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Designing a Token Economy: Incentives, Governance and Tokenomics

Master's thesis

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Tokenimajanduse disain: stiimulid, valitsemissüsteemid ja tokenoomika

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Author’s declaration of originality

I hereby certify that I am the sole author of this thesis. All the used materials, references to the literature and the work of others have been referred to. This thesis has not been presented for examination anywhere else.

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Abstract

In recent years, tokenomic systems have evolved that allow for more complex incentive structures, which have greatly increased the applicability of blockchain systems further than mere transactional use cases. Nevertheless, little has been documented about the design of sustainable token economies, resulting in the collapses of several cryptoeconomic ecosystems, e.g., the collapse of Luna and TerraUSD in early 2022. The majority of the state-of-the-art literature focuses on either 1) niche use cases such as industrials or gaming, some applying Design Science Research (DSR) methodology, 2) theoretical frameworks for token classification, 3) the aspects of token economy in isolation: governance, token incentive design, and tokenomics. No scientific literature exists, however, that proposes a holistic step-by-step token economy design framework which considers these three facets. This thesis aims to provide such a practical design framework, which is fundamentally different from abstract theoretical frameworks. By following a DSR methodology, overlapping ideas in the literature are analysed, and a step-by-step token economy guidebook is synthesised. The artefact is then evaluated using 1) the case study method based on Currynomics – an ecosystem that maintains the Redcurry stablecoin with real estate as the token's underlying asset, and 2) additional expert interviews. Thematic analysis is applied to the semi-structured interviews held both in the case study and expert interviews.

This thesis is written in English and is 103 pages long, including 7 chapters, 8 figures and 9 tables.

Annotatsioon

Tokenimajanduse disain: stiimulid, valitsemissüsteemid ja tokenoomika

Viimastel aastatel on oluliselt arenenud plokiahela virtuaalvääringutel ehk tokenitel põhinevad tokenimajandused ehk tokeniökosüsteemid, mis võimaldavad organisatsioonide sidusrühmade vahel luua keerukaid stiimulstruktuure. Tänu sellistele tokenimajandustele on plokiahela rakendatavus arenenud kaugemale kui pelgalt plokiahela kaudu teostatavad (makse)tehingud. Siiski esineb hetkel vähe teaduskirjandust jätkusuutliku tokenimajanduse disaini kohta, mis on kaasa toonud mitmete tokenimajanduslike ökosüsteemide ebaõnnestumise, nagu näiteks Luna ja TerraUSD kokkuvarisemine 2022. aasta alguses. Valdav osa uuemast kirjandusest tokenimajanduslike süsteemide disainimisel keskendub kas 1) nišikasutusjuhtudele näiteks tööstusvaldkondades või mängudes, 2) teoreetilistele raamistikele tokenite kategoriseerimiseks või 3) eraldiseisvatele tokenimajanduse disainiaspektidele: stiimulite disain, valitsemissüsteemid ja tokenoomika ehk tokenite rahapoliitika kujundamine. Puudub teaduskirjandus, mis käsitleks terviklikku samm-sammult järgitavat tokenimajanduse disainijuhendit, mis arvestaks nimetatud kolme aspektiga. Käesoleva töö eesmärgiks on koostada praktiline disainijuhend, mis erineb oma olemuselt teoreetilistest raamistikest, mis kalduvad olema liiga abstraktsed. Järgides *Design Science Research (DSR)* metoodikat, analüüsib autor kirjanduses leiduvaid tokenimajanduse loomise nõuandeid ja parimaid praktikaid ning sünteesib juhendi ehk artefakti, mis võimaldab lugejal samm-sammult tokenimajanduse disainiga alustada. Artefakti valideerimine toimub esmalt läbi juhtumiuuringu, mille aluseks on Currynomics-nimeline tokeniökosüsteem, mille eesmärk on luua virtuaalvääring, mille väärtus on tagatud alusvaraks oleva kinnisvaraportfelliga. Teise valideerimismeetodina kasutatakse täiendavaid intervjuusid kolme valdkonna eksperdiga. Mõlemas valideerimisetapis viiakse läbi poolstruktureeritud intervjuud, millele rakendatakse temaatilist analüüsi.

Lõputöö on kirjutatud inglise keeles ning sisaldab teksti 103 leheküljel, 7 peatükki, 8 joonist, 9 tabelit.

List of abbreviations and terms

CRE	Commercial Real Estate
DAO	Decentralised Autonomous Organisation
DEX	Decentralised Exchange
DSR	Design Science Research
ICO	Initial Coin Offering
IEO	Initial Exchange Offering
IS	Information Systems
NAV	Net Asset Value
PoP	Proof of personhood
PoaP	Proof of attendance
STO	Security Token Offering
1t1v	1-token-1-vote

Table of contents

1 Introduction 12

1.1 Aim of the Thesis 13

1.2 State of the Art 14

1.2.1 Special Purpose Token Economy Design 14

1.2.2 Theoretical Frameworks of Token Economies 15

1.2.3 Token Economy Design Aspects 16

1.2.4 Summary of the State of the Art 18

1.3 Research Questions 18

1.4 Research Methodology 20

1.4.1 Design Science Research 20

1.4.2 Research Guidelines 21

2 Research Background 24

2.1 Building Blocks of Token Economies 24

2.1.1 Token Definition 24

2.1.2 Token Types 25

2.1.3 Token Economy Definition 27

2.2 Use-Case Problem 28

2.2.1 The Currynomics Ecosystem 28

2.2.2 Premises for Currynomics Token Economy Design 30

3 Incentives 31

3.1 Introduction 31

3.2 Token Economy Value Proposition 32

3.2.1 Token Economy Functions 32

3.2.2 Functions of the Currynomics Token Economy 33

3.2.3 Stakeholder Mapping 33

3.2.4 Stakeholders in Currynomics 34

3.3 Defining Desirable Behaviours 35

3.3.1 Desirable Behaviours in Currynomics 36

3.4 Selection of Incentive Mechanisms 37

3.4.1 Monetary and Non-monetary Incentive Mechanisms 37
3.4.2 Types of Monetary Incentive Mechanisms 39
3.4.3 Types of Non-monetary Reward Mechanisms 40
3.4.4 Incentive Mechanisms in Currynomics 41
3.5 Conclusion 43
4 Governance 45
4.1 Introduction 45
4.2 Governance Decentralisation 47
4.2.1 Governance Areas 47
4.2.2 Governance Areas in Currynomics 47
4.2.3 Governance Decentralisation 48
4.2.4 Decentralisation in Currynomics 50
4.3 On-chain and Off-chain Governance 51
4.3.1 On-chain and Off-chain Governance Mechanisms 51
4.3.2 On-chain and Off-chain Governance in Currynomics 52
4.4 Voting Mechanisms 53
4.4.1 Desired Voting Mechanism Properties 53
4.4.2 Core Voting Mechanisms 54
4.4.3 Support Mechanisms for Voting 57
4.4.4 Voting in Currynomics 58
4.5 Conclusion 61
5 Tokenomics 63
5.1 Introduction 63
5.2 Token Issuance 64
5.2.1 Amount 64
5.2.2 Timing 65
5.2.3 Token Release Schedule in Currynomics 66
5.3 Token Distribution 67
5.3.1 Private and public token distribution 67
5.3.2 Token Distribution in Currynomics 68
5.4 Token Price Sustainability 69
5.4.1 Token Underlying Value 69
5.4.2 Price Management Mechanisms 70
5.4.3 Token Price Sustainability in Currynomics 71

5.5 Conclusion 74
6 Evaluation 76
6.1 Methodology 76
6.1.1 Case Study 76
6.1.2 Expert Interviews 77
6.2 Results 79
6.3 Discussion 82
6.3.1 Case Study 82
6.3.2 To-Be State of the Use-Case 85
6.3.3 Expert Interviews 86
7 Conclusion 91
7.1 Conclusion 92
7.2 Research Questions 92
7.2.1 RQ1: How to Design Token Economy Incentive Mechanisms? 92
7.2.2 RQ2: How to Design Token Economy Governance? 93
7.2.3 RQ3: How to Design Token Economy Tokenomics? 93
7.3 Limitations 93
7.4 Future Work 94
References 95
Appendix 1 – Non-exclusive licence for reproduction and publication of a graduation thesis 102
Appendix 2 – Interviewee List 103

List of figures

Figure 1. The House Framework by Barrera & Hurder (2020) 16
Figure 2. IS Research Framework. Hevner et al. (2004) 21
Figure 3. Redcurry portfolio generation and cash movement cycle 30
Figure 4. Stakeholder map of the Currynomics ecosystem 30
Figure 5. Goal model for designing token economy incentive structures 42
Figure 6. Goal model for designing token economy governance 60
Figure 7. Goal model for designing token economy tokenomics 73
Figure 8. Summary of the code labels in thematic analysis 81

List of tables

Table 1. Required token characteristics by Tapscott (2020) 25
Table 2. Currynomics ecosystem stakeholders... 35
Table 3. Currynomics ecosystem token holders and their desirable behaviours 37
Table 4. Selection guide for monetary or non-monetary incentive mechanisms 39
Table 5. Legend for the goal model 42
Table 6. Use case comparison for centralisation and decentralisation 50
Table 7. Centralised and decentralised governance areas in Currynomics 51
Table 8. Summary of voting mechanisms and their properties 57
Table 9. Summary of interview comments on model evaluation metrics 80

1 Introduction

Blockchain technology has become increasingly popular in recent years due to its ability to provide decentralisation, security, and transparency. However, even with significant advancements in blockchain technology over time, the true potential of it has not yet been fully realised. While simple cryptocurrency transfers are straightforward to execute and comprehend, it remains challenging to link such transactions to real-world objects or activities. The latter makes it difficult to extend the range of beneficial blockchain use cases [1]. As a solution, cryptographic tokens have emerged that can be used to represent various assets or utilities within a network [2].

Before blockchain technology, tokens were commonly associated with vouchers indicating tangible values such as casino chips or beverages at festivals [3]. In the blockchain context, tokens act as a claim on both physical and immaterial assets - e.g., gold ingots, real estate, and the accompanying rental contracts. Establishing a connection between real-life and blockchain technology paves the way for the development of advanced and inventive applications. Thus, tokens play an important role in offering competition to the hyper scaler web2 platforms that have reached a near monopoly status during the last decade [4]. These dominant platforms – e.g., Facebook, Instagram, Airbnb, and Google – own users' data in a centralised manner, allowing the former to use it for the sake of increasing proprietary profits [5]. Such centralisation endangers user data privacy, as well as increases the ecosystem's general vulnerability against hackers [6]. Tokens, however, enable translating various functionalities of such platforms – from social media to search engines and file storage – into a decentralised form, where the user data cannot be maliciously converted into profits for the intermediary platforms.

There is a further range of benefits tokens provide for blockchain startups: they are an innovative channel for financing and can function as an "internal currency" of the ecosystems [7]. Also, due to their decentralised nature, tokens enabled the creation of a novel organisational form - decentralised autonomous organisations (DAOs), which are entities that are led almost entirely by self-executive predefined rules or algorithms that are called smart contracts [8]. Tokens provide the foundation for the governance mechanisms of DAOs by enabling token-based voting when changes need to be made to these smart contracts. Most importantly, tokens can align the interest of various stakeholder groups in a blockchain ecosystem, as the value of the token is tied to the inherent value-add of the ecosystem itself [6].

The wide range of token functionalities, however, brings about the need for careful tokenomic design - a claim supported by a range of academic literature. Developers often do not fully comprehend the incentive structures they are setting up for the users of blockchain systems, as well as how the incentivisation may backfire in the emergence of unexpected market events [9]. For example, an ill-reasoned use of combined token functionalities - asset and payment tokens - can hinder the growth of token ecosystems [10]. Also, excessive token liquidity decreases a token economy's market capitalisation in relation to future profits, setting a limit on financing [11]. Sockin & Xiong [12] warn against a token price collapse - a situation where there is no such equilibrium price that would match the token supply with the demand, commonly caused by speculation.

One of the largest empirical examples of poor tokenomic design is the collapse of Luna and TerraUSD tokens in 2022, causing thousands of stakeholders to lose their investments [13]. Many more blockchain collapses during the year were caused by the excessive accumulation of risk within the cryptocurrency ecosystem [9]. That is, inadequate risk management frequently coincided with poor product design, whereby tokens were created in a manner that left them vulnerable to significant losses when unexpected events occurred. In 2022, a lot of digital asset initiatives and token releases continued to cause damage to individuals who used them and those who bought the tokens [14]. Often, these individuals ended up with worthless tokens after an initial period of success.

1.1 Aim of the Thesis

Considering the challenges and importance of designing a token economy, the objective of this thesis is to propose a design artefact that offers a step-by-step guide for practitioners in establishing the fundamentals of a sustainable token economy. To this end, existing literature is examined to identify overlapping methodologies and theories regarding token economy design and is iterated towards an effective design artefact. The use-case to aid the search process for effective design principles is Currynomics – a token ecosystem that is developing a stablecoin (the Redcurry token) pegged to the Net Asset Value (NAV) of an underlying commercial real estate (CRE) portfolio. The business environment describing the goals of the Currynomics ecosystem can be accessed via its publicly available documentation [15]. Finally, the artefact is evaluated via 1) a case study by assessing the real-life practicality of the proposed design guidelines when employed by the Currynomics ecosystem, and 2) additional expert interviews. Thematic analysis is applied to the semi-structured interviews held both in the case study and expert interviews.

1.2 State of the Art

This chapter introduces the state-of-the-art literature regarding token economy design, which can be categorised into three: 1) the incentive design of various token economy stakeholders (described in Chapter 1.2.1), token economy governance (Chapter 1.2.2), and tokenomics (Chapter 1.2.3). Lastly, Chapter 1.2.4 summarises the existing body of knowledge.

1.2.1 Special Purpose Token Economy Design

A large part of the existing token design research is focused on special-purpose token design cases: for example, [16] [17] in the industrial and [18] [19] [20] in the automotive industry. Furthermore, Direr et al. [21] create an economic design for a Web3 game; Hou et al. [22] establish a mechanism for a public voluntary carbon market while utilising a dual token economic model; and Kim et al. [23] propose a model for token economics that can be implemented within the Insolar business network. The closest study to propose a step-by-step guidebook for token economy design is by Kim & Chung [24], who analyse a tokenised social network Steemit and suggest an 8-step design flow for ensuring a successful initial coin offering (ICO). The latter studies are, however, based on specific use cases and are likely not helpful for building token economies in other fields.

Some of the special purpose design frameworks follow a DSR methodology: Ballandies et al. [25] suggest a new methodology which combines DSR and value-sensitive design to address cryptoeconomic design principles in light of the commons dilemma when an ecosystem is designed with environmental sustainability as one of the underlying values. The proposed methodology and resulting design framework are nevertheless mainly derived from only technical details regarding distributed ledger and consensus mechanisms. Aistov et al. [5] take the narrow definition of a token economy as a financing method for decentralised platforms that include the use of bonding curves. They propose the following design aspects to specify in a token economy: 1) token function, 2) consensus mechanism, 3) the number of token types, 4) use of primary or secondary marketplaces, and 5) the type of the bonding curve. However, the research leaves aside scenarios where the adoption of a bonding curve mechanism is not necessary.

An earlier paper addressing token economy design using a DSR approach is by Hülsemann & Tumasjan [26], who develop an agent-based model for determining and testing the effect of different token types on user incentives to join prediction markets. Their key research questions, however, revolve around selecting an optimal token type for fostering user adoption and retention and are thus not linked to other aspects of token economy design such as governance and tokenomics. Moreover, the proposed artefact is a model which practitioners can use to test the effect of token design on user behaviour pre-launch but does not provide guidelines for the design process itself.

1.2.2 Theoretical Frameworks of Token Economies

Another larger block of existing literature features theoretical frameworks regarding token economy design. Benedetti et al. [27] examine typical tokenomic designs, explore various regulatory approaches, and showcase current applications of utility tokens in decentralised platforms such as decentralised finance and virtual reality platforms. Lage et al. [28] provide a comprehensive analysis of the fundamental characteristics of decentralised platform models based on blockchain technology. Khamisa [6] suggests a theoretical structure for token economy design, which includes defining economic goals, token design, and establishing appropriate governance mechanisms.

A more extensive theoretical concept for designing a token economy is suggested by Barrera & Hurder [29], who borrow most of the insights from economic theory. They introduce the House Framework (see Figure 1), which is a framework aimed at blockchain economic design. It consists of five layers, where each one is foundational to the one above it: 1) value proposition, 2) financing, 3) incentives, 4) token design, and 5) governance. The incentive and token layers are highlighted and considered the key components. Nevertheless, Barrera & Hurder bring out only a few design choices regarding each layer and sublayer, leaving a gap in the literature for a more thorough explanation of how to navigate among the numerous design choices.

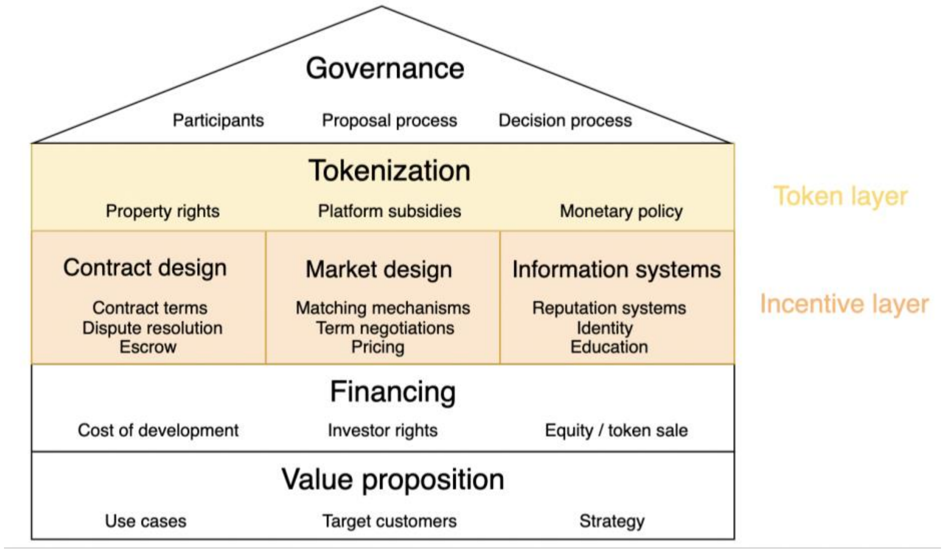


Figure 1. The House Framework by Barrera & Hurder (2020)

Within the theoretical framework domain, several papers address token classification and taxonomy. Freni et al. [30] map three broad channels through which tokens can add value - technology, behaviour, and coordination. They also suggest three core aspects that need to be assessed in designing a token economy - token characteristics, monetary policy, and incentive mechanisms. Oliviera et al. [2] attempt to compile a universal guidebook on token design based on a thorough literature review and 16 expert interviews. Tapscott [31] defines and describes tokens as digital assets, the token taxonomy framework, as well as benefits of shared token standards.

1.2.3 Token Economy Design Aspects

There exists literature that covers various aspects of token economy governance. Fritsch et al. [32] undertake an empirical study of three significant DAO governance systems - Compound, Uniswap, and ENS - and investigate the distribution of voting power within these systems. Bena & Zhang [33] explore the decentralised governance of a token economy, wherein users contribute to the ecosystem's output and face varying costs that are contingent on the type of technology utilized by the platform. Kiayas & Lazos [34] provide a basis for evaluating governance procedures in blockchain systems. Similarly, Liu et al. [35] propose a blockchain governance framework that provides a comprehensive perspective on factors such as the degree of decentralisation, decision-making authority, incentives, accountability, ecosystem, and legal and ethical obligations. Fernandez et al. [36] employ an agent-based model to simulate and examine the concentration of voting rights tokens following a fair token launch. Gazi & Sadhev [37] present a value-based blockchain governance model and analysis that considers blockchain protocols as digital commons, rather than public infrastructure, and Bersani [38] examines the distinctions between governance tokens and securities from the perspective of investment contracts. Mohan et al. [39] delve deeper into the challenges of Sybil attacks, plutocracy and enabling the expression of preference intensity.

Another standalone topic that emerges from the literature is designing the incentive system behind the tokens. Jürjens et al. [40] examine the impact of token design on incentivisation within ecosystems that rely on decentralised ledger technology. They present two use cases - supply chain management and personal data market. Guo et al. [41] suggest a "dual incentive value-based" model that enhances the profitability of a token economy in the business market. Liu et al. [42] investigate the effects of token incentives on the competition between two decentralised exchange platforms – Sushiswap and Uniswap. Liu et al. [4] examine Steemit's incentive mechanism and evaluate the effect of the dual roles of social capital theory and psychological ownership theory on user participation behaviour.

The third prominent category under token economy design revolves around tokenomics, also referred to as token supply strategies or token monetary policy. Lommers et al. [43] examine previous instances of airdrops and deliberate on the strategies for creating effective airdrops. Similarly, Liu & Zhu [44] model the behaviour of greedy hackers (Sybils) in token airdrops. Carvalho [45] compares the effects of tokenomics to the foundational concepts in finance (shares, profits, dividends), and Lommers et al. [46] elaborate on a valuation framework for DAOs. Gan et al. [47] examine the design process for a successful ICO, specifically in the context of post-ICO income and limits on token issuance caps. Kaal [14] examines the commonalities of projects that use "fair token launches", whereas Kaal et al. [48] evaluate existing asset valuation methods and their limited application to digital assets. Kusmierz & Overko [49] analyse the wealth distribution of the richest addresses in various cryptocurrencies. Allen et al. [50] apply corporate finance theory to the practice of token burn and buyback mechanisms.

The most similar study to the thesis at hand is by Schubert et al. [3], who follow a DSR methodology to develop a modular framework that guides the design of token use cases. The framework consists of 1) environment modules, 2) token types and 3) a system configurator. However, it only minimally handles the topic of designing token economy tokenomics. In the system configurator, the authors bring out that a token supply can be fixed/unlimited, burnable/non-burnable, have an expiry date/not, and list five options for token distribution. The reader has no guidelines on how to decide between the options. Token distribution, for example, is closely linked to governance if the tokens also have voting power. As to governance, they list that decisions can be made on-chain / off-chain and can be central / community-based. No steps are offered for the reader to determine what is the best option for the ecosystem.

1.2.4 Summary of the State of the Art

The existing state of the art in token design can at large be categorised into three: 1) studies specialising on niche use cases (e.g., industrials, gaming, carbon credits, and social media) - some of them applying DSR methodology, 2) ones proposing theoretical frameworks for token design and classification but no step-by-step guidelines 3) papers discussing the important aspects of token economy in isolation: governance, token incentive design, and tokenomics. As is also confirmed by Schubert et al. [3], there is a lack of structured and holistic frameworks for developing token economies. Therefore, to the best of the author's knowledge, no scientific literature exists that proposes a step-by-step wholesome token economy design framework which considers the aspects of incentive design, governance and tokenomics.

1.3 Research Questions

Considering the research gap outlined above, the core research question this thesis aims to answer is as follows:

RQ: How to design a sustainable token economy?

After analysing the state-of-the-art literature on the topic of token economy design, three core domains stand out that make up a token economy: the incentive design of various token economy stakeholders, token economy governance, and tokenomics. This is supported by Khamisa [6], who states that designing a token economy needs a "multidisciplinary" framework, where the core components are "stakeholder mapping", "governance mechanisms", and "economic objectives". Thus, the suggested token economy design process in this thesis entails three components that form the three sub-questions explained below. Since establishing clear incentive structures for the token economy participants is a key step in the design of blockchain ecosystems, the first sub-question is:

RQ1: How to design token economy incentive mechanisms?

For the token economy to adapt to the changes in the environment and its users' preferences, changes must likely be made to the underlying protocol. A key aspect in designing a token economy is thus to understand who, when and how can decide on suggesting and implementing the changes to be made to the ecosystem. Governance is heavily linked to the ecosystem's incentive mechanisms (RQ1), in that the ability to participate in the governance acts as an incentive mechanism in itself. Also, to coordinate the participants to take part in token economy governance, it is necessary to establish incentive mechanisms specific to governance. Thus, the second sub-question is:

RQ2: How to design token economy governance?

The last core component in designing a token economy is about understanding how and when are the tokens issued. Tokenomics, the economics of the tokens in circulation, is closely linked to incentive structures, as it directly influences all monetary incentive rewards the ecosystem issues. Also, poor design of token distribution promotes harmful speculative behaviour among individuals who want to benefit from token price movement. Similarly, poor allocation of tokens that have voting rights can work against the objectives set in the governance design. The third sub-question is therefore:

RQ3: How to design token economy tokenomics?

The remaining thesis is structured as follows: Chapter 2 introduces the necessary definitions regarding the token economy as well as the thesis' use case – the Currynomics ecosystem. Chapter 3 elaborates on the steps to consider in laying a foundation for token economy incentive structures. Chapter 4 goes into the details of how to design governance mechanisms for the token economy. Chapter 5 provides guidelines on how to distribute the tokens and manage the supply to guarantee token price long-term sustainability. Chapter 6 evaluates the artefact by 1) applying a case study on the Currynomics ecosystem and 2) conducting additional expert interviews. Lastly, Chapter 7 features the conclusions of the study.

1.4 Research Methodology

This chapter elaborates on the methodology applied in this thesis. Chapter 1.4.1 defines Design Science Research (DSR), and Chapter 1.4.2 explains the core guidelines when applying DSR.

1.4.1 Design Science Research

The chosen methodology for this thesis is DSR, as the latter is well suited for socio-technical systems such as a token economy [51]. DSR is described as an iterative search process, where the aim is to create an artefact or design theory which would enable an organisation to move from an actual to a desired state of operations. DSR aims to contribute to the existing knowledge base by building and evaluating either an artefact or a design theory that solves a real issue in the business environment.

The goal of the current thesis is to build and evaluate a novel artefact - a design process for establishing the fundamentals of a token economy. The core structure of the artefact is inspired by the House Framework [29] - a framework for blockchain economic design introduced in Chapter 1.2.2. Similar to Khamisa [6], it distinguishes token incentives and governance as separate crucial design domains. Freni et al. [30] also bring out that next to token characteristics and incentive mechanisms, setting up token monetary policy is another standalone design category. By synthesising these studies together with the rest of the state-of-the-art literature, three key pillars for the current DSR artefact were formed: incentive structures, governance, and tokenomics.

One of the key inputs for the DSR framework (see Figure 2) is the environmental component that determines the key needs, shortcomings, and objectives of the organisation under analysis. Identifying the organisational goals and resource constraints helps to assure that the research outline has sufficient relevance in real life. For the Currynomics ecosystem, the environment entails 1) the people (mainly the Users, Investors and Community members), 2) the organisations (Partners, Currynomics Labs OÜ, and Currynomics DAO), and 3) the technology - application protocols to accommodate the Redcurry token and the DAO token. All three are introduced in detail in Chapter 2.2.1 and Chapter 3.2.4. Combined, these three pillars of the environment component determine the underlying business needs, which are then conveyed as one of the key inputs for Information Systems (IS) research.

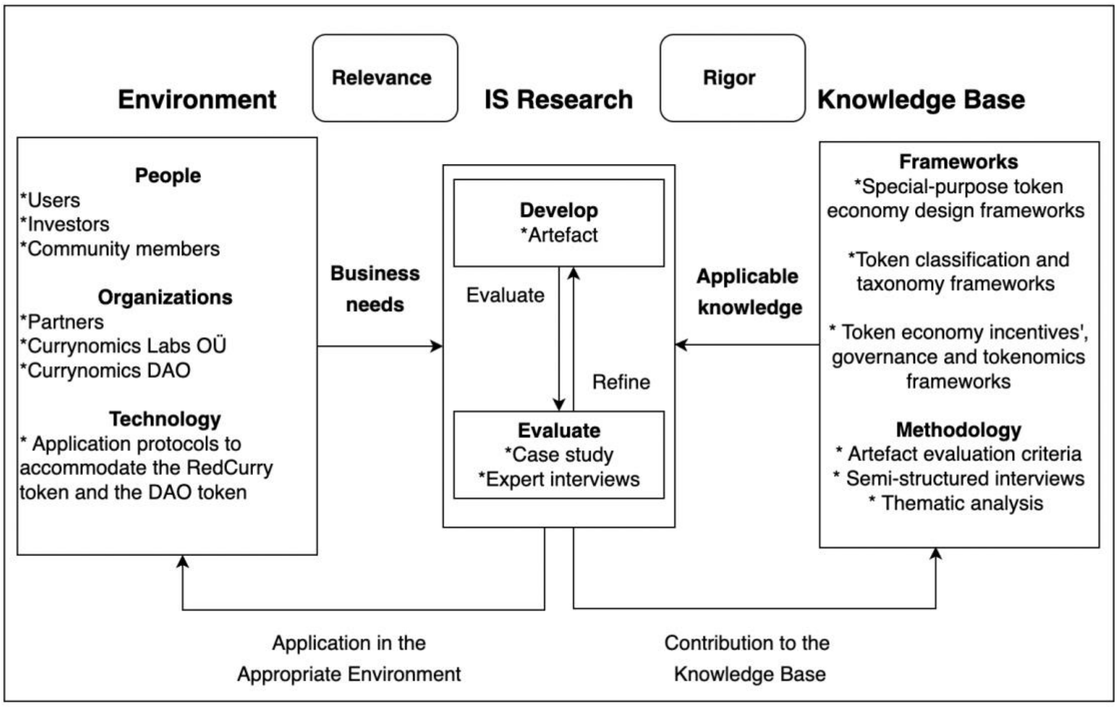


Figure 2. IS Research Framework. Hevner et al. (2004)

The second key input of IS research is the applicable knowledge that can either take the form of foundations or research methodologies. The former can be in the form of theories or frameworks, while the latter represents key methodologies used for similar business problems in the existing literature. Most of the existing theories and frameworks used in this thesis were introduced in the state-of-the-art section (see Chapter 1.2). The methodologies' component includes the selection of relevant evaluation criteria for the artefact, as well as semi-structured interviews together with thematic analysis that is applied to the interview transcripts. To achieve rigour, it is the responsibility of the researcher to study and apply the knowledge base diligently before applying it to the business needs discovered in the environmental component.

1.4.2 Research Guidelines

Hevner et al. [51] propose seven DSR guidelines to instruct the researcher, whereas their underlying standpoint is that the comprehension and knowledge of the problem at hand are obtained during the creation and application of the artefact. In other words, DSR is intrinsically a process of problem-solving. The seven guidelines are as follows:

1) **Design as an Artefact**. The outcome of a DSR study is an IT artefact which serves as a practical solution for organisational problems. Thus, the artefact must be

explicitly defined for it to be easily implemented in the respective business area. Peffers et al. [52] distinguish between six types of artefacts that can be developed via DSR:

- **Construct** - a concept or idea based on other concepts or arguments;
- **Model** - a simpler representation of real life using "a formal notation or language";
- **Framework** - a conceptual "meta-model";
- **Method** - conceptual non-algorithmic guidelines that can be acted upon;
- **Algorithm** - guidelines that are specified using "formal logical instructions";
- **Instantiation** - real-life hardware or software operational applications.

As the aim of this thesis is to create a step-by-step guidebook for practitioners, the most applicable artefact type is in this case method, because the guidelines are non-algorithmic and conceptual rather than representing ready-to-implement software or algorithms.

2) **Problem Relevance**. It is important that the search process for designing the artefact or design theory is to solve a relevant and unsolved business problem [51]. That said, the outcome of DSR needs to serve as a practical guideline to change how an organisation operates. The underlying business problem is elaborated on both in the Introduction (the importance of a comprehensive token economy design) and in Chapter 2.2.2 (the premises for designing a token economy for the Currynomics ecosystem).

3) **Design Evaluation**. As important as the development of theories and artefacts is the evaluation of the latter [51]. The evaluation step in IS research stands in rigorously highlighting the utility, quality and efficacy of a proposed artefact or theory. A key input for applying the chosen evaluation methods is the information about the business environment's requirements and limitations. Secondly, the evaluation process requires determining relevant metrics and reference data [51]. The IT artefact can then be evaluated regarding attributes such as functionality,

soundness, efficiency, and suitability for the organisation. The description of the chosen evaluation method and evaluation criteria for this thesis is elaborated in Chapter 6.1.

4) **Research Contributions**. For a DSR to be successful, the researcher must clearly outline how the developed artefact or design theory contributes to the existing knowledge base regarding the existing state-of-the-art design artefacts, foundations and/or methodologies [51]. At least one of the latter three must be presented in the research. This thesis aims to contribute to the scientific literature by being a first attempt at using DSR to develop step-by-step guidelines for token economy design that simultaneously consider the aspects of token incentive design, token economy governance and tokenomics.

5) **Research Rigour**. When applying the methodologies or foundations in the existing knowledge base to the business needs of the chosen area, the process must follow rigour [51]. That is, the details of the applicable knowledge must be studied and understood properly before being included in the design of a theory or artefact.

6) **Design as a Search Process**. DSR is in essence iterative, meaning that the exact search process is often hard to govern fully [51]. The search process is here initiated by carefully studying the documentation of the Currynomics ecosystem. Then, relevant literature is assessed, and further information is inquired from representatives of Currynomics for specifications if necessary.

7) **Communication of Research**. DSR must be introduced to audiences of both managerial and technological backgrounds [51]. The latter requires enough level of detail in the description of the artefact to apply it in the context of their organisation. This way, the scientific contributions of the novel artefact can be justified in real-life settings, and benefit organisations in the chosen space. More than understanding the artefact itself, the audience must also comprehend the evaluation process of the research - this ensures that the research is repeatable and thus suitable as a building block for future research in IS.

2 Research Background

This chapter details the underlying assumptions that are necessary for comprehending the rest of the thesis. Chapter 2.1 explains the building blocks of token economies, whereas Chapter 2.2 describes the use-case of this thesis – the Currynomics ecosystem.

2.1 Building Blocks of Token Economies

This chapter introduces the presuppositions required for understanding Chapters 3-5: the definition of a token (Chapter 2.1.1), existing token types (Chapter 2.1.2), and the definition of a token economy (Chapter 2.1.3).

2.1.1 Token Definition

Santos et al. [1] define tokens as unchangeable digital records or representations of contracts, which are redeemable either via traditional or cryptographic currencies. Similarly, tokenisation can be defined as the "encapsulation" of value in units that can be easily traded [30]. These units are also used to govern the system's business model, as well as to coordinate their holders' actions and rewards associated with these actions. Thus, the authors note that tokens can be defined along two dimensions: based on the value the tokens represent, as well as token functionality. Tapscott [31] highlights the key requirements a token must have (see Table 1) – a token must be representative, digital, discrete, and authentic.

Table 1. Required token characteristics by Tapscott (2020)

Feature	**Description**
Representative	Token represents its holder’s right to an underlying asset or right.
Digital	Token is issued on a blockchain and can be held in a cryptographic wallet.
Discrete	Tokens are countable and distinguishable among each other.
Authentic	The originality of the token can be controlled via the blockchain.

2.1.2 Token Types

From a board perspective, there exist “protocol” and “application” tokens [53], or synonymously, “native” and “on-chain” tokens [10]. Native tokens symbolise the core value of a protocol - mainly transaction validation (e.g., Bitcoin and Ether). Application or on-chain tokens, however, establish a new code layer of smart contracts on top of protocol tokens for more specific functions such as facilitating ecosystem services and products. Jürjens et al. [40] and Tapscott [31] refer to the native and on-chain tokens as currencies and tokens, respectively. This thesis will adopt the simplified definition of naming them both as tokens, albeit having different functionalities that are explained below. Khamisa [6] sees tokens as intermediates between the “market layer” (where users exchange tokens against the value created in or by the system) and the “ledger layer”, where transaction settlement takes place. Following a socio-technological perspective, the framework proposed in this study mainly considers guidelines regarding the design of application tokens and leaves the purely technical aspects of protocol tokens (such as transaction speed, token standards and custody options) for other lines of study in the field.

ICO guidelines published by the Swiss Financial Market Supervisory Authority assign different regulatory requirements for three different token categories [54]. Combining these with the token classification in other studies [2] [6], three token categories and their subcategories can be outlined:

1) **Store of value tokens.** Khamisa [6] suggests a broad category consisting of both "medium of exchange" and "store of value tokens", which can be further categorized into three subgroups:

   a. **Cryptocurrencies**. According to FINMA [54], cryptocurrencies serve the simplest function of either value transfer or facilitating payments for the acquisition of goods or services. Thus, they also fall under the regulation of the Anti-Money Laundering Act. Drasch et al. [10] specify that such payments are often made across different platforms rather than within one token economy (as opposed to payment tokens described later).

   b. **Stablecoins**. Stablecoins' main function is to facilitate payments but with an important property of reducing token price volatility [55]. By binding its price to chosen underlying assets, typically fiat currencies, stablecoins maintain a stable value about the latter [6]. For example, a single USD Coin can be purchased at a price equal to the underlying asset, one US dollar.

   c. **Crypto collectables**. Due to their unique nature, crypto collectables suit well for application in blockchain-based art and games and can be viewed as both mediums of exchange as well as a store of value type of tokens [6].

2) **Utility tokens.** Utility tokens are commonly established for token economies built based on an existing, native blockchain ecosystem [6]. With their original purpose of upholding a community, utility tokens enable the holder to use the services or products offered by the system [54] [56]. Utility tokens are the most innovative type due to their multiple functions ranging from financial to governance aspects [7]. For example, they can perform both as a means of payment [10] and as an incentive reward for the holder's work of verifying transactions. There are four main classes of utility tokens:

   a. **Payment tokens**. Payment tokens function as a blockchain ecosystem's internal payment mechanism [2]. Some token economies such as Ada, Filecoin and Ethereum have chosen payment tokens as the only type of tokens in the ecosystem with the purpose of establishing transactions among users [57].

b. **Governance tokens**. Governance tokens are for decentralising the governance mechanism of a token economy, and therefore including the user community in the development process of the ecosystem. In this manner, companies can raise financing, while sustaining their autonomy [1].

c. **Discount tokens**. These tokens are meant for granting their holder a discount on the ecosystem's services or products [6]. The discount serves the role of allocating platform revenues to users, but it only activates if the token holder uses the platform's services. Discount tokens can both remain valid or be invalidated (destroyed) after their usage. In the former case, the applicable discount might even increase concerning the overall usage growth of the ecosystem [58].

d. **Work tokens**. Work tokens enable the allocation of rights as to who is eligible to perform work on the platform [6]. For example, in the Augur prediction platform, staking a work token enables the users to contribute a prediction. Oliviera et al. [2] see it differently and add that work tokens are meant for rewarding users upon the completion of desirable behaviours or actions.

3) Asset tokens. Asset tokens (also called security or investment tokens) represent the holder's rights to dividends from the token economy's future earnings and cash flows. Asset tokens may also confer voting rights [56]. Therefore, asset tokens are the most like traditional equity stakes or securities in general. For a token to classify as an asset token, it must pass the Howey test, in which the presence of key characteristics of securities is tested. Khamisa [6] further differentiates between three types of asset tokens: tokenized physical assets, tokenized debt, and tokenized equity, but the detailed consideration of these goes outside the scope of this thesis.

2.1.3 Token Economy Definition

Freni et al. [30] propose an interesting parallel between economics and tokenomics, according to which the former drives innovation by passively observing changes made to the rules of an ecosystem. Tokenomics, however, follows an "active design" approach, meaning that the behaviour of the agents is from the very start aligned and guided towards a common goal. It follows naturally that the following definitions of the token economy include incentive mechanism design as the core component.

Guo et al. [41] define the token economy as a "complex system of reinforcement", which provides a means of exchange for the system's users for redeeming different products and services. For Khamisa [6], a decentralised token economy resembles a complicated token system in which the behaviour (e.g., transactions) of individual actors is incentivised with tokens to strive towards a common goal. Kim & Chung [24] add that the token economy represents a "management system" which directs the participants to apply a desirable behaviour via the use of tokens that are exchangeable for goods provided by the system. Similarly, Kim et al. [23] describe token economics as a study of establishing incentive and governance mechanisms for cryptocurrencies. Kang and Park [59] see a token economy as a fundamental aspect of a blockchain-based project that encompasses a range of factors, including monetary policies, service models, and interactions between agents.

2.2 Use-Case Problem

This chapter explains the use-case that is the subject of the case study applied in this thesis. Chapter 2.2.1 describes the overall functioning of the Currynomics ecosystem, and Chapter 2.2.2 elaborates on the more exact premises that are crucial when designing a token economy for the Currynomics ecosystem.

2.2.1 The Currynomics Ecosystem

In this thesis, the design artefact is evaluated using the Currynomics ecosystem as a practical example. Currynomics is a decentralised blockchain ecosystem that links the value of its stablecoin (the Redcurry token) to the Net Asset Value (NAV) of a commercial real estate portfolio (CRE) [15]. The creation of the Redcurry token is inspired by the common problem among stablecoins that the token holders can never truly trust the validity of a token's underlying assets. That is, the shortfall risk is largely tied to the capability of the ecosystem to maintain the currency peg. Redcurry token, however, represents the value of the CRE portfolio and self-sustainably maintains the peg.

By representing a means of payment and store of value, Redcurry resembles other stablecoins such as USDT but with the difference that the supply of Redcurry is not fixed

[15]. Moreover, the currency is special in the sense that it is not a mere asset token - the holders of Redcurry tokens have no rights to the underlying property. Instead, the system "truly commodities" real estate: the financial gains from the assets owned by the ecosystem are reinvested back into the system. This way, Redcurry acts as a bridge through which money moves from the traditional economy into the crypto economy.

The Currynomics ecosystem consists of various entities. Redcurry tokens are issued by Redcurry Holding, a legal body that is in turn owned by the Currinomics Foundation [15]. The former then uses the funds from token purchases to buy real estate by establishing subsidiaries for each real estate object separately (see Figure 3), where the solid line arrows refer to the cash movement direction). The real estate portfolio will then generate recurring revenue through rent payments and real estate sales. These proceeds will be redirected into purchasing further real estate objects, ensuring that the portfolio will continuously increase in value. To ensure that the portfolio value will be solely used to back the Redcurry token, no money must exit the holding (e.g., via dividends). Should the real estate portfolio be sold, the sales proceeds are equal to the capital used to buy back all Redcurry tokens. From a legal perspective, this is largely guaranteed by having the Currinomics Foundation registered as a non-profit foundation and the sole owner of Redcurry Holding.

The Currynomics ecosystem is summarised in Figure 4. Marked in red are the core bodies of the ecosystem – Redcurry Holding mints the Redcurry tokens, purchases real estate into the CRE portfolio, and distributes the tokens to partners. Marked in orange are the developers and maintainers of the ecosystem: Currynomics Labs OÜ provides development, marketing, and management services, whereas Currynomics DAO is the governing body of the token economy, which uses DAO tokens in its decision-making operations. It needs to be noted that Currynomics DAO operates independently as a decentralised organisation that is distinct from other mentioned legal entities.

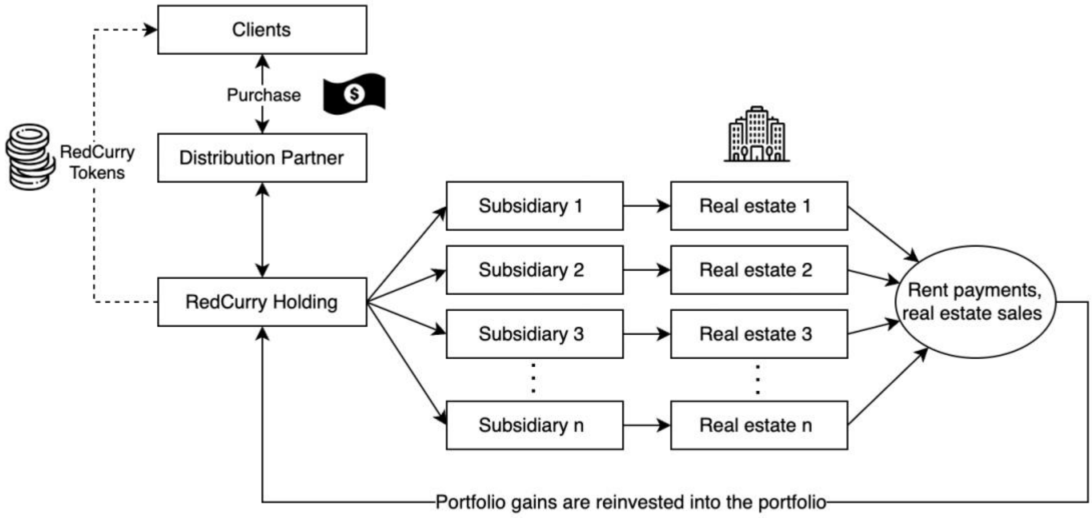


Figure 3. Redcurry portfolio generation and cash movement cycle

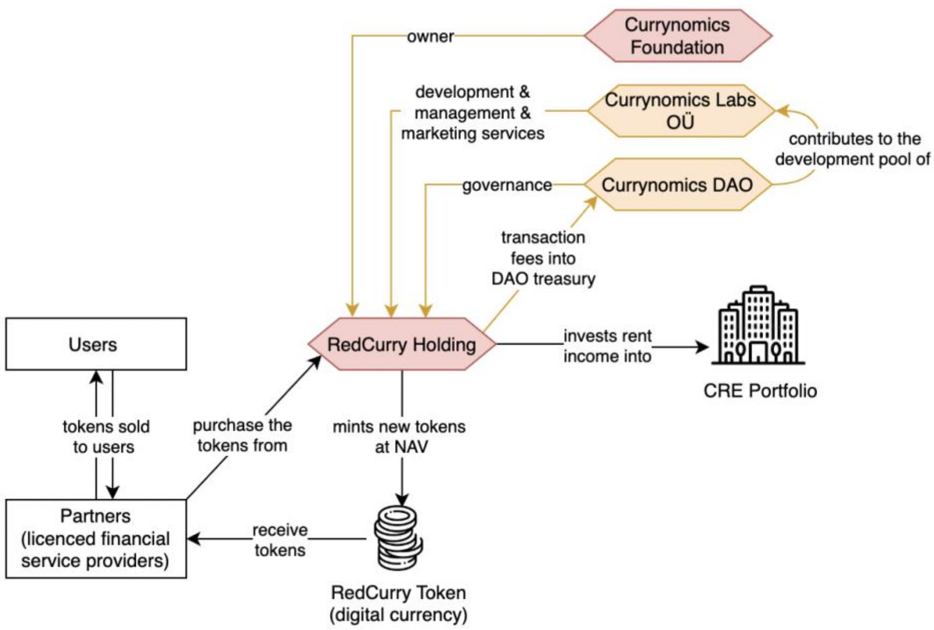


Figure 4. Stakeholder map of the Currynomics ecosystem

2.2.2 Premises for Currynomics Token Economy Design

The token economy that supports the functioning of the Redcurry token faces multiple challenges stemming from the surrounding business environment. One of the most crucial aspects is to understand the levers that build trust for the Users (Redcurry token holders) to purchase the token and retain it in the long term, given that there are plenty of investment alternatives outside the crypto economy that offer a similar value proposition (e.g., real estate funds that follow a low-risk investing approach). The trust of the Users is largely tied to the governing body that oversees the ecosystem. It poses a question of whether (and how) it is sustainable to involve community members in the decision-making process, as opposed to leaving governance only to the power of the project team. Lastly, the creation of a governance token (the DAO token) requires careful consideration of tokenomics: *when*, *how* and *how many* DAO tokens will be allocated.

3 Incentives

Chapter 3 gives insights into how a token economy designer should think of the fundamentals in establishing token economy incentive mechanisms. After developing the research questions in Chapter 3.1, Chapter 3.2 elaborates on determining a token economy's value proposition. Chapter 3.3 introduces the concept of defining desirable behaviours among the ecosystem stakeholders, whereas Chapter 3.4 goes into the details of selecting the exact incentive mechanisms. Chapter 3.5 concludes the core findings of Chapter 3, together with its limitations and insights regarding future work.

3.1 Introduction

The importance of establishing clear incentive structures in a decentralised blockchain ecosystem is highlighted by many [4] [6] [10] [40] [41] [60]. The most important principles in incentive creation are to promote behaviours which satisfy the needs of the maximum number of stakeholders, promote the token economy's main goals, and discourage "destructive" actions [6]. Guo et al. [41] add that incentive mechanisms ought to motivate new users to join the ecosystem. Also, incentives encourage truthful behaviour among participants in a competitive setting [40]. Thus, desirable token incentive structures are ones that: 1) contribute to the fulfilment of token economy goals, 2) motivate users to act in the interest of the ecosystem, and 3) attract new users to join the token economy. Chapter 3 aims to answer the following research question:

RQ1: How to design token economy incentive mechanisms?

Yoo [60] claims that it is crucial to define user groups who will benefit from the ecosystem, including determining their participation rates and necessary reward mechanisms. Therefore, the focus of this chapter is to guide the reader through three key blocks that are necessary for designing token economy incentive structures: 1) understanding the objectives of a token economy and its stakeholders, 2) identifying which behaviours help to fulfil these objectives, and 3) which incentive mechanisms exist to promote these desirable behaviours. Respectively, the sub-questions to be answered in Chapter 3 are as follows:

RQ1.1 What determines a token economy's value proposition?

RQ1.2 What are the desired behaviours in a token economy?

RQ1.3 What are the incentive mechanisms to apply in a token economy?

3.2 Token Economy Value Proposition

The first step in designing a token economy is to distinguish its goals, i.e., the problems that the system is meant to solve [60]. Determining the value proposition of a token system is an essential activity after validating the need for blockchain technology in the first place [3]. Similarly, token economy design is about determining where tokens are to be used, as well as how many use cases a token might have [7]. Barrera & Hurder [29] emphasise that before other aspects of token economy design, one must establish the system's value proposition which consists mainly of 1) the ecosystem use cases, 2) its key users, and 3) its strategy. They also warn that the goals must be consistent and in case conflicts between the fulfilment of strategies occur, superiority among the goals must be planned for in advance. Establishing a token economy value proposition can then be broken down into understanding 1) token economy functions (Chapter 3.2.1) and 2) its stakeholders (Chapter 3.2.3). Respectively, Chapters 3.2.2 and 3.2.4 apply these findings on the Currynomics ecosystem.

3.2.1 Token Economy Functions

Blockchain ecosystems are meant to connect different stakeholders to create value based on a shared set of resources [29]. Value creation can be in the form of the transfer of goods, means of payment, asset status monitoring, enabling access to a specific service/product, or voting [3]. Sockin & Xiong [12] add that the system value comes from either 1) fulfilling transactions among a large set of users or 2) providing an investment vehicle for both investors and users who do not demand such transactional functions. From a financial perspective, a system's value can stand in maintaining price stability (as is common with stablecoins) or ensuring wealth protection against inflation [61]. Some empirical examples include Bitcoin, whose core function is to create a decentralised digital currency that can be used as a medium of exchange for goods and services without relying on traditional financial institutions [62]. Also, Filecoin's function is to provide a decentralised file storage network to create a secure and cost-effective way to store and retrieve data via a peer-to-peer network of nodes [63].

3.2.2 Functions of the Currynomics Token Economy

The core objectives of the Currynomics ecosystem are of financial type. The Redcurry token, which is minted against the acquisition of real estate, serves the following financial functions:

- a wealth protection/liquidity parking vehicle for savings;
- an investment vehicle, since the value of the Redcurry token grows hand in hand with the appreciation of the real estate portfolio;
- a means of payment;
- loan collateral due to its price stability.

3.2.3 Stakeholder Mapping

Understanding users' incentives to participate in the ecosystem is another crucial component besides determining the goal of a token economy [6]. For this, the term "stakeholder mapping" will be adopted in this study. Similarly, Ballandies et al. [25] state that the main "design principles" for a cryptoeconomic system are derived from studying stakeholder values. Only then it is possible to establish incentive structures that induce desirable stakeholder behaviour. For that matter, Kim et al. [23] introduce a useful framework for mapping stakeholders with functions each stakeholder group awaits from the token economy. It is important to note that stakeholder roles common to traditional economics may overlap or be joined in the context of blockchain systems - e.g., a single stakeholder might simultaneously hold the roles of an investor, user, and miner [7]. In the case of many stakeholders, a recommendation is to divide them into clusters based on the strength of their interests in the ecosystem to succeed or their capabilities of impacting that success [25].

Davidson [64] distinguishes between three general stakeholder groups in a token economy: maintainers, contributors, and users. Whereas maintainers have responsibility for protocol creation and maintenance, contributors may do so voluntarily. Allen & Berg [65] are more specific and bring out token holders, developers, founding team of the token economy, miners or validators, and even indirect stakeholders such as the government, venture capitalist investors and environmentalists (the latter might be concerned with the environmental footprint of the blockchain). Token holders can also be distinguished based on incentives into ones who hold the token for transactional purposes and others who are expecting financial gains. For Voshmigr [66], the main stakeholder groups in distributed ledger ecosystems are miners, developers, nodes, and the business environment (e.g., market makers). Liu et al. [35] differentiate between the project team, node operators, users, application providers, and regulators.

3.2.4 Stakeholders in Currynomics

The stakeholders in the Currynomics ecosystem include Users, Partners, Developers, Community, and Investors. Users are regular Redcurry token holders, who have purchased the token for personal financial purposes. Partners represent licensed financial institutions that purchase the token from Redcurry Holding and further distribute these to the users for a transaction fee. The Developers are represented by Currynomics Labs OÜ and provide development, marketing, and management services for the ecosystem. Community refers to individuals (a likely subgroup of Users), who own Currynomics' governance token (the DAO token). They contribute to the ecosystem development via governance processes, in hope that the DAO token will appreciate in the future. The token economy also has stakeholders who maintain the role of Investors. Partly, this role is undertaken by Users, who purchase the Redcurry token to get exposure to the CRE portfolio value appreciation. Another way to define investors are the individuals or institutions who invest in Currynomics Labs OÜ to foster the development of the ecosystem. The expected return on investment will result from the DAO token appreciation. Lastly, it has to be noted that a single individual can simultaneously belong to multiple stakeholder groups - e.g., one can purchase both the Redcurry token and the DAO token, thus acting as a User, Community member and Investor.

Using the stakeholder mapping layout proposed by Kim et al. [23], the stakeholders of the Currynomics ecosystem, together with their expectations from the token economy, are summarised in Table 2. Since the focus of this chapter is on designing token incentive structures, Table 2 also features a column to mark if a stakeholder group can be incentivised via tokens, i.e., whether the entity is meant to be a token holder. For such stakeholders, the design process continues in Chapter 3.3.

Table 2. Currynomics ecosystem stakeholders

Stakeholder	**Expectations from the token economy**	**Can their behaviour be motivated via tokens?**
Users	To use the product - a stable and secure cryptocurrency that protects their investment against inflation	Yes
Developers (Currynomics Labs OÜ)	Receive fees for development, marketing, and management activities	No
Community	A sustainably growing ecosystem	Yes
Partners	Receive transaction fees	No
Investors	Redcurry token / DAO token price appreciation	Yes

3.3 Defining Desirable Behaviours

In an effective token economy, users act not only in the interest of themselves but think about increasing the ecosystem quality as a whole [6] [67]. Khamisa [6] names this phenomenon the "token-network fit", which means that the stakeholders' incentives are aligned to act in the best interest of the system. This is supported by Yoo [60] who explains that a desirable behaviour stimulated by the token does not stem from ethical principles but is solely determined by whether an action in the long term adds economic value to the platform. Yoo [60] and Kang & Park [59] claim that the most desirable behaviour is for the users to be part of the ecosystem over a long-term period. Kim &

Chung [24] explain that in the case of long-term token retention, token supply will gradually decrease, leading to a token price increase. They add that long-term token retention will also decrease undesired token price velocity, and price stability will in turn make holding the token for longer periods more attractive. Nevertheless, holding a token for too long might affect its transactional volume [24].

On a broad scale, a token holder can take three main actions: 1) holding the token, 2) selling the token, and 3) spending the token in exchange for the token economy's services or products [30] [60]. If the token economy goal is to maintain a cryptocurrency, the most desirable action is for the users to hold the token, proving that the users have trust in the ecosystem [60]. Selling a token, however, signal low trust and long-term demand for the token. Following the approach by Yoo [60], it is good to understand if the desirability of these actions can change at the time of token launch and post-launch, or in other words, in the short-term and long-term perspective. The desirable behaviours of the stakeholders in the Currynomics ecosystem are identified in Chapter 3.3.1.

3.3.1 Desirable Behaviours in Currynomics

Table 3 summarises the desirable behaviours of each stakeholder group in the Currynomics ecosystem whose behaviour can be influenced via tokens. Since the Redcurry token does not have any other purpose than being a store of value, the most desirable behaviour for its holders, Users, is to hold the token as long as possible. Another option for the user is to trade the token – an undesirable action in the starting phase, where token liquidity is low and the CRE portfolio is relatively small. However, in the later phases, trading the Redcurry token is more of a neutral activity, as long as the trading does not take place below the market price, which is an undesirable behaviour. As to the Community stakeholder group, it is best if the individuals are active participants in community discussions, and do not become passive DAO token holders. Investors are expected to provide liquidity for the development activities via purchasing and holding the DAO token.

Table 3. Currynomics ecosystem token holders and their desirable behaviours

Stakeholder	Desirable behaviour
Users	Purchase Redcurry token and hold it long-term. Trade the token once ecosystem has reached sufficient liquidity. Do not trade the token below fair market price.
Community	Participate in community discussions, take part in the decision-making process via the use of the DAO token.
Investors	Provide liquidity for ecosystem development via purchasing both the Redcurry and DAO tokens.

3.4 Selection of Incentive Mechanisms

Once stakeholders and their desirable behaviours have been mapped, it is possible to establish incentive mechanisms for promoting the selected behaviours. The need for well-planned incentive mechanisms is confirmed by many [4] [6] [10] [23] [42] [44] [68] [69]. According to [70], introducing a compensation system for platform users is one of the most crucial features for a blockchain-based business model to excel. Without such rewarding mechanisms, the platform's token economy would become unsustainable - after distributing the tokens only via token sales to investors, the only driver for the token value growth would be inflation [60]. The most important principles in incentive creation are to promote behaviours which satisfy the needs of the maximum number of stakeholders, promote the token economy's main goals, and discourage "destructive" actions [6]. Kampakis [69] observes that most tokenomics practitioners are focused on establishing incentive rewards for promoting desirable behaviour rather than penalties for inhibiting undesirable behaviour.

Existing literature distinguishes two main types of incentives: monetary and non-monetary [68], which are compared on a broader scale in Chapter 3.4.1. Respectively, Chapters 3.4.2 and 3.4.3 look into the examples of both of them in more detail. Chapter 3.4.4 describes the incentive mechanisms in the Currynomics ecosystem.

3.4.1 Monetary and Non-monetary Incentive Mechanisms

Monetary incentives refer to mechanisms where individuals are rewarded for their actions with tokens that can be redeemed for monetary value [30]. Kaal [71] adds that introducing “commercial benefits” stimulates the usage of different services linked to the token, and in turn the demand for the token. Also, the use of such benefits reduces the need for implementing more stricter monetary policy measures such as “emergency” sales, establishing token reserves, or adjusting the token’s total supply amount. Yoo [60], however, challenges the concept of monetary rewards by claiming that the digital economy operates fundamentally differently from traditional economies. In a traditional economy, financial incentives typically foster better behaviour, but this might not be the case in digital economies, where implementing only financial incentive mechanisms can lead to an ecosystem failure. Liu et al. [42] add that monetary incentives may be effective but also impose a greater cost for the ecosystem.

Hülsemann & Tumasjan [26] study the effect of token types on incentives in blockchain-based prediction markets and find that utility tokens provide the biggest trigger for people to become long-term users of the system. For asset tokens, the opposite is true: holding a token for the sake of future earnings potential is a weaker incentive compared to non-monetary incentives provided by utility tokens. Similarly, Liu et al. [4] warn that in community activities, economic incentives tend to promote user contribution quantity rather than quality. Kaal [14] adds that incentive mechanisms should not only favour short-term speculative users but also users with more long-term intentions, who are participating in community discussions and voting procedures. Table 4 summarises these observations by suggesting three main categories under which monetary and non-monetary reward mechanisms can be compared: 1) type of behaviour, 2) timeframe of the reward effects, and 3) budget requirements.

Table 4. Selection guide for monetary or non-monetary incentive mechanisms

	Monetary incentives	**Non-monetary incentives**
Type of behaviour	Incentivise behaviours that are tied to monetary outcomes; when the value created is easier to measure.	Effective for behaviours that are more social or community-oriented, such as participating in forums.
Timeframe	More immediately tangible and hence more effective in motivating short-term behaviour.	More effective in motivating long-term participation in the ecosystem.
Budget and resources	Can be costly, as they require the distribution of actual tokens or other monetary rewards.	Can be less expensive to distribute.

3.4.2 Types of Monetary Incentive Mechanisms

There is an increasing amount of literature focusing on monetary incentive mechanisms in token economies [4] [21] [30] [42]. One example of such a mechanism is to offer **token rewards** for actions such as contributing content or completing specific tasks. For example, in Steemit - a blockchain-based social media platform - users are rewarded with cryptocurrency for creating and curating content [24]. Another monetary incentive mechanism is called **staking**, which is about users locking up their tokens to contribute to the ecosystem's operations, e.g., via performing specific tasks of work [30] [46]. Staking entails that the contributors have "skin in the game", which makes them act more in the interest of the token economy rather than themselves. Staking helps to secure the token supply by reducing the likelihood of malicious actors attempting to compromise the ecosystem. For example, Tezos – a decentralised blockchain platform – uses token staking to secure the network and validate transactions [72]. Token holders can participate in the consensus process by staking their tokens and earning rewards for their contributions, incentivising long-term commitment to the Tezos ecosystem.

Liu et al. [42] introduce the mechanism of **liquidity mining**, a process where users can earn tokens by providing liquidity to decentralised exchanges (DEXs) or other decentralised finance (DeFi) protocols. Users can earn a portion of the transaction fees generated on the platform in addition to the tokens they receive for providing liquidity. Examples of token economies that offer liquidity mining include Uniswap and Sushiswap. Fan et al. [73] specify that Sushiswap liquidity mining issues governance tokens as the token reward. Direr et al. [21] criticise liquidity mining by warning against a situation where the majority of liquidity miners may have no significant economic interest in the platform and thus do not actively participate in the governance. They bring an example of the Compound platform, where only 19% of the users retained above 1% of the reward tokens received, selling the rest to the market. A possible mechanism to reduce the short-term sell pressure would be to employ a ve-token model, which is explained in Chapter 4.4.2.

Freni et al. [30] elaborate on monetary incentive mechanisms that are not tied to receiving additional tokens – token holders can also be motivated by getting a share of the ecosystem's **revenues** and **dividends**, or simply by the **appreciation potential** of the token price. If the token holder believes in the token economy growth, the potential gain from token price appreciation might eventually exceed the utility of actually using the ecosystem's products or services [10].

3.4.3 Types of Non-monetary Reward Mechanisms

Freni et al. [30] list three types of non-monetary incentives for the token economy users to engage with the ecosystem. A straightforward example that attracts users to the token economy is to get **access to the products or services**. Secondly, Freni et al. [30] mention **reputational gains**. Reputation is a non-monetary incentive mechanism that can be used in blockchain-based token economies to incentivise positive behaviour and discourage negative behaviour. By assigning reputation scores to users based on their contributions to the network, individuals are incentivised to maintain a positive reputation and engage in behaviours that benefit the network. Thirdly, users can be incentivised via being able to **participate in the governance** of the token economy [61] – they can have a say in the direction and development of the network. Such governance rights incentivise users to hold the tokens as opposed to selling the latter on exchanges.

Network effects can also be considered as an incentive to participate in the token economy [24]. The value of a network often increases as more users participate, which can incentivise new users to join and contribute to the network. Ballandies [74] suggests **gamification** as another non-monetary incentive mechanism. As an example, Steemit's users can earn token rewards for creating and curating high-quality content on the social media platform [24]. The rewards are distributed based on the popularity and engagement of the content, which encourages users to create and share content that is valuable and engaging. The competitive element makes it a non-monetary incentive besides merely receiving tokens as a reward.

3.4.4 Incentive Mechanisms in Currynomics

As the Redcurry token follows solely financial objectives, it is reasonable that Redcurry token holders (Users) are motivated by monetary incentive mechanisms, more specifically, gains from potential Redcurry token price increases. The DAO token, however, serves the core purpose of incentivising community members to take part in governance. As it has a community-engagement component, participation in governance should be incentivised by non-monetary mechanisms, such as reputational gains. This is especially relevant for the Currynomics ecosystem, as a high degree of trust and collaboration is required among participants. Of course, participation in governance itself serves as a (non-monetary) incentive mechanism to engage in community discussions. Lastly, the fact that DAO tokens can also appreciate in value serves as a monetary incentive mechanism for Investors.

The summarising goal model for designing token economy incentive mechanisms is pictured in Figure 5, whereas the legend for understanding the goal models in this thesis is presented in Table 5. The token economy designer should first identify the stakeholders and functions of the token economy (Steps 1 and 2). Provided that token economy functions are matched with stakeholder expectations, these two components define token economy utility. The latter is in turn needed to determine desirable behaviours (Step 3). Only then it is possible to understand whether these behaviours are likely to be promoted via monetary or non-monetary incentive mechanisms (Step 4). Lastly, specific incentive mechanisms can be established (Step 5), whereas desirable mechanisms are ones that 1) contribute to the fulfilment of token economy goals, 2) motivate users to act in the interest of the ecosystem as a whole, and 3) attract new users to join the economy. The latter three are defined as quality goals illustrated with a cloud shape – i.e., a set of criteria that must be met when establishing incentive mechanisms.

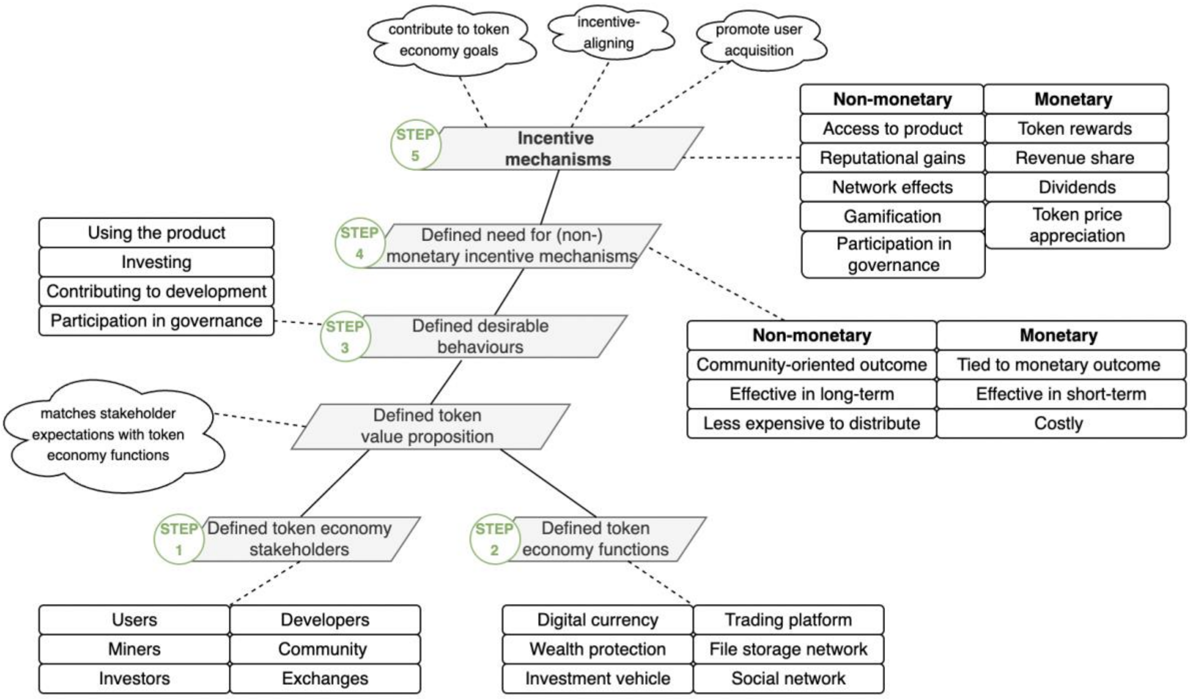
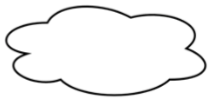


Figure 5. Goal model for designing token economy incentive structures

Table 5. Legend for the goal model

Element	Description	Notation
Goal	A particular situation or state of things in the world that the stakeholders desire to attain.	
Quality goal	A set of precise standards or criteria that must be met in order to achieve a broader goal.	
Decomposition	Relationship to illustrate the connection between two distinct goals, namely a higher-level or parent goal and a lower-level or sub-goal.	
Association	Relationship used to connect a goal with other related elements that aid in defining or describing the goal.	
Example	A set of things that serve as an example of goal outcome.	

3.5 Conclusion

The goal of Chapter 3 was to guide the reader in establishing incentive structures for a token economy by answering the research question:

RQ1: How to design token economy incentive structures?

Literature suggests that laying a foundation for setting up incentive structures needs a good understanding of the token economy's value proposition – its stakeholders and the core functions that the token economy is expected to perform. It is then possible to understand the behaviours that are expected from the ecosystem stakeholders, and lastly, the specific incentive mechanisms to induce such behaviours. The limitation of Chapter 3 is that it does not provide a technical guide on how one should build a token model to support the incentives, e.g., the selection of token standards. Nor does it provide advice from the legal perspective on which types of token properties to choose from so that no unexpected tax or compliance liabilities would arise. Combining the design flow with actionable steps in these two fields would be subject to future work. The answers to RQ1.1, RQ1.2 and RQ1.3 are as follows:

RQ1.1 What is the value proposition of a token economy?

Understanding a token economy's value proposition can be broken down into two aspects. First, one must define the core functions of the token economy. For example, the ecosystem can support the functioning of a digital currency, act as a social network or an investment platform. The next step is to determine the ecosystem stakeholders together with their roles and expectations in the token economy. For example, regular users are most interested in using the core functions of the token economy, investors are looking for financial gains, and community members want to feel good about contributing to the development of something novel and beneficial for society. Only after understanding a token economy's core functions and stakeholders, it is possible to define which kind of behaviours should be promoted among the stakeholders. It is important to note, however, that the next step can only be applied to stakeholders whose behaviour can be influenced via tokens (this would most likely exclude stakeholders such as regulators and the development teams with no token allocation).

RQ1.2 What are the desired behaviours in a token economy?

On a broad scale, the token economy participants can involve in three types of actions: 1) holding the token, 2) spending the token against the ecosystem's products and services, and 3) selling the token. In most token economies, holding the token or redeeming it against the ecosystem's services is the most popular choice. More specifically, desirable behaviours can also include contributing to the development of the token economy, participating in governance, and providing liquidity for the token economy's treasury. As described previously, each desirable behaviour is linked with one or more stakeholder groups.

RQ1.3 What are the incentive mechanisms to apply in a token economy?

A token economy can employ monetary or non-monetary incentive mechanisms. Whereas monetary incentive mechanisms are fit for behaviours linked to direct monetary outcomes, non-monetary mechanisms are best for community-oriented projects. Monetary incentive mechanisms (such as token-based rewards, liquidity mining, staking, revenue sharing, dividend potential and token price appreciation) tend to be more costly for the token economy to distribute. In comparison, non-monetary mechanisms (such as getting access to the ecosystem's product, participation in governance, reputation gain, network effects and gamification) require less of the token economy's monetary resources to be employed. Monetary mechanisms tend to be more tangible and thus of short-term value and are more efficient in ensuring the ecosystem's profitability. Non-monetary incentive mechanisms have a more long-term nature and are suitable for encouraging community-driven discussions and thus fostering innovative developments within the token economy. It needs to be noted, however, that a token economy needs not necessarily use solely monetary or non-monetary mechanisms. Depending on the specific needs of the ecosystem, a suitable blend of both types of mechanisms can be established.

4 Governance

Chapter 4 covers the steps in designing token economy governance. After the introductory Chapter 4.1, Chapter 4.2 discusses determining the optimal level of decentralisation in a token economy. Chapter 4.3 extends the topic of whether a token economy ought to use more on-chain or off-chain governance mechanisms. Chapter 4.4 goes into the details of choosing exact voting mechanisms, and Chapter 4.5 concludes the findings from academic literature about token economy governance design.

4.1 Introduction

Governance in the blockchain context revolves around mechanisms that allow decentralised systems to evolve in time [75]. It is about enabling a blockchain system to progress when exposed to changes in the environment and user preferences [29]. Without a central decision-making body, as is inherent to decentralised systems, it is especially critical to have a well-described process regarding governance. Allen & Berg [50] share a similar viewpoint and see blockchain governance as a method through which stakeholders can bargain about changes to be made to the system. To clarify, Chapter 4 focuses on token economy governance mechanisms. Consensus mechanisms for transaction validation (e.g., proof of work and proof of stake concepts) include more technical protocol-level design parameters that are out of the scope of this thesis.

The importance of governance design within a token economy is confirmed by many [76] [77] [78]. Several decentralised token economies have substantial treasuries, such as Uniswap's treasury of $4 billion, making it important to examine their governance systems and how they come to decisions [32]. Given the unique designs of decentralised governance systems and the amount of power they wield, it is crucial to determine who holds the voting power and how are the actors incentivised in the decision-making process. Voshmgir [66] compares token economies to nation-states and notes that the latter have had ample time to develop and refine their governance structures over centuries. Blockchain ecosystems, however, have only been in existence for a decade, and numerous governance issues regarding protocol modifications remain unresolved. Even though blockchain protocols can effectively replace extensive bureaucracies, they are not equipped to handle the "unknown unknowns" in multi-party environments. Similarly, Barrera & Hurder [29] see that governance stands for mechanisms used by the community to update the system and agree on an operation plan in unexpected circumstances. The core research question of Chapter 4 is the following:

RQ2: How to design token economy governance?

A large debate in blockchain governance is about whether a token economy can be fully decentralised in all decision aspects [35], and it is thus one key step to consider when designing token economy governance [79]. Some argue that there exist critical governance areas which cannot be trusted in the hands of community decision-making, as the governance can then come under attack [80]. Hence, the first sub-question is:

RQ2.1 What determines the extent of governance decentralisation?

Another significant discussion similar to the debate about decentralisation is about the extent of "on-chain" and "off-chain" aspects employed under governance mechanisms [3] [50] [75]. In other words, should a token economy be fully governed by the "rule of code" or should more informal channels such as community forums be used in parallel? The next sub-question is thus:

RQ2.2 What determines the use of on-chain and off-chain governance components?

Lastly, when suitable levels of decentralisation and on/off-chain governance have been identified, one needs to set in place specific mechanisms as to how are the decisions finalised. There are already several academic papers analysing the application of various voting mechanisms. The respective sub-question is thus:

RQ2.3 What are the voting mechanisms for governance proposals?

The three sub-questions are answered in Chapters 4.2-4.4.

4.2 Governance Decentralisation

Decentralisation in token economy governance is about determining who has a say in the governance processes and to what extent can they influence the outcome of the decision-making in different governance areas [35]. This is supported by Barrera & Hurder [29], who claim that the first two steps in designing blockchain governance are identifying the governance areas and stakeholders. Similarly, Fan et al. [75] stress the importance of determining the areas that the decision-making will cover. Chapter 4.2.1 brings examples of potential governance areas in a token economy, and Chapter 4.2.2 does the same in the context of the Currynomics ecosystem. Further, Chapter 4.2.3 elaborates on choosing the optimal extent of decentralisation of governance, and Chapter 4.2.4 applies this to the use-case.

4.2.1 Governance Areas

The areas subject to governance can vary based on the underlying design and goal of blockchain-based systems. Governance decisions can be made regarding general changes and updates to the protocol, ecosystem's service or product development plans, recruitment, management of token treasury, and changes to governance aspects themselves [6]. Governance could also address aspects such as the activation of emergency shutdown mode and distributing funds for infrastructure development [38], as well as adjusting compensation plans [29]. Fritsch et al. [32] bring examples of areas such as modifications to the protocol or the allocation of a project's treasury funds.

Mosley et al. [81] take a broader view and add that blockchain governance can also deal with aspects common to traditional enterprises – e.g., questions related to brand, marketing, and community engagement. They conducted a linear discriminant analysis on the Dash ecosystem and determined that the most common categories for change proposals included, for example, marketing, events, protocol development, projects, and "crypto community outreach". Rejiers et al. [82] claim that governance can cover areas related to parties external to the ecosystem – e.g., legislation of the countries, technological standards, and other binding contracts with chosen third parties.

4.2.2 Governance Areas in Currynomics

The four broad governance areas of the Currynomics ecosystem are as follows:

- **Treasury management**: Decisions related to the allocation and management of the DAO's treasury funds.

- **Governance and Process**: Decisions regarding the DAO's governance structure, voting processes, community goals, and community sentiment towards proposals.

- **Protocol Upgrades**: Decisions regarding the implementation of system upgrades, adjustments to global and treasury-specific parameters in the protocol, and replacement of modular smart contracts in the DAO protocol.

- **Tokenomics**: Decisions related to the design of tokenomics.

4.2.3 Governance Decentralisation

After determining the governance areas, a token economy designer should identify if some of the areas can be decided upon in a more or less decentralised manner. In a comprehensive token economy governance design framework, Liu et al. [35] suggest determining the degree of decentralisation for the governance processes. Based on their observations, three broad types of token economies can be identified:

- **Private and centralised** ecosystems such as enterprise blockchain applications have the least amount of decentralisation when compared to the other two types [35]. Access to the token economy is limited to specific entities, and there is a clear hierarchy structure between its stakeholders. In other words, participation in the token economy or the ability to use the tokens is granted by a trusted entity, such as a corporation or another governing body, which ensures greater security and control in the ecosystem. The governance of permissioned private ecosystems is less demanding than the other types, as decisions are made by the top entities in the internal hierarchy.

  Barrera & Hurder [29] confirm that a centralised board or committee is likely to be a rather time-efficient governance format. Also, there is a higher probability that the individuals who decide on the change implementation possess the necessary expertise for decision-making. Similarly, Davidson [64] notes that in the earlier phases of a token economy, the main decision-making power is in all cases likely to be concentrated in the hands of the management, who as a small group are likely to agree on conclusive outcomes faster when compared to bigger collectives. A logical downside of this approach, however, is that it does not consider the opinions of other ecosystem participants. Rejiers et al. [82] warn against the problem of "personal sovereignty", which happens when one or a few prominent individuals in the committee continue to have a disproportionate influence on the decision-making outcomes. With such excess centralisation, the majority of the token users are held back from governance, resulting in slower technological progress and decreased innovation [75]. Biancotti [9] claims that the concentration of power is one of the core risks of DAOs.

- **Public and centralised** token economies differ from centralised ecosystems in that the token economy is accessible to anyone who meets the permission criteria set by the governing authority. Thus, like in centralised private blockchains, identity verification is required for participation. Logically, a good example of public and centralised token economies could be ones that issue government-backed digital currencies, as the centralised nature enables control of the ecosystem's compliance with laws and regulations.

- **Public and decentralised** ecosystems differ from centralised blockchains in that there are no pre-set privileged stakeholders and entry to the token economy is open to all entities [35]. These ecosystems are typically not controlled by a single entity but rather by a more resilient network of users who collectively manage the system – also named as DAOs [32]. Such openness and transparency may, however, result in higher complexity of governance. Barrera & Hurder [29] and Mosley et al. [81] warn that decentralised governance will not guarantee that all participants have the respective knowledge for establishing a good judgement. Also, a potential problem with user-wide voting is that it entails costs related to information acquisition and blockchain transaction fees. Allen & Berg [50] caution against allocating decision-power to too many stakeholders, as this might unduly prioritise the interests of stakeholder groups that have less skin in the game. Moreover, giving the control rights to the hands of other stakeholders can help to mask the self-interested actions of the founding team - an idea borrowed from traditional economic theory [83].

Whether a token economy should follow a more centralised structure or a decentralised one is up to the specific requirements and use cases of the token economies. Table 6 summarises some core arguments on when is best to choose either of them:

Table 6. Use case comparison for centralisation and decentralisation

Centralised token economy	**Decentralised token economy**
When a high level of regulation and compliance with laws is desired.	When greater transparency is desired.
When greater efficiency and speed is desired for larger volumes of transactions.	When resilience and independency from a central entity are desired.
When greater security and control are critical.	To foster innovation and invite a larger pool of contributors.

4.2.4 Decentralisation in Currynomics

There are some specific governance areas that the Currynomics ecosystem cannot trust in the hands of community members. One example is making treasury decisions on the Redcurry token, as the token issuance is operated by code and the reserve asset composition is decided and controlled by a professional investment board. As another example, the Users cannot directly control the board composition of the Currynomics Foundation, whose purpose is to monitor the functioning of the whole ecosystem. There are numerous governance areas, however, where the decision-making is indeed decentralised and community members can voice their opinions. These are shown in Table 7.

Table 7. Centralised and decentralised governance areas in Currynomics

Centralised governance areas	**Decentralised governance areas**
Decisions regarding Redcurry token reserve asset treasury	DAO treasury decisions, including treasury-specific parameters in the DAO protocol
Composition of the board of Currynomics Foundation, Redcurry Holding, and other organisations in the ecosystem	Global system parameters in the DAO protocol (transaction fees, pool sizes and pool distributions)
	Community goals and targets; extent of on-chain reporting

4.3 On-chain and Off-chain Governance

A major debate in blockchain governance design is about whether decision-making should take place "on-chain" or "off-chain" [3] [50] [75], which is the subject of Chapter 4.3.1. Chapter 4.3.2 takes a look at the respective mechanisms in the Currynomics ecosystem.

4.3.1 On-chain and Off-chain Governance Mechanisms

Rejiers et al. [82] explain that in on-chain governance, developers can suggest new blocks of protocol code, which are then put up for a decentralised collective vote among selected stakeholders. If agreed upon, the changes to the protocol are automatically executed via smart contracts [82]. Thus, on-chain governance functions via the use of smart contracts - fragments of code that are self-executive once pre-set rules or conditions are met [7]. In other words, the decision-making is based on the "rule of code". On-chain governance is beneficial for its transparency, accountability, and inclusivity as the encoded consensus mechanisms make it difficult to manipulate the votes, and all votes are recorded immutably on the blockchain [34] [81]. The decentralisation characteristic, however, makes on-chain governance subject to security risks such as 51% attacks, where a single entity gains control of the majority of the network's decision-making power and can manipulate the decision-making outcome for its own benefit [82]. It needs to be noted that the latter is not specific to application level tokens but applies to protocol level tokens as well. Lastly, on-chain governance also entails a lot of complexity in token economies with sophisticated economic objectives and many different stakeholders [82], which requires costly computational resources to execute the voting process [64].

Governance is considered “off-chain” when the decision-making takes place outside of the protocol. In other words, more “informal” communication channels are used such as social media or community forums [50]. Fritsch et al. [32] describe that in Uniswap's governance process, an off-chain temperature check and a consensus check are conducted, where a particular number of yes-votes is required for the proposal to move into the next step – voting. Off-chain governance can be more cost-effective compared to on-chain mechanisms since it does not require as many computational resources [64]. Buterin [80] adds that off-chain governance is better suited for native protocols such as Ethereum, as it comes with greater security required for governance areas related to transaction validation. That is, off-chain governance is less subject to hacker attacks as described before in the case of on-chain governance. However, off-chain is the most centralised form of governance as the majority of the decisions are made by a small group of trusted contributors or core developers, which can be seen as one of the main disadvantages of this approach [34].

At least in the near future, even the most decentralised blockchain ecosystems will need to involve some off-chain components in their governance, as in many instances the questions subject to governance are hard to foresee and thus fully integrate into the protocol [29]. On-chain governance - such as other consensus-based mechanisms - may fall victim to malicious actions [81]. If an envisaged “crisis governance” requires a majority approval similar to the regular governance procedures, an attacker can in essence hit two birds with one stone - hijacking the main governance while being able to refute the defence mechanisms. Fan et al. [75] specify that this threat is amplified for token systems with small initial market capitalisation and token supply circulation. It is therefore suggested to implement a crisis governance mechanism off-chain.

4.3.2 On-chain and Off-chain Governance in Currynomics

The Currynomics ecosystem aims to have its governance processes as decentralised and community-wide as possible. Hence, most of the governance areas described in Chapter 4.2.4 should be decided via using on-chain governance mechanisms so that the decision-making is transparent and inclusive. The means of mitigating on-chain governance security risks are analysed in more detail in Chapter 4.4.

Some off-chain governance areas such as identifying the most relevant proposals that should be set up for a community-wide vote will, however, be decided off-chain. This process is named as a “temperature check”, and it is held in the community forum. In the event that the proposal successfully passes the temperature check, a key member will then upload the proposal for a DAO vote on Snapshot. Having the temperature check off-chain is reasonable, as the community members are able to express their views in more detailed and complex ways that would be hard to accommodate on-chain.

4.4 Voting Mechanisms

The aim of this chapter is to guide the reader in understanding the desired properties of voting mechanisms in a token economy (see Chapter 4.4.1) as well as the core types of mechanisms employed by existing token economies (Chapter 4.4.2). It is then followed by a discussion on additional support mechanisms that tackle the potential issues left uncovered by the core voting mechanisms (Chapter 4.4.3). Chapter 4.4.4 explains the selection of respective mechanisms in the Currynomics ecosystem.

4.4.1 Desired Voting Mechanism Properties

It has to be noted that no voting mechanism has so far demonstrated complete effectiveness [34]. The voting mechanisms described in Chapter 4.4.2 are analysed based on the following desired properties, which were developed by combining the overlapping ideas in the literature:

1) **Simplicity**. The artefact developed in this thesis aims to follow the first principles mindset by keeping the suggested mechanisms as simple as possible. In the context of governance, this would mean creating decision-making procedures that are not overly complicated and are thus easier to understand and implement.

2) **Accountability**. Governance participants need to have 'skin in the game' in order to be accountable for their decisions [34]. This can come in the form of different resources, such as committed tokens, time, or reputation, as explained later.

3) **Inclusivity**. A good voting mechanism prevents the emergence of plutocracy, where wealthier individuals have excessive influence on the decision-making [39]. Inclusion refers to a mechanism where small stakeholders have equal standing in terms of voting power regardless of their financial means.

4) **Time efficiency**. A voting mechanism should enable urgent reactions to decide on time-sensitive governance areas [34].

5) **Intensity of preferences**. A good voting mechanism enables the expression of strong preferences of the ecosystem participants [39]. Voters can have a larger influence over decisions they are particularly interested in.

6) **Security**. A good voting mechanism prevents voter fraud through Sybil attacks, where voters create several different identities to evade the voting procedure [39].

4.4.2 Core Voting Mechanisms

Literature suggests the following four core types of existing voting mechanisms:

- **1-token-1-vote** (1t1v) is the simplest type of voting mechanism used in blockchain governance that gives equal voting power to each token held by a participant [39]. In this mechanism, the weight of a vote is directly proportional to the number of tokens held by the voter - the more tokens a participant holds, the more influence they have in the decision-making process. However, Buterin [80] warns that the 1t1v model allows an individual to engage in vote purchasing, which gives rise to plutocracy and thus low accountability. To alleviate this, governance mechanisms can be used that do not rely on token voting or where a single token grants the holder less than one unit of the voting power. Similarly, Mohan et al. [39] note that achieving both Sybil resistance and plutocracy resistance at the same time is a challenge when the voting system is dependent on a single factor such as the number of tokens staked for voting. It must be noted in advance, however, that including other factors such as time and reputation does not rule out the possibility of Sybil attacks and plutocracy entirely, which is why none of the voting mechanisms gets a full score in the security dimension. Some of the most prominent alternatives to the 1t1v model are outlined below.

- **Time-weighted voting**. These mechanisms all share the characteristic that they require a “time commitment” from the voters in order to keep them accountable for their decision-making and alleviate the risk of plutocracy and Sybil attacks [39]. Thus, such mechanisms are typically more complex than a simple 1t1v model. Literature covers at least 3 types of time-weighted voting mechanisms:

    a. **Conviction voting** is a mechanism where individuals convey their preferences (votes) for specific proposals, and as they maintain their preference for a proposal over time, their "conviction" in that proposal increases [84]. In other words, as the duration of an individual’s token stake on a particular proposal grows longer, the weight of their vote will also increase. Individuals can change their preferences at any moment. One can argue, however, that determining the most precise conviction of the community requires a certain time period, which makes conviction voting non-optimal for time-sensitive decisions.

    b. **Ve-token model** or vote-escrow model is a voting procedure where users can stake their regular ecosystem tokens for a specified period of time, and in return, receive greater voting power in the form of ve-tokens [39]. The ve-tokens received have a time-based "weight" that determines how much voting power they give to the holder. The longer the ve-tokens are held, the more weight they have, and the more governance power they will give when voting on proposals [21]. Thus, the ve-token model incentivises token holders to make thoughtful and informed decisions, as they are required to make a long-term commitment to their vote. On the flip side, the ve-token model might hinder efficient short-term decision-making for matters that require a fast reaction. Compared to conviction voting, it is also a more complex mechanism to set up and explain to the community.

    c. **Bond voting** is a type of voting system where the voters can show the strength of their preferences and increase their voting power by staking (i.e., locking) their tokens in exchange for bonds [39]. In order to purchase one vote, an individual must purchase a bond by staking a certain number of tokens P for a certain length of time. The tokens are locked until the bond expires, i.e., when the individual receives a refund of P tokens at the bond's maturity date. Thus, bond voting is a "static" and irreversible mechanism that requires voters to commit to a specific period of time at a particular moment, and this commitment cannot be changed later on. This mechanism may be less flexible than other voting mechanisms, as voters are committed to their stake for a specific period of time.

- **Reputation-weighted voting.** Another rather complex alternative to 1t1v mechanisms is to give the participants voting weight based on their reputation [85]. This approach is used by Colony – a platform that enables the creation and launch of DAOs [86]. In Colony, voting power is determined by members' reputation - a numerical value associated with the members, reflecting their contributions to the DAO and their expertise in specific domains. This value is used to weigh members' votes on proposals related to their area of expertise. Reputation is granted through peer evaluations of a member's actions, ensuring that individuals with proven expertise have greater voting power on relevant. Reputation may be diminished due to lack of engagement, misconduct, or generally negative actions. Thus, a likely disadvantage of reputation-weighted voting is that it requires the setup of additional mechanisms for quantifying and standardising user-generated value and expertise.

- **Quadratic Voting** is a mechanism that assigns a higher weight to the votes of individuals who are particularly passionate about a particular issue [87]. Each individual is given a certain number of voice credits, which they can use to vote on different proposals [77]. However, the cost of each additional vote increases quadratically, meaning that individuals who are particularly passionate about a particular issue can allocate more of their credits to that issue. For example, with a given budget of 10 votes, a user can cast 1 vote for one proposal and 3 votes for another proposal. In total, this would cost the voter $1^2 + 3^2 = 10$ credits. The core benefit of quadratic voting is that it takes into account the strong preferences of minority voters. Wright [87] adds that quadratic voting can even out the "weak preferences" of a larger group of users with the strong inclinations of a smaller group. Since the cost of votes increases quadratically, users are held accountable by having to give away a large number of tokens for influencing the outcome of the voting result.

The summary of the four types of voting mechanisms and their relation to the desired properties outlined in Chapter 4.4.1 are provided in Table 8, where: a full node indicates that a voting mechanism fulfils the desired property, a half-filled node represents partial fulfilment, and an empty node refers to weak fulfilment of the respective voting mechanism property.

Table 8. Summary of voting mechanisms and their properties

Voting mechanism	**Simplicity**	**Accountability**	**Inclusivity**	**Time efficiency**	**Intensity of preferences**	**Security**
1t1v	●	○	○	●	○	○
Time-weighted	◐	●	●	○	◐	◐
Reputation-weighted	◐	●	●	●	◐	◐
Quadratic voting	◐	●	●	●	●	◐
Legend: ● - strong fulfilment ◐ - rather strong fulfilment ○ - weak fulfilment						

4.4.3 Support Mechanisms for Voting

There are several issues that the abovementioned voting mechanisms do not directly tackle as the token economy matures. Thus, the artefact also equips the token economy designer with additional modules that can be integrated into governance in later phases when a need occurs. The issues and respective support mechanisms are described below:

- **Inaction from decision fatigue** occurs when there are too many proposals for the participants to analyse. A way to alleviate this is to employ prediction markets - a mechanism where individuals can buy and sell prediction shares based on their belief about the likely outcome of a particular decision [8]. The collective prediction outcome then helps to filter out proposals that are most relevant. Another way is to use algorithmic pre-screening for the proposals [29].

- **Inaction from rational ignorance** can occur when decision-makers choose not to gather the necessary information to make informed decisions [34]. This is because the cost of acquiring the information outweighs the potential benefits. A potential solution is to either provide a more efficient means of educating the decision-makers [29] or to enable delegated voting. Delegate voting allows token holders to delegate their voting power to trusted individuals or organizations [32] [75] [88]. This can help to ensure that decisions are made by knowledgeable individuals who have the best interests of the token economy in mind. According to [75], vote delegation is beneficial as it maintains the decentralisation of governance while turning the voting procedure more flexible.

- **Sybil attacks** can take place regardless of requiring the voters to contribute their tokens, time, and reputation. To prevent Sybil attacks, a trusted identity management system such as Proof of Personhood (PoP) can be employed [39]. These systems aim to verify the human behind an account by creating a unique and singular identity system.

4.4.4 Voting in Currynomics

Out of the five core types of voting mechanisms, the time-weighted voting will be employed in Currynomics DAO. The selection process first eliminated 1t1v as the least innovative and useful voting mechanism. Reputation-weighted voting, however, comes with too much complexity in setting up separate reputation evaluation mechanisms. Quadratic voting has not yet been proven to give an advantage to the smaller stakeholders in the ecosystem [77], so it needs to be better researched if the utility of this mechanism is worth the complexity that comes with integrating and explaining the quadratic voting mechanism to the community. Within the category of time-weighted voting, Currynomics DAO will employ conviction voting as the simplest form, since simplicity is an important characteristic for the ecosystem. As mentioned before, bond voting is a rather inflexible mechanism, whereas ve-token model would require the setup of special-purpose ve-tokens, which again would add unnecessary complexity to the governance processes.

The summary of the design steps created in Chapter 4 is presented in Figure 6. To understand the optimal level of decentralisation in a token economy, one must first map the areas that the governance has to deal with (Step 1), as well as the respective stakeholders who can have a say with respect to each of the areas (Step 2). Once decentralisation has been thought through (Step 3), it is possible to move closer to identifying the specific mechanisms for governance procedures. This would start by first analysing if the token economy should be more inclined towards on-chain or off-chain mechanisms (Step 4). Before moving to the next step – the selection of exact voting mechanisms, it is also necessary to determine what are the desired properties that a voting mechanism should have (Step 5). After the selection of a suitable voting mechanism type, a token economy might also need to establish additional support mechanisms to tackle issues that might arise as the ecosystem matures (Step 7).

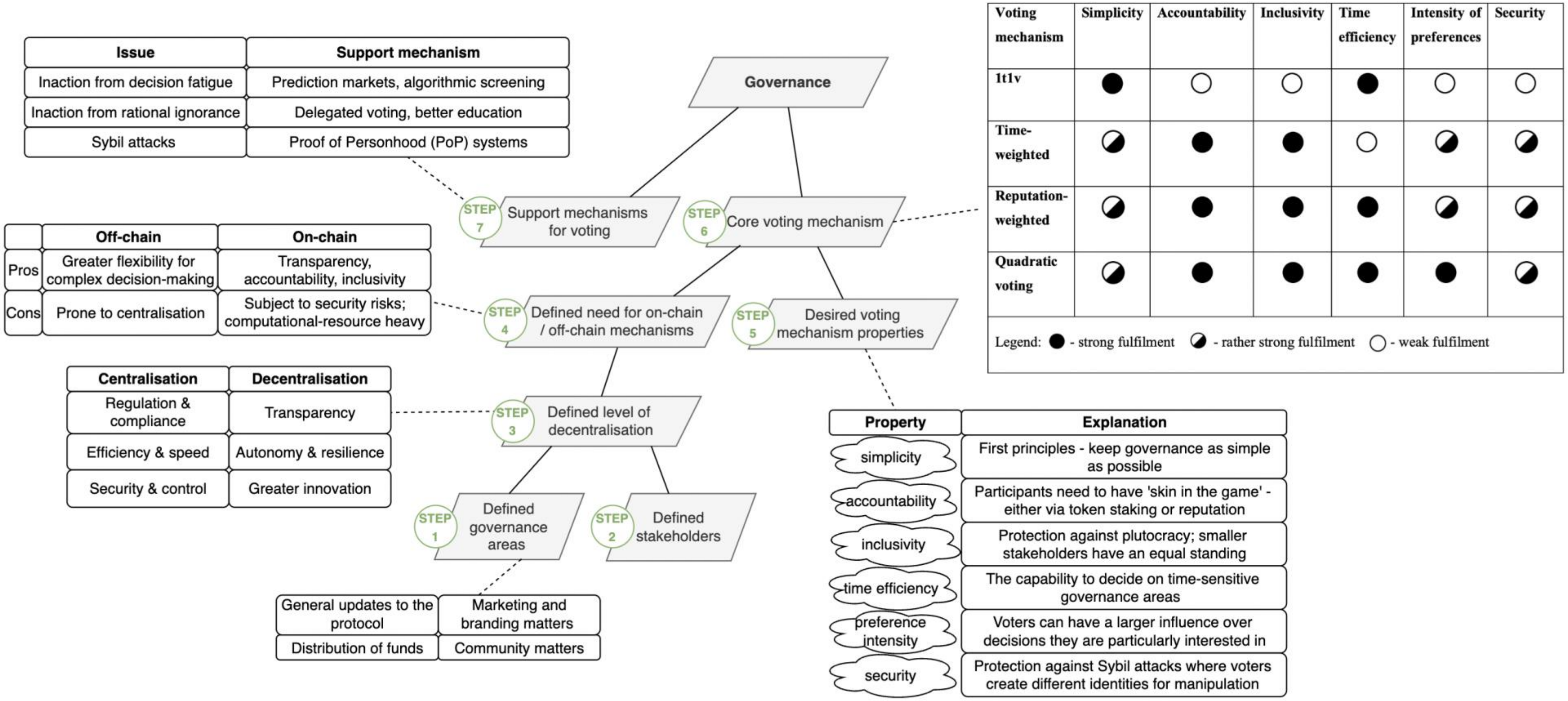


Figure 6. Goal model for designing token economy governance

4.5 Conclusion

The goal of this chapter was to guide the reader through the steps one has to take in establishing a governance structure for a token economy and answer the second core research question:

RQ2: How to design token economy governance?

Similar to Chapter 3, the suggested governance design steps in this chapter are not linked with technical specifications about best code-writing practices. Also, it is necessary to analyse quantitative parameters for the voting mechanisms mentioned - for example, the optimal duration and number of tokens to be locked in the ve-token model, and the effectiveness of conviction voting in time-sensitive issues. The latter can be a subject for future research. The answers to RQ2.1, RQ2.2 and RQ2.3 are as follows:

RQ2.1 What determines the extent of governance decentralisation?

Setting up a governance structure for a token economy starts by first determining the stakeholders and their roles in the governance. This analysis is in turn divided into two parts: identifying the areas subject to governance in the first place (e.g., decisions related to general updates to the protocol, distribution of token economy treasury funds, community, and marketing matters), and 2) deciding the level of decentralisation for each governance area. As a final step, the stakeholder groups can be mapped with governance areas where they can have a say.

RQ2.2 What determines the use of on-chain and off-chain governance components?

It is very likely that a token economy will employ both on-chain and off-chain types of governance mechanisms. There is an increasing amount of literature on on-chain governance, the latter enabling greater transparency, accountability, and inclusivity since every community member can audit the decision-making process. However, a fully on-chain token economy governance is not viable, as there remain security risks (such as exposure to 51% attacks) that no mechanism has yet managed to mitigate entirely. For that matter, some suggest establishing “crisis mechanisms” that should stay off-chain, away from manipulators who aim to hijack the governance via purchasing the majority of the tokens or voting rights. Off-chain mechanisms also come with greater flexibility, as the community members can express their thoughts in a free form either via real-life or forum discussions. The resulting decisions might be too complex to be encoded into the governance protocol. However, these benefits of off-chain governance mechanisms come with the risk of excess centralisation, which is the opposite direction of the desired innovation in decentralised blockchain projects.

RQ2.3 What are the voting mechanisms for governance proposals?

Selecting the most suitable voting mechanism starts with identifying what are the most desired properties this voting mechanism should have. For instance, token economies that are just about to launch may value the simplicity of the governance procedures. Similarly, many communities might appreciate it if the decision-making takes place in a time-efficient manner. Other properties include accountability, inclusivity of smaller stakeholders, intensity of preferences, and security. Four main types of voting mechanisms to choose from are 1t1v systems, time- or reputation-weighted voting, and quadratic voting (or in other words, many-token-1-vote systems). As the literature advances, it is likely that there are not many token economies that will employ the simplest form of 1t1v voting mechanism due to its shortcomings in security, inclusivity, and accountability. Lastly, there might occur a need for adding support methods for the selected voting mechanism as the ecosystem matures. These methods are intended to tackle issues such as community inaction (either due to decision fatigue or rational ignorance), or Sybil attacks.

5 Tokenomics

This chapter gives an overview of how a token economy designer ought to think of the fundamentals of designing a token economy's tokenomics. Firstly, Chapter 5.1 introduces the development of the research questions. Chapter 5.2 answers the first sub-question related to token issuance amount and timing; Chapter 5.3 answers the second sub-question on token distribution mechanisms, and Chapter 5.4 focuses on the third sub-question about ensuring token price sustainability. Lastly, Chapter 5.5 concludes the findings.

5.1 Introduction

Blockchain technologies have received the most attention for their technological issues like consensus mechanisms. However, questions about cryptocurrency distribution and tokenomics have been mostly neglected in academic research on cryptocurrencies [49]. The long-term viability of a blockchain ecosystem is greatly influenced by its tokenomics – mechanisms which determine token supply and distribution, the incentives offered by the token, and its utility [44]. Alternatively, tokenomics revolves around the "economy" that is based on the ecosystem's tokens [28]. Freni et al. [30] suggest that the token supply structure - how and when are the tokens issued into circulation - acts as a summary of a token economy's monetary policy. Conley [89] brings out that next to game theory and financial economics, applying monetary theory is a crucial aspect in the design of a token economy. Poor tokenomics design is often the reason behind the failure of some of the biggest ecosystem projects, e.g., the collapse of Luna and TerraUSD in early 2022. For this reason, the aim of this chapter is to guide the token economy designer through the steps and decisions that need to be made in designing tokenomics.

Good tokenomics is characterised as: 1) stable, for maintaining token price stability and preventing excessive volatility [45]; 2) incentivising by providing motivation for users to hold and use the token [61]; 3) sustainable by ensuring that the token price does not rely solely on inflation [50]; and 4) adaptive to the business environment and user demand. Given these qualities, the chapter aims to answer the following research questions:

RQ3: How to design token economy tokenomics?

According to the definition proposed by Kaal [71], monetary policies in blockchain ecosystems stand for the relationships between token supply, token release and the maximum number of tokens issued. Thus, the first two research questions are:

RQ3.1: What are the aspects of designing a token release schedule?

RQ3.2: What are the mechanisms for token distribution?

As tokens frequently experience significant fluctuations in price [48], it is necessary to maintain token price sustainability post-launch. The research question is thus:

RQ3.3: What are the mechanisms for ensuring token price sustainability?

5.2 Token Issuance

An overlapping theme in the existing literature is that a token release schedule consists of the number of tokens issued (see Chapter 5.2.1), and the timing of token issuance (Chapter 5.2.2). Chapter 5.2.3 reflects on the token issuance amount and timing in the Currynomics ecosystem.

5.2.1 Amount

Token issuance can follow either an inflationary or deflationary "valuation trajectory" [48]. In the last years, there has been a rapid growth of inflationary token models - token economies in which tokens will be gradually minted over time and no cap is implied on the total token supply. The authors explain that an inflationary design permits the use of mechanisms that provide stability by preventing undesirable token price volatility, which is further elaborated in Chapter 5.4.2. As the value of tokens decreases over time, it is likely that inflationary token issuance encourages spending in the token economy.

Kaal [71] adds that a gradual token issuance is similar to operating a fiat currency, which brings about more flexibility in adjusting to the current market conditions. This is supported by Conley [89], who claims that an effective token issuance design that prevents “pump and dump” schemes must take into account the premise that the supply of money has to grow hand in hand with the extent of economic activity - a feature of an inflationary token economy. Also, Gan et al. [90] prove that this approach enables raising more financing and gives the platform a better standing compared to having a capped ICO. In the case of a capped ICO, a relatively larger part of future profits is likely to go into the hands of speculators. According to [90], uncapped token issuance can dilute both the investors' and founders’ token ownership, making the latter less incentivised to develop the ecosystem.

In a deflationary model, the number of tokens to be ever issued is limited [90]. In an analysis of 100 token economies, Kaal [71] finds that 72 of them have chosen to set a cap on the total number of issued tokens. He suggests that such an issuance cap can induce scarcity and have a positive effect on the token price. A deflationary token economy is thus best suited for long-term store of value purposes - the limited supply can make the token more attractive to investors who are looking for a hedge against inflation or a long-term investment opportunity. As argued later in Chapter 5.4, however, scarcity does not necessarily add to the underlying value of a token. Another aspect to consider is that once the token supply is limited, token holders might start to “hoard” the tokens and decrease the accessibility of tokens from other stakeholders who would gain value from the tokens [48].

5.2.2 Timing

Based on [32], there are two main token release timing strategies for a token economy:

- **Pre-launch** token issuance involves distributing tokens before the project or product is launched. Kaal [71] suggests a mechanism of establishing escrow accounts, according to which tokens are stored on specific accounts before being released for financing further project development. Importantly, it must be ensured that the tokens held in escrow accounts will not be released at a discounted price, in order to avoid a token price crash. According to [91], pre-sales can be seen as a means to address the coordination failure that can arise in an ICO due to what they refer to as a "same-side network effect." This refers to a traditional network effect in which the value of using the token economy is dependent on the presence of a sufficient number of other users. By preselling tokens at a discounted rate, issuers can increase the chances of reaching the necessary level of participation, or critical mass, required to create value for all users. However, as described in Chapter 5.4, token price is a function of token demand. In the pre-launch period, the true token demand is unknown, and it might be thus more challenging to determine the initial fair price of the token.

- **Post-launch.** Post-launch token issuance involves distributing tokens after the project or product is launched. This entails either following a schedule-based issuance or to mint tokens in accordance with the demand for the token. Demand-driven issuance can help to ensure that token supply meets token demand, which can support price stability and reduce volatility [71]. Thus, the post-launch issuance approach can provide more flexibility and control over token issuance, as the project team can adjust the token supply based on user demand and market conditions. Post-launch token issuance can thus also help to avoid over-supplying tokens, which can lead to price volatility and reduced user adoption. However, if it is easy to generate initial user interest in pre-launch token distribution, the opposite might be true for a post-launch scenario.

  Kaal [14] also brings attention to a new promising type of token launch mechanism - a "fair launch", which is about launching a new token with no pre-mine or pre-sale, ensuring that all tokens are distributed in a fair and decentralised manner [14]. Thus, fair launches are good for establishing a truly decentralised and community-driven token economy with high transparency.

5.2.3 Token Release Schedule in Currynomics

As the Redcurry token is printed in accordance with the real estate portfolio size, it does not follow a strictly inflationary or deflationary valuation trajectory. However, the fact that tokens are printed on demand refers to inflationary characteristics, which are good for adjusting to the market conditions (e.g., the users can attempt to time the market after assessing the attractiveness of investing in the real estate sector). Redcurry tokens cannot be purchased pre-launch of the ecosystem, as the tokens require the acquisition of the real estate portfolio, which can take place once the token economy is live and operating.

The DAO tokens, however, can be purchased before the launch of the ecosystem, which will help to secure a critical mass of early interested users. The team does not see a problem in the threat of over-supplying the DAO tokens, since the effective token supply can later be adjusted with various mechanisms such as increasing the price for participating in governance. The founding team of Currynomics has chosen that the DAO token follows a deflationary valuation trajectory with a fixed cap for the token supply. However, a deflationary token tends to induce scarcity and act as a long-term store of value. Thus, it might decrease the willingness of the DAO token holders to spend it on participating in the governance.

5.3 Token Distribution

According to [92], token distribution methods are in particular relevant for governance tokens, as the latter determines the number of users who can exercise control over the token economy. Chapter 5.3.1 elaborates on the most prominent distribution mechanisms and Chapter 5.3.2 applies these in the context of Currynomics.

5.3.1 Private and public token distribution

There are several approaches as to what channels can be used for token distribution:

- **Private sale** involves selling tokens to a small group of investors before the public sale, often at a discount [93]. Depending on the funding goals of the token economy, a private sale may be a more appropriate option if the team is looking to raise a significant amount of capital quickly. Also, this method can also be beneficial if the token economy wants to maintain greater control over who holds the tokens. For example, it might be good to attract strategic partners or investors who can provide additional value beyond just the investment capital.

- **Public sale** is about selling tokens to the general public, for example via an ICO [47] or Initial Exchange Offering (IEO) [30] [94]. Public sales can help to raise funds for the project and provide early users with access to the tokens. Howell et al. [93] add that collecting funds from customers through ICOs has the potential to redistribute the profits gained from network growth from financial intermediaries, like venture capitalists, to token economy developers and consumers. Additionally, it can enhance brand recognition among customers and offer the issuer an initial indication of demand. This has led some to view ICOs as a way to democratise access to investment prospects in emerging enterprises

[95]. Thus, a public sale may be better if the token economy is seeking to build a larger community of supporters.

- **Airdrop**: This involves distributing tokens publicly for free to a large number of users as a way to promote the project or increase adoption [43]. Liu & Zhu [44] describe crypto airdrops as a market promotion strategy for startups and new projects. Through airdrops, startups try to gain public awareness and emerge victorious from the crowded market with thousands of tokens. Token holders and users could boost the building of a community for the project, eventually bringing a positive influence on token demand. Thus, airdrops can be used when the token economy wants to create a large community of users and gain awareness. However, if tokens were to be distributed via an airdrop, voting power can go to the hands of token holders who might not be interested in voting or do not possess the necessary expertise to take part in the decision-making [64].

5.3.2 Token Distribution in Currynomics

The Redcurry token inherently requires that it is sold publicly, via licensed financial institutions (Partners). Needless to say, a public sale helps to increase the demand for the Redcurry token. The DAO token, however, is first distributed pre-launch in order to reward early contributors such as developers (Currynomics Labs OÜ), who get 10% of the token supply, advisors (2%) and founders & core team (10%). In the pre-launch phase, the tokens are also sold privately - first via the Seed Sale (12%) to a selected group of early-stage investors such as angel investors and venture capital firms at a significantly discounted price; and later 10% to larger investors and strategic partners at a discount that is lower than the one in the Seed Sale. In addition, there is a smaller public pre-sale (2%) before the public sale, where tokens are offered to a broader audience. From the remaining token pool, 14% is saved for liquidity purposes and 15% for future ecosystem incentives such as paying bounties for bug discovery and rewards for community managers. Also, another 15% is reserved for other rewards and marketing purposes (e.g., early birds can receive more DAO tokens; Redcurry tokens can be staked to get more DAO tokens). The last 10% is left for the general ecosystem reserve.

5.4 Token Price Sustainability

Token price sustainability is a critical aspect of tokenomics that can impact the token's long-term viability and user adoption. The sustainability of the token price depends largely on the token's inherent value [50], which is further explained in Chapter 5.4.1. If the token has a strong inherent value, it is more likely to maintain its price over time. However, in light of the recent empirical examples of the large token economy collapses in 2022, there is still a need for effective price management mechanisms to ensure that the token price remains sustainable over time, even if the tokens have inherent value. The latter is described in Chapter 5.4.2. Lastly, Chapter 5.4.3 illustrates token price sustainability in the context of the Currynomics ecosystem.

5.4.1 Token Underlying Value

It is tempting to believe that tokens can have an intrinsic value in themselves, but this is something that Allen et al. [50] and Kaal [71] argue against. Thus, to determine the real underlying drivers of token value, it is helpful to bring a parallel to traditional corporate finance where a company’s underlying value can originate from claims to its assets, future earnings or voting rights [45]. Combining the findings in [30] [45] [71], these value capture mechanisms for tokens can be of four types:

1) **Governance rights.** One of the most straightforward token designs belongs to governance tokens, which have their value and utility thanks to enabling their holder to participate in the ecosystem’s governance [45] [46].

2) **Representing an asset**. A token may gain its inherent value by representing a claim to a real-world asset such as real estate, art, company stocks, commodities, and other crypto assets [30] [71].Thus, the token price is closely tied to the value of the respective real-life asset. A special case is stablecoins – tokens whose value is tied to an external asset, typically a fiat currency, whose benefit is to reduce token price volatility, as well as provide cost-efficient value transferring [48].

3) **Value from the network**. A token might also become valuable when the users have built a high level of trust for the system and the utility that the system offers [30] [71] - a concept similar to Metcalfe’s Law, according to which the value of a network is relative to the square of the number of system participants [96]. For

this type of value channel, the token price is heavily dependent on supply and demand movements.

4) **Claim to earnings.** When a token acts as a share of the ecosystem's earnings, its value derivation is very similar to the one applied in traditional public stock markets [30] [48]. The value of the work performed in the system is created by third parties - but not token holders - meaning that the value is a representation of expected future cash flows.

5.4.2 Price Management Mechanisms

By managing the token price, token economy designers can ensure that the token's value proposition is sustainable. Without effective price management mechanisms, token prices can be highly volatile, which can erode trust in the ecosystem and undermine its long-term viability. Li & Mann [91] and Mayer [57] specifically warn against speculators - investors who purchase tokens with the intent to gain a profit from the token value appreciation, but without making any transactions on the platform. Therefore, speculators are less concerned about the token price stability, making them more tolerant towards risk-taking. There is no threat from speculators to platform usage in normal conditions, as the platform has high transaction volume, and thus low volatility in the token price. However, it is in the case of high volatility where a "crowding out" effect emerges. Namely, high token price volatility discourages platform users from making transactions. Consequently, the token value depreciates, which in turn attracts speculative investors who gauge a good opportunity for making high-return investments. Therefore, token possession is dominated by speculators rather than platform users. The activity of speculators or "whales" is also more likely when the token launch has a small market capitalisation and thus low market liquidity [14]. In order to avoid excess token price volatility, the literature suggests 4 mechanisms for managing token price:

- **Token Burns**: Token burns refer to the process of permanently removing tokens from circulation, which can reduce the token supply and create scarcity [50]. This can increase the token's value and incentivise long-term holding, which can help manage the token price. However, the authors emphasise that a mere manipulation of the number of tokens in circulation does not increase the underlying value of the token *per se.*

- **Token Staking**: As mentioned in earlier paragraphs, users can stake their tokens to earn rewards in the form of additional tokens or transaction fees. As staked tokens cannot be sold, there is a smaller downward pressure on the token price. However, Lommers et al. [46] warn that staking reduces the token supply in circulation, which can lead to increased demand and higher prices. If, however, the stakers suddenly decide to sell their tokens, it can result in a sudden increase in supply and a drop in prices. Too high staking yields can also disproportionately attract speculative users.

- **Token Buybacks**: Token buybacks involve buying back tokens from the market, which can reduce the token supply in circulation and create scarcity [45] [50]. A token economy can use its accumulated earnings in its treasury to buy back its own tokens, thereby decreasing the number of tokens in circulation and signalling that the ecosystem has sufficient cash resources and does not resemble a Ponzi scheme.

- **Token Vesting**: Token vesting involves releasing tokens to stakeholders over time, rather than all at once [60] [91]. Thus, vesting can help to manage the token price by preventing large amounts of tokens from flooding the market and causing a price drop.

5.4.3 Token Price Sustainability in Currynomics

The underlying value of the Redcurry token is directly tied to real assets - namely, the real estate portfolio against which each Redcurry token is minted. Such an arrangement enables the Redcurry token holder to invest their savings in a low-risk manner while gaining from the token price appreciation that reflects the growth of the underlying real estate portfolio. Another underlying value channel is network value - the more Users that have trusted their investments in the Redcurry token, the greater the trust among new prospective Users to join the ecosystem. The underlying value of the DAO token stands in 1) the ability to participate in governance, and 2) claims to earnings. The latter comes from the fact that in the future, a part of the transaction fees can be indirectly redistributed among DAO token holders via token price appreciation.

The Redcurry token has an inherent token buyback and burn mechanism (“price control”) when a large enough proportion of the Users decides to sell their tokens. In other words, if the Redcurry token demand decreases, so must the underlying supply (real estate portfolio), in order to ensure that the real estate portfolio NAV is the same as the Redcurry token market cap. Also, Users have the option to stake Redcurry tokens and receive DAO tokens as a reward. When a certain amount of Redcurry tokens is staked, it helps to maintain the token price at a stable level. For the DAO token, a token vesting mechanism has been applied to avoid a scenario where early contributors cash out in a relatively short time after the launch of the system. An indirect mechanism to sustain the DAO token price comes from the selected voting mechanism. Namely, in conviction voting, users must stake their DAO tokens for a selected time period to participate in the voting - the longer the token is staked, the greater voting power is allocated. Similar to the staking mechanism in Redcurry, this helps to decrease token price volatility. The Currynomics development team is still considering whether it might be necessary to add more price management mechanisms for the DAO token once the ecosystem becomes more mature.

The design flow for establishing tokenomics is summarised in Figure 7 and comprises of two main parts, the first one being the design of the token release schedule. To establish the token release schedule, one must first understand the number of tokens to release (Step 1), whether tokens will be allocated pre- or post-listing (Step 2), as well as if the token release will be public or private (Step 3). The second core component of tokenomics is about ensuring token price stability, which again comprises of two sub-goals: making sure that the token(s) have an inherent value in themselves (Step 4) and establishing suitable price management mechanisms (Step 5).

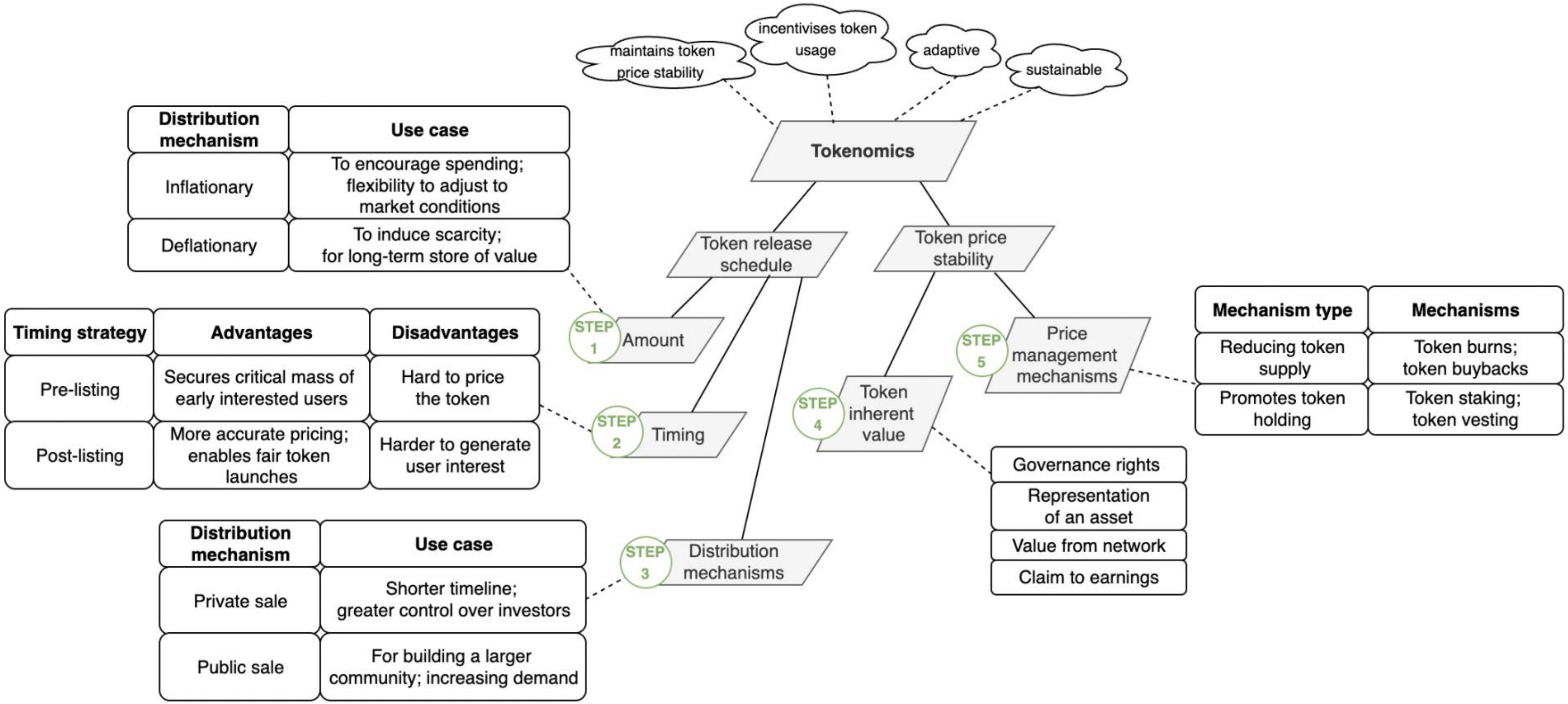


Figure 7. Goal model for designing token economy tokenomics

5.5 Conclusion

The aim of Chapter 5 was to lead the reader through the process of developing tokenomics for a token economy and to answer the research question:

RQ3: How to design token economy tokenomics?

It must be noted that the chapter did not provide details on determining the quantitative parameters such as the relations between token issuance cap, staking yield, and the extent of decentralisation among token holders. Quantitative simulations can be open to investigation in the future. The sub-questions answered in this chapter are as follows:

RQ3.1: What are the aspects of designing a token release schedule?

A token release schedule can be viewed in two main dimensions: the number of tokens issued and the timing of the issuance. A token economy can set a cap on the total token supply, which is referred to as a deflationary token economy. A deflationary trajectory is good for inducing token scarcity in the ecosystem, which is why it is most suitable for store of value tokens that have a long-term retention target. In contrast, an inflationary token economy issues tokens without a pre-determined cap. When drawing a parallel from traditional monetary policy, inflation promotes ecosystem participants to increase spending, as the purchase value of the token decreases over time. Also, an inflationary trajectory might be more effective in adjusting the token supply in accordance with the market conditions.

The question of token issuance timing can also be divided into two. Pre-launch token issuance helps to secure a critical mass of early interested users, but it might be harder to price the token as there is no exact indication of true token demand. Post-launch token issuance can help to avoid oversupplying tokens and enables fair token launches, but it might be hard to attract more users since the initial promotion period of the token sale is over.

RQ3.2: What are the mechanisms for token distribution?

Tokens can be distributed mostly via two channels: private token sales and public token sales. In the former, the timeline is likely to be shorter, and the tokens can be distributed to a controlled group of users. Public sale on the other hand helps to create a wider user base with potentially greater demand. A subcategory of public token distribution is the airdrop method, which is about distributing tokens free of charge to users that are interested in the token economy. This way, the user base can be even wider, as the airdrops come with a significantly greater promotion effect.

RQ3.3: What are the mechanisms for ensuring token price sustainability?

The fundamental aspect of a sustainable token price is that the token has inherent value. The token can either capture the value from the network effects, its governance rights, and claims to potential financial earnings or the token can in a straightforward way represent a real-life asset. Despite the token having an inherent value, the token price can nevertheless be subject to token price volatility mostly due to speculators. To control the token price, options include reducing the token supply via token burns or buybacks, or incentivising users to hold the token for a longer period via token staking or establishing vesting periods. The latter can also be fostered with the help of fair token launches as explained in Chapter 5.2.2.

6 Evaluation

This chapter presents an evaluation of the artefact that was constructed in Chapters 3-5. Chapter 6.1 describes the selection process for suitable evaluation methods. Chapter 6.2 summarises the findings of the evaluation, which is followed by Chapter 6.3, where the findings are discussed and linked with existing literature.

6.1 Methodology

Peffers et al. [97] have distinguished 8 types of methods that can be used in DSR evaluation: 1) logical argument, 2) expert valuation, 3) technical experiment, 4) subject-based experiment, 5) action research, 6) prototype, 7) case study, and 8) illustrative scenario. They bring out that in IS journals, DSR studies whose aim is to provide an artefact – such as the current thesis – most often select a case study as the evaluation methodology. Hence, one of the evaluation methods for the design artefact in this study is the case study method. However, as the case study object – the Currynomics ecosystem – has not yet been launched at the time of writing this study, it is hard to fully assess whether the developed design guidelines are fully effective based on real-world scenarios. Hence, the case study method is supported by expert interviews, which are described further in Chapter 6.1.2.

6.1.1 Case Study

A case study is an observational method of evaluation that is employed to examine the designed artefact in detail within its intended business setting [98]. According to [99] [100] [101], evaluation methods can be classified by asking three questions: how, why, and when to evaluate. Respectively, evaluation methods can be either *artificial/naturalistic*, *ex-ante/ex-post* or *formative/summative*. The case study method used in this study follows the following attributes: 1) *naturalistic*, as the design artefact is studied in the real-life business environment of Currynomics 2) *ex-post*, as the evaluation is held after the application of the artefact on the use-case, and 3) *summative* -

the aim of case study is to understand the design artefact in light of different contexts and, in turn, determine which application types are most suitable for the artefact.

The case study process consists of two main activities, namely *demonstration* and *evaluation* [102]. A *demonstration* is a simplified form of evaluation that exhibits how the artefact can be used to solve a specific problem instance. The *evaluation* activity is more formal and assesses the artefact's performance. The *demonstration* of how the artefact is applied in the context of Currynomics has been provided in respective subchapters throughout Chapters 3-5. For *evaluation*, two Currynomics representatives with whom the *demonstration* was held are presented with questions regarding the five qualitative evaluation criteria as outlined in Chapter 6.1.2 via semi-structured interviews (see reference to the audio files in Appendix 2). The representatives are anonymised and referred to as interviewees IN1 and IN2.

6.1.2 Expert Interviews

Expert interviews for DSR evaluation purposes are 1) *artificial*, as the artefact is studied outside the business environment, 2) *ex-ante*, as the interviews take place prior to applying the artefact on other cases than Currynomics, and 3) *summative*, similar to the case study method. In artefact evaluation, interviews can be an effective research method for eliciting expert opinions [103]. Interviews are a valuable means of gathering data by obtaining insights from experts about their practices, beliefs, experiences, or viewpoints [104]. The objective of conducting expert interviews in this thesis is to obtain information about the artefact’s *completeness*, *simplicity*, *understandability*, and *operational feasibility* – evaluation metrics that are popular in IS research where artefacts are developed [102]. The selection of the four metrics was inspired by Pelt et al. [78], who conducted a DSR study for developing a blockchain governance framework, which is very similar to the aim of the current thesis, albeit having a narrower scope. According to [102], the definition of the chosen metrics is as follows:

- *Completeness* - The extent to which the arrangement of the artefact includes all essential components and associations among those components.
- *Simplicity* - The level at which the structure of the artefact incorporates the minimal number of necessary components and connections among those components.

- *Understandability* - The extent to which the artefact can be understood, both on a broad scale and on a detailed level of the components and connections within the artefact.
- *Operational feasibility* – The extent to which the proposed object will receive backing and adoption from management, employees, and other stakeholders, as well as be effectively utilised and incorporated into their daily operations.

Semi-structured interviews are utilised to gather comprehensive information in an informal conversational format and allow the researcher to ask additional questions as needed [104]. The interviews are then transcribed using online Transkriptor software[1], and thematic analysis is performed [105] using the coding function within the MAXQDA software[2]. At the beginning of the interviews, the interviewees are informed about the purpose of the study, the structure of the interview, and a request is presented to record the interview. Then, in the first core part, the interviewees are introduced to the token economy design framework and are able to express their opinions if they wish to comment or elaborate on a specific design topic. In the second phase, the following questions are asked to judge the artefact's *completeness*, *simplicity*, *understandability*, and *operational feasibility*:

1) How do you perceive the model's *completeness*? Does it contain all the necessary elements required to guide the reader through the first no-code steps in setting up token economy incentive mechanisms, governance and tokenomics?
2) How would you comment on the model's *simplicity*? Is it free from unnecessary features and complexity?
3) How do you perceive the model's *understandability*? Is the general model structure as well as the details easily understandable for somebody with a no-code background?
4) What are your thoughts on the model's *operational feasibility*? Is it possible to successfully integrate the model into the daily operations of designing the core aspects of a token economy?

[1] https://app.transkriptor.com/uploader

[2] https://www.maxqda.com/

When conducting thematic analysis, the need for considering an additional evaluation metric emerged, namely *accuracy* - the level of concurrence between the results produced by the object and the anticipated outcomes [102]. Specifically, *accuracy* refers to how correctly are the details in the model explained to the reader.

The expert interviews utilise a purposive sampling method, which is about the deliberate selection of participants based on their qualities [106]. The experts are sampled based on the criterion that they possess significant knowledge and experience in the field of token economy design, either via practical experience or academic work for at least a minimum of three years. Purposive sampling provides benefits such as higher participant willingness to participate and the ability to communicate experiences and opinions effectively [106]. The aim of the expert interviews is not to generate results that could be generalised to the entire population but to obtain meaningful feedback from experts during the design process to gather further ideas for improving the artefact. In total, semi-structured interviews are conducted with three experts (see reference to the audio files in Appendix 2). To safeguard the confidentiality of the participants, they are anonymised as IN3, IN4 and IN5. These identifiers will be utilised throughout this section to reference the corresponding experts and their views. The subsequent sections will present the findings from the case study and expert interviews.

6.2 Results

Table 9 summarises the results of the thematic analysis applied to all of the five interview transcripts with regard to the five evaluation metrics – *completeness, simplicity, understandability, operational feasibility,* and *accuracy.* The table highlights the number of the most prominent comments related to each evaluation metric. All 55 comments correspond to the respective thematic analysis code labels created in the MAXQDA software, which are summarised in Figure 8 and discussed in detail in Chapter 6.3. The number of supportive comments (in green in Figure 8) shows how many times the evaluation characteristic was strongly supported in a comment. Neutral comments (in yellow) neither support nor oppose the model but indicate that the interviewee wanted to elaborate on the details and offer ideas for future research. Opposing comments (in red) highlight the shortcomings of the model with regard to the respective evaluation metric. The arrows in Figure 8 indicate that one code label is a sub-component of a larger code block. There are five key code blocks, each referring to one of the five evaluation metrics mentioned before. If the same comment occurs multiple times, the code label is supplemented with brackets which contain the number of instances.

Table 9. Summary of interview comments on model evaluation metrics

Evaluation metric	**Supporting comments**	**Neutral comments**	**Opposing comments**
Completeness	3	4	2
Simplicity	7	2	-
Understandability	-	2	3
Operational feasibility	6	8	-
Accuracy	4	11	3

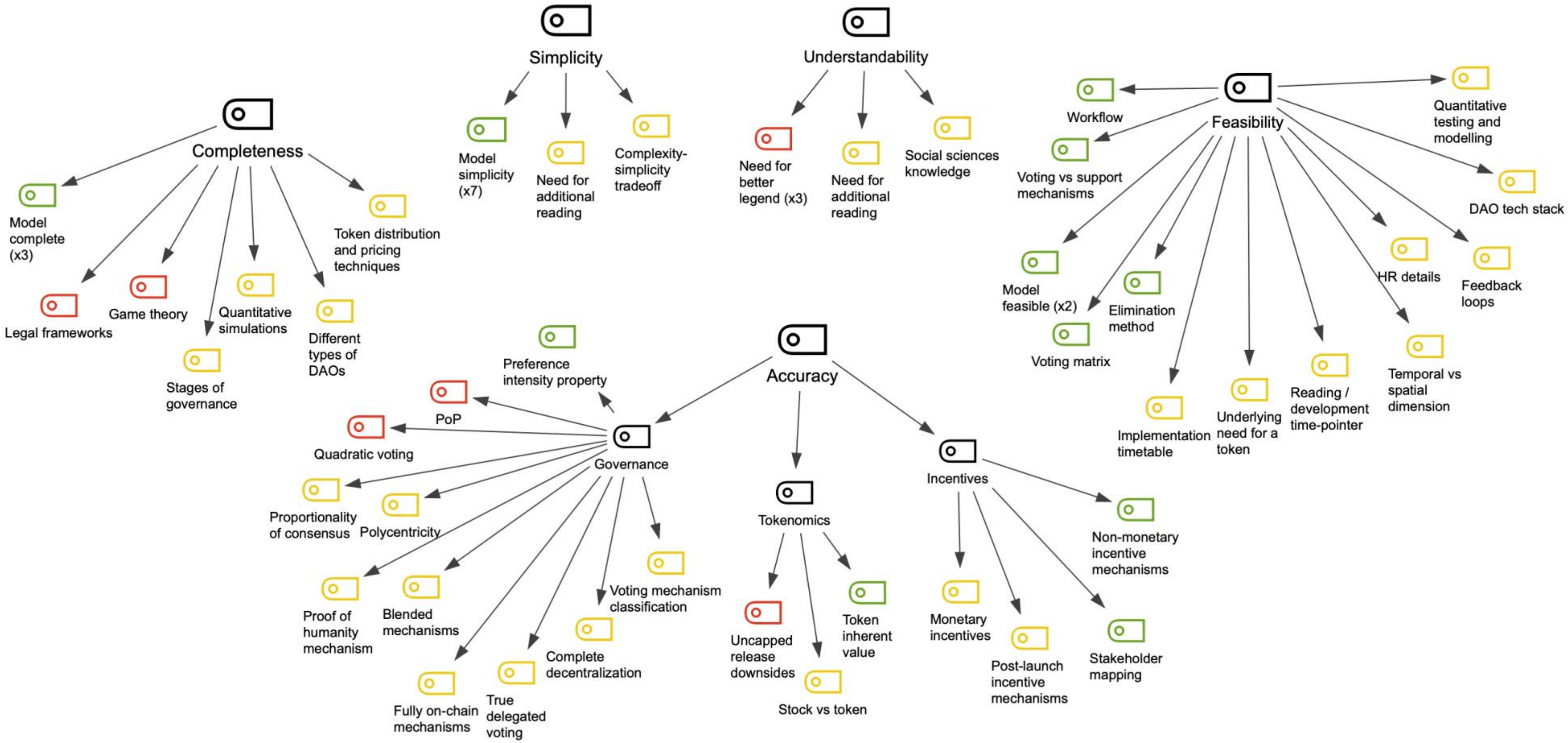


Figure 8. Summary of the code labels in thematic analysis

6.3 Discussion

This chapter analyses the most prominent comments obtained from the semi-structured interviews, which were summarised in Table 9 and Figure 8. To make the transcript excerpts clearer and more concise, the author has modified them while maintaining the interviewee's original statement's authenticity. Chapter 6.3.1 takes a look at the findings from the interviews with Currynomics representatives (IN1 & IN2) in light of the case study *demonstration* phase and Chapter 6.3.2 summarises how the artefact helped the use-case to move from an as-is state into a to-be state. Chapter 6.3.3 considers feedback from three industry experts (IN3, IN4 & IN5), whereas both Chapter 6.3.1 and Chapter 6.3.3 go through the chosen five evaluation metrics – the model's *completeness*, *simplicity*, *understandability*, *operational feasibility,* and *accuracy*.

6.3.1 Case Study

Completeness. Regarding the model's completeness from the point of view of designing Currynomics, IN2 comments, "*I think it covers pretty well the different possible approaches and why something works and does not work for us."* He adds that the next crucial step for Currynomics would be to run simulations to evaluate the chosen mechanisms in governance (e.g., conviction voting) and tokenomics (e.g., capped DAO token supply and monetary reward mechanisms). For this matter, [107] showcase and analyse 18 different blockchain simulators and offer a comprehensive overview of the pros and cons of each simulator.

In general, IN2 believes that the model covers everything that is necessary to understand before starting to implement some project-specific tokenomics such as quantitative token release parameters. He adds, "*[The model] is more than I've seen somebody summarise and make it understandable, so I think it is complete."* IN1 believes that the model could be expanded by providing more details on token distribution both before and after token generation events, together with the best practices for getting the token price right. Cong et al. [108], for example, have developed a token economy model that helps to understand the economics of staking and the impact it has on token pricing.

Simplicity. As to simplicity, IN1 comments, "*I wouldn't say [the model] is too complex. It just takes a moment to grasp because [the topic] is complex. But I think visually everything makes sense and covers the important aspects that need to be actually thought through."* Similarly, IN2 sees that all three core blocks of the model cover aspects that the Currynomics team has also been thinking about during the past year with the help of various experts and advisors. For IN2, the model is a good "abstract" that covers a broad range of relevant topics without unnecessary complexity. IN2 elaborates that he sees complexity and simplicity as two sides of the same coin: the model's complexity could always be expanded, but that would affect the simplicity. Overall, he sees that the model's simplicity is rather optimal – there are some levels that require the reader to do some extra research, but the fundamentals are provided by the model.

Understandability. Both IN1 and IN2 claim that the figures that summarise the model should be complimented with a more comprehensive legend that explains the exact order of how the three core aspects and the sub-goals should be followed. According to this feedback, these changes were already incorporated into the model (see Figure 5, Figure 6 and Figure 7). Further, IN2 believes that regarding the model's understandability, it is not even a question if the token economy designer has prior coding experience. Rather, it is important for the designer to understand social sciences, because designing a token economy is largely about understanding the different behaviours of the ecosystem participants. In this regard, he believes that the model also does manage to guide readers who do not have a social sciences background, as it introduces new and important terminology, especially in the governance chapter.

Operational feasibility. As to operational feasibility, IN1 comments, *"I think [the model] is super helpful. It helps to understand how everything comes together."* He adds that from Currynomics' point of view, it would add more value if it included guidance on choosing the most optimal tech stack for DAO design. He understands, however, that the technical details are outside of the scope of the current thesis and believes that the model provides a good theoretical underpinning for token economy design. IN2 notes that given the current scope of the thesis, it is definitely feasible to design a token economy based on the model. Yet, whether the economic design will be successful is another question. As mentioned before, IN2 suggests that quantitative modelling and testing are crucial aspects to add to the model in the future to ensure that the token economy design will be viable.

Moreover, IN2 appreciates that every topic in the model has a good workflow but suggests that it would be helpful to create a realistic timetable for implementing the theoretical design developed with the help of the model. Interestingly, IN2 finds that the model helps them to narrow down by determining the mechanisms and approaches that will not work for the Currynomics ecosystem (coded as the "elimination method" in Figure 8). He comments, *"99% of the work, I would say, is just about understanding what is not for you, and then going after the 1% is for understanding what works for you."* For making the model more feasible, he suggests two additions: Firstly, the model could include a pointer that informs the reader how long it will take to read the content. Similarly, the chapters could include an estimate of how much time could it take for the practitioners to develop an MVP of the respective design blocks of the token economy. Some aspects can take a week, whereas some might require many months. Secondly, the reader could be educated about the human resources and people skills that the token economy development team must have, such as the requirement of having a code developer, an economist, or simply creative people in the team. IN2 believes that the design could also be put into place without code developers, but with at least a technical lead within the team. The latter depends a lot on the blockchain that the token economy is based on – applications based on Ethereum Virtual Machine allow for a slightly easier design.

Accuracy. The strongest comment about the model's accuracy was put forward by IN1, who feels that the benefits of having an inflationary token economy (see Chapter 5.2.1) are not balanced with the potential downsides of the approach. Regardless of the fact that an uncapped token release schedule promotes spending, IN1 sees that the price and number of tokens is not the key driver for all ecosystem participants and might therefore not act as a strong enough incentive to spend the token. He feels that inflationary ecosystems can lead to unpredictable outcomes and should be designed with more caution, *"I think we shouldn't design inflationary [token economies] unless we exactly know why we do that and then how it works."* This is reflected in the philosophy of the Redcurry token, which is meant to act as an inflation-resistant stablecoin. As an example of what could go wrong, he explains that when minting new tokens, the token price can decrease (tokens get "diluted"), which might give a negative signal to the token holders and launch a selloff cascade. It is only the long-term token holders who are compensated for the inflation, but the more speculative users might decide to flee the ecosystem. He explains, "*These are the main arguments why I am super careful with designing the* *inflationary token in itself because I've seen inflationary systems crash so many times in the space that they are really difficult to decide to design right."* Scepticism towards inflationary token economies is also presented by Kaal [14], namely that unrestricted ICO contributions can lead to significant challenges in determining the actual value of the token.

6.3.2 To-Be State of the Use-Case

In general, the artefact performed well in helping the Currynomics ecosystem to move from a determined set of problems within the business environment into a desired state of having good token economy design fundamentals. Chapter 3 helped to extend the existing stakeholder graph (Figure 1) by first mapping the stakeholders with the exact functions that the latter await from the token economy, and secondly by identifying which of the behaviours can be incentivised with the use of the tokens in the ecosystem (both the Redcurry token and the DAO token). Given the nature of these desired behaviours, the artefact helped to determine that the incentive mechanisms linked to the Redcurry token ought to be mostly of monetary type, whereas incentives regarding the DAO token should be mainly non-monetary in nature.

Chapter 4 defined the desired level of decentralisation in the Currynomics ecosystem by mapping the pre-determined governance areas with stakeholders who can have a say in the respective areas. After determining that the ecosystem aims to have high levels of decentralisation, the artefact suggested applying mostly on-chain governance mechanisms. The key contribution of Chapter 4 was identifying that the most suitable voting mechanism for Currynomics is conviction voting. For this, it was necessary to distinguish that simplicity is one of the most important properties for Currynomics in choosing a voting mechanism. Thanks to the artefact, the Currynomics development team identified that for the sake of simplicity and better community engagement, the chosen voting mechanism will be upgraded to a more complex version using the support mechanisms from Chapter 4.4.3 only once the ecosystem matures.

Chapter 5 helped to confirm that following an inflationary trajectory for the allocation of the Redcurry token is a suitable option, as the literature suggests that inflationary ecosystems promote user activity. As to the DAO token, the artefact could not convince the development team to switch to an uncapped token release schedule, but nevertheless informed the team that a deflationary, capped token release setup could cause the

Community to hold on to the DAO token for financial gains rather than using it for taking part in governance. Chapter 5.3 encouraged Currynomics to first have a private token offering to reward early project contributors and strategic investors, and then allocate the tokens via public sale to increase the demand for the DAO token. Chapter 5.4.1 helped Currynomics to ensure that both tokens have an inherent value, which should mitigate the risk of token price crashes. Namely, the Redcurry token is backed by the CRE portfolio, whereas the underlying value of the DAO token stands in in 1) the ability to participate in governance and 2) claims to future earnings. Chapter 5.4.2 confirmed that Currynomics should take advantage of token staking and vesting mechanisms to avoid excess volatility in the price movements of both tokens.

6.3.3 Expert Interviews

Completeness. IN3 sees that designing a token economy is closely related to legal frameworks. Hence, he would add a guide for legal frameworks surrounding token economies but understands that this is out of the scope of the thesis. This could be built on the study by Momtaz [109], who brings together the concepts of economics, law, and technology as they relate to asset tokens and STOs. Also, van der Linden and Shirazi [110] examine whether the MiCA Regulation, if implemented, will establish legal certainty that facilitates the wider integration of crypto-assets into financial services. To illustrate the necessity of awareness on legal matters, IN3 explains that in some countries such as the US, monetary token incentives immediately count as unregistered securities which cannot be simply sold to retail investors. Also, IN3 finds that the model should include a game theory perspective when designing incentives, "*You are really in some sense setting up a game and you need to think about how the motivations of different stakeholders create like a meta-structure on top of it.*" He brings an empirical example of OlympusDAO, which crashed due to its prisoner-dilemma-like setting, where everybody's token price went up until someone tried to sell and unleashed a cascade of selloffs. He would tie this with so-called Ponzi economics, *"There is always this kind of inevitable Ponzi element to a lot of token structures."*

IN4 has positive comments on the model's completeness, "*I think I feel very comfortable with like the scope that [the model] covers*." He adds that a potential expansion to the governance section is to guide the reader in designing different types of DAOs and suggests developing a more detailed model in the future that has potential modules and plugins that can be integrated respective to the DAO's needs, similar to the existing DAO creation platforms such as Aragon. However, he acknowledges that not every token design team needs an out-of-the-box solution. IN5 suggests that the governance chapter could be complemented by introducing different stages of governance decision-making such as proposal selection or "*pre-decision deliberation*", voting, and execution, whereas the designer could benefit from special tools that might be helpful at different decision-making stages. This is in accordance with Laatikainen et al. [111], who state that blockchain governance is a dynamic process that changes with time. During the formation or design phase, also known as exploration or bootstrapping, the main concern of the token economy is determining the optimal functioning of the ecosystem. Once the token economy is operational, the focus shifts to how it should be maintained and operated. Also, there may be instances where the ecosystem experiences a crisis, and the primary concern is how to resolve conflicts that have arisen.

Simplicity. Regarding the artefact's simplicity, IN5 comments, "*I don't think there's anything that was completely unnecessary in here. It is a very technical in-depth topic, so it's hard to simplify at this stage further than I think what you have already.*" Similarly, IN3 claims, "*I think [the model] is pretty good. Honestly, I would add more than less, but I [personally] like having complete pictures and detailed descriptions, and I realise that's not everybody's cup of tea.*" IN4 confirms that the model has a "clear frame" and is thus "seamless and practical" for people that are new to the industry.

Understandability. Similar to the representatives of Currynomics, IN5 notes that at first glance it is hard to grasp in which order the reader has to go through the model – intuitively, he too would start studying the models top-down not bottom-up. Although all the model components were described in the text preceding the figures, the figures themselves should include a more comprehensive reading guide. As mentioned earlier, these changes have already been implemented after the interviews (see Figure 5, Figure 6 and Figure 7). IN4 sees that the model requires the reader to do a lot of additional reading to understand the details but believes this is not necessarily a bad thing.

Operational feasibility. In terms of operational feasibility, IN5 appreciates the separation of voting mechanisms and support mechanisms in the governance chapter and brings a parallel that the support mechanisms can act as practical "add-ons" like in the WordPress software. Also, both IN5 and IN4 express their appraisal towards the voting mechanism matrix. IN5 adds that in essence the matrix can be summarised via two dimensions on two axes: spatial and temporal. Spatial mechanisms (such as quadratic voting) are about the number of tokens held by the people in the community, whereas the temporal dimension takes in the time component. These dimensions are in essence covered by Mohan et al. [39], albeit the latter defines these as "instruments", namely *quantity of tokens* and time *commitment*.

In the incentives chapter, IN4 would introduce the concept of "value flows" – a mind map that helps to capture the ecosystem participants together with their behavioural feedback loops, which have to be later tested in a quantitative simulation. This is related to a "stock-and-flow" diagram as described by Khamisa [6] - a tool where "stock" refers to the number of tokens created (and not burned) in the past, and "flow" represents the tokens to be created in the future. The diagram would showcase how the feedback loops emerge in between stocks and flows. Lastly, for individuals new to the web3 industry, IN5 emphasises that the model feasibility depends on whether one understands the necessity of creating a token in the first place. The latter is in principle covered by Schubert et al. [3], who propose a token economy design framework, where the first step includes a "blockchain suitability" test, in which the practitioner should distinguish whether the use case is appropriate for a blockchain-based solution in general.

Accuracy. In expert interviews, a large part of the comments related to the model's accuracy was given in the context of token economy governance. As to the debate on decentralisation, IN3 claims that theoretically there can exist completely decentralised token economies. This is, however, a rare case in practice, since full decentralisation leads to an inflexible system. This is supported by Fritsch et al. [32], who prove the difficulties in creating entirely decentralised blockchain governance systems. IN3 adds that we do not have many real-life examples of well-performing token economies that are heavily decentralised. On a similar note, IN5 adds that token economies need not have all operations on-chain, as many existing and sufficient decision-making tools are less costly, less technical, and less confusing. He claims, "*So let's use those [off-chain] tools and let's integrate these tools where we need them."* The impracticality of fully on-chain decision-making mechanisms is also confirmed in [81].

There were quite several comments related to the voting mechanisms and their desired properties. IN5 comments that quadratic voting is not necessarily a voting technique but rather an "*optimisation type of how tokens are weighted within a population.*" He illustrates that quadratic voting is like "*using the lens that magnifies the people with less [tokens] and shrinks the people with more,*" and adds that similar optimisation types can be logarithmic voting, 3rd and 4th power cost functions. In contrast, Dimitri [79] defines quadratic voting as a "voting method" rather than an optimisation method. Lastly, IN5 would add one more potential property for voting mechanisms – "*proportionality of consensus*", which would proportionately consider the popularity of a delegate instead of allocating decision-making power equally among all delegates. Another term to summarise this is true delegated voting, where IN5 comments, "*I don't think we're quite there yet with true delegated voting. We're still in very like discreet delegated voting systems.*" This matter is addressed by Fritsch et al. [32], who describe "liquid democracy" as a setup in which token holders can delegate a desired number of tokens to a chosen delegate so that some delegates can indeed have more voting power than others.

IN5 is particularly fond of the "intensity preference" property, which is especially a problem in 1t1v mechanisms, as confirmed by Mohan et al. [39]. He brings several real-life parallels as to why there are many governance areas where some individuals should possess more decision-making power. He addresses the importance of polycentricity, "*I think, fundamentally, one-person-one-vote is like a fool's errand way to approach democracy. We need to embrace polycentricity, and that means hierarchies where they make sense.*" He sees that we apply polycentricity in our daily lives, but it is hard to represent this on-chain, which would require moving away from a simple 1t1v model.

IN5 agrees that it can be a difficult task to separate voting mechanisms and support mechanisms since the many components of voting are interlinked. He brings an example that delegated voting can be a sub-component of reputation-weighted voting because in delegated voting systems, delegates are using reputation to attract votes for additional decision-making power. IN5 is curious about potential combinations of voting mechanisms and add-ons in the future. For example, the temporal dimension (time-weighted voting mechanisms) could be blended with vote delegation and quadratic voting, resulting in quadratic delegated conviction voting. He emphasises that it would be "*super interesting to see what context the different types of voting will be useful for.*" For example, Kiayas & Lazos [34] mention that a "approval voting" mechanism can be combined with token locking: individuals who have a strong preference for a particular proposal may choose to keep their vote tokens locked in an extended period, suggesting that this election holds significant importance for them. Approval voting on its own is merely a voting mechanism in which each voter is allowed to approve any number of proposals.

Regarding the support mechanisms highlighted in Chapter 4.4.3, IN3 would criticise the proof of personhood (PoP) mechanism, as there might be instances where ecosystem participants may borrow each other's identification documents, which in essence allows for vote-buying. This is supported by Siddarth et al. [112], who claim a protocol needs to be established which can function independently of centralised entities such as countries. This would enable blockchain ecosystems to govern themselves and prevent the accumulation of power and control that exists in current proof of stake or proof of work mechanisms. As a potential solution, IN3 suggests the use of proof of attendance protocols (PoaP). However, there are yet no academic papers that address such protocols in detail. IN4 confirms that proof of humanity mechanisms should be better analysed, as they may cause problems that originally happened off-chain to now happen on-chain. For example, some participants may characteristically win over the votes of other people. Such polarisation issues could eventually lead token economies to a protocol fork.

Another block of comments related to the model's accuracy was related to the design of incentives. In Chapter 3, IN5 likes the focus on stakeholder mapping, as this is a crucial step in enabling the token(s) to connect underprovided needs and overprovision of goods in an ecosystem. The latter matches the views of Barrera & Hurder [29]. IN5 also appreciates that the chapter stresses the importance of non-monetary incentive mechanisms, as using only monetary incentive mechanisms can impose a "crowding out effect" on other reasons to participate in desirable behaviours. The term "crowding out" is also described in the given context by Sockin & Xiong [12], who explain that speculators can increase the token price, but also overshadow the participation of other stakeholders. Just like Liu et al. [42], IN4 agrees that monetary incentives have a less impactful role in the long term and are more costly. He also brings out that is especially important to focus on incentive mechanisms in post-launch token allocation, as the late joiners might be more interested in speculating with the token in secondary markets instead of acting out desirable behaviours such as participating in governance.

Lastly, quite a few comments about the model's accuracy were addressed towards tokenomics. IN5 claims that probably the hardest part in tokenomics is for the token economy designer to determine the token release amount. Thus, he would add that besides inflationary and deflationary token trajectories, there exists one more approach - "*dynamic supply token*", which balances the trade-offs of both capped and uncapped token releases. He explains that the number of tokens allocated should correspond to the number of tokens the ecosystem needs, but not more. Dynamic token supply could be established via the use of special smart contracts called bonding curves that help to determine the optimal price for the token released. Bonding curves are well described by Zargham et al. [113]. IN5 explains further that in the case of dynamic token supply, tokens are only minted if some reserve asset (e.g., a dollar) is committed to the token economy reserve pool in the first place. Similarly, the more tokens that are burned back to the smart contract, the more reserves are released. IN5 explains, "*It is essentially a system that can expand and contract with the demand that is required of it. So, you don't have to set in advance.*"

IN5 especially agrees with the design step of determining the token's inherent value, as he sees token economies almost as a "supportive function" or "engine" for a project or goal. The importance of understanding a token intrinsic value is also emphasised by Carvalho [45] and Allen et al. [50]. IN5 relates it to traditional finance where one cannot merely launch a stock without having an idea of what is the purpose of the underlying company. He elaborates, "*What are you going to do with the money that you raised from the stock is really the question. People invest in stocks because there is a company that's doing something that they think is valuable*". He claims that many token economies have not figured this out yet.

7 Conclusion

Chapter 7 summarises the research findings of the thesis. Chapter 7.1 offers overall conclusions, followed by Chapter 7.2 which addresses each research question introduced in Chapter 1. Chapter 7.3 discusses the limitations of the research, and Chapter 7.4 outlines insights for future work.

7.1 Conclusion

The focus of this thesis is on developing a step-by-step framework for designing a token economy. The framework, also referred to as *the model*, guides an individual who is new to the web3 industry in understanding the fundamentals of token economy incentive mechanisms, governance and tokenomics. The thesis follows a DSR methodology, according to which existing knowledge from the academic literature is gathered and analysed to compose an artefact – the token economy design model. The model is first evaluated using a case study approach based on Currynomics – a blockchain ecosystem that is creating an inflation-resistant CRE-backed stablecoin named Redcurry. In addition, semi-structured expert interviews are held with three industry experts based on the following evaluation criteria: *completeness*, *simplicity*, *understandability*, *operational feasibility*, and *accuracy*. In general, the artefact satisfies all of the five evaluation criteria, since there are more supporting than opposing comments regarding the evaluation criteria as summarised in Table 9 and Figure 8. However, *completeness* and *understandability* are the two characteristics that received slightly more negative comments from the interviews (see thesis' limitations in Chapter 7.3). The interviews also included many neutral comments that provide good insights for future work (see Chapter 7.4).

7.2 Research Questions

The main research question for this thesis is: How to design a sustainable token economy? As explained in Chapter 1, this primary question is further broken down into three sub-questions, which are outlined below.

7.2.1 RQ1: How to Design Token Economy Incentive Mechanisms?

Literature suggests that one of the first steps in designing token economy incentive structures is to define the ecosystem's stakeholders and the functions that the latter await from the token economy. For those stakeholders whose behaviour can be influenced via tokens, the next step is about identifying the desirable behaviours that should be promoted. Next, Chapter 3.4.1 highlights some of the core differences between monetary and non-monetary incentive mechanisms. The former is best suitable for tangible, short-term results, but is more costly to the ecosystem. Non-monetary incentive mechanisms are, however, more community-oriented and have a long-term effect. Lastly, some specific mechanisms under both categories are explained.

7.2.2 RQ2: How to Design Token Economy Governance?

Similar to designing token economy incentives, the first step in establishing token economy governance is about understanding the relevant stakeholder groups. Mapping these stakeholders with governance areas they can have a say helps to define the optimal level of decentralisation in the ecosystem. When it comes to specific governance mechanisms, Chapter 4.3 introduces the concept of off-chain and on-chain decision-making mechanisms, whereas both previous studies and expert interviews held in this study agree that it is not feasible to use solely on-chain governance mechanisms. As the next step, the practitioner has to analyse which of the six desired properties of voting mechanisms are the most relevant for the token economy. Only then can one move further into establishing exact voting mechanisms. As the last step, the reader can adopt support mechanisms to the chosen voting mechanism, which help to tackle issues such as voter inaction and Sybil attacks, which might arise as the token economy matures.

7.2.3 RQ3: How to Design Token Economy Tokenomics?

Designing tokenomics entails two core steps. Firstly, one must determine the most optimal token release schedule by deciding between 1) a capped or uncapped token allocation, 2) a pre-launch or post-launch token allocation, and 3) a private or public token sale. The second step is about maintaining token price stability as the ecosystem matures. Here, understanding the token’s inherent value is of major importance. A token can either directly represent a real-life asset, be valuable due to governance rights, or provide exposure to future financial gains. After the token's inherent value is understood, one must also think of possible price management mechanisms that might be necessary post-launch of the ecosystem. These mechanisms can either come in the form of promoting token holding (via token staking or vesting schemes) or reducing token supply (e.g., via token buyback and/or burn mechanisms).

7.3 Limitations

One of the core limitations of the artefact is that it is not intended to guide the reader through the technical aspects of designing a token economy. That is, the selection of underlying blockchain protocol, token standards, and methods for quantitative test runs and simulations are out of the scope of the model. Another key limitation revolves around legal frameworks for establishing token economies, which are not covered within the scope of the thesis. Lastly, as highlighted in one of the evaluation interviews, the model ought to consider the fundamentals of game theory with regard to designing incentive mechanisms, as blockchain ecosystems often have the threat to resemble so-called Ponzi economics. All of these limitations can be mitigated by turning a focus on them in future studies.

7.4 Future Work

All interviewees used the chance to elaborate on the accuracy of the model components, especially in Chapter 4, which covers governance mechanisms. This is not to say that the details in the governance section are the most flawed – rather that governance is a token economy design aspect that is developing fast, and practitioners have different understandings of particular matters. A practical way how the model could be adjusted is to divide the voting mechanisms suggested in the voting matrix into temporal and spatial mechanisms. The former refers to voting measures that require a time commitment from the voters. The spatial dimension, on the other hand, is about the number of people in the community who hold a number of tokens that can be optimised. Another component to add to the governance chapter is to study the design requirements aimed at different types of DAO such as social DAOs, protocol DAOs, investment DAOs, and more.

From a general perspective, the model could be expanded in the future by guiding the reader in understanding the human resources needed to develop a token economy – e.g., the necessary proportion of developers, strategists, financial experts and alike in the development team. Also, the operational feasibility of the model could be improved by adding information on the likely duration of each design and development phase, e.g., the time required for studying the stakeholder needs, identifying the most optimal voting mechanism, or running quantitative simulations about tokenomics.

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Appendix 2 – Interviewee List

Interviewee IN1: Male, Redcurry Representative, Audio Recording 10/04/2023, “IN1.m4a”

Interviewee IN2: Male, Redcurry Representative, Audio Recording 11/04/2023, “IN2.m4a”

Interviewee IN3: Male, Industry Expert, Audio Recording 05/04/2023, “IN3.m4a”

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