A Work Project, presented as part of the requirements for the Award of a Master's degree in Management from the Nova School of Business and Economics.

Backward Integration into Bitcoin Mining

A cost-benefit analysis for the Swiss digital asset broker Relai

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Abstract

Bitcoin is an emerging cryptocurrency that allows people to transfer value digitally peer-to-peer. The Bitcoin blockchain is powered and secured by Bitcoin miners, who can be considered the backbone of the network. This work project aims to support the decision of the management of the Swiss digital asset broker Relai regarding its potential backward integration into Bitcoin mining. To assess the project, a cost-benefit analysis and a project valuation are conducted. The analysis shows that accurately evaluating a Bitcoin mining project is challenging, as it is mainly based on assumptions, and thus the results should be interpreted with caution.

Keywords: Bitcoin Mining, Digital Asset Broker, Backward Integration, Cost-Benefit Analysis

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Glossary

Bitcoin	Bitcoin with a capital "B" typically refers to the protocol and payment network. The term "Bitcoin" is also frequently used to refer to the ecosystem as a whole or when writing about it in general terms (Blockchain.com 2014).
bitcoin	bitcoin with a lowercase "b" typically refers to bitcoin as a currency. When you want to talk about how much bitcoin you have exchanged or sent, bitcoin is written in lowercase (Blockchain.com 2014).

1. Introduction

"I do think Bitcoin is the first [encrypted money] that has the potential to do something like change the world." – Peter Thiel, Co-Founder of PayPal

Only time will tell whether Bitcoin will have a lasting world-changing impact, and what that impact will be. But already to this day, Bitcoin has achieved previously unimaginable things since its inception in January 2009. It is the fastest asset to have reached a market capitalization of $1 trillion, doing so in just 12 years, compared to major tech stocks that took, on average, 33 years (Ali 2021). Today, Bitcoin has a larger market capitalization than well-known companies like Mastercard or Nestlé, and high-profile companies like Tesla hold it on their balance sheet (Infinite Market Cap 2022; Kovach 2021). In addition, one of Bitcoin's most notable recent achievements has been its acceptance as legal tender in the nation-states of El Salvador and the Central African Republic (Knight 2022). These achievements show that Bitcoin has the potential to further change the world and therefore should not be ignored, but rather, closely monitored and understood.

A key component of the Bitcoin network is the process of Bitcoin mining. It is considered the backbone of Bitcoin, and the mechanics and economics behind it will be the focus of the following work project (Liquid n.d.).

1.1 Organizational Context

This work project is conducted in the format of a Direct Research Internship (DRI), where a specific organizational challenge of a company is addressed in a problem-solving format. The DRI for this work project is performed with the two-year-old Bitcoin startup Relai in Zurich, Switzerland.

1.1.1 Relai AG

Relai (www.relai.app) is a licensed Swiss digital asset broker that was founded in 2020 by Julian Liniger and Adem Bilican. Relai's ambition is to be Europe's easiest Bitcoin app and to give everyone fast and secure access to Bitcoin. Their beginner-friendly, bitcoin-only investment app allows users to buy, sell and store bitcoin with ease. Relai's unique selling point is that it is possible to buy bitcoin within one minute, as no registration, verification or deposit is needed. Its business model is based on a fee model, as they charge its user an all-inclusive brokerage fee that ranges from 1% to 2.5% per transaction (Relai 2022).

Figure 1: Relai Company Logo

Since the launch of Relai, the company has grown to over 20 full-time employees and closed a seed financing round of $2.6 million. As of now, the Relai app has been downloaded over 100,000 times, and over $50 million has been invested through Relai (Startup 2022).

1.1.2 Organizational Challenge

Relai's management is currently considering a backward integration into its supply chain by starting to mine bitcoin themselves via a hosting partner, who would run the mining operation (see Appendix 1). At the moment, Relai is executing buy and sell orders of its customers via crypto exchanges like Kraken. By starting to mine bitcoin themselves, Relai would potentially be able to cut out its supplier of bitcoin by vertically integrating into its supply chain. Relai would be able to mine its own bitcoin and sell them directly to its users without the need for an exchange as a middleman. This would allow Relai to potentially increase its margins and generate an additional revenue stream. Relai's CEO, Julian Liniger, mentioned that they are currently facing the challenge of not having the necessary Bitcoin mining knowledge and the time to conduct an in-depth analysis/calculation of the potential costs and benefits of a backward integration into Bitcoin mining (see Appendix 1).

1.2 Approach & Structure of the Work

The goal of this work project is to provide Relai's management with the necessary Bitcoin mining knowledge and a tool to take an informed strategic decision regarding their plan to start Bitcoin mining themselves. The main output of the project is an in-depth cost-benefit and scenario analysis regarding Relai's backward integration into Bitcoin mining.

The structure of the following work project is as follows: In a first step, the theoretical background of Bitcoin - its ecosystem and Bitcoin mining - is discussed. A closer look is taken at the economics behind bitcoin mining and at how it generates value. In a second step, the applied methodology to solve Relai's organizational challenge is described. In a third step, a comprehensive analysis of Relai's planned backward integration into Bitcoin mining is conducted. Finally, the results of the analysis are discussed and specific recommendations for Relai are made.

2. Theoretical Background

2.1 Bitcoin

Invented in 2008 by an anonymous person or group of people under the name Satoshi Nakamoto, Bitcoin is a decentralized digital currency, also called cryptocurrency (Frankenfiel 2022). It was revealed to the world with the release of the Bitcoin white paper "Bitcoin: A Peer-to-Peer Electronic Cash System" (Nakamoto 2008). Being the first cryptocurrency, Bitcoin is today the largest and most well-known of the more than 20,000 cryptocurrencies in existence (Ashford 2022; CoinMarketCap 2022).

2.1.1 Purpose and Technology

According to Satoshi Nakamoto, Bitcoin is intended to serve as a new form of digital money and means of payment that isn't based on trust but on cryptographic proof (Nakamoto 2008, 1). Bitcoin eliminates the need for third parties to be involved in transactions, as it is outside the

control of a single person, group or organization. It allows to exchange value directly between two users using the Bitcoin peer-to-peer network, which is open and accessible to everyone (Frankenfiel 2022).

Unlike traditional money, Bitcoin is issued, stored and sent using a distributed ledger technology (DLT) called blockchain (Majaski 2021). A blockchain is a specific kind of shared database that differs from other databases in that it stores data in blocks that are subsequently connected via cryptography (Hayes 2022a). This gives a blockchain the hard-to-emulate properties of security, resiliency, immutability, transparency, verifiability and permissibility (Jung 2019). In the case of Bitcoin, it is a public blockchain that is operated by a decentralized network of computers that run Bitcoin open-source code. There are three main types of computers, also called nodes, in the Bitcoin network: (1) Full-Nodes, which maintain and distribute copies of the entire Bitcoin blockchain; (2) Light-Nodes, which are primarily designed to enable the end user to easily access the Bitcoin network to send, store and receive bitcoin; and (3) Mining-Nodes, which bundle transactions, add new blocks to the blockchain, and earn newly issued bitcoin as a reward for their work (Beedham 2019).

2.1.2 Value of Bitcoin

Whether Bitcoin is a valuable asset or not is highly controversial. On the one hand, there are non-believers like the legendary investor and Berkshire Hathaway CEO, Warren Buffet, who called Bitcoin “rat poison squared” and therewith clearly sees no value in it (Kim 2018). The non-believers mainly argue that Bitcoin doesn’t have an inherent value, as it doesn’t produce anything and therefore is solely a speculative asset (Newbery 2021). They like to compare Bitcoin to the 17th-century tulip market bubble in Europe (McGrath 2021).

On the other hand, there are believers like the famous hedge fund manager Ray Dalio, who said that Bitcoin “has merit as a small portion of a portfolio” (Yue 2022). Within the group of believers, there are two main perspectives on why Bitcoin has value. On one side, they claim

that Bitcoin fulfils the six characteristics of money, which are durability, portability, divisibility, fungibility, scarcity and acceptability (Federal Reserve Bank of St. Louis n.d.; NYDIG 2022). They argue that Bitcoin is a superior form of money for the digital age and that it derives its value from being a new form of money. On the other side, some of the believers see Bitcoin's value as digital gold due to its verifiable limited supply of close to 21 million bitcoin (Uddin, Ali and Mansur 2020).

In general, something has value if people decide that it has value. As people are willing to exchange services, goods or fiat money for Bitcoin, it has value for the same reason money does (Ashford 2022). At the time of writing, people are willing to pay approximately $19,000 for one bitcoin (CoinMarketCap 2022). Even though the price of bitcoin is highly volatile, there has been a clear upward price trend since its inception (see Appendix 2).

2.2 Bitcoin Ecosystem

According to Auerswald and Dani (2017, 246), an ecosystem is a dynamic network of interconnected companies. Since the inception of Bitcoin in 2009, a healthy and ever-growing Bitcoin ecosystem has developed. Bitcoin's ecosystem consists of a vast number of participants, ranging from players in the field of information/news, development and custody, to bitcoin miners and exchanges/digital asset brokers (Dantoni 2019).

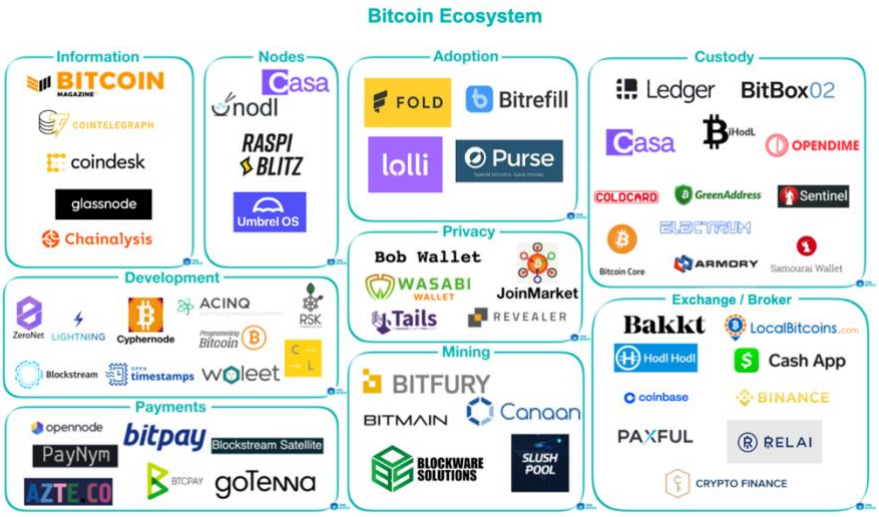

Figure 2: Bitcoin Ecosystem (adapted from Dantoni 2019)

2.2.1 Digital Asset Brokers vs. Cryptocurrency Exchange

According to Baker McKenzie (2022, 13), there is a clear distinction between a digital asset broker and a cryptocurrency exchange. A digital asset broker is a financial intermediary that acts for people who want to exchange money for cryptocurrencies and vice versa (Bitpanda n.d.). The broker charges a predefined brokerage fee for facilitating the trade on behalf of the customer (Baker McKenzie 2022, 13). In contrast, an exchange is a company that provides buyers and sellers of cryptocurrencies with an online platform and an order book so they can trade directly themselves. The exchange provides the system, but the transaction is carried out directly between buyers and sellers of cryptocurrencies by matching buy and sell orders (Baker McKenzie 2022, 13; Bitpanda n.d.).

2.2.2 Supply Chain of Bitcoin

A supply chain is a network of suppliers and companies that are involved in the production of a product or service. It includes everything from the raw material to the finished product that is delivered to the end user (Nastase and Felea 2013, 75).

The supply chain of Bitcoin is comparable with that of a commodity. However, Bitcoin is a digital commodity, as it exists only in electronic form and therefore has some special supply chain characteristics (Rotta and Paraná 2022, 4). On the one hand, Bitcoin's total supply is programmatically limited to 21 million and thus has a finite supply (CoinGecko 2022). It is expected that the last bitcoin will be mined around the year 2140 (George 2022). On the other hand, newly mined bitcoin is the end product that an end user wants; thus there is no processing of raw material compared with, for example, gold (Hoffmann n.d.).

The main players in the supply chain of Bitcoin are miners, exchanges, brokers, custodians & end users (The Block 2018). Bitcoin’s supply chain works as follows: new bitcoin are created by miners that receive them as a reward for their contribution of computing power to their wallet (Beedham 2019). Bitcoin miners typically then sell their bitcoin on exchanges and in some

cases - especially with larger quantities - directly to digital asset brokers (CryptoQuant 2021). These bitcoin are then bought by the end user either directly on an exchange or via a broker that is usually connected to multiple exchanges (Jocham 2021). Finally, the end user decides how to store its bitcoin in its preferred custody solution.

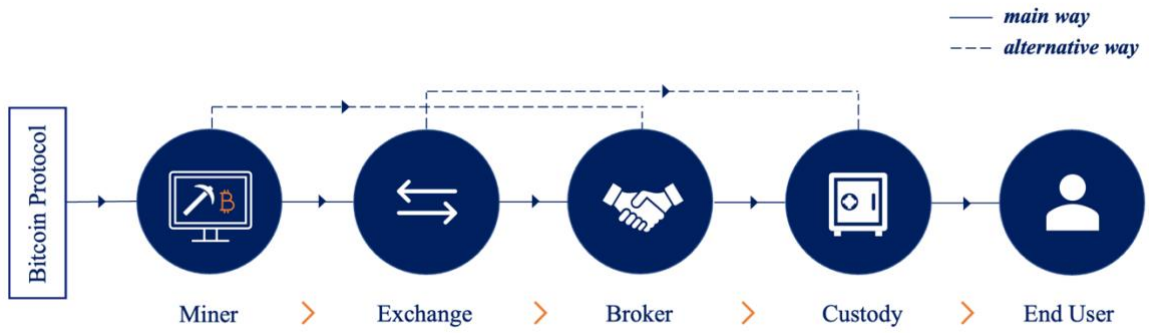

Figure 3: Bitcoin Supply Chain (own representation)

2.3 Bitcoin Mining

2.3.1 Definition and Purpose

Mining nodes, also called Bitcoin miners, are Bitcoin network participants that are responsible for Bitcoin mining (Beedham 2019). Bitcoin mining is a key process in maintaining and developing the Bitcoin network and is therefore considered the backbone of Bitcoin (Liquid n.d.; Sun et al. 2022, 1). Bitcoin miners are computers that are distributed all around the world (Sun et al. 2022; see Appendix 3). They serve the following two main purposes:

1. To securely add new transactions to the Bitcoin blockchain (see Appendix 4) and ensure that consensus is reached between the participants without the need for a central authority (Ashford 2022; Braiins n.d.).
2. To distribute the total supply of 21 million bitcoin by rewarding newly issued bitcoin to miners who produce a new block. The so-called block reward is the incentive for miners to provide computing power and energy to the Bitcoin network (Braiins n.d.). As of August 2022, 19.1 million bitcoin have already been mined, with about 1.9 million bitcoin still to go (CoinGecko 2022).

In a nutshell, Bitcoin mining is a method for securely storing and maintaining records in a decentralized ledger that offers monetary incentives to the miners (CFI Team 2022).

2.3.2 Consensus Mechanism: Proof of Work

To protect the Bitcoin network from miners adding new blocks in a chaotic and unstructured manner, Bitcoin uses a consensus mechanism called proof of work (Jungen 2022, 9). Proof of work ensures that only the first person that solves a mathematical puzzle has the right to add the next block to the blockchain (Ashford 2022). The difficulty of the puzzle changes dynamically to guarantee that a new block is only found approximately every 10 minutes and thus all network participants have sufficient time to update to the latest version of the blockchain. Approximately every two weeks, the difficulty of the puzzle increases or decreases according to the number of miners trying to solve the puzzle (Braiins n.d.; see Appendix 5).

Proof of work functions in the way that before a block is added permanently to the blockchain, the block is hashed using the mathematical hash function SHA-256 (Kharoo 2019; see Appendix 6). It is called a blockchain, as miners hash together the block header, the hash number of the previous block, all new transactions, and a randomly selected number, called nonce (Jungen 2022, 10; see Appendix 7). Miners change the nonce until the hash function produces a valid hash value for this block. Thus, finding the right nonce for a certain block is the mathematical puzzle all miners try to solve simultaneously. Once a valid hash value is found, the miner propagates the new block to the network and collects the block reward and transaction fees (CFI Team 2022).

2.3.3 Factors Impacting the Profitability of Hosted Mining

Bitcoin miners have an incentive to contribute their computing power to the Bitcoin network because they expect to receive a reward that is higher than their expenses (Arora 2022). Hosted Bitcoin mining is a service offered by data centres to Bitcoin miners, where, for a fee, customers

can store their miners and mine bitcoin without having to build the capital-intensive mining infrastructure themselves (Ashraf 2022). According to the research of Deutsch (2018), Delgado-Mohatar, Felis-Rota und Fernández-Herraiz (2019), and the Bitcoin mining software company Braiins (2022), the profitability of a hosted mining operation is dependent on various factors that are summarized below.

- *Timeframe*: To measure the profitability of a mining operation, the used timeframe is a key factor. As mining is a long-term game, Braiins (2022) suggests using a longer timeframe of between 6 and 60 months.
- *Bitcoin Price:* A miner's mining reward is paid in bitcoin. Therefore, the current and future bitcoin price greatly impacts profitability (Deutsch 2018, 3).
- *Mining Reward:* A miner's reward for finding the next block consists of a block subsidy and a transaction fee. Currently, block subsidy per block is 6.25 bitcoin and the transaction fee paid per block varies depending on network usage (Braiins 2022). The block subsidy is cut in half roughly every four years in the so-called halving event, and thus must be considered in a profitability analysis (Fitzpatrick 2021; see Appendix 8).
- *Network Difficulty:* The Bitcoin network difficulty determines how hard it is to mine a new Bitcoin block (Blockchain.com 2022a; see Appendix 5). More miners participating in the bitcoin network (= Total Hash Rate; see Appendix 9) results in a higher difficulty, which ultimately leads to less mining reward per miner (Blockchain.com 2022b). Thus, current and future network difficulty is impacting profitability (Deutsch 2018, 4).
- *Mining Pool Fee:* A mining pool combines the computing power of a group of miners to increase the probability of finding a new block. Once a block is found, the mining reward is proportionally split among the mining pool participants. Most miners join a mining pool to have a steady income and not rely on luck to find a block. Mining pools charge an average fee of approximately 2% and thus impact profitability (Beigel 2022).

- *Mining Hardware:* To mine bitcoin, specially designed computers called ASICs (Application Specific Integrated Circuits) are used. They are optimized to generate as many hash values per second as possible in order to solve the mathematical puzzle for the next block (Kim 2022). As the main cost involved in running an ASIC is electricity, the efficiency of an ASIC - denominated as watts per terra hash (W/TH) - is a key figure for an ASIC. The efficiency of an ASIC compared to the most efficient ASIC and the current bitcoin price are the two key price drivers of ASICs. As buying ASICs is capital intensive, the purchase and resale price of ASICs greatly impact the profitability of a mining operation (Braiins 2022; Kim 2022).
- *Electricity & Hosting Price:* In the case of a hosted mining operation, your main operating expense is an all-in fee that the data centre operator charges per kilowatt-hour (kWh). It includes the electricity cost and a hosting and maintenance fee for the miners (Braiins 2022).
- *Miner Uptime:* ASIC miners need maintenance from time to time, as they need to be cleaned or repositioned (Mineur 2022). The associated downtime must be considered in the profitability analysis.

2.4 Backward Integration

Companies that follow the strategy to gain more control over their supply chain conduct a vertical integration (Mpoyi 2003, 44). A backward integration is a type of vertical integration where a company takes on activities that were previously handled by companies further up the supply chain (Kenton 2021). Companies using a backward integration want to achieve better control over raw materials and expect revenue growth, cost saving and increased production efficiency (CFI Team 2020; Mpoyi 2003, 44). A backward integration is usually pursued either by the acquisition of, or merger with, suppliers or by setting up their own subsidiary to carry out this step in the supply chain (Kenton 2021).

3. Methodology

The theoretical background on Bitcoin and Bitcoin mining, described and elaborated in chapter 2, is used as a foundation for the analysis of Relai's planned backward integration into Bitcoin mining. The methodology of a cost-benefit analysis and a scenario analysis is applied to analyze the identified uncertainties about the planned mining project. Input variables for the analysis are collected either through secondary data in a secondary literature review or by searching publicly available resources, such as websites and white papers.

3.1 Cost-Benefit Analysis

According to Mishan and Quah (2020, 7), a cost-benefit analysis is a method used to assess whether a project is desirable by comparing costs and benefits in a systematic and analytical way. Its main objective is to support the decision-making process in the evaluation of a project with data. In general, a project where the benefits outweigh the costs is a project that a company should undertake (Anami, McCoy and O'Rourke 2020). In practice, there exist several frameworks for conducting a cost-benefit analysis which include comparable phases (Anami, McCoy and O'Rourke 2020; Nas 2018, 68; Stobierski 2019). Each framework typically comprises some variant of the following five phases, which are applied in this case: (1) define the scope and purpose of the project; (2) identify the project's benefits, which include mainly explicit benefits, like the expected cash flows, but also implicit benefits, like higher customer satisfaction; (3) identify the project's costs, which include direct, indirect and intangible cost; (4) conduct a project valuation, which includes a net present value (NPV) calculation and a sensitivity and break-even analysis; and (5) provide recommendations for the project.

The cost-benefit analysis is chosen as method because it provides the management of Relai with the necessary insights to make a substantiated data-driven decision on the mining project. To gain knowledge into Relai's current operations and identify potential benefits and costs, qualitative research will be conducted in the form of interviews with Relai's management.

3.2 Scenario Analysis

According to Golfarelli, Rizzi and Proli (2006, 51), a scenario analysis - also known as a what-if analysis - aims to assess how a complex system (i.e. a company or project) behaves under various circumstances (called scenarios). A scenario is described as a possible future situation and the sequence of events leading to that future (Kosow and Gaßner 2008, 11).

The three main scenario techniques are, according to Kosow and Gaßner (2008, 42), trend extrapolation, systematic-formalized scenarios, and creative-narrative scenarios. For the cost-benefit analysis of Relai's backward integration into Bitcoin mining, the creative-narrative scenario technique is used, because its non-formalized approach provides the needed flexibility to analyze different scenarios impacting Bitcoin mining (Kosow and Gaßner 2008, 61). Schwab, Cerutti and Reibnitz (2003) suggest developing beside a base-case scenario, which uses the forecasting technique, two further scenarios: a best-case and a worst-case scenario. The best-case and worst-case scenarios are developed with the creative-narrative scenario technique in its most intuitive variant, where a single author creates a quasi-literary text of scenarios that describes possible future situations (Kosow and Gaßner 2008, 62).

The scenario analysis methodology is chosen as an additional method for the cost-benefit analysis of Relai's planned backward integration into Bitcoin mining, as it allows the management to better understand how the project would perform in different future situations. As we currently live in highly uncertain times, a scenario analysis is a tool that enables the management to make a more informed investment decision on the Bitcoin mining project.

4. Analysis of Relai's Backward Integration into Bitcoin Mining

In the following chapter, Relai's backward integration into Bitcoin mining will be analyzed using a cost-benefit and scenario analysis. The results of the conducted analysis are discussed in chapter 5. The analysis is based on information and data available at the end of October 2022.

4.1 Cost-Benefit Analysis

The cost-benefit analysis for Relai's Bitcoin mining project includes the following five steps: (1) project scope, (2) potential benefits, (3) potential cost, (4) project valuation, and (5) recommendations. The last step, the recommendations, is presented in chapter 6.

4.1.1 Project Scope

Relai is a digital asset broker that acts on behalf of its user, who wants to exchange money for bitcoin and vice versa. In addition, Relai provides each user a non-custodial Bitcoin wallet, called Relai Wallet. The management of Relai is considering a backward integration into its supply chain by starting to mine bitcoin themselves via a Bitcoin mining hosting partner. Today, the supply chain of Relai works in the way that all transactions by Relai users are conducted through an exchange, which acts as a middleman in each transaction (see Figure 4).

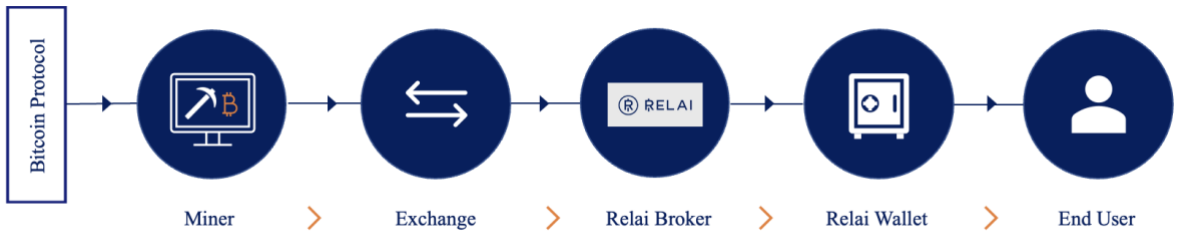

Figure 4: Today's Supply Chain of Relai (own representation)

Relai's project of a potential backward integration into Bitcoin mining would allow to (partially) remove the exchange form the supply chain, as Relai could directly sell the self-mined bitcoin to its users. Figure 5 shows what Relai's supply chain would look like after such

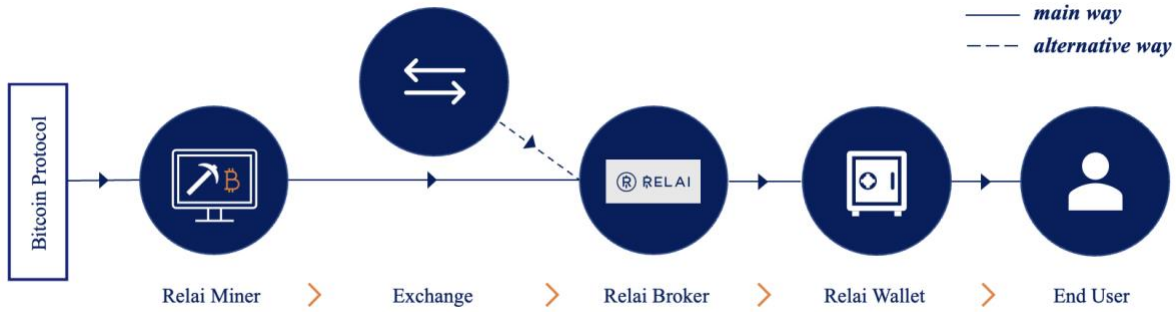

Figure 5: Supply Chain of Relai after Mining Project (own representation)

a backward integration. Ideally, the exchanges would only be needed if the self-mined bitcoin were not sufficient to cover Relai's trading volume (see the dashed line in Figure 5).

The purpose of the following cost-benefit analysis is to provide Relai's management with an in-depth analysis of the potential benefits and costs of the mining project, including a project valuation. It should give the management the needed insights and a tool to make a substantiated data-driven decision on the project once they decide on it. According to Relai's CEO, an investment of around $25 million could potentially be invested into the Bitcoin mining project (see Appendix 1). All metrics used for the analysis are denominated in US dollars.

4.1.2 Potential Benefits

Based on the theoretical background in chapter 2 and interviews with Relai's management, four potential benefits were identified for Relai's planned backward integration into Bitcoin mining (see Appendixes 1 & 10). The explicit benefits, a new revenue stream, a capital gain on ASICs and a higher sales margin, and the implicit benefit, an increased interest in the company, are described below (Braiins 2022).

New revenue stream: By starting to mine bitcoin themselves, Relai would be able to generate a new revenue stream for its business. Relai's Bitcoin miners would receive a daily reward in bitcoin for their contribution of computing power to the network. How high this reward is in dollar terms, and therefore the new revenue stream, is highly dependent on numerous variables like bitcoin price, difficulty level and height of block reward. A detailed calculation of the expected new revenue stream of the mining project is conducted in chapter 4.1.4, as part of the project valuation.

Capital gain on ASICs: The price of ASICs is strongly correlated with the price of bitcoin, as the bitcoin price determines the value of the mining reward (Willms 2021). Thus, a rising bitcoin price could potentially lead to a significant increase in the value of the miners bought by Relai. Relai could realize a capital gain on the purchased ASICs if the mines were sold.

Higher sales margin: With a backward integration into its supply chain, Relai would be able to remove, at least partially, exchanges as a middleman and thus be able to increase its sales

Today	
Avrg. Relai Brokerage Fee	1.33%
- Exchange Taker-Fee	0.10%
- Other COGS	0.54%
Relai's Sales Margin	**0.69%**

With backward Integration	
Avrg. Relai Brokerage Fee	1.33%
~~- Exchange Taker-Fee~~	~~0.10%~~
- Other COGS	0.54%
Relai's Sales Margin	**0.79%**

Figure 6: Relai's Sales Margin - Today vs. With Backward Integration (own representation)

margin. Currently, according to Relai's CFO, Relai charges its users an average brokerage fee of 1.33% and has COGS that are around 0.64%, which includes exchange fees, referral bonuses and bank transaction fees (see Appendix 10). Relai operates with market orders to guarantee the customer the price and thus has to pay its main exchange, Kraken, the higher exchange taker-fee of 0.1% (Kraken 2022; see Appendix 10). With the backward integration, Relai could remove exchange fees from its COGS and thus increase its sales margin by approximately 14.49% for its self-mined bitcoin (see Figure 6).

Increased interest in company: A backward integration would potentially increase the interest of new investors in Relai. According to the CEO, investors were interested in the idea, as it would provide Relai with a new and independent revenue stream (see Appendix 1). However, this potential benefit is hard to quantify and thus will not be further elaborated in this analysis.

4.1.3 Potential Cost

Based on the theoretical background in chapter 2 and interviews with Relai's management, four potential costs were identified for Relai's planned backward integration into Bitcoin mining (see Appendixes 1 & 11). The direct costs of ASIC miners, hosting and set-up/maintenance, and the indirect costs of reputational damage, are described below.

Purchase of ASIC miners: Mining bitcoin requires an upfront investment into ASIC miners (Kim 2022). As Bitcoin mining is capital intensive, Relai's investment in miners represents the

main cost of setting up the mining project. ASIC prices fluctuate with the price of bitcoin, and thus vary greatly. According to Luxor's Bitcoin ASIC Price Index, a Bitcoin miner in the highest efficiency category of under 38 joules per terahash (J/TH) currently costs an average of $30.65 per TH (Luxor 2022a). Relai's CEO, Julian Liniger, said that an investment of around $25 million into ASIC miners could be realistic after a Series B or C financing round (see Appendix 1). The total amount of hashrate that Relai could acquire with this investment amount is calculated in chapter 4.1.4, as part of the project valuation.

Cost of hosting: Relai is planning to locate their Bitcoin miners at a third-party data centre, which charges an all-in fee for electricity usage and hosting of the miners. This cost is a recurring cost that is paid on a monthly basis and is dependent on the total kWh Relai's miners use. According to Luxor's ASIC hosting dashboard, data centre operators charge on average $0.08 - $0.09 per kWh (Luxor 2022b). The monthly hosting cost to run Relai's mining operation is calculated as part of the project valuation in chapter 4.1.4.

Set-up and maintenance cost: The integration of the self-mined bitcoin into the current operation and code base of Relai requires an initial set-up and recurring maintenance. According to Relai's CTO, the initial set-up needs one month of work and thus costs initially approximately $12,500 and the annual maintenance costs are around $2,500 (see Appendix 11).

Reputational damage: Due to its high-power consumption, Bitcoin mining is widely regarded by the public as an unnecessary process that pollutes our planet (Kowalski 2022). If Relai starts to mine Bitcoin themselves, it could have a negative impact on Relai's public reputation, as the mining operation would draw additional attention to them. However, potential reputational damage is hard to quantify and thus will not be further elaborated in this analysis.

4.1.4 Project Valuation: Base-Case

The project valuation of Relai's Bitcoin mining project is conducted in two steps. First, the expected Bitcoin mining revenues and the associated mining costs are calculated. Second, the

expected revenue and cost are used to calculate the free cash flow and to determine the net present value (NPV) of the project (see Excel-Sheet in Appendix 12). The project valuation spreadsheet is constructed dynamically so that it can be used as a tool in the future when input variables change. In general, if the NPV of the mining project is positive, Relai should consider pursuing the project. A time horizon of four years was chosen for the project, as making assumptions in an asset class that is only 12 years old would be less reliable if a longer time horizon were chosen. Further, well-known mining companies like Blockware Solutions or MIM use a three- to four-year time horizon as well in their Bitcoin mining calculators (Blockware Solutions 2022; MIM 2022).

The base-case scenario for Relai's bitcoin mining project was developed using the forecasting technique. Historical data was used to identify trends and extrapolate them into the future to make well-founded assumptions about future developments of key variables like bitcoin price or mining difficulty. In Appendix 13, the key variables affecting the project valuation and their underlying assumptions are described. The project valuation of the base-case scenario resulted in a negative NPV for Relai’s mining project of -$1,252,194 and an internal rate of return (IRR) of 59.6%. The profitability index is 0.95 (see Appendix 12). As the NPV for the base-case scenario is negative, Relai should not execute the mining project based on the taken assumption.

4.2 Scenario Analysis

In addition to the project valuation in the base-case scenario, a project valuation for a best-case and worst-case scenario is conducted. These scenarios are built on the base assumption that the bitcoin price continues to be strongly correlated with traditional markets (Zuckerman 2022).

4.2.1 Best-Case Scenario: Economic Growth

The best-case scenario analyzes the impact of future global economic growth on the project valuation of Relai's bitcoin mining project. Global economic growth is a potential future

scenario that would result from the resolution of current global uncertainties, like the war in Ukraine, high inflation, and/or supply chain issues (IMF 2022). This would lead to more certainty in the market and a more risk-on sentiment among capital allocators (Henricks 2022). Therefore, a faster increase in various asset prices, including bitcoin, can be expected.

In Appendix 14, the adapted input variables and assumptions based on the best-case scenario of economic growth are described. The project valuation of the best-case scenario resulted in a positive NPV for Relai's Bitcoin mining project of $4,433,966, an IRR of 72.1% and a profitability index of 1.18 (see Appendix 12). As the NPV for the best-case scenario is positive, Relai should execute the mining project based on the taken assumption.

4.2.2 Worst-Case Scenario: Recession

The worst-case scenario analyzes the impact of a future recession on the project valuation of Relai's bitcoin mining project. A global recession is a potential future scenario if central banks across the world continue to raise rates at unprecedent speed to fight inflation. This sharp raise of rates pressures the global financial system and slows global growth sharply (OECD 2022; World Bank 2022). A recession could be the result, which would put heavy sell pressure on risk assets like bitcoin for some time (Henricks 2022).

In Appendix 15, the adapted input variables and assumptions based on the worst-case scenario of a recession are described. The project valuation of the worst-case scenario resulted in a negative NPV for Relai's bitcoin mining project of -$6,657,361, an IRR of 46.1% and a profitability index of 0.73 (see Appendix 12). As the NPV for the worst-case scenario is negative, Relai should not execute the mining project based on the taken assumptions.

4.2.3 Scenario Comparison

The scenario comparison provides an overview of the three previously described scenarios: base-case, best-case and worst-case. Figure 7 shows in a direct comparison how in the different

potential future scenarios certain variables change and how they impact the overall project valuation metrics.

	Base-Case	Best-Case	Worst-Case
Assumption:	*Forecasting Technique*	*Economic Growth*	*Global Recession*
Changing Variables:			
Growth Rate of Bitcoin Price per month	4.75%	5.70%	3.80%
Mining Difficulty increase per month	3.04%	3.50%	2.74%
Avrg. Transaction Fee per Block	0.10	0.21	0.07
Avrg. Difficulty decrease after halving	25%	20%	30%
Results:			
NPV	**-1'252'194**	**4'433'966**	**-6'657'361**
IRR	**59.6%**	**72.1%**	**46.1%**
Profitability Index	**0.95**	**1.18**	**0.73**

Figure 7: Scenario Comparison for Relai's Bitcoin Mining Project (own representation)

5. Discussion

The aim of the in chapter 4 conducted cost-benefit analysis for Relai's planned backward integration into Bitcoin mining was to provide Relai's management with an analysis of the potential benefits and costs, as well as with a project valuation tool. The tool should enable the management to make a data-driven decision on the project. The potential benefits and costs were successfully identified, quantified, and then used in the project valuation calculation (see Appendix 12). The project valuation resulted in a negative NPV for the base- and worst-case scenario and a positive NPV for the best-case scenario (see Figure 7). Based on these results, conducting the backward integration is not ideal, as even the base-case scenario resulted in a negative NPV and thus is not a good investment. However, the calculated results need to be put into perspective and further findings need to be discussed:

Hight number of input variables: The project valuation of Relai's mining project is based on a calculation that uses 26 different input variables (see Appendix 12). The high number of input variables make the calculation not only complex but also prone to inaccurate inputs for some variables. Especially since 18 of the 26 variables used for the calculation are based on assumptions about the future, the calculated NPV for the three scenarios should be interpreted

with caution, as assumptions about the future are rarely accurate. For example, the base-case scenario was built using the forecasting technique, which uses historical data to identify trends for variables and extrapolate them into the future. In this case, only time will tell whether these extrapolated trends will prove to be true and therefore also the calculated NPV of the base case. In order to address this known issue about inaccurate assumptions, the project valuation spreadsheet was built in a dynamic form, so that the management is able to easily adapt input variables should any variable or underlying assumption change in the future.

High sensitivity to certain input variables: As Relai's Bitcoin mining project valuation is based on several assumptions, a sensitivity and break-even analysis was conducted to understand how changes in certain assumptions about input variables would affect the base-case NPV and thus the success of the project. The sensitivity and break-even analysis in Appendixes 16 & 17 show that the NPV is highly sensitive to changes in the following input variables: monthly growth rate of bitcoin price; mining difficulty increase per month; hosting price and discount rate. For example, if the monthly growth rate of the bitcoin price were only 3% higher (4.89% instead of 4.75%), the NPV of the project would increase by 110% to a positive number. Further, the break-even point for the bitcoin price growth rate is only at 4.88% (see Appendix 17). This shows that the results of the project valuation should be interpreted with caution, as inaccurate assumptions about input variables have a significant impact on the NPV.

High discount rate: Future cash flows of Relai's Bitcoin mining project were discounted with a high discount rate of 62.5% for the project valuation. This figure was provided by Relai's CFO and is in line with average discount rates for non-profitable, early-stage startups (PwC 2018). The high discount rate had a strong impact on the negative NPV of the project, as a reduction of the discount rate by only 5% to 57.5% would already turn the NPV positive at $985,689. As the stand-alone mining project would be able to generate positive cash flows from day one, a lower discount rate than assumed could possibly be considered for the project.

Limited cost reduction synergy: In theory, a major benefit of Relai's backward integration is that it eliminates exchanges as intermediaries for transactions and thus removes exchange fees as a cost position. The issue is that an initial investment of $25 million into Bitcoin miners would only mine about half of the bitcoin needed each month. For example, in month one, Relai would be expected to mine 121.4 BTC worth $2.14 million, but actually would need nearly double the amount of bitcoin to cover Relai's monthly trading volume of $5.27 million. Thus, the cost reduction synergy of Relai's mining project is limited, and exchanges are still needed.

Relying on hosted mining: By locating your Bitcoin miners at a hosted mining facility, Relai can keep the initial capital requirement for its mining project to just the Bitcoin miners. The construction and maintenance of the mining infrastructure are conducted by the hosting partner, which charges a fee per kWh for this service. The downside is that hosted mining increases the operating costs of your mining operation and thus lowers your profit margin. To self-host all its 25 million dollars' worth of Bitcoin miners, Relai would need to build a 30+ MW strong data centre that would cost approximately $15 million (Rogers 2022). Raising an additional $15 million to build a data centre doesn't seem feasible currently. Thus, Relai is relying on hosted mining.

Covering OPEX: Assuming that the historical trend of a rising bitcoin price continues, Relai should ideally try to hold the self-mined bitcoin for as long as possible and sell them later for a greater profit. The issue is that Relai's planned mining project is estimated to have a yearly OPEX of $22+ million. Therefore, unless Relai is able to cover its annual OPEX of more than $22 million from other sources, such as fresh investor money or cash flows from its business, it will have no choice but to sell its self-mined bitcoin to cover OPEX.

Execution risk: The cost-benefit analysis of Relai's backward integration into Bitcoin mining focused mainly on the financial side of the project. Thus, it is important to note that deploying $25 million worth of Bitcoin miners with a combined power of 30+ MW comes with execution

risk. In particular, hosting counterparty risk, regulatory risk and hosting space limitations are execution risks that should be examined as the project becomes more concrete (Alden 2021).

6. Conclusion & Recommendation

Relai's management is currently considering a backward integration into its supply chain by starting to mine Bitcoin itself. The goal of this work project was to assess Relai's mining project and to provide the management with a tool to take a data-driven decision on it. To do so, a cost-benefit analysis that included a project valuation was carried out for the Swiss digital asset broker. The analysis identified that Relai could mainly benefit from the mining project through an increased sales margin and an additional separate revenue stream. However, these benefits only come with a significant investment in Bitcoin miners and a substantial risk due to the commitment to recurring high operating costs. The result of the project valuation suggests that Relai should not pursue the backward integration at this point in time, as the NPV of the base-case scenario is negative and thus considered a bad investment. However, this result should be interpreted with caution, as the project valuation is based on 26 input variables that are mostly based on assumptions and on a model that is highly sensitive to minor changes in input variables, such as bitcoin price, mining difficulty level, or discount rate.

In conclusion, accurately analyzing, and especially valuing, a Bitcoin mining project is challenging and is based on a lot of assumptions. Therefore, I recommend Relai's management should not view the negative result of the analysis as a discouragement regarding their planned backward integration into Bitcoin mining. Rather, I suggest that they should consider the conducted cost-benefit analysis and its result as a basis for future evaluations of the project and thus use the analysis as a tool in the future. The project valuation spreadsheet was built in a dynamic way, so that once the project becomes more concrete and input variables, like project budget, are fixed, Relai's management could relatively quickly reassess the Bitcoin mining project with updated input variables.

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8. Appendix

Appendix 1: Interview with Julian Liniger, CEO of Relai (27.09.22, translated)

D: Hi Julian, thank you very much for the opportunity to conduct my Direct Research Internship with Relai. It is great that I have the chance to help you and the company with a real organizational challenge: The potential backward integration into Bitcoin mining. Great that you quickly take the time to answer a few questions. To kick things of what is your exact role and what are your responsibilities at Relai?

J: I am the CEO and Co-Founder of Relai – Europe's easiest Bitcoin App made in Switzerland. I run the company and am the face of it. Thus, I represent Relai in various events, podcasts, and seminars. Currently, my main focus is on fundraising, as Relai is in the process of raising its Series A round. So, I have currently a lot of calls and meetings with potential investors in my agenda.

D: So, when did the idea that Relai could conduct a backward integration into Bitcoin mining first arise?

J: A backward integration into our supply chain is nothing new for Relai. In 2021, we received the Swiss broker license and thus were able to cut out our partner Bity, which we used until this point as a broker. So, with obtaining our own broker license, we were able to cut out a supplier and were able to cut cost and offer our customers a better service. Bitcoin Mining would be the next logical step in our supply chain. I always compare it with gold mining, which is similar to Bitcoin mining. E.g. companies like Glencore want to own the whole supply chain, as they like to have the full control over it.

D: What did you have exactly in mind when you had the idea that Relai could mine Bitcoin itself? How could Relai benefit?

J: Well, I looked at where the bitcoin we sell to our customers come form and thought we could "produce" our own bitcoin and sell them directly to our customers. So, I had the idea that Relai would buy bitcoin miners and host them at a hosting partner, who runs the whole mining operation. Our self-mined bitcoin we would than directly sell to our customers without the need of a middleman, which is in our case the exchanges. This would allow us to save on fees on the exchanges and pocked this as additional revenue. But more important, we could sell Bitcoin at a market price, which we mined at a lower price, ideally. The thing is, we never calculated it through or made any kind of analysis.

D: You mentioned hosted mining with a partner, so you don't want to build the infrastructure yourself?

J: Correct – I know that building and running a data centre/infrastructure to host Bitcoin miners is very capital intensive, as you need to build out first the facility and need to hire qualified staff to operate it. As Relai wants to keep focusing on its core business – being the easiest Bitcoin App in Europe – only hosted mining is an option for us, as we "only" need to raise the capital to buy the miners and the rest is taken care of the hosting partner. Raising capital for the miners only will be already hard enough.

D: So, Relai would need to raise money from investors to do so?

J: Yes absolutely, as an early-stage start-up we don't have that kind of money laying around. So, the mining project would need an investment form external investor. For example, in a potential Series B. But first we need to get our Series A, otherwise there is no Series B/C.

D: Did you already pitch this idea to investors? And if so, how was their reaction?

J: Yes, and the reaction of the investors were mixed. Some found it very interesting as a smart addition to the offering of Relai and saw the potential to own the supply chain. E.g. one larger Swiss VC was very interested and said that once the Bitcoin Mining project would become more concrete, I should reach out again. Other investors were less interested, as they said that mining is a very capital intensive and that they are not focusing on infrastructure investments.

D: For Relai to start Bitcoin Mining itself, the company needs capital to deploy into Bitcoin miners. How much capital could Relai invest in a bitcoin mining operation (estimation)?

J: Hard to tell, ideally, we should invest as much into Bitcoin miners, that we can cover our monthly order volume with our self-mined Bitcoin. Not sure if this is possible, but I hope your analysis will give an indication. But realistically, at a Series B/C financing round we would raise around $40-50 million, where about $25 million could potentially be used for setting up and buying miners for the mining project.

D: So, in regard to my planned analysis: What do you hope to see as a result of my analysis of Relai's potential backward integration into Bitcoin mining?

J: At the moment we lack mainly two things in regard to this mining project: Mining Knowledge and an in-depth analysis/calculation. So, I hope that your work will allow us to gain the missing bitcoin mining knowledge in general and we see on paper the potential benefits and needed investments of such a mining project. So, at the end we want to have a basis to start analysis such a project when it would get more concrete.

D: Do you think Relai's community and current investor could have a problem with Relai starting to mine Bitcoin? And general reputation of Relai?

J: Not really - our community and investors are bitcoiners and thus know the value of Bitcoin mining and understand why it uses a lot of energy. I guess they rather see it as a very good thing, as with mining we support the security of the Bitcoin protocol. Without mining there is no Bitcoin, so it is an essential part of the protocol. In regard to the reputation in the public, it could have a small negative impact, as most people just look at the high energy use. I guess over time, when more people get educated about Bitcoin this will get more and more less relevant in the public discussion. Already today, Bitcoin miner have a more sustainable energy mix than most of us have at home.

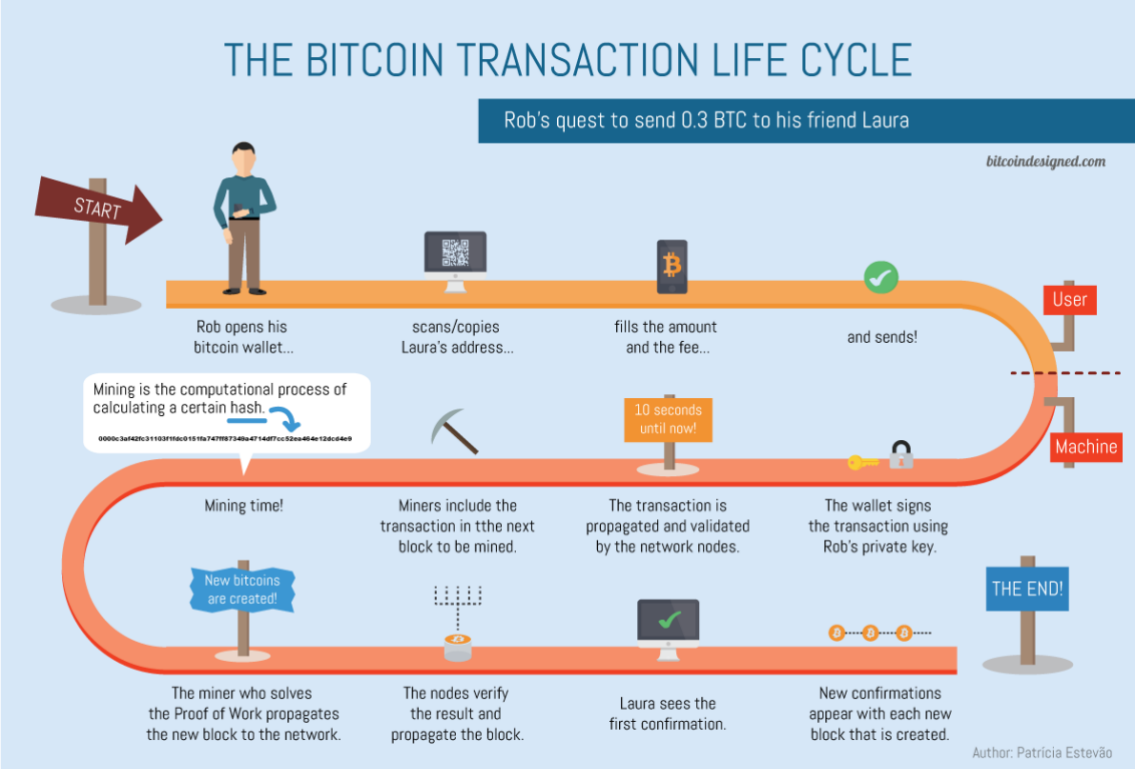
D: Thanks Julian for these answers.

J: Your welcome – happy to help.

Appendix 2: Bitcoin Price Trend (CoinGecko 2022)

Appendix 3: Global Presence of Bitcoin Mining Activity (Sun, et al. 2022, 3)

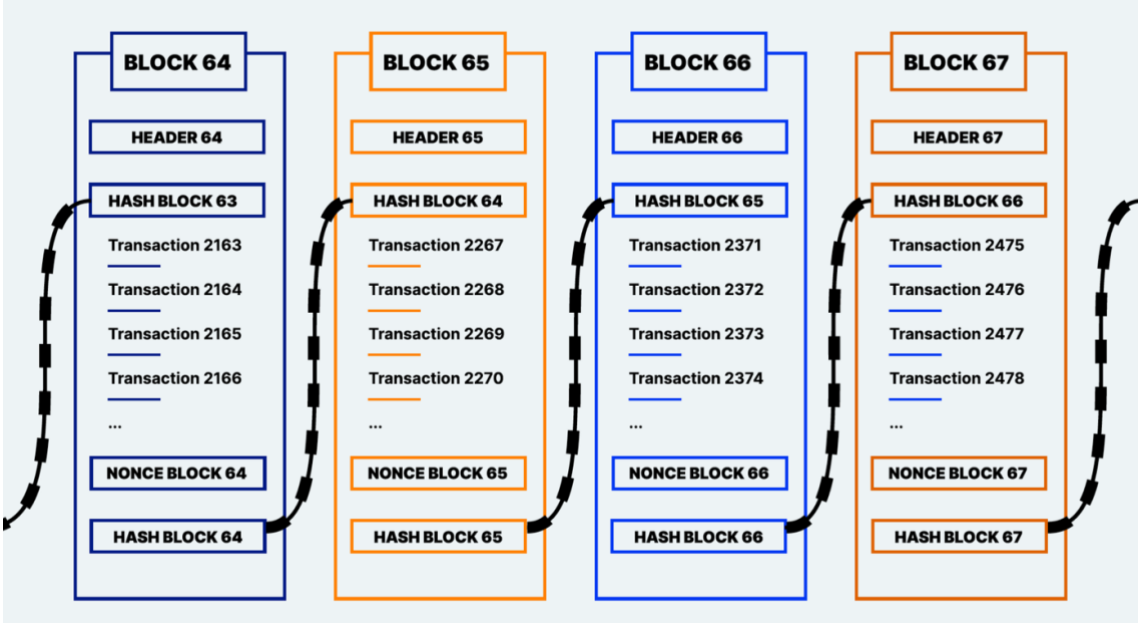
Appendix 4: The Bitcoin Transaction Life Cycle (Estavão n.d.)



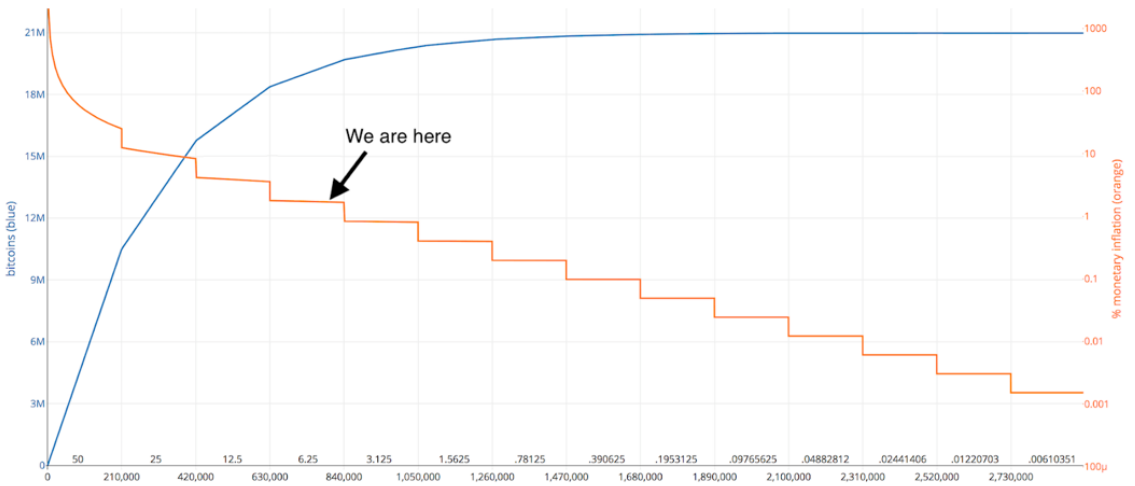
Appendix 5: Bitcoin Network Difficulty from 2020 – now (Blockchain.com 2022a)

Appendix 6: Mathematical Hash Function SHA-256 (Kharoo 2019)

Appendix 7: How the Bitcoin Blockchain works (Jungen 2022, 10)



Appendix 8: Bitcoin Total Supply and changing Block Rewards (Fitzpatrick 2021)



Appendix 9: Bitcoin Network Total Hash Rate from 2020 – now (Blockchain.com 2022b)

Appendix 10: Interview with Maurizio Trenti, CFO of Relai (26.09.22, translated)

D: Hi Maurizio, thank you very much for the opportunity to conduct my Direct Research Internship with Relai. It is great that I have the chance to help you and the company with a real organizational challenge: The potential backward integration into Bitcoin mining. Great that you quickly take the time to answer a few questions. To kick things of what is your exact role and what are your responsibilities at Relai?

M: I am the CFO of Relai and am responsible all things concerning the finance of Relai. From budgeting to financial modelling to paying bills - it all falls under my responsibility.

D: So, when did the idea that Relai could conduct a backward integration into Bitcoin mining first arise?

M: The topic came up when we in the leadership team were thinking about what could be done in the future as a company. I have always been a big fan of vertical integration as it brings great advantages. When we would start to mine Bitcoin, we would have more control over our supply chain and therefore less risk. Also, the potential to have an additional source of revenue, which would diversify our revenue stream, is interesting.

D: Now some short questions about some of Relai's financial metrics. How many monthly active users does Relai have?

M: At the moment we have around 30k.

D: What is Relai's current monthly volume?

M: In the last month, we had a total volume of CHF 5.27 M

D: What is Relai's current monthly revenue?

M: In the last month, we made a total revenue of approx. CHF 70,100

D: What is the current average brokerage fee Relai charges per invested CHF or EUR?

M: Currently, we have an average brokerage fee of around 1.33%.

D: How high are the current COGS relative to the total volume?

M: Currently, our COGS relative to our total volume is around 0.64%. It includes referral bonuses, bank transactions fee and exchange fees.

D: Your CEO, Julian Liniger, mentioned that a backward integration into Bitcoin Mining would allow Relai to (1) generate additional revenue by selling the cheaper mined bitcoin at market price to customers. And (2) Relai could keep the fee it pays today to exchanges and thus generate also additional revenue? How high are these exchange fees of exchanges today?

M: We currently pay 0% if we place an BTC order in the order book (Maker-Fee) and 0.1% if we take an offer in the orderbook (Taker-Fee). The fee is dependent on the 30-day volume on the exchange. Have a look at the fee model of Kraken here: https://www.kraken.com/features/fee-scFhedule#kraken-pro For nearly all our trades we pay the taker-fee, as we buy & sell Bitcoin with market orders to guarantee the price. Therefore, you can assume we pay 0.1% on every trade we execute.

D: To conduct a project valuation of Relai's potential backward integration into Bitcoin mining, the potential cash flow of the miners has to be discounted. Did you calculate the WACC in the past?

M: Indeed – in the last financing round I made a financial model to estimate our WACC or cost of capital which ended up at 62.5%. Obviously, it is based on a lot of estimations, but it is the best number I can give you.

D: Maurizio, what do you hope to see as a result of my analysis of Relai's potential backward integration into Bitcoin mining?

M: From a finance perspective, I hope you can develop a financial model for the Bitcoin mining project, which allows us to play around with parameters to simulate different scenarios and so better understand how the project is performing under different scenarios. So basically, a tool that can be used in the future, when the project gets more concrete.

D: Thanks Maurizio, for you time.

Appendix 11: Email Exchange with Adem Bilican, CTO of Relai

Question to CTO

Adem Bilican <adem@relai.app> Tue, Sep 27, 2022 at 10:45 AM
To: Dominik Bütikofer <dominik@relai.app>

Hey Dominik,

Please find below the answers to your questions
1. I consider the initial configuration of the mining system and the integration to our existing codebase to take about 1 month for 1 full-time developer. Therefore a cost of ~10-15K USD in total
2. The maintenance costs will be relatively low as these systems are quite stable and the code might need to be checked and updated once in a white. In that case I would estimate a cost of 2-3K USD per year for the maintenance

Let me know if there is anything else I can help you with.

Best,
Adem

On Tue, 20 Sept 2022 at 16:11, Dominik Bütikofer <dominik@relai.app> wrote:

> Hi Adem
>
> As you know, I am currently working on my Master Thesis, which analyses the potential backward integration of Relai into Bitcoin Mining. In short: Does it make sense that Relai starts to mine bitcoin and to sell the self-mined bitcoin directly to the end-customer.
>
> For the analysis I conduct a cost-benefit analysis of the project and am currently looking at the potential cost of such a project. Next to the main cost, electricity of the miners, I identified that the initial technical integration of selling self-mined bitcoins to our customers via our broker is a cost I need to consider.
>
> I have the following two questions for you:
>
> 1. What would you estimate would be the cost of your team developing such an implementation in the back end initially? The implementation means that the self-mined bitcoins on a wallet are automatically matched with incoming customer orders and sold to them at market price.
> 2. Could there be maintenance costs on a yearly basis to come for this setup and if so, how high might they be?
>
> If possible, it would be great if you could give me an estimation in dollars.
>
> Thank you for your help and best regards,
> Dominik

Appendix 12: Project Valuation Excel Sheet

Link to the full Excel Sheet here: https://tinyurl.com/5fzbhmyb

Project Valuation of Relai's backward Integration into Bitcoin Mining (RELAI)

Date of the valuation : End October 2022

INPUTS

General Inputs		*Comments*
Start Date	01.11.22	
Project Budget for ASICs	$25'000'000	
Incremental reduction of COGS (due to removal of exchanges)	0.1%	
Taxes	n/a	
Discount Rate (WACC of Relai)	62.5%	
Mining Setup		
Initial Setup Investment in Relai's Backend Integration	$12'500	
Yearly Maintenance Fee	$2'500	
Total Hashrate (in TH/s)	1'019'575.86	
Assumed price per TH for ASICs (in USD)	24.52	
Avrg. price per TH for ASICs under 38 J/TH (in USD)	30.65	
Large ASIC Quantity Discount (%)	20%	
Avrg. power consumption of ASICs (kW/TH)	0.03	
Hosting Price ($ per kWh)	0.08	
Mining Pool Fee	2%	
ASIC price to BTC price correlation (From 0-1)	0.7	
ASIC price to BTC price yearly correlation adjustment	25%	
Mining Inputs		
Mining Difficulty at start date	31'360'548'173'144	
Mining Difficulty increase per month	3.04%	
Mining Difficulty increase past four year	321%	
Mining Difficulty Sep. 2018	7.45	
Mining Difficulty Sep. 2022	31.36	
Bitcoin Price at start	$19'000	
Avrg. Growth Rate of Bitcoin Price per month	4.75%	
Bitcoin Price increase past six year	2720%	
Bitcoin Price Sep. 2016	$654	
Bitcoin Price Sep. 2022	$18'442	
Bitcoin Price End of Year 1	$33'148	
Bitcoin Price End of Year 2	$57'831	
Bitcoin Price End of Year 3	$100'895	
Bitcoin Price End of Year 4	$176'025	
Current Block Reward	6.25	
Block Reward after next Halving	3.125	
2024 Halving Date ETA	21.03.24	
Avrg. Difficulty decrease after halving	25%	
Avg. Transaction Fee per Block	0.103	
Rig Uptime	99%	

MINING REWARDS & COST

	Year 0	Year 1	Year 1	Year 1	Year 1	Year 1	Year 1
Avrg. Days per Month		30.42	30.42	30.42	30.42	30.42	30.42
	01.11.22	30.11.22	31.12.22	31.01.23	28.02.23	31.03.23	30.04.23
Mining Revenue	Month 0	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Assumed Mining Difficulty	31'360'548'173'144	32'313'814'250'511	33'296'056'741'468	34'308'156'441'591	35'351'020'919'986	36'425'585'333'123	37'532'813'263'407
Assumed Price of BTC (in USD)	19'000.0	19'902.0	20'846.7	21'836.3	22'872.9	23'958.7	25'096.1
Gross Mining Reward (in BTC)		121.4	117.8	114.4	111.0	107.7	104.5
Gross Mining Reward (in USD)		2'416'609.9	2'456'654.4	2'497'362.4	2'538'745.0	2'580'813.3	2'623'578.7
Cumulative Mining Reward (in BTC)		121.4	239.3	353.6	464.6	572.3	676.9
Cumulative Mining Reward (in USD)		2'416'609.9	4'987'983.7	7'722'131.6	10'627'455.4	13'712'766.7	16'987'306.8
Mining Cost							
Hosting Fee incl. Electricity Fee (in USD)		1'786'296.9	1'786'296.9	1'786'296.9	1'786'296.9	1'786'296.9	1'786'296.9
Cumulative Hosting Fee incl. Electricity Fee (in USD)		1'786'296.9	3'572'593.8	5'358'890.7	7'145'187.6	8'931'484.5	10'717'781.4
Mining Pool Fee (BTC)		2.428515411	2.356873564	2.287345169	2.219867881	2.154381191	2.090826375
Mining Pool Fee (USD)		48332.2	49133.1	49947.2	50774.9	51616.3	52471.6

Appendix 13: Key-Assumptions for Base-Case Scenario

What	Input	Comment / Assumption
Taxes	N/A	As Relai is currently and for the foreseeable future (next 4 year according to the financial model) making a yearly loss, taxes are not applicable + losses in past years can be deducted in case a profit is made (up to 7 years back according to Swiss law). Thus, potential taxes are no considered.
Cashflow Discount Rate (WACC)	62.5%	The WACC (Weighted average cost of capital) of Relai is used as the discount rate for the cashflows of the mining project. According to the calculations in Relai's financial model created by its CFO, the WACC is approx. 62.5%. Thus, the discount rate for future cashflows has to be 62.5%.
Assumed price per TH for ASICs	$24.52	The average price per TH for ASICs under 38 J/TH (in USD) was taken from Luxor's Bitcoin ASIC Price Index (Luxor 2022a) and a 20% discount for large order volume ($25 million investment in miners) was applied.
Hosting Price ($ per kW)	0.08	Comparing Luxor's disclosed hosting price, a four-year contract with an assumed $0.08 per kW for a large amount of miners (total worth of $25 million) was assumed for the mining operation (Luxor 2022b).
Mining Pool Fee	2%	Industry average for a reliable and trustworthy mining pool (Beigel 2022)
ASIC price to BTC price correlation (From 0-1)	0.7	New ASIC miners with a high efficiency have a relative high correlation to the BTC price. This correlation is reduced, as the machines get older, which is taken into account with a yearly correlation adjustment of 25% (MIM 2022).
Mining Difficulty increase per month	3.04%	Calculated the average mining difficulty increase over the past four years to use as a growth rate for future development of the difficulty. Choose four years, as is it include one full halving cycle and is the same duration as the time horizon of the project.

Avrg. monthly Growth Rate of Bitcoin price	4.75%	Calculated the average monthly growth rate of the Bitcoin Price of the past six years to use as a growth rate for future development of the Bitcoin price. The duration of six years was chosen as the duration includes two halvings and represents a growth rate and thus a Bitcoin Price after four years ($176,025) that in line with prediction of experts.
Avrg. Difficulty decreases after halving	25%	Based on historical difficulty decreases after a halving event (Madeira 2020)

Appendix 14: Changed Assumptions for Best-Case Scenario

What	New Input	Comment / Assumption
Avrg. monthly Growth Rate of Bitcoin price	5.7%	In case of economic growth, it is assumed that the average monthly growth rate of the Bitcoin price would be approx. 20% higher than in the base-case scenario due to a more risk-on sentiment among capital allocators (Henricks 2022)
Mining Difficulty increase per month	3.5%	Economic growth and thus a higher bitcoin price growth rate will nearly certainly come with a faster increase of mining difficulty. As it becomes more lucrative for miners to mine Bitcoin, more miners will want to contribute hashrate. It is assumed that the difficulty would increase by approx. 15% compared to the base-case scenario.
Avrg. Transaction Fee per Block	0.206	When the Bitcoin price rises and more activity comes to the bitcoin network, the average transaction fee per block will rise as well. Based on historic data found on Braiins, a 100% increase in transaction fee per block can be assumed (Braiins Insights 2022)
Avrg. Difficulty decreases after halving	20%	It can be assumed that due to the faster rising Bitcoin price and thus increasing profitability, the average difficulty decrease after the halving will be less than in the base case. Thus, a 20% difficulty decrease is expected.

Appendix 15: Changed Assumptions for Worst-Case Scenario

What	New Input	Comment / Assumption
Avrg. monthly Growth Rate of Bitcoin price	3.8%	In case of a recession, it is assumed that the average monthly growth rate of the Bitcoin price would be approx. 20% lower than in the base-case scenario due to a less risk-on sentiment among capital allocators (Henricks 2022)
Mining Difficulty increase per month	2.74%	A recession and a lower bitcoin price growth rate will nearly certainly come with a slower increase of mining difficulty. As it becomes less lucrative for miners to mine Bitcoin, less miners will contribute hashrate. It is assumed that the difficulty would decrease by approx. 10% compared to the base-case scenario.
Avrg. Transaction Fee per Block	0.07	With a lower Bitcoin price, less interest and activity come to the Bitcoin network. The average transaction fee per block will get reduced as well. Based on historic data found on Braiins, a 30% decrease in transaction fee per block can be assumed (Braiins Insights 2022)
Avrg. Difficulty decreases after halving	30%	It can be assumed that due to the lower Bitcoin price and thus decreasing profitability, the average difficulty decrease after the halving will be higher than in the base-case. Thus, a 30% difficulty decrease is expected.

Appendix 16: Sensitivity Analysis for one Variable of Bitcoin Mining Project Valuation

	NPV	-1'252'194.3	var %
Avrg. Growth Rate of Bitcoin Price per month	4.32%	-5'135'594	310.1%
	4.46%	-3'885'305	210.3%
	4.60%	-2'591'438	107.0%
	4.75%	**-1'252'194**	0.0%
	4.89%	134'303	-110.7%
	5.03%	1'570'018	-225.4%
	5.17%	3'057'005	-344.1%

	NPV	-1'252'194	var %
Mining Difficulty increase per month	2.77%	944'751	-175.4%
	2.86%	193'580	-115.5%
	2.95%	-538'538	-57.0%
	3.04%	**-1'252'194**	0.0%
	3.13%	-1'947'960	55.6%
	3.22%	-2'626'385	109.7%
	3.31%	-3'288'001	162.6%

	NPV	-1'252'194	var %
Discount Rate (WACC of Relai)	55.00%	2'228'394	-278.0%
	57.50%	985'689	-178.7%
	60.00%	-172'091	-86.3%
	62.50%	**-1'252'194**	0.0%
	65.00%	-2'261'143	80.6%
	67.50%	-3'204'815	155.9%
	70.00%	-4'088'516	226.5%

	NPV	-1'252'194	var %
Hosting Rate ($ per kWh)	0.092	-5'658'940	351.9%
	0.088	-4'190'024	234.6%
	0.084	-2'721'109	117.3%
	0.08	**-1'252'194**	0.0%
	0.076	216'721	-117.3%
	0.072	1'685'636	-234.6%
	0.068	3'154'551	-351.9%

	NPV	-1'252'194	var %
Avrg. Difficulty decrease after halving	32.50%	825'444	-165.9%
	30.00%	83'430	-106.7%
	27.50%	-607'410	-51.5%
	25.00%	**-1'252'194**	0.0%
	22.50%	-1'855'380	48.2%
	20.00%	-2'420'866	93.3%
	17.50%	-2'952'080	135.8%

Appendix 17: Break-Even Analysis for various Variables of the Bitcoin Mining Project