C. C., Meyer, A. D., & Coleman, H. J., Jr. (1978). Organizational strategy, structure, and process. *Academy of Management Review*, *3*(3), 546–562. https://doi.org/10.2307/257544

Miller, D., & Mintzberg, H. (1983). The case for configuration. In M. G. (Ed.), *Beyond method*. CA: Sage.

Miller, D., & Friesen, P. H. (1978). Archetypes of strategy formulation. *Management Science*, *24*(9), 921–933. https://doi.org/10.1287/mnsc.24.9.921

Momtaz, P. P. (2020). Entrepreneurial finance and moral hazard: Evidence from token offerings. *Journal of Business Venturing*. https://doi.org/10.1016/j.jbusvent.2020.106001

Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system. https://bitcoin.org/bitcoin.pdf

Nalebuff, B. J., & Brandenburger, A. M. (1997). Co-opetition: Competitive and cooperative business strategies for the digital economy. *Strategy & Leadership*, *25*(6), 28–33. https://doi.org/10.1108/eb054655

Nambisan, S. (2017). Digital entrepreneurship: Toward a digital technology perspective of entrepreneurship. *Entrepreneurship Theory and Practice*, *41*(6), 1029–1055. https://doi.org/10.1111/etap.12254

Nambisan, S., Siegel, D., & Kenney, M. (2018). On open innovation, platforms, and entrepreneurship. *Strategic Entrepreneurship Journal*, *12*(3), 354–368. https://doi.org/10.1002/sej.1300

Nambisan, S., Wright, M., & Feldman, M. (2019). The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes. *Research Policy*, *48*(8), 103773. https://doi.org/10.1016/j.respol.2019.03.018

Narayanan, A., Bonneau, J., Felten, E., Miller, A., & Goldfeder, S. (2016). *Bitcoin and cryptocurrency technologies: A comprehensive introduction*. Princeton University Press.

Natarajan, H., Krause, S., & Gradstein, H. (2017). *Distributed ledger technology and blockchain*. World Bank, Washington, DC. https://doi.org/10.1596/29053

Panico, C., & Cennamo, C. (2020). User preferences and strategic interactions in platform ecosystems. *Strategic Management Journal*. https://doi.org/10.1002/smj.3149

Panurach, P. (1996). Money in electronic commerce: Digital cash, electronic fund transfer, and ecash. *Communications of the ACM*, *39*(6), 45–50. https://doi.org/10.1145/228503.228512

Parity Technologies. (2017). A postmortem on the Parity multi-sig library self-destruct. Retrieved December 10, 2021, from https://www.parity.io/blog/a-postmortem-on-the-parity-multi-sig-library-self-destruct/

Parker, G., Petropoulos, G., & Van Alstyne, M. (2020). *Digital platforms and antitrust.*

Parker, G., & Van Alstyne, M. (2018). Innovation, openness, and platform control. *Management Science*, *64*(7), 3015–3032. https://doi.org/10.1287/mnsc.2017.2757

Parker, G., Van Alstyne, M., & Choudary, S. P. (2016). *Platform revolution: How networked markets are transforming the economy and how to make them work for you.* W. W. Norton & Company.

Parker, G., & Van Alstyne, M. W. (2014). *Platform strategy.* https://doi.org/10.2139/ssrn.2439323

Parker, G., Van Alstyne, M. W., & Jiang, X. (2017). Platform ecosystems: How developers invert the firm. *MIS Quaterly*, *41*(1), 255–266. https://doi.org/10.25300/misq/2017/41.1.13

Patel, P. C., Messersmith, J. G., & Lepak, D. P. (2013). Walking the tightrope: An assessment of the relationship between high-performance work systems and organizational ambidexterity. *Academy of Management Journal*, *56*(5), 1420–1442. https://doi.org/10.5465/amj.2011.0255

Peterson, A. (2014). Hal Finney received the first Bitcoin transaction. here's how he describes it. Retrieved December 10, 2021, from https://www.washingtonpost.com/news/the-switch/wp/2014/01/03/hal-finney-received-the-first-bitcoin-transaction-heres-how-he-describes-it/

Popper, N. (2015). *Digital gold: The untold story of Bitcoin.* Penguin UK.

Punj, G., & Stewart, D. W. (1983). Cluster analysis in marketing research: Review and suggestions for application. *Journal of Marketing Research*, *20*(2), 134–148. https://doi.org/10.1177/002224378302000204

Rapoport, A., Chammah, A. M., & Orwant, C. J. (1965). *Prisoner's dilemma: A study in conflict and cooperation*. University of Michigan Press.

Rietveld, J., Schilling, M. A., & Bellavitis, C. (2019). Platform strategy: Managing ecosystem value through selective promotion of complements. *Organization Science*, *30*(6), 1232–1251. https://doi.org/10.1287/orsc.2019.1290

Ritala, P., & Hurmelinna-Laukkanen, P. (2009). What's in it for me? Creating and appropriating value in innovation-related coopetition. *Technovation*, *29*(12), 819–828. https://doi.org/10.1016/j.technovation.2009.07.002

Rochet, J.-C., & Tirole, J. (2003). Platform competition in two-sided markets. *Journal of the European Economic Association*, *1*(4), 990–1029. https://doi.org/10.1162/154247603322493212

Schär, F., & Berentsen, A. (2020). *Bitcoin, blockchain, and cryptoassets: A comprehensive introduction*. MIT Press.

Schmeiss, J., Hoelzle, K., & Tech, R. P. G. (2019). Designing governance mechanisms in platform ecosystems: Addressing the paradox of openness through blockchain technology. *California Management Review*, *62*(1), 121–143. https://doi.org/10.1177/0008125619883618

Schückes, M., & Gutmann, T. (2020). Why do startups pursue initial coin offerings (ICOs)? The role of economic drivers and social identity on funding choice. *Small Business Economics*. https://doi.org/10.1007/s11187-020-00337-9

Shapiro, C., & Varian, H. R. (1998). *Information rules: A strategic guide to the network economy*. Harvard Business Press.

Shen, M., Spencer, C., Deeter, K., & Garg, A. (2021). Electric capital: Developer report. https://github.com/electric-capital/developer-reports/blob/master/dev_report_2020_updated_april_2021.pdf

Shermin, V. (2017). Disrupting governance with blockchains and smart contracts. *Strategic Change*, *26*(5), 499–509. https://doi.org/10.1002/jsc.2150

Shipilov, A., & Gawer, A. (2020). Integrating research on interorganizational networks and ecosystems. *Academy of Management Annals*, *14*(1), 92–121. https://doi.org/10.5465/annals.2018.0121

Short, J. C., Payne, G. T., & Ketchen, D. J., Jr. (2008). Research on organizational configurations: Past accomplishments and future challenges. *Journal of Management*, *34*(6), 1053–1079. https://doi.org/10.1177/0149206308324324

Singh, M., & Kim, S. (2019). Blockchain technology for decentralized autonomous organizations. In *Advances in computers* (pp. 115–140). Elsevier.

Srinivasan, D. (2018). The antitrust case against Facebook. *Berkeley Business Law Journal*, *16*(1), 39–98.

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. https://doi.org/10.1111/isj.12206

Szabo, N. (1996). Smart contracts: Building blocks for digital markets. *Extropy: The Journal of Transhumanist Thought,(16)*, *18*(2).

Szabo, N. (2005). Bit Gold. Retrieved December 10, 2021, from https://nakamotoinstitute.org/bit-gold/

Teece, D. (2010). Business models, business strategy and innovation. *Long Range Planning*, *43*(2), 172–194. https://doi.org/10.1016/j.lrp.2009.07.003

The Guardian. (2021). Australian man Craig Wright who says he created Bitcoin takes £4bn claim to London high court. Retrieved December 10, 2021, from https://www.theguardian.com/technology/2021/may/13/australian-man-craig-wright-who-alleges-he-created-bitcoin-takes-4bn-claim-to-london-high-court

Thomes, T. P. (2015). In-house publishing and competition in the video game industry. *Information Economics and Policy*, *32*, 46–57. https://doi.org/10.1016/j.infoecopol.2015.07.005

Tiwana, A., & Konsynski, B. (2010). Complementarities between organizational IT architecture and governance structure. *Information Systems Research*, *21*(2), 288–304. https://doi.org/10.1287/isre.1080.0206

Tiwana, A., Konsynski, B., & Bush, A. A. (2010). Research commentary—platform evolution: Coevolution of platform architecture, governance, and environmental dynamics. *Information Systems Research*, *21*(4), 675–687. https://doi.org/10.1287/isre.1100.0323

Vergne, J. P. (2020). Decentralized vs. distributed organization: Blockchain, machine learning and the future of the digital platform. *Organization Theory*, *1*(4). https://doi.org/10.1177/2631787720977052

Viens, A. (2019). Mapping the major Bitcoin forks. Retrieved December 10, 2021, from https://www.visualcapitalist.com/major-bitcoin-forks-subway-map/

von Briel, F., Davidsson, P., & Recker, J. (2018). Digital technologies as external enablers of new venture creation in the IT hardware sector. *Entrepreneurship Theory and Practice*, *42*(1), 47–69. https://doi.org/10.1177/1042258717732779

Wareham, J., Fox, P. B., & Cano Giner, J. L. (2014). Technology ecosystem governance. *Organization Science*, *25*(4), 1195–1215. https://doi.org/10.1287/orsc.2014.0895

Web3 Foundation. (2017). Web3 multi-sig wallet update. Retrieved December 10, 2021, from https://medium.com/web3foundation/web-3-multi-sig-wallet-update-245d30df0fb3

Web3 Foundation. (2021). Polkadot and Ethereum 2.0. Retrieved December 10, 2021, from https://wiki.polkadot.network/docs/learn-comparisons-ethereum-2

Weber, R. P. (1990). *Basic content analysis*. SAGE.

Wirtz, B. W., Pistoia, A., Ullrich, S., & Göttel, V. (2016). Business models: Origin, development and future research perspectives. *Long Range Planning*, *49*(1), 36–54. https://doi.org/10.1016/j.lrp.2015.04.001

Wood, G. (2014). Ethereum: A secure decentralised generalised transaction ledger. https://gavwood.com/paper.pdf

Wood, G. (2016). Polkadot: Vision for a heterogeneous multi-chain framework. https://polkadot.network/PolkaDotPaper.pdf

Wood, G. (2019). Gavin Wood: Building tech that protects our interests. Retrieved December 10, 2021, from https://relaychain.fm/1-gavin-wood

Wood, G. (2020). Polkadot behind the code, episode 1: The idea, featuring Gavin Wood. Retrieved December 10, 2021, from https://youtu.be/GcOKXAOh4Xw

Yin, R. K. (2003). Designing case studies. In *Qualitative research methods*. Sage publications London, UK.

Zammuto, R. F., Griffith, T. L., Majchrzak, A., Dougherty, D. J., & Faraj, S. (2007). Information technology and the changing fabric of organization. *Organization science*, *18*(5), 749–762. https://doi.org/10.1287/orsc.1070.0307

Zhu, F., & Iansiti, M. (2012). Entry into platform-based markets. *Strategic Management Journal*, *33*(1), 88–106. https://doi.org/10.1002/smj.941

Zhu, F., & Liu, Q. (2018). Competing with complementors: An empirical look at amazon.com. *Strategic Management Journal*, *39*(10), 2618–2642. https://doi.org/10.1002/smj.2932

Zott, C., & Amit, R. (2010). Business model design: An activity system perspective. *Long Range Planning*, *43*(2), 216–226. https://doi.org/10.1016/j.lrp.2009.07.004

Zott, C., Amit, R., & Massa, L. (2011). The business model: Recent developments and future research. *Journal of Management*, *37*(4), 1019–1042. https://doi.org/10.1177/0149206311406265

A. Appendix

A.1 Striking Characteristics of DLT Business Model Archetypes

Dimensions	**Variables**	**Striking characteristics**	**Federated Platform Ecosystems**		**Autonomous Platform Ecosystems**	
			Platform Consortium	**DLT as a Service**	**DLT Ecosystem**	**DApp**
Target customer	*Target group*	End users	secondary	secondary	dominating	dominating
		Businesses customers	dominating	dominating	dominating	dominating
	Relationship model	Ecosystem building	dominating	secondary	dominating	secondary
		Two-sided market	secondary	secondary	secondary	dominating
		Bilateral exchange	secondary	dominating	secondary	secondary
Value proposition	*Offering*	DLT-based asset management	dominating	secondary	secondary	dominating
		DLT-based data management	dominating	dominating	dominating	dominating
		DLT-based organization & process management	dominating	secondary	dominating	secondary
		Advisory & consulting	secondary	dominating	secondary	secondary
	DLT-induced differentiation	DLT-induced data protection & data sovereignty	dominating	secondary	dominating	secondary
		DLT-induced cost & time efficiency	dominating	secondary	secondary	dominating
		Complementary features & services	secondary	dominating	dominating	secondary
Value creation	*Knowledge allocation*	Specific industry knowledge	dominating	dominating	secondary	dominating
		Sophisticated DLT expertise	secondary	dominating	dominating	secondary
	DLT development	Leveraging prevailing DLT developments	dominating	dominating	dominating	dominating
		Contributing to DLT protocols or modules	secondary	secondary	dominating	secondary
		No DLT developments	secondary	dominating	secondary	secondary
	Token integration	Token has inherent network functionality	secondary	secondary	dominating	dominating
		Business requirements lead to token omission	dominating	dominating	secondary	secondary
Value capture	*Adoption mechanism*	Token distribution	secondary	secondary	dominating	dominating
		Community engagement	dominating	dominating	dominating	secondary
		Online marketing	secondary	dominating	secondary	dominating
		Leveraging reputation	dominating	secondary	secondary	secondary
	Revenue generation	Commission/Transaction fees	dominating	secondary	dominating	dominating
		Pay-per-use	secondary	dominating	secondary	secondary
		Subscription model	secondary	dominating	secondary	secondary

Figure A.1: Key characteristics of DLT business model archetypes

A.2 Further Publications

Articles

Schmück, K.; Schückes, M.; Möllers, T.; Gutmann, T.; Gassmann, O. (2021). *Less Trust, More Truth: Design Choices and Implications for Platform Business Models and Ecosystems in the Age of Distributed Ledger Technologies* Manuscript submitted for publication.

Conference Papers

Schmück, K., Möllers, T., Rogalla, C. (2018): *Business Model Innovation in the Era of Distributed Ledger Technologies*, EURAM 2018.

Schmück, K.; Kranz, S., Gassmann, O. (2019): *Open Source Governance Mechanisms in the Era of Distributed Ledger Technologies: An Analysis of Bitcoin, Ethereum, and Polkadot*, SMS 2019 (Proposal)

Schmück, K; Schückes, M.; Möllers, T.; Gutmann, T.; Gassmann, O. (2021): *Aligning Platform Ecosystems through Distributed Ledger Technologies*, AoM 2021

Book Chapters

Schmück, K; Gassmann, O. (2019). *DLT/Blockchain-basiert Geschäftsmodelle.* In: Gassmann, O.; Sutter, P. (Eds.). Digitale Transformation

Schmück, K.; Sturm, M.; Gassmann, O. (2021). *Decentralized Platform Ecosystems for Data Sharing and Digital Trust in Industrial Environments.* In: Gassmann, O.; Ferrandina, F. (Eds.). Connected Business

Schmück, K; Gilgen, N. (2021). *Governing Democratized Platform Ecosystems.* In: Hilb, M. (Ed.). Governance of Ecosystems

Newspaper or Magazine Articles

Gassmann, O.; Schmück, K.; Gilgen, N. (2019). *Democratizing the Platform Economy: The Quiet Revolution Through Blockchain*, coinjournal.net

Schmück, K.; Gilgen, N. (2019). *The Democratization of the Platform Economy.* Medium series together with the Share&Charge Foundation

A.3 Curriculum Vitae

Personal Details

Date of birth	October 13, 1988
Place of birth	Frankfurt/Main, DE
Nationality	German

Higher Education

Since 08/21	**Boston University Questrom School of Business** *Boston, MA, USA* Visiting Scholar
Since 09/17	**University of St.Gallen** *St. Gallen, CH* Research Associate & Project Manager
10/09 – 05/17	**RWTH Aachen University** *Aachen, DE* Studies of Mechanical Engineering

Working Experience

07/17 – 12/21	**Institute of Technology Management (ITEM-HSG), University of St.Gallen (HSG)** *St. Gallen, CH* Project lead: research cooperation with *Siemens AG* & *Siemens Energy AG*
07/17 – 06/18	**BMI Lab** *St. Gallen, CH* Consultant & Doctoral Researcher
2012 – 2017	**Volkswagen Group Digitalization** | *Wolfsburg, DE* **FEV GmbH** | *Aachen, DE* **FEV North America, Inc.** | *Auburn Hills, MI, USA* **Volkswagen Slovakia** | *Bratislava, SK* **AUDI AG** | *Neckarsulm, DE* Intern