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The Impact of blockchain financial products on cost of capital

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The impact of blockchain financial products on cost of capital

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Abstract

Traditional enterprise valuation techniques focus on computations of forecasted free cash flows and discount rates based on the company's exposure to risk, capital structure and historical performance. Most of these factors are computed on a single currency basis and, most commonly, whenever the company operates in multiple currencies, entries in the financial reports are quoted in the main currency which the firm holds for the most part or operates with. These approximations are validated by the low volatility nature of most exchange rates. However, in a world where cryptocurrencies are being increasingly adopted for both financing and operating purposes, these assumptions may not hold. Considering the trends that see drastic increases in the adoption of DLT on blockchain technology by non-financial institutions with different scopes, it is important to discuss the risks and the features associated with corporations modifying their sources of finance in such way. In particular, how these modifications affect their cost of capital.

This paper strives to explore a situation in which a company is partly financed through the emission of financial securities on blockchain and collects revenue streams while operating via money denominated in cryptocurrencies. The aim of this paper is to hypothesize a formula for the cost of capital comprehensive of the features and risks of the new sources of finance.

In order to do so, a model based on fundamental assumptions is presented. The paper lays out this theoretical background and constructs a model so that, once enough data will be available to establish a significant sample, it can be tested on its accuracy. Unfortunately, at the time of this research, a significant sample that can sustain statistical examinations does not exist, and the reasons for this are discussed in the first section.

The model proposed, is based on the assumptions gathered by the literature that surrounds cost of capital for corporate investments and their estimation models. It encompasses a number of features, risks, opportunities, and benefits stemmed from the introduction of blockchain financial products.

With this paper I seek to contribute to the literature that explores alternative corporate financing techniques and their assessment models.

Table of Contents

Chapter 1 : financial products on blockchain

1.0.1 The goal of this paper

The goal of this paper is to envision a fundamental approach in order to derive a model for the calculation of the cost of capital for a firm that, other than through equity and debt, finances itself by issuing financial products on blockchain that are denominated in cryptocurrencies, executes transactions denominated in cryptos and holds a wallet of crypto assets that manages internally.

1.0.1.1 Objectives of this chapter

This chapter introduces the modern environment of financial products on blockchain (as of August 2021). It provides definitions and descriptions for cryptocurrencies, tokens on blockchain and cryptocurrencies' derivatives, explains Distributed Tech Ledger and Blockchain technologies and offers an overview of Initial Coin Offerings mechanisms, features, and trends. In order to achieve the goal of the paper, it is essential to determine which of these financial products can be employed or issued by a firm in order to raise capital, and which ones can be held by the firm under its assets as to facilitate transactions with other businesses, third parties or suppliers. These objectives are met in this chapter. Moreover, this chapter also describes the inconsistencies in blockchain products reporting standards which constitute a relevant problem that has been affecting companies, regulators, and analysts since the introduction of these financial products.

1.1 Introduction on blockchain technology

Blockchain can be classified as a distributed ledger system in which digital records of transactions and items are accessible by every participant running the system's protocols. The protocols comprise set of guidelines governing the messages and inputs within the system. Differently from traditional distributed ledgers, blockchain holds means of creating and safeguarding consensus among its participants without needing a third-party intermediary or central authority within the system. The main aspects of blockchain can be summarized into:

- A cryptographic component

- A distributed ledger composition

"Distributed ledger" refers to an accounting system in which all transactions are recorded, and the bookkeeping practice is not entrusted to a single entity or person, rather all participants hold a written form of the history of all transactions within the system. The first form of distributed ledger dates back to the 19th century Yapese society[1]. In this instance, problems with multiple records not matching, flawed accounts and informal recordings would eventually make the participants appoint a single bookkeeper. Blockchain as a system, however, does not present such problems to a larger extent.

Whenever a transaction is executed on blockchain, all the relevant information regarding it is broadcasted worldwide to a peer-to-peer network consisting of nodes (servers and computers). Each node runs the same verification and validation algorithms and stores a copy of the ledger. The nodes then strive to reach a consensus and create blocks of information containing transactions. These blocks are respectively printed on the blockchain using cryptographic algorithms and become immutable. The consensuses are reached following a 51% majority ensuring a certain level of difficulty in corrupting the system. The blocks of information are public: they contain amounts of units, time stamps and digital signatures.

Cryptocurrencies were born as a side effect of blockchain creation[2]. In 2008, the creation of Bitcoin (by Satoshi) was a side product of the peer-to-peer digital cash system platform containing it. The feature on the blockchain that sees blocks' information distributed everywhere and crypted, rather than copied from a central holder, gave birth to a new perception of the cash circulating within said system. This new perception saw this digital cash not only merely as a medium of exchange within the system but as having both an intrinsic value and potential to store more value.

Blockchain associated technology has had a relatively slow build-up over the years (since 2008) to then burst into public consciousness in 2015. Related DLT (distributed ledger technology) tech and blockchain financial instruments such as ICOs, bitcoin bonds and other derivatives have been steadily implemented in the daily routines of risk management and operational and financing divisions of corporate entities given their recently discovered benefits. Most important benefits include the eclipsing of third-party central coordinating authorities' confirmations and involvement when transacting with both suppliers and end consumers as well as a heightened control over the provenance of stock and heightened control over the

[1] Ryan, R., & Donohue, mayme. (2021). Securities on blockchain, pp. 87–95.: dealing with the history of distributed ledgers.
[2] der, A. E. van, Schoutens, W., Giudici, M. P., & Alessi, L. (2020). In *Financial risk management for cryptocurrencies* (pp. 3–8). essay, Springer. : explaining blockchain "in a nutshell".

mostly immutable bookkeeping records that seem to lower overall recording costs, increase orders' accuracy, and provide positive signaling[3].

More and more major companies are getting involved in blockchain related affairs. On Monday 8th of February 2021, Tesla has completed its SEC filing stating the automotive company has acquired $1.5 billion worth of Bitcoin while also separately announcing that it will start accepting that same currency as means of payment for its products[4]. Acceptance being the keyword, the high volatility of cryptocurrencies and blockchain related tokens[5] is nowadays proving its spread as a currency to be an oxymoron[6].

In traditional economics' literature, a currency, in order to be successful and exert wide acceptance, needs to satisfy several requirements. Assuming cryptos have been to some extent successful medium of exchange and/or means of payments, they have undoubtably continuously failed to behave as units of accounts and, arguably, as stores of value. Cryptocurrencies holds several intrinsic flaws in their design and behavior and in the use that is being made of them, which causes them to be highly volatile and, to a greater extent, unfit to be treated as a traditional currency.

Blockchain technology has, on the other hand, successfully created an alternative infrastructure for hosting financial products which cater to certain types of needs.

1.1.1 Introduction on financial products of blockchain tech.

Blockchain technology has been truly disruptive and has changed the way financial systems operate.[7] The accommodation of numerous forms of securities within the system has raised numerous concerns in the

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[3] Positive signalling has been found to be provided by announcements of adoption of blockchain tech for financing and operational purposes by *Fisch, Christian, and Paul P. Momtaz. "Institutional Investors and Post-ICO Performance: an Empirical Analysis of Investor Returns in Initial Coin Offerings (ICOs)." Journal of Corporate Finance, vol. 64, 2020, p. 101679., doi:10.1016/j.jcorpfin.2020.101679.*

[4] CEO Elon Musk has later announced that Tesla will not be accepting Bitcoin as payment medium for environmental reasons: the "green" image that Tesla perpetuates is in direct conflict with the impact that the mining of Bitcoin has on the environment.

[5] See 1.3.1.2 Financial product: Tokens

[6] As a currency, cryptos' spread is highly unjustified according to the features and rules of thumb that govern successful currencies, namely, their ability in behaving as units of account, as means of payments, stores of value etc. As a financial product, their spread is explainable: see 1.1.1: financial product: cryptocurrencies .

[7] See Boshkov, T. (2019). Blockchain and digital currency in the world of finance. *Blockchain and Cryptocurrencies*. https://doi.org/10.5772/intechopen.79456. Boshkov has written and spoken of the game changing role of blockchain within the world of finance. The blockchain system supports models of mass collaborations which makes existing forms of finance redundant.

eyes of legal practitioners and regulators. These financial products have been called "uncertified securities" (Ryan & Donohue)[8] due to their features and fit within the legal framework provided by article 8 of the Uniform Commercial Code (UCC). They can be classified as securities given their compliance with the definition of "security" laid out by the UCC[9]. And they can be defined as "uncertified" because, pursuant to section 8-104(a)(1), an "uncertified" security's transfer occurs by "delivery". Delivery is achieved:

- Through the registration of the buyer as the recognized owner, during the original issue; or
- Whenever a third party, other than an intermediary, either becomes the registered owner on behalf of the buyer or acknowledges that it is holding for the purchaser.

Which is consistent to the way transactions of financial products on blockchain are carried out. Particularly, while the rights of ownership are embedded into blocks that update the system, private and public keys do have legal implications and intrinsically grant rights over the accounts because of how the system is built.

1.1.2 Introduction on cryptocurrencies and crypto digital cash

Cryptocurrencies are defined as digital money embedded on blockchain or on similar infrastructure that ensures decentralization and a cryptographic component for secure access. The "crypto" part, included in their name, indicates the extreme forms of cryptography that support the consensus algorithm which govern their flow. Cryptocurrencies, in fact, originally strived in realizing a decentralized peer-to-peer system meant for payments. The envisioned system was supposed to remove any human interference with the management, supply, and supervision of the flow of the currency. The substitution of a hypothetical central bank with a set of algorithms governing the supply and validation of the money, proved to yield many benefits to some people. The original goal of these systems (to be merely designed for payments) has been outclassed by the actual utility that these systems are providing nowadays. The characteristics of these currencies which led to the unexpected success and spread of these systems, can be summarized into transactional features and monetary properties[10].

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[8] Reade, Ryan, and Mayme Donohue. "Securities on Blockchain." 2021.

[9] U.C.C. 8-102 (a) (15) defines a security as *"an obligation of an issuer or a share, participation, or other interest in an issuer or in property or an enterprise of an issuer".*

[10] *1: Cryptocurrency Army 2019 describes transactional properties that are attractive to people in need of lowering their transaction costs; transaction costs also include time of transfer of money, ease of use and carry costs. BlockGeeks 2019 explains the controlled supply of most cryptos drawing parallels with traditional currencies and applying macroeconomic notions in order to show how cryptocurrencies do not fall under certain defining factors of "money" such as the "unit of account" feature.

The transactional features are:

- Irreversibility
- Pseudonymity
- High velocity, Cheapness, internationality
- Security
- Permissionless

These transactional features have proven to be very attractive initially to a surprisingly big share of the world population since 2008 with the introduction of the first cryptocurrency: Bitcoin[11]. In most systems, funds are locked in public keys that can only be accessed through private keys for money transferring. The enhanced security stemming from this, coupled with the irreversibility of the process has been a strong promoter of faith in the system. Initially, a proof-of-work algorithm would be the most common process to regulate such transfers; recently a newly discovered proof-of-stake algorithm is spreading among crypto systems which sacrifices, to a small extent (arguably) security and irreversibility for lighter demands of computing power.

Transaction costs are defined as the costs in terms of effort, money and time involved in the transfer and carrying of money. High velocity, cheapness and internationality are features that refer to the overall lowering of transaction costs: money is stored in the global online system which virtually makes the carrying costs tend to 0; once a transfer is approved by the global mining power, the transferring of funds is immediate and the costs for such transfers are negligible[12].

Pseudonymity refers to the ability of the users to hide their true identity to a certain extent. Differently from anonymity, the pseudonymity feature makes it very difficult (but not impossible) to track down the flow of cryptos allowing users to benefit from enhanced privacy. Transactions also do not need to be approved by third parties constituted by human factors (permissionless).

The monetary characteristics of cryptos are the following:

- Intrinsically controlled supply
- The currency itself is not a debt by a bank towards the carrier

[11] as of May 11th, 2021, Chapkanovska Evangelina in an article on her blog highlighted how how more than half of global corporations are prioritizing the adoption of cryptocurrencies, specifically Bitcoin and that already around 84% of companies use such tech to a certain extent.

[12] Transfer costs are not entirely negligible. Although sending funds is very cheap, depending on the brokerage platform of choice (such as Coinbase etc.…) there are some consistent fees on the exchange processes that convert the cryptos into fiat currencies. This has implications on the profitability of micro trading practices.

Crypto systems either limit the total amount of cryptocurrency available in total or they cap the yearly number of cryptocurrencies to be created. The creation process of units of a cryptocurrency, known as "mining", occurs during the validation of transactions between external parties. In order to validate and finalize a transfer, both the "proof-of-work" and the "proof-of-stake" (and the Byzantine Fault Tolerance[13]) systems require computational power. Anyone can grant computational power on the grid by offering hardware and connecting their computers or servers to the crypto system in question. In exchange for their work, additional units of a cryptocurrency are generated and given to the avatar that has validated the transaction. The mining process is free from human interaction.

The mining of cryptos generate a number of units that is governed by 2 factors: the volume of transactions validated, and the total number of units present on the system (or the total number of units generated that year). There exists an asymptotic limit of generable units (either in total or yearly). These systems are built this way in order to counter an inflation in the system's economy given the absence of a central bank. The supply of units of crypto is intrinsically controlled by the algorithm.

Since the end of the gold standard, fiat money has been backed by governments through legislation and policies and backed by the people through their widespread acceptance. In spite of this, fiat money is still seen as a debt that the central bank has towards the carriers. On the other hand, cryptocurrencies lack this sort of identification.

Numerous problems stem from this lack of identification.

From a macroeconomic perspective problems of identification impact on applications of predictive models. Bitcoin, for example, has been classified as many things through a wide range as means of payment and store of value in 2012[14], as a "semi-inelastic synthetic commodity money"[15], and as an alternative investment option or speculative asset[16].

From a legal perspective, problems with the identification of cryptocurrencies and derivatives and of other financial products on blockchain, have caused numerous issues with reporting standards boards, authorities, regulators, and analysts.

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[13] The Byzantine Fault Tolerance system is a combination of an iterative consensus ledger and servers that are independent and strive in validating all transactions. This allows transactions to be 10 times quicker than the ones on previous systems. This system is adopted by Ripple and Stellar currencies.

[14] Keromytis, A. (2012). Bitter to better. In *Financial cryptography and data SECURITY 16TH international Conference, FC 2012, kralendijk, Bonaire, Februray 27-March 2, 2012, revised selected papers* (pp. 399–420). essay, Springer.

[15] Selgin, G. (2015). In *Synthetic commodity money* (pp. 92–99). essay, J. Financ Stability .

[16] O'Connor, R. V. (2015). Bitcoin: asset or currency? In *Systems, software and services PROCESS IMPROVEMENT: 22nd European CONFERENCE, eurospi 2015, Ankara, Turkey, September 30-October 2, 2015, Proceedings*. essay, Springer. (Glaser).

These monetary and transactional characteristics have developed a favorable environment to certain groups of market players. Renowned benefits of cryptocurrencies include their ease to acquire and use, their ease to trade as well as their high volatility, their sensitivity to news and expectations and their ability to perform as hedge instruments in portfolios. Unsurprisingly, their benefits and peculiar performance in financial markets has inevitably led cryptocurrencies to suffer less from identity crises and be treated as financial products (see section 1.1.1) from which derivatives have been developed.

1.2 Financial products on blockchain

Financial products on blockchain refer to all "contracts", items, "securities" which serve a purpose of raising capital, storing value, investing, hedging against (outside-of-blockchain) risk, speculate and secure certain rights (such as equity rights) that are traded, issued, and resolved on blockchain[17].

Financial products on blockchain include derivatives of cryptocurrencies, some types of tokens and the cryptocurrencies themselves. More and more types of new cryptocurrencies, blockchain systems, coins, and tokens on blockchain are added periodically to this category pursuant to the various needs for financing by institutions, corporations, and individuals. There exist many types of products on these platforms which can be categorized under several aspects.

Traditional finance distinguishes between debt and equity markets which present different types of contracts and financial products based on the rights they grant. The FOREX market also presents numerous types of derivative contracts tailored to individuals and enterprises in need of diversifying currency and hedge against (or speculate on) exchange rates' fluctuations. The market surrounding the financial products on blockchain encompasses many aspects of the above markets in terms of the kind of products it offers.

1.2.1 Financial product: cryptocurrencies

As explained previously[18], cryptocurrencies can be viewed as behaving differently than traditional currencies (fiat). For the sakes of simplicity, and to avoid applying macroeconomic concepts and definitions

[17] This definition was shaped also according to the journal: Schroeder, J. L. (2015). Bitcoin and the Uniform commercial code. *SSRN Electronic Journal*, 66–78. https://doi.org/10.2139/ssrn.2649441
[18] See 1.1.1

from money & banking literature, we will treat them as financial products that can be used for a number of objectives. The objectives which can be pursued through the use of cryptocurrencies range from individuals' portfolios' diversification to enterprises' risk management strategies and speculating practices. However, the initial objectives which cryptocurrencies strived in attaining drastically differ from these practices.

Cryptocurrencies can be classified based on their 5 original objectives which were designed to tackle:[19]

- Digital cash cryptos
- Payment infrastructure cryptos
- Securities cryptos
- Utility cryptos
- General platform cryptos

"Digital cash cryptos" such as Monero and Bitcoin were born as an alternative liquidity solution independent of any government which also allowed for pseudonymity[20]. As the most renowned form of cryptocurrency, it has been intensively studied as a "significant sample" since its behavior has been proved to lead other cryptos.[21]

Payment infrastructure cryptos, like Ripple and Utility Settlement Coins (USC), originally strived in improving the reliability of transaction, accelerating the processes, and lowering the costs. Initially, they were used on the spot by those willing to transfer fiat currencies: fiat money was converted into these cryptos, transferred, and converted back in very short time frames. Several banks nowadays still make use of these.

Securities cryptos represent claims on units of a commodity, service, or product, redeemable at any time. An example is The Royal Mint Gold (RMG) which grants ownership on gold held by the LBMA (London Bullion Market Association). This system has powerful implications on the volatility behavior of the crypto in question. It is relatively steady, following the closest system since the gold standard.

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[19] DJ, Elliot., & Lima., de L. (2018). Crypto assets: their future and regulation.

[20] See 1.0.1.2: introduction to cryptocurrencies, transactional features.

[21] Bitcoin remains, on the investors market, the leader and the trendsetter. This is probably because the transactions that involve the acquisition of other cryptocurrencies are either done via Ethereum or Bitcoin for the most part, and because the first mover advantage that Bitcoin secured in 2014, in a market proven to host herding behavior, is granting its benefits even today. Bitcoin, also, is becoming a synonym for cryptocurrencies in the ears of many people who are not familiar with this digital world, and it will remain, in some sense, the model to which the cryptocurrency market's success is measured. The expectations for Bitcoin may be exerting self-fulfilling prophecies on other cryptos.

Utility cryptos are very similar to securities crypto; the difference being the time frame of the claim. Whereas securities cryptos allow the owner to exercise the claim at any moment, utility cryptos grant future access to a product or service. Like Golem and Filecoin, these products are used to raise money for the development of a project in exchange for the access to the final product.

General platform cryptos are used on a platform which creates digital applications. This allows for automation of payments and transactions and the creation of other, more complex algorithms that govern the flow of the currency. Ether (a token on Ethereum blockchain) is a renowned example.

Another typology of cryptocurrency, known as the "toy coins" or "meme coins", has broken into public consciousness recently in 2018. Cryptos such as Kitty Coin, Jesu*coin, Shi*coin, Secretcoin and Sata*coin and, most importantly, Dogecoin have also surfaced without any particular advantage or objective over the other types. Doge coin has, however, managed to reach a market capitalization of 87b dollars on the 8th of May 2021.

Cryptos surface to the public and sink periodically. Consistently renowned cryptocurrencies are shown in table 1.1. Their consensus algorithms (proof-of-work, proof-of stake, Bizantine Fault Tolerance) are shown on the side along with their computing power requirements, supply, and rewards for mining processes.

	Consensus algorithm	Block reward	Block creation time	Supply	Transaction confirmation time
Bitcoin	PoW	12.5 BTC	10 min	21 million	60 min
Ethereum	PoW	5 ETH	14-15s	Unlimited	6 min
Ripple	BFT like			100 billion	4 s
Litecoin	PoW	12.5 LTC	2.5 min	84 million	30 min
EOS	dPoS	1% of yearly inflation	500 ms	1 million	0.25 s
Stellar	BFT like			Unlimited	2–5 s
Monero	PoW	0.6 XMR	2 min	300 million + 0.3 XMR/min if supply runs out	30 min
Tether	PoS/PoW			Unlimited	Depending on the blockchain

Table 1: summary of key characteristics for major exchanges as of November 2019. Source: Financial Risk Management for Cryptocurrencies (E. Van Der Auwera et. Al.) page 38.

As of August 2021, there exist over 4,000 cryptocurrencies. Bitcoin, Ethereum, XRP, Litecoin, and Bitcoin cash, account for roughly *"80% of the total assets – equivalent to $395bn (€324bn) – traded on the top cryptocurrency exchanges, according to industry estimates."*[22]

1.2.2 Financial product: cryptocurrency derivatives

A financial derivative is a contract or product (such as a warrant, forward, future or option) whose value derives from the value of an underlying asset and floats depending on it. The underlying could be a commodity, currency, security, group of assets or benchmark.

A derivative of a cryptocurrency is priced and subsequently valued also following the expectations surrounding the value of the underlying cryptocurrency. Differently from traditional derivatives, derivatives of cryptocurrencies do not follow standardised sets of pricing models. Corporations and institutions which issue and price these kinds of contracts price their own financial products basing on their needs and on their proprietary algorithms and models.

Derivatives of cryptocurrencies surfaced for the first time in October 2017 when LedgerX started trading options on Bitcoin. This was made possible by the U.S. Commodity Futures Trading Commission which approved of such products only months earlier. That same year, CBOE and the Chicago Mercantile exchange obtained the authorization to trade Bitcoin futures. Nowadays numerous derivative contracts, and crypto financial products are traded both on exchanges and on the blockchain itself. Blockchains such as Ethereum[23] allow to start derivative contracts and develop new algorithms directly on the blockchain (also with the use of Tokens).

Many of these derivative contracts are not standardised and are traded OTC[24]. They appeal to investors who seek tailored solutions to their hedging or speculative needs. The most traded types, however, can be summarised into:

- Crypto bonds

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[22] Dodds, L. S. (2021, August 3rd). *Briefing: Bonds on the blockchain*. IPE. https://www.ipe.com/home/briefing-bonds-on-the-blockchain/10053638.article.
[23] General platform cryptos' blockchains allow for the creation of automatic algorithms that settle and regulate contracts throughout time: see 1.1.1 Financial products: cryptocurrencies.
[24] Over the counter contracts have risen in light of the many different needs that crypto investors have: Dodds, L. S. (2021, June 30). *Briefing: Bonds on the blockchain*. IPE. https://www.ipe.com/home/briefing-bonds-on-the-blockchain/10053638.article.

- Crypto futures and forwards
- Crypto options

1.2.2.1 Crypto bonds and bonds on blockchain

Crypto bonds refer to bonds that are issued, available, purchasable, executed, renumerated, and settled on blockchain via cryptocurrencies. Bonds are financial contracts which promise to pay back to the purchaser a steady stream of cash periodically (coupons) and the principal at maturity in exchange for an initial endowment.

On the 25th of January 2017, the Commonwealth Bank and QTC created the first government bond on Blockchain. Queensland Treasury Corporation (QTC) successfully generated a bond tender on Bitcoin blockchain. The technology allowed them to view investors' bids in real time, finalise investment allocation and settle the contracts instantly. The QTC bond, created in digital form, holds the capabilities to automatically pay coupons at the due times. At first, the bond was not tradable and did not grant any legal obligation.[25] This bond was not a crypto bond.

In 2019, the European Investment Bank (EIB), issued its very first digital bond on a "public"[26] blockchain. Goldman Sachs, Santander and Société Générale handled the issuance and the representation on behalf of EIB for 100m, 2-year digital bonds. Investors purchase the "bond tokens" via fiat currencies though the tokens were registered on Ethereum network. Bank of France's digital cash was used for settlements. For the sakes of simplicity "bond tokens" are not necessarily "crypto bonds".

Bond tokens refers to financial contracts that mirror traditional bonds which have been uploaded on a blockchain through a process called "tokenization". Tokenization can occur in several ways but the most 2 common ones are:

- The creation of a security token which makes a real legal bond redeemable (on proprietary blockchain)

[25] ICMA group. (2021). *New fintech applications in bond markets*. ICMA group . https://www.icmagroup.org/Regulatory-Policy-and-Market-Practice/fintech/new-fintech-applications-in-bond-markets/.

[26] A "public" blockchain refers to a DLT blockchain system which hosts cryptocurrencies that are multi-purpose (BTC, ETH…). On the contrary, a private blockchain (Like Overstock.com's TZero) hosts tokens meant to represent some enterprise's obligations.

- The creation of a token app on a general platform crypto blockchain (e.g., Ethereum) which is the contract itself (1 token algorithm is 1 bond).

Although EIB collected fiat money through the sales of token bonds, this is not always the case. Bonds on blockchain can function in different ways depending on the currency which they are purchased with, which they use to quote coupon rate and which they use to quote their price and also based on whether they are tokenized or not.

Let us define Crypto Bonds as tokenized bonds whose instalments are denominated and accounted for in the underlying crypto. Table 1.2 strives in explaining some differences between bonds on blockchain.

	Issuer collects cryptocurrency[27]	Instalments quoted in cryptocurrency[28]	Price denominated in cryptocurrency (percentage)	Bond has undergone tokenization on public blockchain
Tokenized bond	Not necessary	Not necessary	Not necessary	Not necessary
Bond on blockchain	Not necessary	no	no	Not necessary
Crypto bond	yes	yes	Mostly yes	yes

Table 1.2 crypto bonds features: we define crypto bonds as being tokenized on a public blockchain, as being redeemable through that blockchain's currency and as quoting their coupon rate on the crypto value. Source: the author.

Crypto bonds pay periodic instalments based on the coupon rate and on the crypto value of the principal. A coupon rate of such a bond is a percentage of the principal denominated in cryptocurrency and thus the coupons' (fiat) value may float at each instalment.

[27] Some institutions' algorithms collect cryptocurrencies and instantly start the exchange process. The price of the bond depends also on the exchange rates quoted at the time of purchase. In this way, the issuer basically collects fiat currency. Other Institutions (such as ledgerX and Overstock.com) hold a wallet of cryptocurrencies and manage the timing of currency exchanges internally. Other firms, instead, collect fiat currency directly.

[28] Most commonly, coupon rates are quoted in fiat currency (on the 12th of September 2019, Santander has launched a 1.98% coupon rate on the 100-dollar blockchain bond). Sometimes, the coupon rate is quoted on the crypto principal of the bond, making the dollar amount float at each instalment.

On august 2020[29], the worlds' first blockchain bond exchange has gone live through BondBloX: a product of BondEvalue. The exchange, known as BondBloX Bond Exchange (BBE) offered instant settlement (on a T+0 basis) as opposed to the normal two-day settlement cycle done on most exchanges OTC.

This event marked the start of the standardization of bonds on blockchain. All these bonds are not crypto bonds because they pay the holder cryptocurrency amounts that equal the fiat currency amount of the coupon. On the contrary, we have defined crypto bonds as paying fixed amount of cryptocurrency at each instalment period. Crypto bonds are tailored solutions and are much rarer financial blockchain contracts.

A crypto bond is made of a price percentage denominated in crypto and a coupon rate denominated in crypto. The issuers of crypto bonds promise to pay steady amounts of the crypto at each date and the principal (denominated in crypto at maturity).

1.2.2.2 Crypto futures and forwards

Futures are financial contracts which impose the obligation and right to buy or sell an asset at a given time and predefined price. Futures are standardized and uniform in both time frames and the nature and quantity of the underlying. Forwards are very similar in regard to their core objectives but differ in how they are created and their tailored nature. Forwards are traded OTC, and their underlying components are crafted and decided on by the two parties (buyer and seller).

We define crypto futures and forwards as financial products on the blockchain which see the issuer promising to pay a specified amount of cryptocurrency at a given date in the future in exchange for an amount of cryptocurrency at time 0.

Until March 2019 the Chicago Board Options Exchange offered crypto futures. Nowadays, not many exchanges offer uniformed futures on cryptos. A very renowned exchange that does so is the Chicago Mercantile Exchange Group (CME). The CME prices these futures based on spot Bitcoin/USD reference rates. The rates are derived by the trade flows of major spot exchanges.

Other practices involve the selling of futures on general platform tokens and perpetual futures.

[29] Bondevalue. (2020, August 12). *The BondbloX Bond exchange goes live*. Track Live Bond Prices Online with BondEValue App. https://bondevalue.com/news/the-bondblox-bond-exchange-goes-live/.

Deribit[30] offers futures on both BTC and ETH as well as options and other crypto derivatives; Kraken offers perpetual futures on many cryptocurrencies.[31] Okex (2019) is another renowned crypto futures exchange.

Many of these exchanges allow issuers to purchase and trade forwards of general platform tokens. General platform tokens (e.g., tokens on ETH blockchain) can themselves yield rights on other securities such as ownership rights.[32]

1.2.2.3 Crypto options

Options are financial contracts which grant, to the purchaser, the right of buying (call) or selling (put) an asset or a basket of assets at a prespecified price (strike price) at a predetermined time (maturity).

Let us define crypto options as financial products on blockchain (which can be tokenized) which grant the possibility to purchase or sell at a predetermined amount of fiat currency, a predetermined amount of cryptocurrency or tokens[33] on public blockchain at a specific time in the future (European style[34]).

Deribit, Quedex, LedgerX are the most well know exchanges that offer these types of contracts. Options can also grant the right to sell or buy general platform tokens. The most spread method of pricing crypto options is the Black and Scholes model for European options. The model needs important assumptions on the nature of the implied volatility[35].

1.3 Financing via blockchain technology

Traditional financing for enterprises and corporations involves the participation in equity and debt markets. Firms can issue bonds and other obligations with the help of financial institutions, or they can issue equity

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[30] An institutional grade crypto derivatives platform: Deribit. (n.d.). *Deribit - about us*. Deribit.com. https://www.deribit.com/pages/information/about-us.

[31] (Kraken 2019, about us): perpetual futures allow the purchased of the contract to decide the expiration date. Long and short position, in the meantime, pay each other basing on the funding rates.

[32] See Initial Coin Offerings

[33] See 1.3.1.2: financial product: tokens

[34] Most crypto options offered on exchanges are European style options: they can be executed only at maturity as opposed to American style options.

[35] See chapter 2: Cryptos' risks and cost of capital

securities such as common, preferred stock and other rights. Most often, the intervention of third-party enterprises, banks or financial institution is needed for legal structuring and pricing of securities, brokerage services and investment banking services.

Blockchain technology has opened up new possibilities in financing and the option of eclipsing third parties from the financing process. The enhanced security stemming from the blockchain design coupled with the automatization achievable through the tokenization processes makes legal structuring of contracts redundant as algorithms ensure settlements[36].

Nowadays, it is possible and achievable for a corporation to raise both cryptocurrency denominated and fiat currency denominated capital through blockchain platforms.

Based on the nature of the obligations issued, liabilities can be denominated in both cryptocurrencies and fiat currencies. For example, if a firm issues bond on blockchain, it can raise either crypto capital or fiat capital and the due amount to the investors would be denominated in fiat denominated currency. If, however, this firm issued crypto bonds, the amounts owed would be denominated in cryptocurrencies and the firm will have to either pay through cryptos at the settlement date or with an equal amount denominated in fiat currency. Same goes for the other types of financial products discussed above: crypto options and crypto forwards/futures on both currencies and/or tokens.

As mentioned above, traditional financing requires issuance of either debt or equity obligations. It is possible to state that through the financial product discussed above (i.e., crypto bonds, crypto options, crypto futures, and forwards) firms issue a form of debt. Differently from other debt obligations, these crypto financial products' value is highly volatile. The high volatility is due to the underlying currency being way more volatile than any currency, financial or real asset in history. A firm that issues these types of financial products has to deal with the risks that are intrinsic to the utilized cryptocurrency because the amounts that it has to repay at due times are also dependent on the underlying crypto. Therefore, it is not mathematically viable to generalize this type of liability as merely part of the debt portion of the firm. The same contracts, however, can be purchased by said firm in order to enact portfolio strategies or hedging practices.

[36] These algorithms A.K.A Smart contracts are *"self-executing contracts that include the terms of an agreement between a buyer and seller being directly written into lines of code. Smart contracts permit trusted transactions and agreements to be carried out among disparate, anonymous parties without the need for a central authority, legal system, or external enforcement mechanism at the time of execution."*- OECD.org. (2021). The potential for blockchain in public equity markets in Asia.

Issuance of "equity" obligations on blockchain is also possible. Stock and stock options can also be tokenized and distributed on blockchain. Contrary to tokenized bonds, tokenized "equity" obligations do not contain self-executing algorithms for compensation or payout. This is because firms do not have clear ideas on their future payout policies nor ways to compensate at inception. These tokens usually represent an IOU which can be executed in a number of ways, not always through a conversion in actual stock or equity securities. Often, rewards can translate into products of the firm or digital crypto cash.

1.3.1 Initial Coin Offerings and IPOs on blockchain

Initial coin offerings start after a new token, coin or cryptographic asset has been created on blockchain. They involve the sale of these new blockchain-based assets which are related to a specific project, asset, currency, or enterprise. ICOs emerged in 2014 with aspects that mirror crowd-funding practices, IPOs, and venture capital. The tokens involved in ICOs are of three main types[37] but not only tokens are offered; tokenized securities and derivatives can also be included.

Initial public offerings can also be conducted on blockchain. Nowadays, electronic book-keeping is used by underwriting banks during IPOs, but direct interactions with investors and market soundings require some sort of physical presence which is not achievable through the digital platforms. Theoretically, blockchain tech could be used for all stages of the IPO issuance process. The digital platforms could substitute all physical documents. Fig.1.1 highlights how the full digitalization would need to be conducted. Several tokenization of multiple items would be required to be uploaded on the blockchain:

- Tokenization of the asset itself: a digital representation of the ownership rights
- Tokenization of the proceeds from the investor
- Tokenization of the derivative value/share of value (number of shares) and voting power
- Tokenization of the collateral in case of settlement failure (responsibility of the investor)
- Tokenization of the total funds raised

[37] See 1.3.1.2: Financial product: tokens

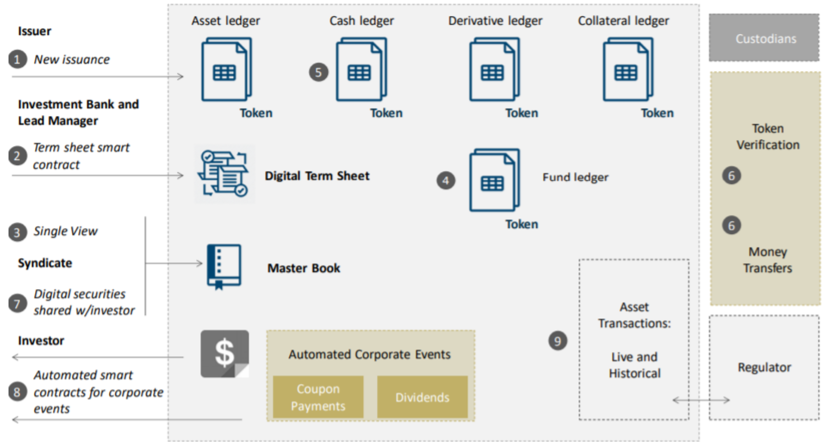

Figure 1.1: IPO process using blockchain. The figure highlights the need for tokenization of multiple items if the IPO is entirely digitalized on blockchain.

IPOs on blockchain essentially are issuance of equity rights through cryptocurrencies. The blockchain in question, however, are private and closed to the tokens relative to the process.

ICOs on the other hand, may or may not be treated as "equity" rights issuance processes, depending on the nature of the tokens. They do not follow a strict procedure and the tokens can be issued on public blockchains.

1.3.1.1 Characteristics of ICOs' market and investors

Although the first "successful" ICO on blockchain (whose tokens granted rights of ownership) was the one initiated by Overstock.com Inc in December 2017, the very first ICO conducted entirely on public blockchain was concluded by Mastercoin in July 2013 and it was bult on Bitcoin's blockchain (rather than Overstock's Tzero's Ethereum based blockchain). By 2018, in a report from CoinSchedule[38], 6.2b USD were raised through 366 ICOs worldwide.

The ongoing wide spread of this funding tool can give an insight over the nature of the investors that are attracted to this kind of financial products.

In a study by Christian Fisch in 2019[39] on the success factors of ICOs, a signalling theory was applied to hypothesize the regressors for a model that could predict whether an initial coin offering would have short

[38] Coinschedule News: *initial coin offerings worldwide (2018)*
[39] Fisch, Christian. "Initial Coin Offerings (ICOs) to Finance New Ventures." *Journal of Business Venturing*, vol. 34, no. 1, 2019, pp. 1–22., doi:10.1016/j.jbusvent.2018.09.007.

term success. Among the contributing factors, the perception of information asymmetry was argued to be responsible in numerous ways. Fisch argued that investors have considerably less information because, to them, the adoption of DLT was unclear, the potential for frauds were high and because, currently, there are not standard disclosure requirements to enact such funding methods[40]. The author goes on to hypothesize regressors based on their ability of to mitigate risk to the eyes of investors. He hypothesized and tested for the relevance of the presence of white papers, patents, reliable source coding as signals that could decrease perceived risks and thus affect the success of the ICO processes.

The study did succeed in disproving statistically the relevance of most of these factors. By quoting this study, we can deduce a few qualities of the investors involved with this kind of fund-raising method. We can hypothesise that, since they are, to a very small extent, susceptible to signals that tend to decrease risk in highly risky investment opportunities, and, since these signals require extensive research (white papers, patents, source code), these investors may be, to some extent, risk prone agents who actively seek riskier investment opportunities where information is hard to find for everyone outside of the enterprise; they do understand the problem spanned by asymmetry of information but do rely partly on the quality of firms' marketing tactics, (such as presentations, advertisements and social media hype surrounding ICOs) to finalize their investment decisions.

The study by Christian Fisch also discovered that the use of DLT on Ethereum blockchain (used as a dummy variable) has a net positive effect on the overall signalling. This could be due to the higher liquidity of the tokens, since Ethereum blockchain also hosts other openly tradable cryptocurrencies used for many other purposes.

In 2020 a study conducted on the trade-off between liquidity and returns in a portfolio composed partly by cryptocurrencies following China's ban of ICOs in 2017,[41], authors Sijia Zhang & Andros Gregoriou show that, by adding a component that accounts for the liquidity of the cryptocurrencies in question[42], the benefits derived from the diversification of the portfolio using cryptos are eliminated. In other words, whereas the presence of ICOs spanned benefits for investors willing to diversify their portfolios using firms' tokens on public blockchain[43], forbidding such crowd funding process from the nation, resulted in investors' crypto portfolios having worse Sharpe's ratio and other worse adjusted risk-returns' measures. The study proves the importance of ICOs in public blockchain: a flourishing ICO market is directly correlated with a more

[40] See 1.4.2: Current practices
[41] See Zhang, Sijia, and Andros Gregoriou. "Cryptocurrencies in Portfolios: Return–Liquidity Trade-off around China Forbidding Initial Coin Offerings." *Applied Economics Letters*, 2020, pp. 1–5., doi:10.1080/13504851.2020.1796908
[42] In Zhang et al paper, a liquidity measure was embedded into the value of the tokens and their returns.
[43] Public blockchains host other general platform tokens see 1.3.1.2: financial product: token

liquid environment on the public blockchain (regardless of the typologies of tokens) and better tools for investors willing to improve their portfolios' performances.

In another subsequent study by Christian Fisch and Paul P. Momtaz[44] , more light was shed on the nature of the investors in this market, namely the fact that institutional investors are numerous and able to realize above-market financial returns when it comes to investments in ICOs. This is mainly due to the superior screening practises and coaching quality that allows them to tamper with information asymmetries. Interestingly, in order to conduct this study, they found out that out of the sample of 2905 ICO ventures, only 19.4% were of listed enterprises. Institutional investors, at the time of the study backed approximately 50% of the listed ICOs and 1 out of 6 of the total sample.

ICOs have also been found to be strictly correlated to market cycles of bitcoin and ether. In a 2019 study on the Initial coin offerings by Masiak et al.[45] it has been found that the ICOs market remains bullish in periods of approximately 4 weeks which is in line with IPOs literature. A strong influence of Ethereum and bitcoin fluctuations was found in the pricing of other tokens and the behaviour of investors. Additionally, investors in the ICOs and the crypto market share a sort of irrational herding behaviour, where news and fear on missing out on opportunities of investments based on asymmetry of information, tend to result in many "followers" investors. Most importantly, this study showed how the growth rates of ICOs have insignificant correlation with the fluctuations in volatility of cryptos.

In other words, investors who want to diversify their crypto portfolios know that investing in ICOs crypto denominated tokens and cryptocurrencies themselves is not advised. It is possible to treat some tokens on public blockchain and many cryptocurrencies as substitutes in our analysis.

Furthermore, in a study published in February 2021 by Ju-Chun Yen et al.[46] it has been discovered how these investors tend to positively value public disclosures of firms stating they will initiate operations on blockchain both to fund themselves and to operate. However, they also found that investors react negatively to disclosures that imply that the blockchain itself will be of an existing cryptocurrency or token (public). In other words, while market participants value DLTs on blockchains, they are averse to Ethereum and bitcoin and other public and famous crypto's blockchains.

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[44] See Fisch, Christian, and Paul P. Momtaz. "Institutional Investors and Post-ICO Performance: an Empirical Analysis of Investor Returns in Initial Coin Offerings (ICOs)." *Journal of Corporate Finance*, vol. 64, 2020, p. 101679., doi:10.1016/j.jcorpfin.2020.101679

[45] See Masiak, Christian, et al. "Initial Coin Offerings (ICOs): Market Cycles and Relationship with Bitcoin and Ether." *Small Business Economics*, vol. 55, no. 4, 2019, pp. 1113–1130., doi:10.1007/s11187-019-00176-3.

[46] See Yen, Ju-Chun, and Tawei Wang. "Stock Price Relevance of Voluntary Disclosures about Blockchain Technology and Cryptocurrencies." 1 Feb. 2021.

1.3.1.2 Financial product: financial Tokens

A broad definition of tokens comprises all digital items on blockchain which can represent:

- legally binding contracts
- self-executing smart contracts (e.g., financial, derivatives)
- Diverse amounts of other tokens
- Diverse amounts of other cryptocurrencies
- rights of ownership, voting power, shares of representation
- IOUs
- "Digital cash"

"Digital cash" tokens on blockchain are the cryptocurrencies used as medium of exchange. Broadly, this definition sees cryptocurrencies as a subset of tokens on blockchain. However, for the sakes of simplicity whenever we refer to tokens, we refer to subsets of "financial tokens".

Financial tokens comprise security tokens, general purpose tokens, and utility tokens.

Security tokens represent financial securities that have undergone tokenization either on proprietary blockchain through means of contract representation algorithms (tokenized legally binding contracts) or through means of smart contract tokenization (self-executing contracts) on public blockchains.

Security tokens on private blockchain ID real legally binding contracts which could fall under equity or debt obligations under the issuer's point of view (e.g., tokenized shares, tokenized loans, tokenized bonds…etc.…).

Security tokens on public blockchains (e.g., Ethereum blockchain) represent smart contracts which mirror uncertified securities.[47] They can be secure algorithms which grant automatic rewards in the future (i.e., tokenized bonds, crypto futures, crypto forwards, crypto options). Pricing strategies of security tokens mirror the ones for the contracts they contain. In the case that payments and principal quotations are denominated in cryptocurrencies, their price is also heavily reliant on the underlying crypto's volatility and trends. Fig.1.2 expresses differences between private and public blockchains.

Utility tokens, most diffused in ICOs, mirror promises that the issuer makes during the issuance, marketing, and book building processes but do not contain self-executing algorithms nor include legally binding promises. Most utility tokens offer future payouts depending on the issuer's financial performance and/or

[47] See 1.1.2: introduction on cryptocurrencies and crypto digital cash

promise convertibility into tokenized equity shares, other tokens, or cryptocurrencies (non-financial tokens). Some utility tokens offer future access to the issuer's final products and services. The pricing process of utility tokens does not follow prespecified models and heavily depends on the market's interest and the needs of the issuer.

Tokens on public blockchain are heavily influenced by the underlying blockchain environment. Fluctuations in the underlying cryptocurrency brings about uncertainty in the tokens themselves regardless of whether their rewards would be denominated in fiat currencies or not. Certainly, the price of security tokens which promise instalments quoted to the crypto, is way more dependent on the crypto's expected future value.

There have been utility tokens hypothesized to grant rewards based on payout policies denominated in crypto. The payout ratio would quote the crypto earnings instead of the dollar earnings.

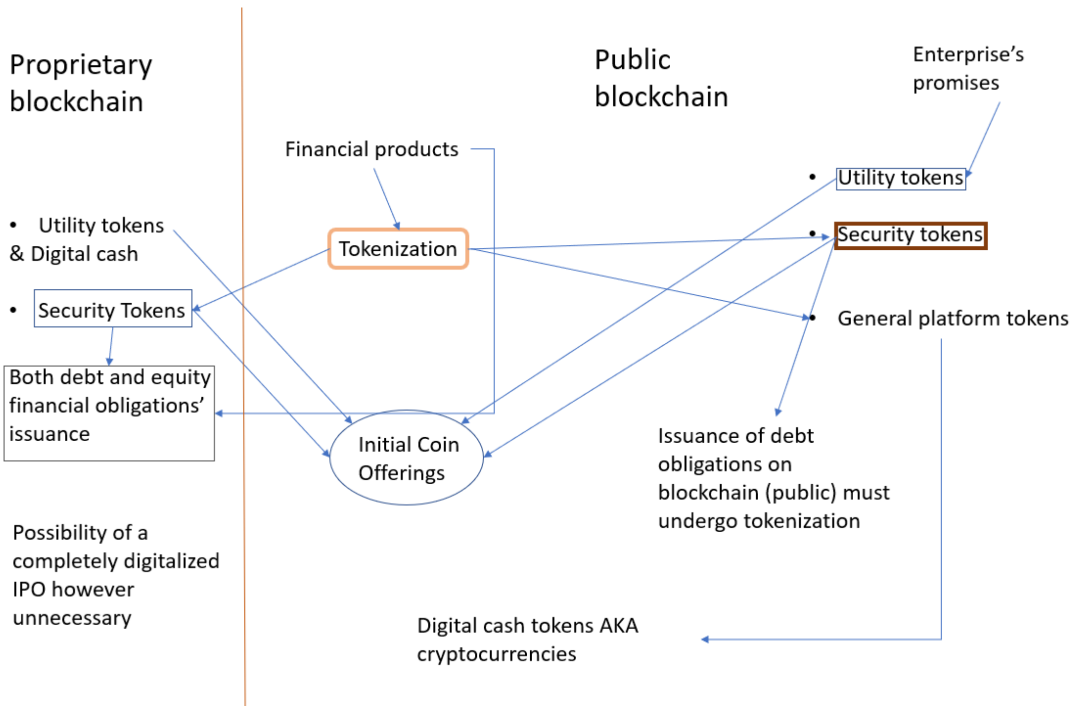

Figure 1.2: summary of tokens in private and public blockchains. Source: author.

1.4 Corporate reporting of financial products on blockchain

Assuming the issuer to be an enterprise, financing via the products mentioned above on blockchain could bring numerous benefits in terms of time to market, settlement risks, issuance costs and monitoring costs.

Also, via the tokenization process, premeditated corporate events could occur automatically via smart contracts. Dividends, coupons, interests, bonuses etc.… can be planned in advance and embedded into the algorithm.

The corporate reporting of such liabilities and assets would theoretically be easier given the enhanced transparency of the DLT side of the blockchain. This, however, is not the case for all of these products. Financial products on blockchain that are quoted in fiat currencies and whose price is not directly dependent on the underlying cryptocurrency's value are registered as the nature of the product they mirror (e.g., a bond on blockchain would be identified as a bond). This, however, is not the case for financial products that float on the crypto (e.g., crypto bond). They register on different levels depending on the use that the institution makes of the cryptocurrencies it collects.

Non-standardized reporting standards for cryptocurrencies translate into problems for auditors, regulators and analysists who wish to examine the institution's financial position on cryptos and on their derivatives.

1.4.1 History of analyses of regulations on reporting of crypto assets

In December 2015 the U.S. Securities and Exchange Commission ("SEC") approved the sale of Overstock.com, Inc.'s digital securities through its own blockchain. One year later, the company was the first publicly traded entity to issue stock via blockchain[48]. In order to do so, an interpretation of UCC article 8 was needed to include securities on blockchain as "securities" so that rights and obligations could be applied to the parties in connection.

Although amendments to UCC Article 8 were already implemented in years 1999-2000 to cover uncertified securities, *"securities on blockchain would be regarded as uncertified securities to be covered under UCC article 8's guidelines but not without some interpretation and understanding."*[49]

In a journal published by the AAR in 2017, authors Boon Seng Tan and Kin Yew Low discuss this issue by applying accounting principles to practical cases and conclude that standard setters may have to issue interpretation in their financial reporting[50]. The authors distinguish three market players as individuals, trading firms (B2C) and DICE (B2B). They argue that since the last two groups are the ones which need to

[48] See Reade, Ryan, and Mayme Donohue. "Securities on Blockchain." 2021 pg.6
[49] Reade, Ryan, and Mayme Donohue. "Securities on Blockchain." 2021 pg.3
[50] See Tan, Boon Seng, and Kin Yew Low. "Bitcoin - Its Economics for Financial Reporting." *Australian Accounting Review*, vol. 27, no. 2, 2017, pp. 220–227., doi:10.1111/auar.12167.

prepare financial statements, they should organize their items accordingly. However, whereas for trading firms, securities on a blockchain represent an alternative to fiat money when collecting revenue, for DICE these securities represent a property (since 2015 they were taxed as such) or a financial asset. The authors then argue that transactions should instead follow the conceptual framework to determine appropriate accounting treatment. They hypothesize that the applicable standard would be *IAS2 Inventory* and even in the case of participation in the loanable market they should not be treated as *IAS 32 Financial Instruments – Presentation and IFRS 9 Financial Instruments.* For cryptocurrency denominated assets to be classified under inventory, it would mean that the changes in value due to the high volatility would be registered as impairments and losses and, to some extent, revaluations, making an analysis of these items in the records more complex to undergo.

They then conclude that for the financial reporting of securities on blockchain no new accounting standards are needed, instead they exhort authorities to develop interpretations through the IFRS Interpretation Committees.

Following this line of thought, nowadays there is a lack of consensus among specialists in crypto assets and professional communities on the evaluation and classification of such items. For the purposes of this paper, this constitutes a severe problem as data are masked under multiple items classifications and mixed with other assets denominated in fiat currencies. Moreover, a clear and cut way to identify crypto denominated assets and liabilities is imperative to delineate a way to assess a company's exposure to systematic risks. Although, the data problem is almost impossible to overcome due to the heterogeneous ways that companies nowadays classify such items and to the statistically insignificant samples that would be gathered following procedures of cash flow examinations, in order to construct a model, this paper will need to make strong assumptions on identification methods.

1.4.2 Current practices

In a study published in March 2020 by Morzova et al. on "Crypto asset assessment models in financial reporting content typologies"[51] the authors highlight the main issues and the most problematic applications while studying the position of the IFRIC (International Financial Reporting Interpretations Committee). They underline the importance of doing so by mentioning the increasing relevance of major international

[51] See Morozova, Tatiana, et al. "Crypto Asset Assessment Models in Financial Reporting Content Typologies." *Entrepreneurship and Sustainability Issues*, vol. 7, no. 3, 2020, pp. 2196–2212., doi:10.9770/jesi.2020.7.3(49).

auditing institutions to assess and implement procedures for fair evaluations of cryptographic assets. According to them, the best solutions would be to develop new IFRS standards, regardless they report the main methodologies used across the world and assess their pros and cons while grounding them to the guidelines imposed by the authorities. Nowadays, the classification of crypto assets could, theoretically, be organized under four intuitions:

- Money
- supplies
- intangible assets
- financial assets.

Interestingly, a recurring theme within this research that strive to find better methods of identifying crypto assets, consists of proposing to base their classification on their function as means of payments, many authors argue how it would simplify reformulations and revaluations practices it these were treated as digital monetary assets whose pros and cons are shown in fig1.3, but the IFRIC does not allow this recognition.

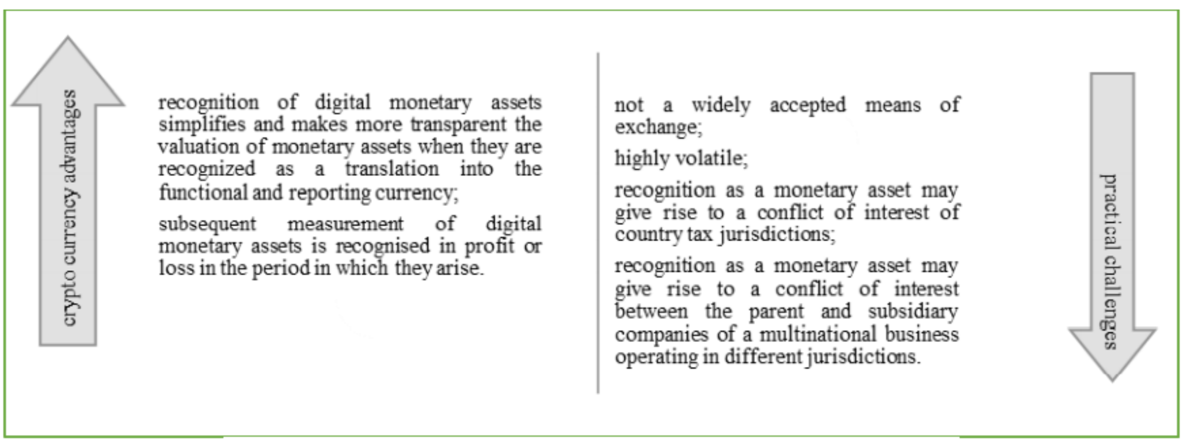

Figure 1.3: Advantages and disadvantages of recognizing crypto assets as digital monetary assets. Source: Morozova, Tatiana, et al. "Crypto Asset Assessment Models in Financial Reporting Content Typologies." Entrepreneurship and Sustainability Issues, vol. 7, no. 3, 2020, pp. 2196–2212., doi:10.9770/jesi.2020.7.3(49).

Morzowa et al.' paper result summarizes the issues : *"The rationale is that crypto assets are considered as means of payment by some companies, in particular, companies that accept digital money through special services or directly – AirBaltic, Microsoft, DELL, Whole Foods, Amazon, eBay".* Moreover, they express the incongruence with the legal systems: *"Recognition of a crypto asset as a means of payment has several advantages in terms of cost formation and subsequent revaluation following IAS 21 "Impact of Changes in Foreign Exchange Rates". However, the IFRIC concluded that crypto assets do not have cash features. At* *the same time, the interpretation contains a thesis that the Committee is not aware of the cryptographic currency that can be used in exchange for a particular product or service as a monetary unit".*[52]

The fact that today crypto assets cannot be officially identified as digital monetary assets following a logic based on their function as means of payments, constitutes a problem that forces enterprises to resort to interpretations which often hardly fit the nature of the items.

In the study of crypto asset assessment models in financial reporting content typologies, Morozowa et al. summarize crypto asset valuation models after recognition that they have found in global markets following the logic displayed by the graph in fig.1.4.

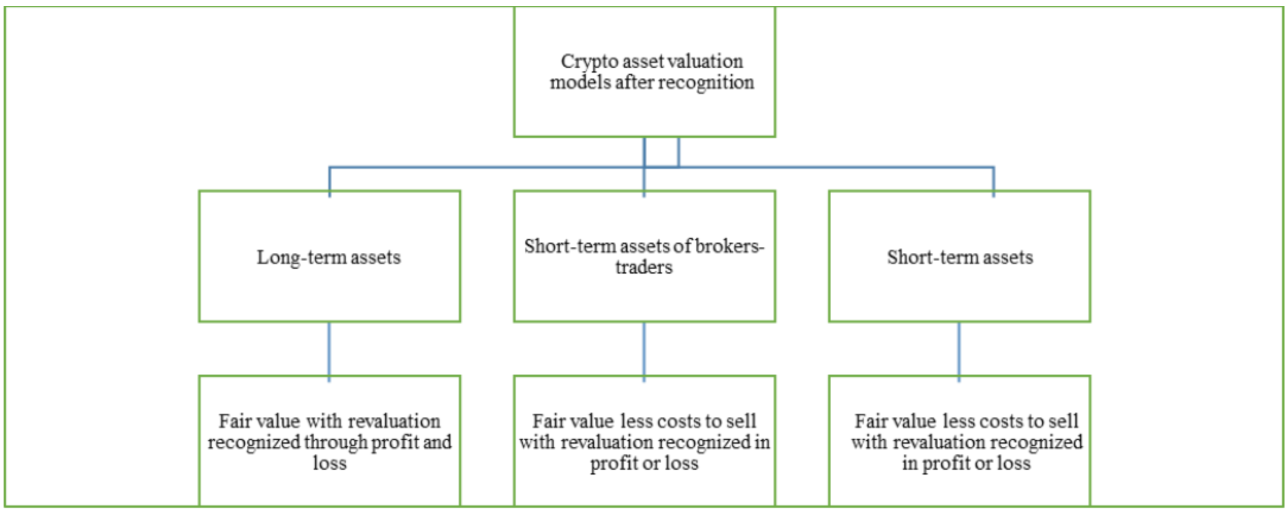

Figure 1.4: Valuation methods for reporting after recognition. Source Morozova, Tatiana, et al. "Crypto Asset Assessment Models in Financial Reporting Content Typologies." Entrepreneurship and Sustainability Issues, vol. 7, no. 3, 2020, pp. 2196–2212., doi:10.9770/jesi.2020.7.3(49).

The models firstly distinguish estimated time of holding and purpose of holding crypto assets but ultimately recognise revaluations (or revaluations less costs to sell depending on the purpose of said assets) through profit and loss means.

The observed models that the study refers to, in order to generalise the classification process displayed in fig.1.4, fall under 3 major categories: classification of crypto assets as intangibles, as inventory items, or as financial assets. Moreover, for auditing purposes, it is imperative to accurately assess single companies' accounting policies as their methods of internal and external reporting may be subject to operational specific caveats. In other words, depending on the nature of holdings of crypto assets and liabilities, a firm's balance

[52] Morozova, Tatiana, et al. "Crypto Asset Assessment Models in Financial Reporting Content Typologies." *Entrepreneurship and Sustainability Issues*, vol. 7, no. 3, 2020, pp. 2196–2212., doi:10.9770/jesi.2020.7.3(49). Page. 3-6.

sheet and income statement and thereafter consolidated reports and firms' holding companies' reports may be subject to modifications expressed in the notes.

For example the company Digital X reports cash held with the exchanges of bitcoin within its statements while overlooking deposits of bitcoin under "cash equivalents" to conform with the IFRC guidelines*: "For presentation in the statement of cash flows, cash and cash equivalents includes cash on hand, deposits held at call with financial institutions, cash held with bitcoin exchanges, other short-term, highly liquid investments that are readily convertible to known amounts of cash and which are subject to an insignificant risk of changes in value, and bank overdrafts. Cash and cash equivalents do not include the Group's holdings of bitcoins"*[53]

Companies such as this or Overstock.com Inc may instead treat these holdings as "Intangible assets" or "Prepaids and other current assets".

Overstock accounting policy specifically states: *"We hold cryptocurrency-denominated assets ("cryptocurrencies") such as bitcoin, and we include them in Prepaids and other current assets in our consolidated balance sheets. Our cryptocurrencies are recorded at cost less impairment. We recognize impairment on these assets caused by decreases in market value, determined by taking quoted prices from various digital currency exchanges with active markets, whenever events or changes in circumstances indicate that the carrying amount of an asset may not be recoverable". In its turn, the classification of crypto assets as intangible assets under IAS 38 "Intangible Assets" is an algorithm of professional judgment recommended by the International Financial Reporting Interpretations Committee. It may be noted that the established criteria are, to a maximum extent, typical of crypto assets."*[54]

Due to these problems, it appears quite difficult to gather data related to holdings of crypto assets and liabilities on a statistically significant scale, a study such as this would have to be conducted by looking at cash flows, revaluations of cryptos, accounting policies and scope of operations for every single firm.

[53] Information on financial statements https://www.digitalx.com/asx-announcements

[54] Overstock: about us: *financial reporting standards*: Overstock.com

Chapter 2: the impact of blockchain products on cost of capital.

2.0. Objectives of this chapter

As the goal of the paper is to design an estimation method for the cost of capital of an enterprise which deals on blockchain (for both investing, financing and operating activities), it is necessary to review what cost of capital is and how it could be affected by the introduction of the financial products discussed in Chapter 1.

The objectives of this chapter are:

- To review Cost of capital concepts, objectives, and models for its calculation
- To highlight how cost of capital considers the risk profile of the issuer, environment, and market
- To understand the risks associated with the financial products discussed in chapter 1
- To broadly explain how they would affect an enterprise's cost of capital; assuming that the enterprise deals with crypto products in both financing, investing and operating activities

2.1 Review of Cost of capital

The cost of capital is a metric used in finance to determine the value of a project, investment, business, enterprise, or asset. It may encompass all direct and indirect costs as well as opportunity costs of funding something and it is expressed as a percentage of the reward which that "something" yields.

It represents a hurdle rate: a rate of return which has to be beaten by the real future rate of return in order to make the funding worthwhile for the investors. [55]

"Opportunity cost" refers to the cost of not choosing alternative investment opportunities which are similar in risk. An investor who can generate an expected return A% on a cryptocurrency derivative will not choose to invest in a corporation security token that yields B% if A%>B% and if the two blockchain securities are similar in the risks which they are exposed to in the eyes of the investor. In a hypothetical world where B%

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[55] See: Maxwell, I. (2015). Project valuation. In *Mathematical finance* (pp. 28–33). essay, Clanrye Intl.

is the only achievable return by almost everyone, an investor who could achieve A% return would have to discount his future inflows using B% as a hurdle rate.

Securities do not need to be fundamentally very similar in the risks they present in order to be comparable for opportunity costs' reasons; they just need to be similar in risk to the eyes of the investors and of the market.

An enterprise which funds itself in multiple ways and through the issuance of multiple securities has to provide returns which conform to all other enterprises, assets, businesses, and investment opportunities which yield similar risks to it[56].

A firm which issues a bond expects the bond to be sold at a price which reflect the firm's default risk and the potential investors' returns which are offered by all other debt securities of similar risk.

The cost of capital metric is used to discount future forecasted inflows (earnings, coupons, cash flows, free cash flow, cash flow to equity etc.…). Depending on whose claims (or accessibility) are on these inflows and on the nature of the flows themselves, the cost of capital varies.

If we suppose that a fixed percentage of a firm's cash flows will be divided among a certain category of investors (not necessarily delivered), the hurdle rate used to discount these future cash flows will be depending on:

- The alternatives that this particular group of investors had before finalizing their investment decision (on both real assets and financial assets).
- The pattern of responses (in terms of required returns) that investors have to different levels of risk
- The risks that the company presents given all its sources of financing and operations
- The historical performance of the company
- The historical performance and risks of the alternatives
- The strategies that investors can enact on their portfolios of investments
- The information that can be gathered by the parties

The equivalent of this analysis can be done proactively for the pricing of securities. Retroactively, it could be conducted to estimate hurdle rates for subsequent valuations of projects and firms.

For an issuer to determine its competitors on the financial market, it is necessary to resort to the same models and intuitions used most commonly by the investors. Competitors on the financial market are not

[56] This assumes that investors have access to the other investment opportunities (no barriers) and that there is symmetry of information within the market.

necessarily the same ones found in the market sector[57]. Moreover, financial securities compete with other assets across categories and markets. Debt securities may compete with equity securities, currencies, cryptocurrencies, tokens, and real investment opportunities. The competition depends on what these investors have access to, what information they have, and on what they view as comparable in terms of risk.[58]

An analysis of comparable firms is used most commonly to set a benchmark for operating and financial performance and involves looking at other issuers' performance ratios.

Performance ratios include profitability ratios, financial performance ratios, cost efficiency ratios and stock performance ratios which all scale back the size of the businesses. This provides an idea of what other businesses with similar operational and financial statuses are achieving on stock value.

Similar approaches can be conducted for cost of capital estimation. An issuer's financial product may have similar risk-adjusted measures and ratios[59] to so many others. This could provide intuitions on the nature of the competing products whose rate of returns would be used to estimate the issuer's product hurdle rate.

Alternatively, delineating the behavior of a particular group of investors in terms of risk proneness and sensibility to certain signals, may work proactively in finding out what minimum rate of returns they would demand out of certain investments. This approach presents challenges.

First of all, it makes many assumptions on the nature of the investors. Ideally, it would need statistically significant data on their behavior to prove some kind of pattern in responses to risks. Secondly, it has to account for the hedging and speculative strategies which can be conducted by them through portfolio management. Thirdly, it has to assume, to some extent, the quantity and the quality of information that are accessible by them.

The target group of investors needs to be delineated by the basket of financial and real products on which it invests. This basket of investment opportunities would be the reference "market" to which the issuer's performance would be compared to; it would provide a reference hurdle rate. Adjusting for the risks of the issuer, if the risk response patterns are statistically significant, a statistically significant estimation of the

[57] The sector in which a firm operates is relevant to the firm's risk. Investors' portfolio differentiation strategies involve including enterprises from different sectors to bypass the risk of a whole industry going under.
[58] See: Khaki, A. R., Al-Mohamad, S., Bakry, W., & El-Kanj, N. (2020). Bitcoin and Portfolio Diversification: Portfolio optimization approach. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3614606
[59] Risk adjusted measures and ratios include Sortino, Omega and Sharpe ratios. See: Benhamou, E., Guez, B., & Paris, N. (2019). Omega and Sharpe ratio. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3469888

hurdle rate could be achieved[60]. In this case, the estimated hurdle rate would be the issuer's cost of capital, if and only if, the issuer finances itself only with units that financial product.

This cost of capital would be used to discount flows of cash on which management or ownership claims are solely of the target investor group; not of governments (through taxes) nor other financial institutions and creditors.

For an enterprise which finances itself on equity and debt markets, issuing an array of financial obligations, the cost of capital is first explicated on the basis of what it discounts. Two of the most common practices of business valuation entice:

- A "flow to equity" approach
- A "WACC or APV" approach

These fundamental approaches could give insights on the cost of capital for projects and on "fair values" [61]but, ultimately, practices such as book-building, brokerage, and ex-post market analyses reveal the true required value and cost of capital because of the products' prices adjusting according to the market.

2.1.1 Cost of capital in "Flow to equity" approach

The flow to equity approach is a business valuation model which involves isolating a portion of forecasted yearly cash inflows and discounting them using a cost of capital derived from the financing via equity issuance: the cost of equity.

The model first finds the periodic Free Cash Flows to Equity (FCFE) defined[62] as:

$$FCFE_i = Net\ Income_i - Capex_i - \Delta NWC_i + Net\ Borrowing_i + Depreciation_i$$

[60] The wording of this explanation is broad in order to be applied to multiple typologies of cost of capital (e.g., cost of equity, cost of debt, projects' hurdle rates)

[61] Fair values calculated on IFRS 13's guidelines*: "the price that would be received to sell an asset or paid to transfer a liability in an orderly transaction between market participants at the measurement date"*- https://www.accaglobal.com, A. C. C. A.-. (2011). *IFRS 13, fair Value measurement*. Home. Retrieved September 10, 2021, from https://www.accaglobal.com/lk/en/student/exam-support-resources/professional-exams-study-resources/strategic-business-reporting/technical-articles/ifrs-13.html.

[62] Hillier, D. (2021). Capital budgeting and valuation with leverage. In *Corporate finance* (pp. 679–688). essay, McGraw-Hill Education.

The FCFE is the cash flow free from other destinations other than the shareholders if they choose to make use of it.

Because of the nature of this cash flow, the future FCFEs are discounted using a cost of capital metric which accounts only for the funding raised by equity issuance.

The cost of capital used in this method equals the cost of equity.[63]

2.1.2 Cost of capital in WACC and APV approaches

The WACC and APV approaches use a different cost of capital metric than the one used in the FCFE approach. This is due to the fact that they do not isolate the portion of cash on which only the equity holders have access on but rather compute a cost of capital which accounts for multiple points of access.

The WACC valuation method begins its course by isolating Free Cash Flows.

Free Cash flows[64] are the amounts of cash generated at specific periods after accounting for the outflows used in maintaining business operations and capital assets. Free Cash flows exclude noncash expenses and includes Capex and changes in net working capital: ΔNWC_i:

$$FCF_i = EBIT_i\ (1 - t_c) + noncash\ expenses\ (depreciation, amortization\ \ldots)_i - \Delta NWC_i - Capex_i$$ [65]

Contrary to the FCFE, FCF does not consider the net borrowing and considers the after-tax interest expenses:

$$FCF_i = FCFE_i - Net\ Borrowing_{at\ time\ i} + After\ tax\ interest\ expenses_i$$ [66]

Net borrowing is positive when the firm increases its debt. In the FCFE, an increase in debt translates into more cash available for the shareholders. The FCF is what is available to shareholders and debt holders, the FCFE is only what is available to shareholders.

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[63] See 2.0.2: review of the cost of equity

[64] See: Subramanyam, K. R. (2014). Reformulation of Income statement. In *Financial statement analysis* (pp. 109–121). essay, McGraw-Hill Education.

[65] Capex refers to total Capital expenditures: outflows of cash destined to the acquisition of fixed assets, PPP, and others….

[66] The free cash flow worksheet. (2011). *Free Cash Flow*, 65–100. https://doi.org/10.1002/9781118266847.ch6

Because the valuation method needs to discount these forecasted metrics, it needs a cost of capital or a hurdle rate which accounts for the metric's nature: to whom this cash is available to.

The WACC: weighted average cost of capital is an estimation of the hurdle rate needed for FCFs discounting. It starts by diving the firm's sources of finance into two major categories: equity and debt.[67]

It creates a capital structure composed by these two also on the basis of financial reporting standards and legal frameworks[68]. Supposedly, Cost of Debt[69] and Cost of Equity are reliable measures in summarizing the hurdle rates of the obligations issued in their respective markets.[70]

The after tax WACC is then defined as:

$$After\ Tax\ WACC = r_d(1 - t_c)\frac{D}{V} + \frac{r_e E}{V}$$

Where D & E constitute debt and equity portion of the capital structure : $E + D = V$ and r_d & r_e are respectively the costs of financing with debt and equity; t_c is the corporate tax rate in this case.

The Adjusted Present Value approach uses a pre-tax WACC to find the present values of the unlevered project and of the interest tax shield. It assumes that the value of the project equals its unlevered[71] value plus the tax shield stemming from taking on the project through debt issuance:

$$V^l = V^u + PV_{interest\ tax\ shield}$$

The APV discounts the FCFs using a pre-tax $WACC = \frac{r_d D}{V} + \frac{r_e E}{V}$ to find the unlevered value of the project and then uses the same hurdle rate to discount the forecasted interest tax shields found as a percentage of future interests paid because of the project : $tax\ shield_i = interests\ paid_i\ x\ t_c$ where: $Interests\ paid\ _i = r_d\ x\ D_{i-1}$.[72]

[67] See 2.0.4: review of capital structure
[68] Compulsory public reporting of financial statements includes differentiation of liabilities through debt and equity subcategories in the balance sheet.
[69] See 2.0.3: review of cost of debt
[70] This involves generalization of the costs of capital depending on these two broad categories, which is not necessarily a thorough differentiation.
[71] The unlevered value is the value of the business if the business does not finance through debt markets' obligations' issuance.
[72] The interests are paid on the previous year's outstanding debt.

These approaches are the most commonly preferred among practitioners when it comes to business valuations[73]. Theoretically, these costs of capital symbolize the required rate that investors would need in order to accept investments in businesses with such risks.

2.1.3 Review of cost of equity's basics

At its core, the Equity cost of capital r_e equals the expected return of investments with similar risks in the equity markets. It is most commonly estimated by the Security Market Line under the Capital Asset Pricing Model (CAPM)[74]:

$$r_{e\ of\ i} = r_f + \beta_i\ x\ (E(R_{mkt}) - r_f)$$

Where r_f refers to the risk-free rate and $\beta_i\ x\ (E(R_{mkt}) - r_f)$ refers to the risk premium.

The risk-free rate is the rate of return achievable by investing in seemingly risk-free obligations (such as government bonds, treasury bills etc.…) whereas the risk premium refers to what return investors would require additively for their commitment in taking risks.

Risk premium is defined as a linear function of the market risk premium:

$$Market\ risk\ premium = \left(E(R_{mkt}) - r_f\right)\ and\ Risk\ premium_i = Beta_i\ x\ \left(E(R_{mkt}) - r_f\right)$$

Where Beta is usually estimated by a regressor that links historical market risk premiums to the firm's historical premiums on stock[75]. The market risk premium is explicated by the difference in the expected market returns and the risk-free rate. The reference market in question can be selected in several ways[76].

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[73] Around 85% of practitioners use APV and WACC approaches. See: 徐 少华. (2020). How to use WACC method AND APV method to evaluate the market value of leveraged companies. *Finance*, *10*(01), 47–59. https://doi.org/10.12677/fin.2020.101006

[74] See: Multifactor CAPM. (n.d.). *Springer Reference*. https://doi.org/10.1007/springerreference_1996

[75] Beta can also be estimated by re-levering the average of the unlevered betas of comparable firms. Source: Hillier, D. (2021). In *Corporate finance* (pp. 530–538). essay, McGraw-Hill Education

[76] References markets can be selected either through market proxies, portfolios' indexes or by building a market based on competition. They are selected based on the nature of the business or security and on the nature of the accessibility and behaviour that target investors have.

The SML function of the CAPM is the most widely used way to estimate a cost of equity, however it heavily depends on the assumptions over the market, the market participants, and the relationship that the firm in question has with the selected market.[77]

2.1.4 Review of cost of debt's basics

Essentially, the cost of debt capital entices the expected return that creditors require of the firm. If it is assumed that the firm in question has little to no risk of default, the cost of debt would be the IRR[78] of the debt obligations that it issues. Otherwise, a metric which accounts for default risk has to be included. The cost of debt of a firm which finances itself with one standard of bonds can be expressed as:

$$r_d = Yield\ to\ maturity\ of\ the\ bond - probability\ of\ default\ \ x\ \ expected\ loss\ rate$$ [79]

Traditionally, the average unsecured debt's loss rate is around 60%[80] whereas the probabilities of default are usually sourced by rating agencies' reports. Table 2.1 gives an example of the interconnectedness between default rates and ratings.

Table 2.1: Annual default rated by rating. Source: "corporate defaults and recovery rates, 1920-2011". Moody's' Global Credit policy. 2012.

Rating:	AAA	AA	A	BBB	BB	B	CCC	CC-C
Default Rate:								
Average	0.0%	0.1%	0.2%	0.5%	2.2%	5.5%	12.2%	14.1%
In Recessions	0.0%	1.0%	3.0%	3.0%	8.0%	16.0%	48.0%	79.0%

Estimation of cost of debt can be done in multiple ways.

For a firm which reports interests paid and debt structure, it can be derived historically by dividing the interests by the outstanding debt, and then find the time frame's average and forecast for the future.

[77] The SML model confides in the reliability of the beta regressor in being statistically significant (high R^2).
[78] IRR or Internal rate of return is the discount rate that solves the NPV=0 of bonds and other securities assuming a flat yield curve.
[79] Hillier, D. (2021). Capital budgeting and valuation with leverage. In *Corporate finance* (pp. 679–680). essay, McGraw-Hill Education
[80] See: Resti, A. (2010). Exposure to default and loss given default. *Encyclopaedia of Quantitative Finance*. https://doi.org/10.1002/9780470061602.eqf09027

However, this method requires a consistent capital structure policy[81] in order to be accurate to a significant extent.

Another method involves looking at the Debt Betas provided by rating agencies (which are reported by rating and maturity) and use the betas in a directly proportional function similar to the CAPM's SML. [82]

Cost of debt addresses multiple heterogeneous issued securities. It accounts for obligations towards financial institutions such as loans, mortgages, and tailored deals as well as obligations issued with and without the banks' help such as bonds, notes, options etc.…

Another way to estimate the cost of debt for a firm is through the use of historical data on interests paid by the firm and its levels of outstanding debt. By using this approach, a profile of historic costs of debt can be constructed:

$$cost\ of\ debt\ _{period\ i} = \frac{interests\ paid\ _i}{total\ outstanding\ debt\ _{i-1}}$$

From these past metrics, an estimate based on average, moving averages and other methods can be computed for the current cost of debt.

2.1.5 Review of capital structure's basics

The capital structure of a firm refers to a combination of the sources of financing namely equity and debt (both short and long term). Debt consists of sources of finance which owe interest expenses while equity comprise sources with no legally binding compensation, but which grant ownership rights in the firm. The state of a firm's borrowing practices can be described by the debt-to-equity ratio (D/E).

The firm's value is then defined as: $V^{firm} = Equity + Debt$

Debt and equity are two major categories in the balance sheet and in other official reports which are used for internal and external auditing practices, which is why they are the two categories represented in the capital structure.

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[81] See 2.0.4: review of capital structure

[82] Rating agencies report debt betas as regressors which link the fluctuations of historical costs of debt within the market to the ones of the company i:

$$r_{debt\ of\ i} = \alpha + \beta_{i\ debt}\ x\ (E(r_{market\ debt}) - \alpha)$$

The capital structure, however, should strive in dissecting a firm's financing sources on the basis of:

- Maturity
- Typology of assets on the basis of the markets they are traded in

Traditionally, more thorough analyses distinguish between long term and short-term debt, and between common and preferred stocks and others.

Equity does not have an expiration date as opposed to debt. Debt, however, creates tax advantages in the form of interest tax shields and is easier to access. High leverage ratio refers to high D/E ratios. Having high leverage may impact the cost of debt: since it makes the risk of default more probable, the rating might be affected negatively.

Most commonly, firms have policies regarding fixed or floating target capital structures. These policies have various intents; most commonly, they aim to minimize WACC. [83]

2.2 The impact of blockchain

The impact of the products discussed in chapter 1 can happen to a firm in a number of ways.

An enterprise could issue any type of obligation on blockchain (including equity products) through tokenization processes which could include smart contracts.

Moreover, the company could purchase products on blockchain and crypto products to hold an array of crypto assets in order to execute faster and more "secure" transactions with suppliers and other businesses.

Also, payments from end customers could be collected partly or in their entirety in digital cash tokens on either public or private blockchain.

Finally, the firm could issue crypto bonds, crypto options, crypto futures, and forwards as well as tokens on blockchain and other traditional obligations on blockchain.

It is important to remember that risks arise differently in:

[83] Ju, L., Lu, T. J., & Tu, Z. (2015). Capital flight and bitcoin regulation. *International Review of Finance*, *16*(3), 445–455. https://doi.org/10.1111/irfi.12072

- Crypto financial products (special class of financial products on blockchain which has cryptocurrencies as underlying of value)[84]
- Financial products on blockchain (whether tokenized or not)

The impact of blockchain on cost of capital depends on several factors. However, the first step is to determine:

1. The type of blockchain (proprietary or public)[85]
2. The types of activities that the blockchain integrates in the firm
3. The types of blockchain products included in the activities

For a more comprehensive discussion of blockchain's impact on cost of capital we assume that:

1. We refer to a public blockchain
2. The blockchain is involved in the firm's investing, operating, and financing activities
3. Any set of financial products from chapter 1 are included

2.2.1 Assumptions regarding the impact of blockchain

For the discussion on cost of capital for a firm that operates, invests, and finances itself via crypto products and financial products on public blockchain, we make six major assumptions at the initial stage:

1. The introduction of blockchain yields considerably different risks for the firm to the degree that they would affect its cost of capital if it were included.

2. there are quantifiable measures of these risks and features of the blockchain which could be embedded into the company's cost of capital's computation.

3. The firm manages its blockchain assets and liabilities internally and organically.

4. The crypto products are priced so that their yields to maturity depend partly on the ones of the firm's current debt securities[86].

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[84] As discussed in Chapter 1, crypto financial products yields are denominated in cryptocurrency because their payments, prices and contract feature are all denominated in cryptocurrencies.
[85] See chapter 1: Introduction on Blockchain
[86] We assume that the risk profile of the firm and of the market has the same impact on the bonds YTMs, the implications being that blockchain and cryptocurrencies are the other factors influencing crypto products' prices

5. the relevant market of reference for the discussion of crypto financial products' required rates and opportunity costs cannot be the general market; because cryptos' historic returns and volatility is unlike anything in the world.[87]

6. there is a quantifiable amount of future savings (such as tax shields and cut costs) that can be embedded in the estimation of a new cost of capital.

The first assumption is on the nature and the degree of these risks: whether they significantly affect the firm's cost of capital. . In chapter 1 we have discussed some benefits of employing the blockchain in obligations' issuance and investments, however, these practices still yield considerable risks. Moreover, products on blockchain do not yield the same risks as crypto products: this is because crypto products' value is directly dependent on exchange rate fluctuations.[88]

The second assumption is on the modelling of cost of capital after the introduction of blockchain. It states that there exists a way to incorporate features and risks of the blockchain into the numerical computation of the firm's cost of capital. Features of the blockchain also include characteristics of the products within the system. Products on blockchain present designs that are different than traditional equity and debt obligations. For example, whereas the average loss rate (in case of default) of debt obligations is around 60%, the loss rate of debt securities tokenized with smart contracts and issued on blockchain is 100%. This is because the smart contract's algorithms are not prepared for empty or negative wallets. This could affect the cost of debt as seen by its estimation methods discussed above[89] and thus the average cost of capital of the firm.

The modelling of risks includes both the benefits and risks stemming from the blockchain system itself and the risks stemming from the crypto financial products' underlying factors. For example, crypto financial products' values (such as crypto futures, crypto forwards, crypto options, and crypto bonds) are heavily dependent on the values of the underlying cryptocurrency. Traditionally, when a firm issues floating rate bonds and notes, it prices them by deriving a fixed rate which would account for the floating rate's future expectations. The fixed rate[90], which is also used for interest rate swaps, would then be embedded into the cost of debt as the yield to maturity of the security.

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[87] See: Akhtaruzzaman, Md, et al. "The Influence of Bitcoin on Portfolio Diversification and Design." *Finance Research Letters*, vol. 37, 2020, p. 101344., doi: 10.1016/j.frl.2019.101344.
[88] See chapter1: Financial product: crypto bonds
[89] See 2.0.3: review of cost of debt
[90] See: Interest rate swaps in practice. (2011). *Interest Rate Swaps and Their Derivatives*, 43–65. https://doi.org/10.1002/9781118267967.ch3

The third statement spans by the formulation of a hypothetical company which operates in a certain manner: company omega.[91] For now, let us just assume that a firm is issuing and purchasing any set of financial products on blockchain which also contains crypto financial products. However, it is important to understand whether the firm takes the full risk of issuing crypto securities or employs risk management tactics to hedge against the floating exchange rates[92].

The 4th assumption is on the nature of the crypto financial obligations issued by the firm. It assumes that the firm's inner risks, default probability and ratings are mirrored in its currently issued securities' yields to maturity already. It states that the pricing of its crypto products aims to provide yields to maturity that are directly connected to the yields of its traditional issued fiat securities.

The 5th assumption is on the nature of the investors. It states that the general securities' market, or its proxies' approximations are not a good estimate of opportunity costs adjusted for risk-returns. The assumption segregates the group of crypto securities to account for its peculiar utilities.

Although not entirely quantifiable, these utilities appeal to certain investors in different ways. These investors behave differently and create entirely different market environments:

In chapter 1 we defined ICOs and mentioned how the participation of financial institutions in their funding would be an indicator to their successes. This was due to the superior abilities in screening, monitoring, and coaching, that experts within financial institutions have over other investors.

We also pointed out how, in spite of the difficulties in gathering information such as white papers, patents and source coding assessments, these are very insignificant signals for investors who are considering making purchases in tokens; we considered the distorted importance of the liquidity factor as ICOs whose tokens were on Ethereum blockchain, were observed to have better short-term performances. Also, we observed how the nature of the tokens themselves, whether utility tokens or security tokens or actual cryptocurrencies, influenced investment prospects because of their rewards' systems.

Overall, in a market where information is hard to gather and requires some level of expertise to examine, the dynamics are distorted from what can be found in an efficient market. It can be assumed that there exist some restrictions on who can invest, who can participate and how the market is different at different levels of risk prone participants.

The sixth statement deals with the quantifiable benefits of including financial products of blockchain in the firm's financing, operating, and investing activities. Any savings, tax shields, benefits on the major business

[91] Company Omega is a fictitious company dissected in Chapter 3
[92] Tactics involve strategic investing in sets of crypto options, crypto futures, and cryptocurrency themselves

should be accounted for in the estimation of the hurdle rates. The APV approach makes a clear case of interest tax shields derived from debt obligations' issuance. Tax regimes on futures, options, and crypto bonds differ broadly, but they are important in determining such benefits.

2.2.2 The impact of Blockchain on cost of capital

Congruent to the WACC model, [93] we can express the cost of capital of a firm as a function of its cost of debt, cost of equity, corporate tax rate, and capital structure:

$$r_{wacc} = f(r_d, r_e, \frac{D}{E}, t_c)$$

We can also express cost of debt as a function of the capital structure, the probability of default, the loss rate and yield to maturity of the obligations issued by the firm on debt markets:

$$r_d = f(\frac{D}{E}, probability_{default}, LR, YTM_{debt\ obligations})$$

Congruent to the SML of the CAPM model, we can define cost of equity as function of risk-free rate, the market risk premium, and the beta regressor that links the company's historic stock performance to the market's one[94]:

$$r_e = f(r_f, Beta_i, MRP)$$

And : $Beta_i = f(company\ stock\ performance, market\ performance, risk - free\ rate)$

Moreover, we can state that the MRP depends on the broad market, used market proxy or a selected restricted market as well as the risk-free rate itself:

$$MRP = f(the\ returns\ of\ a\ set_{reference}(securities), r_f)$$

We can hypothesize that the inclusion of products on blockchain influences the cost of capital by affecting the following:

- The performance of the company due to the cost benefits of blockchain systems
- The performance of the company's operating and investing activities by the held crypto products' fluctuations in value and by the exposure to the blockchain's risks and cost benefits.

[93] See: Chapter 2 Wacc and APV approaches
[94] See above Chapter 2.1: review of cost of equity

- The risk profile of the company which could be translated into an updating of the rating.
- The dollar YTM of the issued debt securities by the addition of securities with cryptocurrency as underlying.
- The Loss Rate given default by the nature of tokenized debt contracts
- The firm's risk management practices (such as hedging) involved in managing the exposure to cryptocurrencies' exchange rate[95].
- The tax benefits derived from the (interest) payments[96] due to issuance of products on blockchain

The introduction of blockchain as a whole has an impact on performance and on cost of capital.

As we have showed above[97], cost of capital is directly influenced by the cost of equity and, therefore, by the forecasted performance of the company. The forecasted performance of the company is quantifiable by forecasted measures of FCFs and FCFEs depending on the approaches used[98].

The transactional features[99] of blockchain (discussed in chapter 1) include cheaper transactions, cost benefits in terms of velocity, ease of use, monitoring costs and others. In the issuance process, and the payments of installments, these benefits can come into play.

If the inclusion of blockchain in the funding methods provides reduction in expenses and other quantifiable benefits in terms of costs, it can directly impact the selling, general and administrative expenses of a firm (SG&A[100] expenses) which impact EBIT[101] and, subsequently, FCFs and FCFEs. This translates into a direct impact on the performance and thus cost of equity in the long run.

Figure 2.1 exacerbates the impact of blockchain products. The diagram shows that the inclusion of blockchain (through both the issuance and acquisition of fiat and crypto products) has effects on determinants of a firm's cost of capital.

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[95] See 2.2.5 Summary of impacts on cost of capital
[96] Tax rates on crypto losses and gains are different than the ones applied to traditional securities and interests paid. See Chapter 1: Corporate reporting of financial products on blockchain and Chapter 3: Tax rates regimes for crypto financial products.
[97] See Chapter 2: Review of cost of capital
[98] See Chapter 2: review of WACC and APV approaches
[99] See Chapter 1: introduction on cryptocurrencies
[100] Selling General and Administrative expenses are realized expenses in the reformulation of income statements which comprise expenses not related to Cost of Goods Sold. They comprise managerial, fixed, and other expenses of operating nature.
[101] Earning Before Interests and Taxes: Revenues minus COGS minus SGA and depreciations and amortizations.

Node "A" in the figure represents investments in cryptos and operations with them. It has a direct effect on the performance of the firm, its risk profile or rating, and its hedging strategies (against the crypto exchange rates).

Node "B" represents investments and operations with traditional securities on blockchain. The features and risk of the blockchain impact the assets that exist on it, so they might impact the performance of the company directly more than anything. Impairments in assets due to the blockchain platform, or the cutting of brokerage expenses, assets monitoring costs may have a negative or positive impact on the COGS[102] and SG&A expenses which affect EBIT and FCFs. Note that all nodes carry blockchain risks and features.

Node "C" refers to the issuance of crypto products. It impacts directly cost of debt through the adding of new diverse YTMs and through new diverse Loss Rate expectations. It also impacts it through the features represented by node "D".

Node "D" or the issuance of fiat securities on blockchain may directly impact performance through the introduction of blockchain systems in the funding, the LGD[103] rate through the smart contract designs of securities (if they are tokenized in a certain way[104]) and tax benefits.[105]

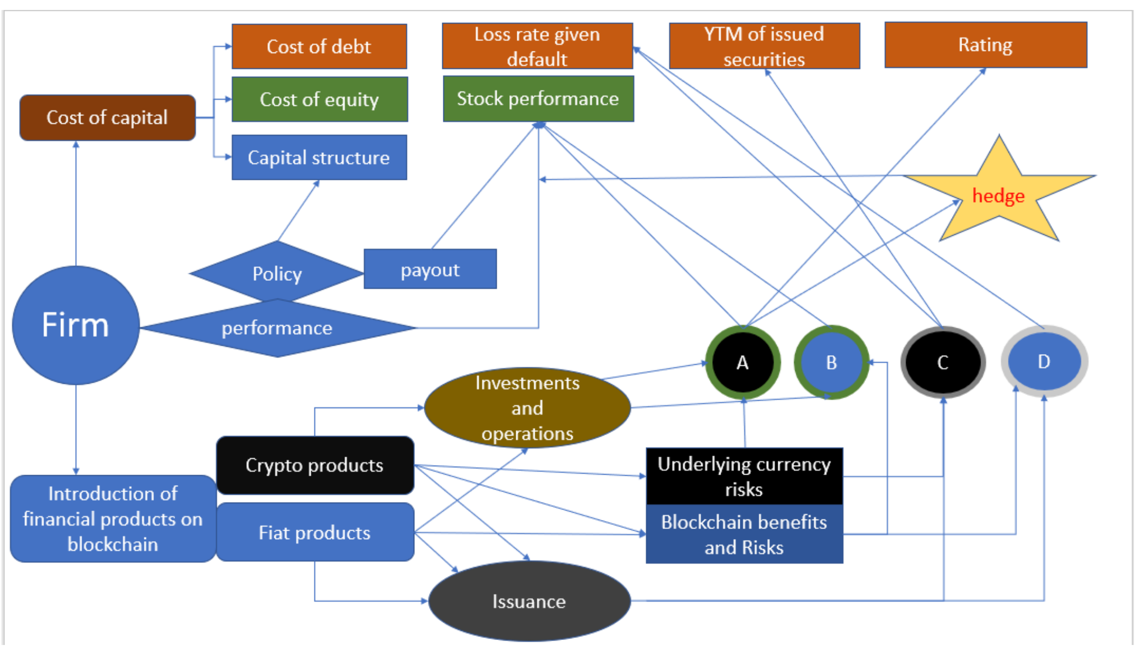

Figure 2.1: the impact of including blockchain products on the firm's cost of capital' estimators. Source: the author

[102] Cost Of Goods Sold by the company. The costs related to the final product up until final delivery
[103] Loss Given Default rate computed on the expectations of the amounts recoverable by creditors of the company in percentage to the amount they are owed
[104] See Chapter 1: Financial product: tokens
[105] Tax benefits include interest tax shields and other tax deductibles due to losses

2.2.3 The impact of fiat blockchain financial products on cost of capital

2.2.3.1 The impact of fiat denominated blockchain's debt securities' issuance on cost of capital

Fiat denominated debt securities on blockchain described in Chapter 1 include all the securities and derivatives denominated in fiat currencies, tokenized or not, whose rewards are quoted in fiat currencies and that are recognized as debt issuance.[106] These are represented by node "D" in figure 2.1.

We can state that, for obligations on blockchain denominated in fiat currencies, their price will depend on the yielded compensations, on the compensations of securities with similar risk (reference set)[107] and, therefore, on the risks that stem from the company, the market and the blockchain system:

$$Price_{security\ on\ blockchain} = f(Rewards_{security\ on\ blockchain}, YTM_{(set\ of\ reference\ securities)}, Risks_{security\ on\ blockchain} \dots)$$

$$YTM_{(set\ of\ reference\ securities)} = f(Returns_{within\ the\ set\ of\ reference\ securities}, \dots)$$

$$Set\ of\ reference\ securities = \{i_1, i_2, i_{3,} \dots \forall\ i\ who\ appeal\ to\ a\ class\ of\ investors\}$$

Let us assume that classes of investors are rational[108] and make decisions on risk-returns bases, on liquidity needs and on desires to expose themselves to certain risks for certain potential rewards. There exist investors with different levels of risk aversion.

Let us assume that a class of investors contains any individual or institution who has access to certain securities, the interest in investing in those[109], the confidence and the skills to finalize the investment decision, and the ability in assessing the risks associated.

For the sake of simplicity, let us assume that the set of reference securities includes all financial obligations whose value's oscillations throughout time are contained within defined boundaries that are also consistent with the security on blockchain.

[106] See Chapter 1: financial product: crypto bonds
[107] A reference set for opportunity costs estimation
[108] See: Mukherjee, S., & De, S. (2012). Are investors ever rational? *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2156047
[109] The interest can stem from any need or want hedging needs, speculative needs, portfolio diversification needs, storing of value needs, liquidity needs, etc….

We can use metrics such as the historical variances and standard deviations[110] of the distribution of prices or of returns of securities to determine whether they are contained within the set of reference.

Ultimately, in this case, volatilities and standard deviations are measures of risk[111]:

$$\sigma = f(historic\ prices, number\ of\ dates\ considered) = \sqrt{\sigma^2}$$

Therefore:

$$Set\ of\ reference\ securities = \{i_1, i_2, i_{3,} \ldots \forall\ i\ whose\ historical\ volatility\ is\ within\ a\ range: \sigma^2_{min} < \sigma^2_i < \sigma^2_{max}\}$$

This is not true. It is an assumption for the sakes of simplicity: the set of reference depends on the risk of the security and thus, on its volatility.

If we make these assumptions, we can demonstrate that:

Since:

$$Price_{security\ on\ blockchain} = f(Rewards_{security\ on\ blockchain}, YTM_{(set\ of\ reference\ securities)}, Risks_{security\ on\ blockchain} \ldots)$$

Then

$$Required\ rate_{security\ on\ blockchain} = f(\ YTM_{(set\ of\ reference\ securities)}, Risks_{security\ on\ blockchain}\ \ldots)$$

And

$$YTM_{security\ on\ blockchain} = f(risks_{security\ on\ blockchain}, returns_{(set\ of\ reference\ securities\ chosen\ on\ risk\ bases)}, Rewards_{security\ on\ blockchain}, \ldots)$$

The traditional computation of cost of debt, explained above, involves:

$$r_d = f(YTMs\ _{firms'\ issued\ securities}) - Loss\ rate\ x\ probability\ of\ default$$

[110] See: Spiegel, M. R., & Stephens, L. J. (2018). Chapter 1: sample analysis. In *Statistics* (pp. 31–44). essay, McGraw-Hill.
[111] A highly volatile security has a high degree of price changes in short times

We have shown how the $YTMs_{firms' issued\ securities}$ component is heavily reliant on the set of reference securities' yields and on the risks of the securities issued on blockchain, which could be estimated by volatility or higher moments metrics[112].

To understand the enhanced risks derived from investments in blockchain, we need to discuss all the risks of the blockchain system itself.[113]

Moreover, the Loss Rate component of the cost of debt equation is affected by blockchain usage:

Whereas it is traditionally estimated to be around 60% given historical bankruptcy procedures[114], for securities issued on blockchain that might not be the case.

Tokenized securities which involve self-executing smart contracts do not hold legally binding written contracts in their algorithms. They are simply built to execute payments at certain dates by transferring value from a wallet to another. If the wallet is empty, the algorithm fails: in case of default, legal claims will not be present to make the creditor recover a percentage of the value.

Tokenized debt securities on blockchain, unless specified otherwise, have 100% loss rate in case of default.

It can be argued that issuing debt securities on blockchain could impact the probability of default negatively by considering the increased risks of the blockchain.

Regardless, we conclude that an examination of blockchain risks is needed to understand their impact on the reference set of securities from which the yield to maturity component of the cost of debt is derived.

It is important to note that the issuance of tokenized securities on blockchain can bring about regulatory caveats which impact tax regimes. This mainly depends on whether the securities issued are regulated or not and on the types of securities (whether they pay interests or a substantial amount at maturity). If regulated, the tax applied to fiat securities on blockchain is the same as usual, the corporate tax rate.[115]

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[112] Higher moments include measures of Skewness and Kurtosis. See: Sttckl, S., & Kaiser, L. (2016). Higher moments matter! cross-sectional (higher) moments and the predictability of stock returns. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2747627

[113] See 2.2: Risk profile of investments on blockchain

[114]See: Resti, A. (2010). Exposure to default and loss given default. *Encyclopaedia of Quantitative Finance*. https://doi.org/10.1002/9780470061602.eqf09027

[115] The tax rate applied to after-WACC computation: see Chapter 2: review of WACC and APV approaches

2.2.3.2 The impact of fiat denominated blockchain's securities holdings on performance

Other than affecting the firm with the risks and benefits of the blockchain, fiat assets on the blockchain system are easier to manage, to monitor, to dispose of, generally more liquid, and the carrying costs al lower. These allow for faster responses in risk management practices, reallocation of capital and other benefits stemming from the blockchain system. These impact performance.

2.2.3.3 The impact of tokenized equity issuance on performance

Tokenized equity contracts refer to any financial contract which is tokenized, issued on blockchain, and is given representation of a real financial contract which involves ownership and/or voting rights over the issuer.

These tokens do not have self-executing smart contracts because of the payout policies not being constant.

They behave exactly like shares, preferred stock and other rights issued on traditional equity markets; however, they might present different risks given the blockchain platform on which they are issued.

These tokens are usually distributed on proprietary blockchain, however, general purpose blockchains such as Ethereum can host companies' financial equity contracts.

Overall, the impact they have on cost of capital translates into the impact they have on equity capital, the cheaper blockchain platform, the cost savings due to the absence of investment banks in the issuance process, and general reduced administrative expenses can directly improve a firm's performance, and while not necessarily impacting the cost of equity capital, they could impact the company's stock performance.

Moreover, as seen in the trends of ICOs in chapter 1, the announcements concerning the adoption of proprietary blockchain for equity issuance has positive signaling among investors.

It makes it easier, cheaper, and faster to acquire stock in a company. The risks of blockchain, however, directly translate on the financial product.

2.2.3.4 The impact of utility tokens on cost of capital

As explained in chapter 1[116], Utility tokens refer to items on blockchain which represent an issuer's promise or some undiscovered utility. Most commonly, they are not designed to have self-executing algorithms for the rewarding of the holder nor legally binding representations of any rights over the issuer.

Utility tokes could represent:

- A general IOU which is up to the issuer to repay and in what way
- A promise to deliver goods or services
- A promise to have free access to other equity securities in the future
- A promise to have discounts on a set of the issuer's financial products

Most commonly, they are used as crowd-funding tools in platforms (like Kickstarter). In these instances, they most commonly promise access to a product or service if the issuer manages to develop the project.

In this case we can explicate the value of a utility token as the one of a call option with strike price equal to 0:

$$Utility\ token_{project\ i} = \max(\ product'value_{project\ i}, 0)$$

For an established business that most certainly will succeed in realizing the product, utility tokens can be used as some sort of preorder or early access. In this case, they would be identified as "payables" under the working capital requirements, thus not affecting cost of capital.

For a business that is uncertain about the project and is funding it through utility tokens' issuance, the cost of capital for the token could be seen as integral to the debt cost of capital.

In this case:

$$r_{token} = f\left(\frac{product's\ cost}{cost\ of\ token}\right) - \ probability\ of\ project's\ default$$

Where $f\left(\frac{product's\ cost}{cost\ of\ token}\right)$ is a function that discounts the yield of the token depending on the delivery date, accounts for resale value of the product, and for the modifications in the issuer's promises.

[116] See Chapter 1: financial product: tokens

2.1.1.3 The impact of tokenized equity issuance on cost of capital

Tokenized equity contracts refer to any financial contract which is tokenized, issued on blockchain, and is given representation of a real financial contract which involves ownership and/or voting rights over the issuer.

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Moreover, as seen in the trends of ICOs in chapter 1, the announcements concerning the adoption of proprietary blockchain for equity issuance has positive signaling among investors.

It makes it easier, cheaper, and faster to acquire stock in a company. The risks of blockchain, however, directly translate on the financial product.

2.2.4 The impact of crypto products on cost of capital

2.2.4.1 The impact of crypto issuance on cost of capital

In chapter 1, we have defined crypto products as securities on blockchain with the following features:

- They are tokenized with self-executing smart contracts
- They are quoted in digital cash tokens or cryptocurrencies

- They are issued and are traded on public general platforms blockchains
- The instalments and rewards are denominated in cryptocurrencies
- Their prices and yields are directly influenced by exchange rates on the underlying cryptocurrency

Crypto products include crypto bonds, crypto options, crypto futures, crypto forwards, and other tailored OTC crypto financial contracts which pay amount cryptocurrencies that are independent of their exchange rates.

We can define the dollar yield of a crypto product as being directly dependent on the underlying cryptocurrency's exchange rate.

For crypto futures and forwards and crypto bonds:

$$dollar\ return_{crypto\ futures\ and\ forwards\ and\ crypto\ bonds} =$$
$$f(initial\ endownment_{crypto}\ \ x\ Exchange\ rate\left(\frac{USD}{crypto}\right)_{at\ inception},$$
$$Future\ installments_t\ x\ Exchange\ rate\ (\frac{USD}{crypto})_t, \forall\ t)$$

Crypto futures and forwards are priced through a required rate that summarizes future expectations of exchange rates. Future expectations of exchange rates can be translated into future expected returns of the underlying cryptocurrency.

For crypto options:

$$dollar\ return_{crypto\ call\ option} = f(option\ cost_{crypto}, E_{t0}, E_{tk}, strike\ price\ in\ USD_{tk})$$

Crypto call options[117] purchased through the underlying cryptocurrency grant the right to purchase more of the cryptocurrency at a certain time k in the future for a fixed amount of fiat currency decided at inception.

We can conclude that all crypto financial products' returns are dependent by the fluctuations in the underlying cryptocurrency's exchange rate with fiat currencies.

We can rearrange the above equations to transform exchange rates into the returns of the cryptocurrencies themselves:

$$dollar\ return_{crypto\ products} = f\ (price_{crypto}, rewards_{crypto}, \Delta E\ \left(\frac{usd}{crypto}\right)_{throughout\ time})$$

[117] See chapter 1: financial product: Crypto options

$$dollar\ return_{crypto\ products}$$
$$= f\ (price_{crypto}, rewards_{crypto},\ returns\ on\ the\ cryptocurrency_{throughout\ time})$$

We can conclude that cost of debt of a firm that issues crypto products is directly dependent on the returns of the crypto products which is dependent on the underlying cryptocurrency's returns.

We can assume that:

$$r_d = f(\frac{D}{E}, probability_{default}, LR, YTM_{debt\ obligations}, YTM_{blockchain\ obligations}, LR_{blockchain}, YTM_{crypto\ products}, \frac{C}{D})$$

Where the fiat $YTM_{crypto\ products}$ is highly dependent on the returns on the underlying cryptocurrency, LR_{crypto} is 100% and C/D refers to the portion of crypto debt with respect to total debt.

Let us assume that $YTM_{crypto\ products} = f(YTM_{blockchain\ obligations}, E\left(r_{underlying\ cryptocurrency}\right))$

The yield to maturity of the crypto products issued by a firm is a function of the yields to maturity of the fiat obligations issued by the firm on blockchain and a return component based on the future expected returns of the underlying cryptocurrency.

Let us define $E\left(r_{underlying\ cryptocurrency}\right)$ as the cost of cryptocurrency.

2.2.4.2 The impact of crypto holdings on cost of capital

Crypto products holdings can be categorized under multiple categories of assets for a firm.[118]

They can be used by firms for hedging purposes or for conducting other risk management strategies linked to the firms' operating activities. Holding of cryptocurrencies can be used to hedge against the crypto debt discussed above and to execute payments to suppliers and other businesses through blockchain. Also, payments from customers could be collected in cryptocurrencies without them being instantly converted into fiat currency. The firms can hold crypto wallets and other crypto assets.

A firm holding a portfolio of crypto assets and/or a crypto wallet entices multiple revaluations of assets which could lead to losses (due to impairments)[119] or gains following revaluations.

[118] See Chapter 1: corporate reporting of financial products on blockchain
[119] See chapter 1: history of reporting practices

As the price of crypto products is heavily reliant on the price of the underlying cryptocurrency (as shown above), we can state that the revaluations of holdings of crypto assets are closely connected to the returns of cryptocurrencies.

The cryptocurrency returns, therefore, heavily impact the evaluation of the company's crypto assets and, if they hold derivatives of cryptocurrencies, the interests collected.

The performance of the company is, therefore, affected also by the inclusion of these crypto financial products in its assets. They can affect changes in net working capital due to the firm's needs for fiat or crypto cash, thus affecting FCFs; they can affect other cash expenses and Capex costs[120].

We can hypothesize that, by affecting a company's performance, holdings of crypto assets indirectly affect cost of equity capital.

They, however, grant the possibility to directly hedge against the fiat cost of financing through crypto obligations. If a firm holds a wallet of cryptocurrencies specifically to cover the payments to debt holders of crypto products, then the risks stemming from the fluctuations in exchange rates would be hedged against.

The firm would not have to worry entirely about the crypto component in the "crypto required rate[121]" on which the cost of debt depends.

We can infer that cryptocurrencies' returns, the risks of holdings of cryptocurrencies as well as the hedging capabilities of the firm must be included in the cost of capital's estimation:

- Cost of capital is directly affected by the cryptocurrencies' risks and returns through the firm's crypto obligations' underlying cryptocurrencies (directly affect cost of debt).
- Cost of capital is indirectly affected by the firms' operating activities being riskier due to the inclusion of crypto products. (Indirectly affect cost of equity).
- Cost of capital is directly affected by the firms' hedging practices against cryptocurrencies' exchange rates. (Directly affects cost of debt).

In particular cost of debt is reduced if the exposure to exchange rates' fluctuations is reduced. This is because less volatile interest payments directly affect both FCFs' performance and ratings.

[120] Capital Expenditures
[121] A.K.A the cost of cryptocurrency

2.2.4.5 Summary of the impacts on cost of capital and a blockchain's risk premium

The use of financial products on blockchain has many effects on the cost of capital of an enterprise. First of all, the inherent risks, benefits, and limitations of blockchain are transposed onto the firm's activities with the introduction of these products (fig.2.2):

- Transactional features[122]
- Design, operational and regulatory risks[123]
- Inconsistency of tax regimes[124]
- Smart contracts features[125]

These factors are carried within each financial product on blockchain regardless of its use. Secondly, cost of capital is impacted by both fiat financial products on blockchain and by crypto products on blockchain regardless of their use.

Crypto products, other than carrying the same risks, benefits, and limitations of the fiat products on blockchain, carry another layer of risk in their value being dependent on crypto exchange rates fluctuations. Investments and operations with crypto products can allow for hedging against the exchange rates' risks. In the issuance of financial products on blockchain, the features of smart contracts affect the cost of debts' loss rate.

Finally, we can theorize that for the modelling of a quantitative impact on the cost of capital the following estimates should be needed:

- An estimate of the performance benefits of blockchain (impossible)
- A risk premium derived from the inclusion of blockchain
- An estimate of the crypto returns on which crypto products' YTMs depend (the cost of cryptocurrency)
- A measure of the efficacy of hedging practices that reduce exposure to the cryptocurrencies' returns

[122] See Chapter 1: introduction to Blockchain
[123] See Chapter 2: risk profile of blockchain
[124] See Chapter 1: corporate reporting of financial products on blockchain
[125] See Chapter 1: financial product: tokens

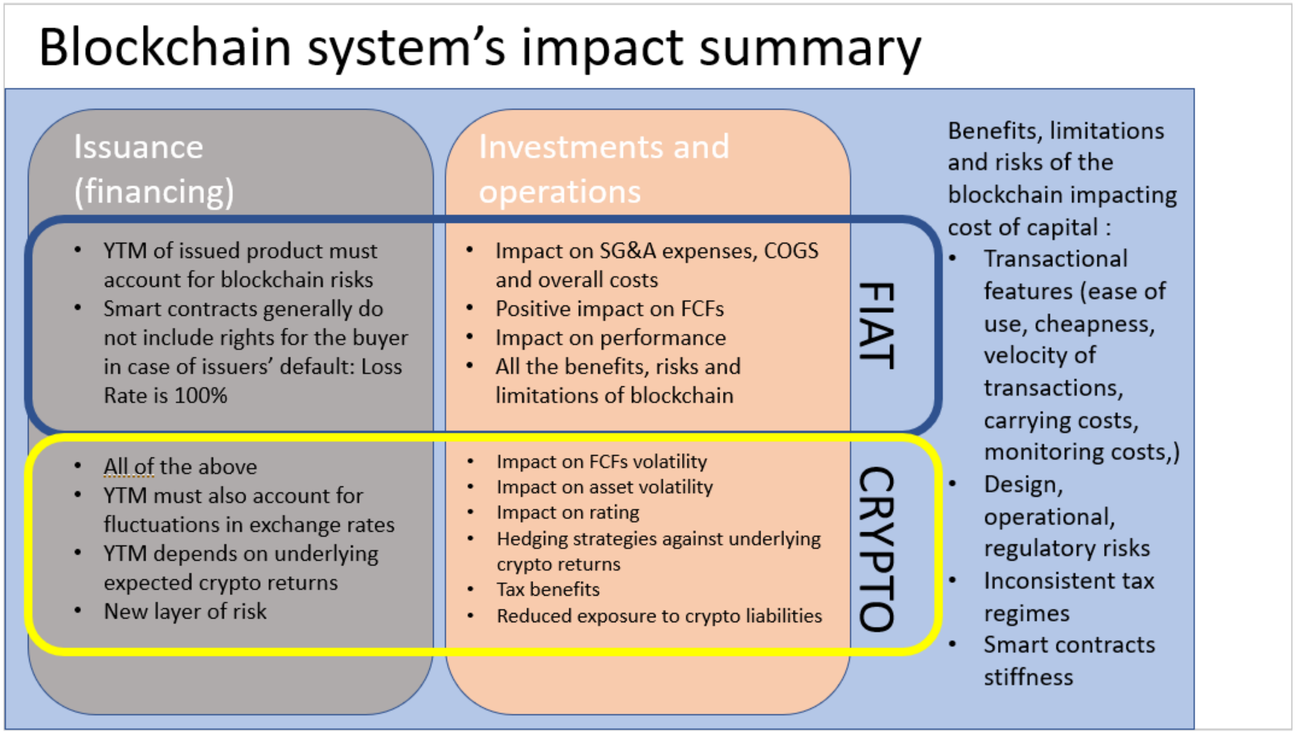

Figure 2.2: summary of the blockchain's impact on cost of capital. Note: some of the impacts specified under 1 category belong to multiple categories. Source: the author

2.2.5 The cost of cryptocurrency and the blockchain risk premium

We define the cost of cryptocurrency or the "crypto required rate"[126] as the hurdle rate which accounts for fluctuations in crypto exchange rates.

It is a required rate that is integral to the crypto products' yield to maturity: If we suppose that financial products on blockchain have a yield to maturity depending on the company's risk profile and on the blockchain system risk profile, crypto products add a layer of risk due to their value being dependent on cryptocurrency exchange rates' fluctuations or, as seen above, dependent on the returns of the underlying crypto.

$$E\left(r_{underlying\ cryptocurrency}\right) = f\left(YTM_{blockchain\ obligations}, YTM_{crypto\ products}\right)$$

[126] See 2.2.4.1: The impact of Crypto products issuance on cost of capital

The cost of cryptocurrency is the required rate that separates the yield to maturity of fiat obligations on blockchain from the yield to maturity of crypto obligations on blockchain.

The exposure to this cost can be hedged against through the selection of crypto assets by the company's investment activities.

It can be estimated by looking at the risks and returns of the underlying cryptocurrency.[127]

We define the "Blockchain risk premium" as the premium required by investors for purchasing products that are on blockchain. It is a return required simply on the basis of the security being on the blockchain.

We have shown how the YTM of a security on blockchain can be expressed as a function of other yields to maturity of securities chosen on the basis of similarities in risks and of the risks stemming from the security itself:

$$Required\ rate_{security\ on\ blockchain} = f(\ YTM_{(set\ of\ reference\ securities)}, Risks_{security\ on\ blockchain}\ \dots)$$

Let us assume that the set of YTMs is comprised of securities of the same firm that are not on blockchain. The required rate of the security on blockchain should be:

$$Required\ rate_{security\ on\ blockchain} = f(\ YTM_{s(firm'securities\ not\ on\ blockchain)}, perceived\ Risks_{of\ blockchain})$$

If we hypothesize that the premium required because of blockchain is additive[128], then we would have:

$$Required\ rate_{security\ on\ blockchain} = f\left(\ YTM_{s(firm'securities\ not\ on\ blockchain)}\right) + \ BRP$$

Where the function could be an arithmetic average. The BRP would be the Blockchain Risk Premium.

2.3 The risk profile of blockchain

The risk profile of blockchain is integral for the discussion of a blockchain risk premium BRP.

[127] The modelling and estimations are discussed in Chapter 3

[128] Rather than multiplicative or other. It assumes that, regardless of the degree of the return on the security, the fact that the security is on blockchain has a flat impact. This is just speculation.

The risk profile of investments in crypto products mentioned in chapter 1 can be categorized by the design risk of the underlying cryptocurrencies and systems, the risks stemming from the underlying blockchain system's transactional features as well as the political and regulatory environment risks:

- Design risks
- Operational risks
- Political risks

2.3.1 Regulatory and political risks

Setting up legal frameworks around the use and spread of cryptocurrencies has been proven to be more than challenging for nations and institutional authorities for many reasons. First of all, cryptos are spread globally on the net and the mining process disregards any possibility of governmental control. A central bank cannot be present for cryptos, as it is impossible for a single authority to gain powers such as manipulation of supply or interest rates in said market; moreover, a legal framework that strives in tampering arbitrage opportunities and market manipulations is almost impossible to create if the anonymity on the blockchain has to be preserved. Another reason is stemmed by the governance models that surround the various blockchain, they can be of 2 main models: "off-chain" or "on-chain"[129]. The network revolves and especially evolves around the users and while in the "on-chain" model protocols are modified by rulings and voting systems intrinsic in the protocol itself, in the "off-chain" model the system can add new stakeholders and new voters and influencers within the system itself. Thus, while the systems are not fully decentralized, users, that are ultimately humans, are in charge of the rules, or better, their collective is. Any attempt by an outsider in interfering with the rules can be overridden. The most important reason why regulations are hard to craft and enforce in this market is because pre-existing rulings cannot be applied, cryptos have interchangeable functions and cannot be treated as any of the currently existing items; as discussed in Chapter 1[130], cryptos can be a commodity, a security, a currency, or any of them at the same time. International regulators worldwide, because of these reasons, have adopted a "wait and see" approach (such as the European Commission in 2018)[131] while nations and national authorities have tried to tamper

[129] Off-chain networks have predisposed protocols for the validations of events in the system such as the adding of a new block or transaction. On-chain models add "nodes" which are involved in the rulings and in validating events. Nodes are pieces of hardware and computing power on which the blockchain expands. Most commonly, they are servers or computers.
[130] Chapter 1: Corporate reporting of financial products on blockchain
[131] See *Press corner*. European Commission - European Commission. (n.d.). https://ec.europa.eu/commission/presscorner/detail/en/IP_18_1403.

with the market causing severe instabilities, crashes, and unsustainable volatilities. These ones are the authorities that ultimately represent the political and regulatory risks associated with the cryptos' market, and these risks represent the most detrimental category. Although China in September 2019 tried to launch its own digital currency through the people bank of China[132] to maintain foreign exchange sovereignty, claiming it to be as safe as the central bank issued bonds, the very same regulators have later banned ICOs and similar crowd-funding methods on blockchain from the nation as well as declaring illegal transactions of cryptos in 2021[133]. China, in spite of this, remains the state that hosts most crypto mining facilities, which are estimated to constitute more than 40% of the global mining power. Examples such of this show both the resilience of this market to external political shocks and the enormous price sensitivity of cryptos to such announcements. Moreover, as the international authorities stop refraining from judgement, abandoning their "wait and see" approaches, it is impossible to state that long term changes will not affect the overall crypto market.

Nowadays, national regulations restrict, to some extent, indirectly the operational activities that can be conducted on blockchain or through cryptos. This is because some national legal frameworks that were already in place before 2014 can be enforced in this market. In the United States, for example, the exchange of cryptos can is considered as a money transmitter business. Companies willing to operate and exchange on blockchain must comply to AML (Anti Money Laundering) and KYC (know your customer) schemes. The ECB in 2018 has also enforced such practices in the meantime[134]. However, as cryptos can fall under many categories, financial regulators can opt to exclude certain transactions from complying to these rules, and it has been found that many crypto exchanges do not comply to KYC regulations thus exhibiting different prices from the ones that do, probably because of their lower management costs.

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[132] See: Bloomberg. (n.d.). *China says its own cryptocurrency is close to releasing*. Bloomberg.com. https://www.bloomberg.com/news/articles/2019-08-12/china-s-pboc-says-its-own-cryptocurrency-is-close-to-release.

[133] See Orji, C. (2021, September 1). *The countries where Bitcoin and crypto are banned or restricted*. euronews. https://www.euronews.com/next/2021/08/30/bitcoin-ban-these-are-the-countries-where-crypto-is-restricted-or-illegal2.

[134] See: Pierre, A., & Schweiger, M. (2021, March 30). *In brief: Banking regulatory framework in Luxembourg*. Lexology. https://www.lexology.com/library/detail.aspx?g=860892b5-0d0e-4028-942c-7fa55039cadb.

2.3.1.1 Crimes and environment risks

Due to the nature of cryptocurrencies which account for anonymity and offer a way to own money without the possibility of showing the origins of them, criminal activity has been using cryptos since their launch for money laundering purposes. Investors are aware of this feature and are also aware than national jurisdictions often try to dismantle criminal organizations by gaining info regarding their cryptocurrency activities. Europol, for example, has discovered numerous organization (such as the famous 2 in Spain in 2018) by investigating on wallets[135]. As authorities get more and more involved with these digital currencies, many risks can arise. One of them, could be the fact that criminal organization that transact on blockchain could conduct pump or/and dump tactics to mislead investigations. Since there are no estimations of the market share that is held by investors with something to hide, news regarding new powers from the authorities with respect to cryptos, could alter prices and returns.

Whereas this hypothesis is circling the media but is not based on concrete proof, the fact that blockchain tech and, in particular, Proof-of-work protocols consume a lot of energy is certainty. A huge percentage of the total proof of work computation and the total mining computation is currently estimated to reside in China, where costs of electricity are considerably lower than western countries and regulations about power usage ceilings are less strict. Tesla has recently backed down from its previous statement regarding a more intense involvement with cryptos due to the desire to retain its image as a "green" enterprise. The use of crypto is apparently responsible to lots of fossil energy consumption and investors should be aware that enterprises that value the environment might step back causing prices to drop. This represents a very real risk. Note that Tesla's CEO Elon Musk could arguably have conducted a blatant market manipulation through its twitter profile in recent May 2021; note that his remarks to the "green" aspect could have been both a marketing tactic and signals to crypto investors. Regardless, since authorities have not yet interfered on the blockchain, nothing illegal would have been done, besides, many players in this market already possess the power to emit strong signals.

[135] Ljubas, Z. (n.d.). *Spanish police bust an international drug trafficking ring*. OCCRP. https://www.occrp.org/en/daily/15005-spanish-police-bust-an-international-drug-trafficking-ring.

2.3.2 Design's risk

The programming and the coding behind both the blockchain technology and the platforms owned by exchange companies are not entirely flawless. Although bugs and errors are to an insignificant degree present on the blockchain, the system itself could be exploitable. A 51% attack refers to the possibility that an individual or a large group of people who hold the majority of the computing power of a cryptocurrency , could theoretically prevent certain transactions and reverse the ones that have not been approved by the majority in spite of their legitimacy. The possibility of a 51% attack initiated by colluding parts represents a major risk and impacts the reliability of the blockchain systems, noted that manipulation of the markets themselves is not prohibited under international legal frameworks and that the possibility of a 51% attack is not a bug itself, rather a feature of the design, miners and traders are aware of the major complexities that manipulators would face in attempting this, therefore, although possible, the 51% attack is almost impossible to pull off in already successful blockchains such as bitcoin and Ethereum which see their market capitalization spread out all over the world. In other words, the coordinating skills of players and the amount of capital required to successfully execute such an attack, are so high, that players in the market who understand it, completely disregard such possibility. For ripe cryptocurrencies, a problem of "selfish mining" can arise, where basically miners tend to mine their own transactions to generate more coins; but this is not a problem nowadays. In spite of this, the platforms offering exchange services (such as Coinbase etc.…) have indeed displayed weaknesses to attacks, weaknesses due to bugs and coding errors as well as periods of the services shutting down. Even small errors limited to just few seconds can cause losses of millions for investors, especially given the times sensitiveness of transactions and the high volatility of cryptos. This represents a challenge for exchange and trading companies whose platforms strive to compete for better reliability, lower costs of transactions and minimization of operational risks.

2.3.3 Operational risks

For a firm interested in initiating operations and finance via cryptocurrency and crypto denominated assets, operational risks represent the qualitative risks to which exposure is the highest. If we define the exposure of a firm to a risk by multiplying the probability of the event happening by the vulnerability of the firm to the event, operational risks are the most important to assess; although their impact on the vulnerability is lower than political and design risks, their probability of happening is much higher. Operational risks define all kinds of risk associated with the transfers, exchanges and storing of cryptos. They can be summarized under 2 major categories: wallet risks and exchanges' risks.

2.3.3.1 Exchanges' risks

Exchange systems are privately owned entities who offer exchange services on online platforms and apps with possibly bidirectional flows of capital: fiat money or real goods to cryptos and vice versa. These systems can be categorized under two major types: the systems that allow for exchanges of fiat currencies to crypto (or crypto to crypto) and the systems that are basically derivatives exchanges and offer futures on crypto allowing their user to take long and short-term positions to either hedge or speculate on the fluctuations. In this last type, financial contracts are exchanged rather than cryptos and the cryptos themselves are the underlying. In December 2017 on the Chicago Board Option Exchange (CBOE) the first future contracts on Bitcoin/Dollar were traded[136]. Other examples of platforms that offer such services include the previously mention LedgerX and Derembit. Operational risk due to these platforms is created in 2 ways: the platforms need maintenance, and the platforms compete with one another, and they offer different exchange rates, different prices and base their calculations on different algorithms. While the risk stemming from the maintenance part can be summarized by mentioning the time lag created in transactions further exposing value to volatilities, the risk associated with different quoted prices can be discussed in terms of arbitrage attacks. Quoted value on a platform will change drastically if investors start exploiting arbitrage opportunities stemming from the differences in quoted prices. Although theoretically, in the long run, this should not be a problem due to the fact that, eventually, an equilibrium would be reached, this is not the case. Delays in transactions, confirmation of ownership, transaction costs etc.… often make it unprofitable to exploit seemingly risk-free arbitrage opportunities, thus it is, nowadays, unpredictable whether and when investors find it suitable to initiate such seemingly obvious strategies. Other risks associated include the complete powerlessness of authorities and regulators over many of these exchanges, as trust in these platforms (trust in their evaluation of crypto value, trust in them holding their end of the bargain, trust in their algorithms etc..) is directly connected to the trust in the cryptos themselves, loss of faith in a single exchange platform could prove to be one of the riskiest factors. It could lead, eventually to a potential risk of exchange runs, as in bank runs. Exchange service providers do not have to comply to authorities' reserve requirements issued by certain states, and often hold very little capital while investing at high leverages, their "deposits". This, as history told us, could prove catastrophic for both directly

[136] See Chapter 1: Financial product: crypto futures and forwards

connected investors, and unrelated investors who simply see the value of their crypto assets crash. Furthermore, the faith in Exchange service providers relies also on the perception that they have high quality cybersecurity systems in place and can defend elegantly from hacking attempts. This, however, is not always the case, as hacker attacks happen on regular bases, and, more often than not, cause serious concerns. On 11th of June 2019 Bitpoint was attacked[137] in this fashion and experienced losses amounting to 32m USD worth of cryptos.

2.3.3.2 Wallet's risk

For private companies who wish to own securities on blockchain, public and private keys are needed to interact with the systems, check balances, send assets, and conduct other operations. Crypto wallets differ from traditional wallets as they do not store the actual coins but the encrypted keys that access the systems. Hardware wallets are tangible items that store code and can go online, when connected to an exchange platform, to access one's digital value; they are the safest choice for individuals who wish to not get hacked as these reduce the time frame of vulnerability whereas online wallets are much more susceptible to attacks. Paper wallets are a mixture that print, when needed, private and public keys through QR codes. Other than the risks of the wallets being hacked, the wallets are periodically updated and undergo maintenance to ensure higher security. During these times, they are completely inaccessible and thus the accounts are as well. If the time frame of updates and maintenance of the wallets coincide with periods in which conducting operations on the blockchain are critical, serious disruptions could be caused to the realized returns of operations.

[137] See: Phil Muncaster UK / EMEA News Reporter. (2019, July 15). *Japanese exchange Bitpoint hit By $32m Cyber-Attack*. Infosecurity Magazine. https://www.infosecurity-magazine.com/news/japanese-exchange-bitpoint/.

2.4 The risk profile of cryptocurrencies

The risk profile of cryptocurrencies is integral for the discussion of a "cost of cryptocurrency".[138]

Digital cash tokens, general purpose tokens, cryptocurrencies, and other crypto products whose price and returns derive from cryptocurrencies' fluctuations in value, specifically, suffer from:

- Crypto Market risks
- Crypto Credit risks
- Liquidity risks of tokens

2.4.1 Market risk and credit risks applied to financial product: cryptocurrencies

Important differences between the trading of cryptocurrencies and the traditional trading of stock and forex impact market and credit risks to a significant extent. The financial oversight for crypto-based companies and for exchanges of crypto translates into risks of manipulation of the market, pump and dump practices[139] and market frauds, these are also significant reasons for drastic changes in prices. Compared to the stock market, traditional brokers are absent in the cryptos market, they are replaced by algorithm-based software and platforms which heavily influence prices. Also, crypto exchanges (which could be seen as brokers) do not provide neither asset nor cash insurance, exposing the investors to heavy losses in case of cyber-attacks and bugs in the systems.

Market risk is a consequence of market variables: interest rates, asset prices, crypto prices, and forex rates.

The Basel Committee on Banking Supervision underlined how the securitization process transforms credit risk into market risk[140]. Although the definition of market risk can be applied to the cryptos' market, the

[138] See above Chapter 2: the cost of cryptocurrency and the blockchain risk premium

[139] Pump and dump practises refer to strategies of market manipulation where a player has enough of a product to influence supply and prices: the player sells a lot of the product until the prices go down to match the increase in supply. The player then buys back a lot of the product until the prices move up again.

[140] Lerario, D. M. (2016). The Basel committee and the international organization of Securities commissions' 'Criteria for IDENTIFYING simple, transparent and Comparable Securitisations': Not so simple. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2727772

one of credit risk cannot. The system is simply built to make sure that transactions are executed at the given dates.

A paper by Dean Fantazzini et al. defines credit risk for cryptocurrencies as the *"gains and losses on the value of a position of a cryptocurrency that is abandoned and considered dead according to professional and/or academic criteria, but which can be potentially revived and revamped".* Both market and credit risk are quantifiable separately. [141]

A market event occurs when financial losses and/or technical problems can be resolved with existing financial and technical resources. If the problem persists, and the currency "dies" we have a credit event.

These concepts are explained in table 2.1.

	Market risk	Credit risk
Definition	Gains and losses on the value of a position or portfolio of ***alive*** cryptocurrencies, that can take place due to the movements in market prices in centralized and decentralized exchanges	Gains and losses on the value of a position of a cryptocurrency that is ***abandoned and considered dead*** according to professional and/or academic criteria
Differences from traditional finance	Lack of financial oversight means that coins prices can be susceptible to manipulations, pump and dump schemes and other market frauds	Dead coins can be revamped several times;
	Lack of regulatory oversight also explain why prices can differ widely across exchanges	Dead coins are very different from "zombie firms"
	Cryptocurrency exchanges do not provide neither cash nor asset insurance (but there are exceptions)	Traditional credit risk models cannot be used due to the (current) lack of derivatives data, bond data and/or accounting data

Table 2.1 Market and credit risk for cryptocurrencies. Remodelled by the author from the original source. Original source: Fantazzini, Dean, and Stephan Zimin. "A Multivariate Approach for the Simultaneous Modelling of Market Risk and Credit Risk for Cryptocurrencies." Journal of Industrial and Business Economics, vol. 47, no. 1, 2019, pp. 19–69., doi:10.1007/s40812-019-00136-8.

[141] Fantazzini, Dean, and Stephan Zimin. "A Multivariate Approach for the Simultaneous Modelling of Market Risk and Credit Risk for Cryptocurrencies." *Journal of Industrial and Business Economics*, vol. 47, no. 1, 2019, pp. 24., doi:10.1007/s40812-019-00136-8.

2.4.2 Liquidity risk and diversification benefits applied to financial product: cryptocurrencies

Cost of capital literature in finance assume that investments of equal risks and maturities should be discounted at the same hurdle rates: required rates for investors to be indifferent between different projects from a risk/return perspective.

As investors can diversify their portfolios usually lowering risks associated by including negatively correlated assets, they also have access to cryptocurrency and crypto securities and thus can shape their portfolios in many ways according to their risk tendencies.

They can then measure their portfolios' risk using tools and assessment models proven efficient by financial literature whereas they do not have literature approved risk measures for companies that are involved with cryptos. However, it is possible to look at the impact on portfolios' risk/return measures when these investors add cryptos in their portfolio to see whether they garner any benefits from it. Theoretically speaking, an investor who has a portfolio constituted by stock and bonds with some weights and cryptos with some other weights should have similar risk tendencies and return requirements as a company whose capital structure and risk performance mirror those same weights, assuming no synergies within such company exist.

A July 2019 study by Emmanouil Platanakis[142] et al. examined the benefits of including Bitcoin in a portfolio for a range of 8 popular asset allocation strategies (stock-bond portfolios). The results were found to be robust and included considerations of transaction costs, rolling estimation windows, alternative indices, short selling[143], and the inclusion of commodity portfolios[144]. The two optimization techniques used were based on higher moments and variance-based constraints[145]. The authors concluded that Bitcoin offered substantial benefits and especially higher risk adjusted returns. Furthermore, the study divided portfolios based on the different level of risk aversion and found clear benefits at all stages in terms of Sortino, Omega and Sharp ratios changes[146].

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[142] Platanakis, Emmanouil, and Andrew Urquhart. "Should Investors Include Bitcoin in Their Portfolios? A Portfolio Theory Approach." 19 July 2019.

[143] The financial practice of selling something that was borrowed.
[144] Portfolios containing real assets and commodities such as gold, oil etc….
[145] See 2.3. modelling of crypto risk and expected returns
[146] These are financial metrics which link volatility and returns. See : modelling of crypto risks and returns.

This shows that investors hold potentially viable strategies to incorporate cryptos in their portfolios and increase their value on a risk adjusted basis whenever short selling is allowed and even including transaction costs.

Furthermore, the inclusion of cryptos in portfolios has proven to garner extremely significant benefits in terms of liquidity.

Liquidity risk refers to the situation in which an entity fails to meet its short-term obligations due to barriers in selling assets, timing of sales and other constraints. By adding a liquidity constraint to portfolio optimization, it is possible to further mimic the portfolio of a company in the "going concern" phase as short-term obligations impact liquidity requirements more severely. The Mean-Variance-Liquidity framework[147] imposes additional constraints by assuming a required minimum level of liquidity in a portfolio. It creates a minimum-variance-liquidity efficient frontier and allows to account to a pre-specified level of liquidity requirement. In a study from Yosra & Ghabri et al.[148] a MVL frontier was added to two similarly structured portfolios, one without Bitcoin and one with some weight level of the crypto. The analysis of such portfolio demonstrated beneficial shifts in the MVL frontiers and found that adding low levels of the cryptocurrency to the portfolio, improved the Sharpe ratio from 0.041 to 1.072. From this it is possible to confirm that investors can further improve their positions through the inclusion of cryptos in their portfolios by improving both their liquidity risk exposure and portfolios' Sharpe ratios.

The possibility of investing in crypto spans concrete possibilities of hedging against liquidity risks.

Among the reasons behind these findings there are two majors features of the market in question. The first is that most trades are believed to be conducted by retail investors instead of algorithms. The second consists in the nature of bid-ask spreads observed on major exchanges which are found to be lower than the ones of major equity exchanges.

A 2018 study by Anne H. Dyhrberg et al.[149] confirmed these two points by comparing high frequency intraday data on three major US crypto exchanges with the US market trading hours and the average quoted and effective spreads for those times. Furthermore, the study found that the volume of trades is positively

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[147] See: Minimum-variance frontier. (n.d.). *Springer Reference*. https://doi.org/10.1007/springerreference_1962

[148] See Ghabri, Yosra, et al. "Bitcoin and Liquidity Risk Diversification." *Finance Research Letters,* vol. 40, 2021, p. 101679., doi:10.1016/j.frl.2020.101679.

[149] See Dyhrberg, Anne H., et al. "How Investible Is Bitcoin? Analyzing the Liquidity and Transaction Costs of Bitcoin Markets." *Economics Letters*, vol. 171, 2018, pp. 140–143., doi:10.1016/j.econlet.2018.07.032.

correlated with variance and negatively correlated with bid-ask spreads providing more considerations about transaction costs and liquidity features of the crypto market.

Interestingly, returns on cryptocurrencies have been found to be negatively correlated with liquidity in the market.

A study published in December 2020 by Wei Zhang and Yi Li [150]used the Amihud[151] measure as a liquidity proxy and examined the pricing of liquidity risk in the cross section of cryptos' returns.

Although the negative relationship was found (through univariate, bivariate portfolio analysis and Fama-MacBeth regression analysis[152]), an intertemporal relationship between liquidity and returns was not found, suggesting that these proxies could not be used for predictions of expected future returns in time series.

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[150] See Zhang, Wei, and Yi Li. "Liquidity Risk and Expected Cryptocurrency Returns." *International Journal of Finance & Economics*, 2021, doi:10.1002/ijfe.2431.

[151] Amihud, Y., Amihud, Y., Mendelson, H., & Pedersen, L. H. (n.d.). Illiquidity and stock returns cross-section and time-series effects∗. *Market Liquidity*, 110–136. https://doi.org/10.1017/cbo9780511844393.010

[152] See Welch, I. (2008). The link between Fama-french Time-Series tests and Fama-Macbeth Cross-Sectional Tests. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1271935

Chapter 3: modelling of cost of capital for a firm involved with blockchain

3.0 Objectives of this chapter

The purpose of this chapter is to incorporate blockchain and crypto financial products into the computation of a cost of capital for a firm that employs blockchain financial products into investing, operating, and financial activities.

This chapter aims to develop a new WACC model that summarizes the impact of the risks stemming from cryptocurrencies and blockchain described in Chapter 2.

The output of this chapter is a new WACC formula.

Congruently, this chapter also discussed the limitations and the assumptions made relative to the model.

3.0.1 Methodology

The Chapter will first begin by underlining several assumptions regarding the activities of a firm in question, the way financial products on blockchain are included, some theoretical assumptions on the impact of blockchain on the performance of the company and some other assumptions on the recognition process of blockchain products and taxation regimes.

Secondly, the chapter will be dealing with the modelling of blockchain risks into the cost of capital. It will provide other assumptions regarding "blockchain risk premium" defined in chapter 2. It will derive a WACC model that accounts for this measure, and it will provide estimation techniques for that measure.

Thirdly the chapter will be modelling the risks derived from crypto products into the same WACC model. It will make other assumptions on the nature of the relationship between cryptocurrency returns, the hedging practices of the company, the yields to maturity of the crypto products, and the cost of capital.

Once the cost of capital has been modelled it will provide estimation techniques for the hypothesized determinants.

A numerical example will be provided to show the application of the model. Assumptions on the hedging and risk management practices of the company will be made through the designing of a fictitious company called Omega.

Finally, the chapter will discuss the limitations and conclusions of the models and the assumptions made.

3.0.2 General assumptions

The initial general assumptions for the modelling of cost of capital are:

1. Blockchain is introduced in a firm which is public and in the "going concern" phase
2. Blockchain is introduced at all levels to different extents and with a mix of every product discussed in chapter 1
3. It is possible to recognize amounts of debt, equity and assets that are on blockchain and that are floating with cryptos
4. The traditional tax regime is applied to all financial product on blockchain (corporate tax rate) until specified otherwise
5. The exposure to cryptocurrency exchange rate can be hedged against and its effect impacts the cost of capital

The first assumption is made so that reference historical estimates of cost of capital's determinants are available. Determinants include historical performances, historical cost of debt, cost of equity and others.

The second assumption is made to produce the most general model of cost of capital with blockchain. The model considers investing, operating and financial activities being affected by blockchain products.

The third assumption circumvents the complications related to the corporate reporting standards of financial products on blockchain discussed in chapter 1. We assume that the firm has released publicly its categorization policies and accounting practices regarding both fiat and crypto products on blockchain. Therefore, we assume that it is possible to derive percentages of the items of interest with respect to the total.

The fourth assumption aims to generalize the modelling before tackling the different tax regimes (which depend on country, recognition of items and whether the products on blockchain are regulated or not).

The fifth assumption states that the company's hedging practices against fluctuations in crypto returns affecting their issued products, must be accounted for in the internal computation of cost of capital.

3.1 Modelling of blockchain risks into cost of capital

This section deals with the modelling of the blockchain's risks' impact on cost of capital. Blockchain risks can be categorized under design, operational and political/regulatory risks.[153]

The impact of blockchain is translated directly onto the cost of debt and cost of equity and indirectly onto the performance of the company.[154]

We assume that the impact of blockchain's benefits[155] on the performance of the company will be embedded into the estimation of cost of equity in the future. In chapter 2, we have stated that the cost of equity is a function of the historical performance of the company and the historical performance of the market (and the risk-free rate). Therefore, we assume that the benefits on blockchain will impact cost of equity in the long run by impacting the firms' performance.

We, however, do not assume that the risks of blockchain are embedded into the estimation of such cost of capital. On the contrary, we hypothesize a factor of blockchain risks that makes the investors require a premium for selecting securities that are on blockchain instead of selecting the ones that are not: a blockchain risk premium.

3.1.1 Blockchain risk premium assumptions

The blockchain risk premium is a hypothesized measure of risk premium stemming from the risks of blockchain translating onto the firm via the issuance of blockchain financial products.

Congruently to the literature surrounding cost of capital and hurdle rates[156], we can assume that the yield to maturity of a security on blockchain is a function of the yields to maturity of a selected set of securities with similar risks and the risks of the security in question.

$$YTM_{security\ on\ blockchain} = f(\ YTMs_{(set\ of\ reference\ securities)}, Risks_{security\ on\ blockchain}\ \dots)$$

[153] See Chapter 2: risks of blockchain
[154] See Chapter 2: summary of blockchain's impact on cost of capital
[155] See Chapter 1: Introduction to Blockchain
[156] See Chapter 2: review of cost of capital

If we assume that the reference set is comprised of the company's issued securities on blockchain (debt or equity securities), we can infer that the only risks that are added on the security on blockchain stem from the blockchain itself:

$$YTM_{security\ on\ blockchain} = f(\ YTM_{s(firm'securities\ not\ on\ blockchain)}, perceived\ Risks_{of\ blockchain})$$

We hypothesize that the main difference between the returns required by investors on this security and the returns normally required on the firm's traditional securities is a flat value:

$$YTM_{security\ on\ blockchain} = f\left(\ YTM_{s(firm'securities\ not\ on\ blockchain)}\right) +\ BRP$$

We call that flat value the blockchain risk premium or BRP. It can be negative or positive.

Thus far we have to make the following 3 assumptions (other than the literature involved):

1. The yield to maturity required by investors for a security on blockchain is dependent on the historical firm's issued securities' yields to maturity
2. The premium required by investors on blockchain is a flat return value: additive to the returns of the firm's traditional securities not on blockchain
3. The BRP in equity and debt markets is similar to some extent

These assumptions present the following limitations that will be discussed at the end of the chapter:

- The reference set of YTMs is not necessarily a good estimate of opportunity cost because the benefits of blockchain include enhanced accessibility to other securities (which were not easily accessible by investors before)
- The BRP being a "flat" return addendum is not necessarily true. It has not been proven to behave like this. It is suggested by the literature surrounding market risk premium; however, it could be of multiplicative, logarithmic natures or other natures.
- We also assume that the BRP is equal in both equity and debt markets. This is a very risky assumption for many reasons. First of all, the maturity of debt obligations is set unlike equity ones; this could affect the BRP differently as the risks discussed in Chapter 2, mainly, design and regulatory/political are more likely to manifest. Secondly, equity issuance is mostly conducted on private blockchain platforms, however, we assume that we deal with a public general platform blockchain. Finally, the overall behavior and tendencies of investors towards equity and debt issuance on blockchain can differ drastically, or not, no studies have been conducted on the matter

(other than Yen and Tawei[157] on the relevance of blockchain announcements on stock price and [158]Jo et al. on many aspects of the signaling of Bitcoin on cryptocurrency markets.)

3.1.2 The cost of blockchain on debt

If we assume the BRP to be a good estimate of the behavior of investors towards securities on blockchain, we can prove the impact on the debt portion of cost of capital by the introduction of blockchain in a fundamental manner.

From the review of cost of debt in Chapter 2, we can infer that cost of debt is a function of the YTMs of the debt obligations of the firm, the loss rate given default LR, and the probability of default of the firm often estimated through rating agencies' reports.

$$r_{d_{traditional}} = f(YTMs_{trad}) - LR_{trad}\ x\ PD_{firm}$$

The function of the YTMs of the company's historical debt securities is an average of some sort, it could be weighted on value, maturity, and other factors; for the sakes of simplicity let us call YTM_{trad} the value that summarizes them.

$$f(YTMs_{trad}) = Average\ estimate\ of\ YTMs_{trad} = YTM_{trad}$$

On the basis of the theorized Blockchain Risk premium component, mentioned above, we can state the estimate of the yields to maturity on blockchain YTM_B differs from YTM_{trad} due to the BRP.

$$YTM_B = YTM_{trad} + BRP$$

We recall[159] that all of the unregulated securities on public blockchain are tokenized, do not grant legally binding rights and do not necessarily contain smart contracts' algorithms which consider the eventuality that the firm defaults on its debt. Some contracts do contain clauses for the scenarios in which wallets become empty, but this is not comparable to the defaulting of the issuer. We can safely assume that the Loss Rate given default of the securities issued on blockchain is 100%.

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[157] See: Yen, Ju-Chun, and Tawei Wang. "Stock Price Relevance of Voluntary Disclosures about Blockchain Technology and Cryptocurrencies." 1 Feb. 2021.

[158] See: Jo, Hoje, et al. "Bitcoin and Sentiment." *SSRN Electronic Journal*, 2018, doi:10.2139/ssrn.3230572.

[159] See Chapter 1: Financial products: tokens

$$LR_B = 100\%$$

Let us suppose that the firm will now begin to issue all of its debt securities on blockchain. The cost of debt in this case could be estimated as $r_{\underset{b}{d}}$:

$$r_{\underset{b}{d}} = YTM_{trad} + BRP - PD_{firm}$$

We ignore LR_B because it is equal to 1.

From this we can infer that the cost of debt for a firm that issues debt securities on both blockchain and on traditional exchanges will be a weighted average of $r_{\underset{b}{d}}$ and $r_{d_{traditional}}$ where the latter was the cost of debt before introducing blockchain debt securities:

$$r_d = r_{\underset{b}{d}}\frac{B}{D} + \frac{r_{d_{traditional}}T}{D}$$

Where $\frac{B}{D}$ refers to the portion of debt issued on blockchain with respect to the total outstanding debt and $\frac{T}{D}$ refers to the debt portion issued on traditional exchanges. By replacing $r_{d_{traditional}}, r_{\underset{b}{d}}$ with their respective functions we find the comprehensive real cost of debt:

$$r_d = YTM_{trad} - PD_{firm}LR_{trad}\frac{T}{D} + \frac{B}{D}\left(BRP - PD_{firm}\right)$$

Since $YTM_{trad} = r_{d_{traditional}} + PD_{firm}LR_{trad}$ we can also express the equation as:

$$r_d = r_{d_{traditional}} + \frac{B}{D}(PD_{firm}LR_{traditional} + BRP - PD_{firm})$$

Where $(PD_{firm}LR_{traditional} + BRP - PD_{firm})$ could be seen as the "cost of blockchain debt".

Note that the blockchain would still have an effect on the cost of debt if the BRP was 0. This is due to the Loss rate component being different on blockchain. For the blockchain introduction having 0 effect:

$$BRP = PD_{firm} - PD_{firm}LR_{traditional} = PD_{firm}\,(1 - LR_{trad})$$

In this case, the Loss rate being 100% would be balanced out by the premium required.

3.1.3 The cost of blockchain on equity

Let us assume that there exists a Blockchain Risk premium in equity markets such that the cost of equity of a firm that issues all of its equity rights on blockchain would be:

$$r_{e_b} = r_f + BETA_{firm}\left(r_{mkt} - r_f\right) + BRP_{equity}$$

This formula states that the cost of financing through equity is also dependent on the risks stemming from the platform on which equity rights are issued. This is the 4th assumption that we make on the nature of BRP.[160]

The formula is implying that investors who purchase equity securities issued by the firm on blockchain require a premium to compensate for the system's risks.

It is the equivalent of assuming the following:

$$V_{common\ share} = \sum_{i=0}^{T} \frac{Dividend\ Payment\ (on\ blockchain)_i}{e^{(r+BRP)*i}} + \frac{(terminal)^{161} Payment_{T+1}\ (blockchain)}{(r + BRP - g)x(e^{(r+BRP)T})}$$

The equation is derived by the Dividend Discount Model[162] for the pricing of stock. It assumes a payout policy which makes the forecast of future dividends predictable and models their increase through a growth rate g . The value of the share is found by discounting future dividends at the rate required by investors.

The rate required by investors, the yield of the stock, can be seen as a good estimate of the cost of equity. The above equation shows that the value of a common share issued on stock is found by discounting the forecasted dividend payments at the rate $r + BRP$. This assumption is consistent with the first assumption of this paragraph:

There exists a flat value that accounts for the increase in required returns by investors in the eventuality that the equity security of interest is issued on blockchain.

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160 We assume the BRP (equity) to be close to 0 or 0.
161 Terminal date refers to an arbitrary date in the DDM on which the perpetuity starts see *[10]
162 The DDM formula see: Laopodis, N. (2013). *Understanding investments: Theories and strategies*. (p136-140) Routledge.

If we allow for the equations above to be true, then the cost of equity for a firm which issues stock on both traditional exchanges and blockchain would be:

$$r_e = \frac{r_{e_b} B}{E} + \frac{r_{e_{trad}} T}{E}$$

Which would impact the original cost of equity in the following way:

$$r_e = r_f + BETA_{firm}(r_{mkt} - r_f) + \frac{B}{E} BRP_{equity}$$

$$r_e = r_{e_{trad}} + \frac{B}{E} BRP_{equity}$$

Where BRP_{equity} would be both the Blockchain Risk Premium and the cost of issuing equity on blockchain.

3.1.4 The cost of blockchain

We can remodel the WACC computation so that it includes the new cost of blockchain debt and the new cost of issuing equity on blockchain:

$$WACC = \frac{D}{V}(1 - t_c)\left(r_{d_{traditional}} + \frac{B}{D}\left(PD_{firm} LR_{trad} + BRP - PD_{firm}\right)\right) + \frac{E}{V}\left(r_f + BETA_{firm}(r_{mkt} - r_f) + \frac{B}{E} BRP_{equity}\right)$$

Let us assume that $BRP_{equity} \cong BRP$.

If it is possible to prove that the premium required in equity markets because of blockchain is the same as the premium require by investors in debt market in the YTMs of the securities, we can state:

$$\begin{aligned} WACC_{impacted} &= \frac{D}{V}(1 - t_c) r_{d_{traditional}} + \frac{B}{V}(1 - t_c)\left(PD_{firm} LR_{trad} + BRP - PD_{firm}\right) + \frac{E}{V} r_e \\ &\quad + \frac{B}{V} BRP_{equity} \\ &= \frac{D}{V}(1 - t_c) r_{d_{traditional}} + \frac{E}{V} r_e + \frac{B}{V}\left(BRP(2 - t_c) + (1 - t_c)\left(PD_{firm}(LR_{trad} - 1)\right)\right) \end{aligned}$$

Following all the assumptions from previous paragraphs, the $WACC_{impacted}$ measure would be an estimate of the WACC after the company has begun issuing a portion of securities, both on debt and equity markets, on blockchain. The impact is a function of the BRP the Loss Rate given default of traditional debt securities not on blockchain and the probability of default of the firm estimated by rating agencies.

If $BRP_{equity} \cong BRP$ we can isolate the "cost of blockchain" as:

$$WACC\ impacted = \frac{D}{V}(1-t_c)r_{d_{traditional}} + \frac{E}{V}r_e + \frac{B}{V}\Big(BRP(2-t_c) + (1-t_c)\big(PD_{firm}(LR_{trad}-1)\big)\Big)$$

$$cost\ of\ blockchain = \Big(BRP(2-t_c) + (1-t_c)\big(PD_{firm}(LR_{trad}-1)\big)\Big)$$

Where the cost of blockchain is, essentially, the impact of the risks and the features stemming from the blockchain on the WACC.

Other than the assumptions:

1. The yield to maturity required by investors for a security on blockchain is dependent on the historical firm's issued securities' yields to maturity
2. The premium required by investors on blockchain is a flat return value: additive to the returns of the firm's traditional securities not on blockchain
3. The BRP in equity and debt markets is similar to some extent
4. $YTM_B = YTM_{trad} + BRP$
5. $LR_B = 100\%$
6. There exist a Blockchain risk premium BRP_{equity} such that the cost of equity financing on blockchain can be expressed as $r_{e_b} = r_f + BETA_{firm}(r_{mkt} - r_f) + BRP_{equity}$
7. $BRP_{equity} \cong BRP$

The limitations include:

1. A need for an estimate of future expected change in performance of the company due to blockchain benefits (which would translate into better rating, lower probability of default etc.….)[163]
2. A need for a more thorough analysis of blockchain tax regimes depending on the company's reporting policies, state, and incoming regulations[164]

[163] See the benefits of blockchain in Chapter 1: introduction to blockchain
[164] See Chapter 1: corporate reporting of blockchain financial products

3.1.5 Estimating the blockchain risk premium

The Blockchain risk premium is a hypothetical measure devised to translate the blockchain's risks into a simple component of cost of capital estimation. It comprises the added return that would be required by investors for executing the investment on blockchain. We can treat the risks as a barrier to entry due to the systems belonging to a fairly new technology that has not been fully explored yet, is not decently regulated, and presents meaningful threats.

The BRP, however, could also be negative in our computations of WACC: if we assume that blockchain systems are more favorable and present more benefits and less risks in the eyes of investors, then they might require less out of their investments' offered returns.

Regardless the BRP could be estimated by:

- BRPs of other firms that have issued securities on blockchain
- Historical BRPs of other issuers at the beginning (or at another arbitrary point in time) of their acquisition of blockchain
- Looking at current market prices of securities on blockchain and market prices of securities on traditional exchanges

Overall, an interesting study that should be conducted would be on the statistical significance of BRP on both equity and debt markets. Proving that $BRP \neq 0$ would be the first step.

The second step would be to statistically prove that $BRP_{equity} \cong BRP$ at some confidence interval.

3.2 Modelling of crypto risks into the cost of capital

The crypto financial products[165] affect the cost of capital even further than the fiat[166] products issued on blockchain.

They introduce all the risks of blockchain estimated above through the BRP and all the risks of the underlying cryptocurrency detailed in chapter 2[167]:

[165] See Chapter 1: financial products: crypto futures
[166] See [15]
[167] See Chapter 2: summary of the impact of blockchain on cost of capital

- Crypto Market Risk
- Crypto credit risk
- Crypto liquidity risk

The crypto financial products include crypto bonds, crypto options, crypto futures, crypto forwards, cryptocurrencies themselves and OTC tailored crypto financial products.

Since we have assumed that the firm is dealing on a public blockchain, the issuance of crypto products does not include the issuance of general platform cryptocurrency. The value of the products issued, however is dependent on the value of the underlying general platform cryptocurrency.

For the discussions of cost of capital, we recall assumptions 2,3, and 5 from the general assumptions made at the beginning of the chapter[168]. Moreover, we make the following assumption:

- Crypto products are priced so that the yields to maturity that they offer already include expectations of exchange rates' changes and the fiat return mirror, to some extent, the yields to maturity of securities on blockchain. The volatility of future exchange rates adds a layer of risk.

3.2.1 Assumptions on the pricing of crypto products

The assumptions on the pricing of the firm's crypto products include:

1. The YTM of the crypto products issued on blockchain mirror the expectations in future crypto exchange rates
2. The YTM of the crypto products are a function of the YTMs of the firms' issued securities on blockchain, and the risks of exchange rates fluctuations

We have assumed the firm that issues crypto financial products does not issue general platform cryptocurrencies.

Let us assume also that the price of general platform cryptocurrencies is the present value of the expected future prices discounted at a certain rate $R_{currency}$:

[168] See: 3.0.2 general assumptions

$$Price\ (cryptocurrency) = \frac{E_i^{e\ 0}\left(\frac{fiat}{crypto}\right)}{e^{R_{currency}\ i}} = \ E_0^{quoted}\left(\frac{fiat}{crypto}\right)$$

Where $E_i^{e\ 0}\left(\frac{fiat}{crypto}\right)$ represents the expected exchange rate, estimated at inception, at a future time i. It can be seen as the expected amount of fiat currency necessary to purchase one unit of the cryptocurrency at a future date. $E_0^{quoted}\left(\frac{fiat}{crypto}\right)$ is the price today estimated by crypto exchanges.

Then $R_{currency}$ would be the yield to maturity or IRR[169] of the investment in the general platform cryptocurrency.

Let us assume that a firm which bears no risk of default issues a crypto future contract: it collects general platform cryptocurrency today and promises an amount of cryptocurrency at a later date T.

At inception we assume that the fiat price of a crypto future would be:

$$crypto\ future, price_{fiat} = \frac{E_T^{e\ 0}\left(\frac{fiat}{crypto}\right)\ crypto\ reward_T}{e^{f\left(r_f, R_{currency}\right)T}}$$

We are assuming that the pricing of the crypto future contract grants a YTM that is a function of the $R_{currency}$ and of the r_f since the firm bears no risk[170].

From the first equation of this paragraph, we can demonstrate that:

$$R_{currency} = \ln E_i^{e\ 0}\left(\frac{fiat}{crypto}\right) - \ln E_0^{quoted}\left(\frac{fiat}{crypto}\right)$$

Congruent to the literature surrounding Bitcoin and Ethereum currencies[171], we can assume that the best estimate of future exchange rates for cryptocurrencies is the spot exchange rate:

$$E_0^{quoted}\left(\frac{fiat}{crypto}\right) \approx E_i^{e\ 0}\left(\frac{fiat}{crypto}\right)$$

Then making the expected YTM, $R_{currency} \approx 0$.[172]

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[169] Internal rate of return, see Chapter2: review of cost of capital

[170] An obligation of a firm which bears no risk should be discounted at the risk-free rate, which is the rate provided by investments with no risks.

[171] See: Kavanagh, Donncha, et al. "The Bitcoin Game: Ethno-Resonance as Method." *Organization*, vol. 26, no. 4, 2019, pp. 517–536., doi:10.1177/1350508419828567.

[172] This is not necessarily true; it is an assumption for demonstration sakes

For example, for a firm that bears risks, the pricing of the crypto future would be:

$$crypto\ future, price_{fiat} = \frac{E_T^{e\ 0}\left(\frac{fiat}{crypto}\right)\ crypto\ reward_T}{e^{f(RISKS,\ \ returns\ of\ similar\ securities^{173}\ldots)T}}$$

So that it would provide a YTM congruent also to the risks of the firm. [174]

Therefore, we can state that the YTM at inception of crypto futures issued by the firm would be:

$$YTM_{crypto\ future} = \ln(\ (E_T^{e\ 0}\left(\frac{fiat}{crypto}\right)\ crypto\ reward_T) - \ln(crypto\ future, price_{fiat})$$

Which already encompasses expectations of future crypto exchange rates.

It is also possible to state that the YTMs of crypto products partly depends on the YTMs of the firm's already issued securities on blockchain and on the risks of exchange rate fluctuations and cryptocurrencies are amplified by the crypto products' time to maturity:[175]

$$\begin{aligned} YTMs_{crypto\ obligations} \\ &= YTMs_{blockchain} \\ &+ f\left(E_T^{e\ 0}\left(\frac{fiat}{crypto}\right)_{at\ different\ Ts}, Maturities_{products}, Risks_{cryptocurrencies}\right) \\ &= YTMs_{blockchain} + Premium_{cryptos} \end{aligned}$$

We define $Premium_{cryptos}$ as the average premium required on crypto products with respect to blockchain products on debt markets.[176]

3.2.2 Assumptions on the exposure to exchange rates fluctuations and on risk management practices

We assume that companies which employ crypto financial products in their activities can hedge against the exchange rates fluctuations in 2 ways:

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[173] See Chapter2: review of cost of debt

[174] See [21]

[175] Exposure to changes in exchange rates is time sensitive. The longer the time to maturity, the higher the exposure to the risks of crypto.

[176] See Chapter 3: estimation of the premium on crypto products

- by replicating hedging portfolios strategies onto their crypto assets and liabilities[177]
- by managing the timings of exchanges into fiat currencies for general platform cryptocurrencies (wallet)[178]

the exposure to exchange rates fluctuations is located both in the holdings of crypto financial products and in their issuance. Suppose the value of Ethereum skyrockets right before a payment of Ethereum interests on an Ethereum Bond or a future on Ethereum is due. If a firm has a wallet of Ethereum, or crypto financial products floating on Ethereum with some level of liquidity or which grant interests, then the exposure to the sudden change in exchange rate is reduced. The internal risk management division of the firm in question could also enact hourly micro trading strategies to maximize returns on the wallet of Ethereum.

We infer that cost of capital is directly affected by these risk management practices as it is affected by the exposure to the exchange rates.

In chapter 2[179], we have formulated cost of debt as:

$$cost\ of\ debt_{\ period\ i} = \frac{interests\ paid_{\ i}}{total\ outstanding\ debt_{\ i-1}}$$

If the interests paid on crypto financial products are more volatile due to the exchange rates' fluctuations, then there is an exposure of cost of debt to the crypto exchange rates. If, however, the portion of excess capital spent on these interests due is partly recovered by other assets of the company at the same rate, then the exposure is reduced.

Thus, we assume that:

$$\begin{aligned} &cost\ of\ crypto\ debt\ (fiat)_{period\ i\ (omega)} \\ &\qquad = \frac{crypto\ interests\ paid\ (fiat)_{\ i}}{total\ crypto\ debt_{\ i-1}} \\ &\qquad - f(Hedging\ against\ unexpected\ exchange\ rates) \end{aligned}$$

The cost of crypto debt is also dependent on the performance of hedging practices of the company against exchange rates.

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[177] See examples in: Kang, Sang Hoon, et al. "Bitcoin as Hedge or Safe Haven: Evidence from Stock, Currency, Bond and Derivatives Markets." *Computational Economics*, vol. 56, no. 2, 2019, pp. 529–545., doi:10.1007/s10614-019-09935-6.

[178] We assume the risk management division to conduct micro trading on the crypto wallet or to have bid-ask algorithms to prevent huge losses

[179] See chapter 2: review of cost of debt

3.2.4 Derivation of the cost of crypto capital

We define the cost of crypto capital as the sum of cost of blockchain capital and an averaging function of the difference between the forecasted excess relative payments on crypto liabilities and the forecasted excess returns on crypto holdings and crypto wallet :

$$r_{d\,(crypto) in\, fiat} = r_{\substack{d\\b}}{}^{180} + Premium_{cryptos} + f\left(EPC_i - ERC_i - \frac{\Delta E_i^{unexpected}}{Z}_{i-1}, \forall\, i \in set(A)\right)$$

Or

$$r_{d\,(crypto) in\, fiat} = r_{\substack{d\\b}} + CRP_{firm}$$

Where:

$$CRP_{firm} = Premium_{cryptos} + \frac{\Delta E_i^{unexpected}}{Z_{i-1}} f\left(ipay_{i\,(crypto)_i}^{e\,0} - ireceive_{i\,crypto}^{expected} - W_i, \forall\, i \in set(A)\right)$$

The cost of crypto capital takes into consideration the following:

- The risks of the company and the returns of securities in the debt markets embedded into the return on blockchain issuance
- The BRP embedded into the return on blockchain issuance
- The risks of the issued crypto financial products floating values through EPC_i
- The hedging practices of the company against crypto exchange rates through: ERC_i, $\frac{\Delta E_i^{unexpected}}{Z}_{i-1}$
- The different maturities by averaging periodic excess returns $\Delta E_i^{unexpected}$

The added assumptions needed:

[180] See Chapter 3: the cost of blockchain

1. The company prices its issued crypto products so that the crypto interests that they pay, considers expectations of Exchange rates. The company strives to adjust the prices so that their YTMs reflects the YTMs of the fiat products issued on blockchain.
2. The cost of crypto capital takes into consideration the company's hedging practices against unexpected amounts of payments due.

The demonstration:

We can hypothesize that the cost of crypto capital is a special subset of the cost of blockchain issuance with added layers of risks. The added risks stem from the payments to debt holders being floating with regards to exchange rates fluctuations. We also have to include the reduction to the exchange rate exposure that the firm enacts by investing in crypto financial products.[181]

We can translate this intuition into:

$$\begin{aligned} r_{d\,(crypto)in\,fiat} &= YTM_{crypto} - PD_{crypto} + BRP \\ &\quad + f\left(risks_{underlying}, E_T^{e\,0}\left(\frac{fiat}{crypto}\right)_{at\,different\,Ts}, Maturities_{products},\right) \\ &= YTM_{crypto} - PD_{crypto} + BRP + \ Premium_{cryptos} \\ &\quad + f(performance\ of\ crypto\ holdings\ and\ crypto\ obligations) \end{aligned}$$

Also pursuant to:

$$\begin{aligned} YTMs_{crypto\ obligations} &= YTMs_{blockchain} + Premium_{cryptos} \\ &= YTMs_{blockchain} \\ &\quad + f(E_T^{e\,0}\left(\frac{fiat}{crypto}\right)_{at\,different\,Ts}, Maturities_{products}, Risks_{cryptocurrencies}) \end{aligned}$$[182]

We recall from Chapter 2 that the cost of debt can be estimated through the quotient of interests paid in a period on the outstanding debt of the previous period:

$$cost\ of\ debt\ _{period\ i} = \frac{interests\ paid\ _i}{total\ outstanding\ debt\ _{i-1}}$$

Pursuant to this estimation model, we can hypothesize the following model:

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[181] For the moment, the demonstration includes crypto products which yield crypto capital, later in the demonstration an emergency wallet of general platform cryptocurrency will be included.
[182] See Chapter 3: assumption on pricing of crypto financial products

1. Assume that the number of crypto interests paid(in cryptocurrency) at a certain period is known[183]:

$$interests\ due_{i\ cryptocurrency}\ are\ known\ amounts$$

2. Assume that the fiat interests because of crypto issuance at a time is equal to the sum of the expected amount and an error term: $crypto\ interests_{i\ (fiat)} = E\big(interests\ due_{i\ (fiat)}\big) + \epsilon_i$

3. Define the error term as: $\epsilon_i = unexpected\ amount_{fiat} = f(interests\ due_{i\ (cryptocurrency)}, unexpected\ change\ in\ E(\frac{fiat}{crypto})_i)$

4. Note that the unexpected change of the exchange rate can be translated into a function of unexpected (compound factor) returns on the underlying cryptocurrency:

$$unexpected\ \Delta E_i = E^{e\ 0}{}_{expected\ at\ i}\left(\frac{fiat}{crypto}\right) - E_{realised\ at\ i}\left(\frac{fiat}{crypto}\right)$$

$$E_i = e^{r_i} E_{i-1}$$

$$E_i = \prod_{j=0}^{i-1} e^{r_{i-j}}\ E_0$$

$$unexpected\ \Delta E_i = \left[\prod_{j=0}^{i-1} e^{r_{i-j}^{realised}} - \prod_{j=0}^{i-1} e^{r_{i-j}^{expected}}\right] E_0$$

5. Redefine the error term as: $interests\ due_{i\ (cryptocurrency)}\ \ x\ \Delta E_i^{unexpected} = \epsilon_i$ note that:

$$E(\Delta E) = 0\ \rightarrow E(\epsilon_i) = 0$$

6. Construct a set of dates (periods): $set(A) = \{arbitrary\ future\ or\ past\ dates\}$
7. Define the interests paid in fiat currency (because of demanded crypto interests) as:

$$interests\ paid_{i\ (fiat)} = interests\ to\ be\ paid_{i\ (fiat)}^{expected} + interests\ unexpected_{i\ (fiat)}^{excess} - unexpected\ interests\ received_{i\ (fiat)}^{cover}$$

Where the expected interests refer to the amount that the firm expected to pay on its crypto issued financial products (due to their pricing, YTMs target, Exchange rate forecasting). The unexpected interests refer to the amount to be paid that deviates from predictions. The excess interests received refers to the amount of

[183] This is congruent to the assumptions made on the hypothetical company Omega. See: assumptions on the activities involved.

interests received by crypto holdings that was unexpected due to a change in exchange rates. We are accounting for the reduction to exchange rate exposure.

If $E_T^{e\ 0}\left(\frac{fiat}{crypto}\right)_{at\ different\ Ts} = realised\ Exchange\ rates\ \forall\ T$ then every excess would be 0.

8. Define cost of crypto capital as:

$r_{d\ (crypto)} = f(D_{i-1\ (fiat)}, interests\ to\ be\ paid_{i\ (fiat)}^{expected}\ ;\ \forall\ i \in set(A), interests\ unexpected_{i\ (fiat)}^{excess}, unexpected\ interests\ received_{i\ (fiat)}^{cover} holdings\ of\ crypto_{i-1\ (fiat)})$

So that:

$$r_{d\ crypto\ (in\ fiat)} = f\left(\frac{ipay_{i\ (fiat)}^{expected}}{C_{(fiat)\ i-1}} + \left(\frac{C_{(fiat)i-1}}{C_{(fiat)i-1} + H_{fiat\ i-1}}\right)\frac{ipay_{i\ fiat}^{excess}}{C_{(fiat)i-1}} - \left(\frac{H_{fiat\ i-1}}{C_{(fiat)i-1} + H_{fiat\ i-1}}\right)\frac{ireceive_{i\ fiat}^{covered\ excess}}{H_{fiat\ i-1}}\ , \forall\ i \in set(A)\right)$$

Where f is an averaging function of the set. The excess yields on the excess interest rate payments and receivables are weighted on their references debts. Let us call $C_{(fiat)i-1} + H_{fiat\ i-1} = Z_{fiat\ i-1}$ the sum of the holdings of crypto assets and the liabilities denominated in crypto.

9. Redefine $ipay_{i\ fiat}^{excess}$ and $ireceive_{i\ fiat}^{covered\ excess}$ by the equation on point 5:

$$r_{d\ (crypto)} = f\left(\frac{ipay_{i\ (fiat)}^{e\ 0}}{C_{(fiat)\ i-1}} + ipay_{i\ crypt}^{e\ 0}\ \frac{\Delta E_i^{unexpected}}{Z_{(fiat)\ i-1}} - ireceive_{i\ crypto}^{expected}\ x\ \frac{\Delta E_i^{unexpected}}{Z_{(fiat)\ i-1}}, \forall\ i \in set(A)\right)$$

10. By the assumptions made for the pricing of crypto securities[184], let:

$$r_{\substack{d\\b}} = YTM_{trad} + BRP - PD_{firm} = \frac{Ipay_{i\ (fiat)}^{e\ 0}}{C_{(fiat)\ i-1}} - Premium_{cryptos}$$

11. So that:

[184] $E(interests\ due_{i\ (fiat)}) = f\left(YTMs_{blockchain\ securities}, E^{e\ (since\ inception)}_{\frac{fiat}{crypto}\ at\ time\ i}\right)$

$$r_{d\,(crypto) in\,fiat}$$
$$= f\left(r_{\underset{b}{d}} + Premium_{cryptos} + \Delta E_i^{unexpected} \left(\frac{ipay_{i\,(crypto)}^{e\,0}}{Z_{(fiat)\,i-1}} - \frac{ireceive_{i\,crypto}^{expected}}{Z_{(fiat)\,i-1}} \right), \forall\, i \in set(A) \right)$$
$$= f\left(r_{\underset{b}{d}} + Premium_{cryptos} + \frac{\Delta E_i^{unexpected}}{Z_{(fiat)\,i-1}} \left(ipay_{i\,(crypto)}^{e\,0} - ireceive_{i\,crypto}^{expected} \right), \forall\, i \in set(A) \right) =$$

Let: $\frac{ipay_{i\,(crypto)}^{e\,0}}{Z_{(fiat)\,i-1}}$ be the weighted crypto yield (denominated in crypto) at i [185]: $r_{cc\,(i)}$ and $\frac{ireceive_{i\,crypto}^{expected}}{Z_{(fiat)\,i-1}}$ be the weighted return on crypto holdings at time i (denominated in crypto): $ROCH_i$

Then the cost of crypto capital:

$$r_{d\,(crypto) in\,fiat} = f\left(r_{\underset{b}{d}} + Premium_{cryptos} + \Delta E_i^{unexpected} \left(r_{cc\,(i)} - ROCH_{c\,i} \right), \forall\, i \in set(A) \right)$$
$$= r_{\underset{b}{d}} + Premium_{cryptos} + f\left(\Delta E_i^{unexpected} \left(r_{cc\,(i)} - ROCH_{c\,i} \right), \forall\, i \in set(A) \right)$$

Where $Premium_{cryptos} + f\left(\Delta E_i^{unexpected} \left(r_{cc\,(i)} + ROCH_i \right), \forall\, i \in set(A) \right)$ is the cost of introducing crypto products on the issuance of blockchain products.

We can rearrange the cost of crypto capital as:

$$r_{d\,(crypto) in\,fiat}$$
$$= r_{\underset{b}{d}} + Premium_{cryptos} + f\left(\Delta E_i^{unexpected} r_{cc\,(i)} - \Delta E_i^{unexpected} ROCH_{c\,i}, \forall\, i \in set(A) \right)$$

Where $\Delta E_i^{unexpected} r_{cc\,(i)}$ is the fiat excess interest payments that the firm pays at time i and $\Delta E_i^{unexpected} ROCH_{c\,i}$ is the fiat excess returns on the holdings of crypto products. Let us call the first

[185] These yields are not to be used as the numerators' currencies are different to the denominators' ones. These names are purely for ease of computations.

factor "excess payments for cryptos obligations" and the second factor "excess returns for cryptos assets": $EPC\ and\ ERC$.

The cost of introducing crypto capital or "crypto premium" CRP can be expressed as the sum of $Premium_{cryptos}$ with a function of a set of historical or forecasted differences between EPC and ERC:

$$CRP_{firm} = Premium_{cryptos} + f\left(\Delta E_i^{unexpected} r_{cc\,(i)} - \Delta E_i^{unexpected} ROCH_{c\,i}\,, \forall\, i \in set(A)\right)$$
$$= Premium_{cryptos} + f\left(EPC_i - ERC_i, \forall\, i \in set(A)\right)$$

Let us assume that the company also holds an emergency wallet of cryptocurrency[186] W on which gains due to unexpected revaluations, aim to hedge against unexpected excess returns on interests due. note that W_{i-1} is a portion of H_{i-1}. Then, by following the same protocol:

$$r_{d\,(crypto) in\, fiat} = r_{\underset{b}{d}} + Premium_{cryptos} + f\left(EPC_i - ERC_i - \frac{\Delta E_i^{unexpected} W_{i(crypto)}}{Z}_{i-1}, \forall\, i \in set(A)\right)$$

The emergency wallet W realizes gains on the crypto micro trading practices of the firm. There are no known amounts of crypto interests yielded because the wallet does not grant interest installments, however, we can approximate that the fiat amount of "interest"[187] gains on the wallet at a particular time i can be expressed by: $\frac{\Delta E_i^{unexpected} W_{i(crypto)}}{Z_{i-1}}$.[188] The CRP would be:

$$CRP_{firm} = Premium_{cryptos} + f\left(EPC_i - ERC_i - \frac{\Delta E_i^{unexpected} W_{i(crypto)}}{Z_{i-1}}, \forall\, i \in set(A)\right)$$

Or

$$CRP_{firm} = Premium_{cryptos} + \text{f}\left(\frac{\Delta E_i^{unexpected}}{Z_{i-1}}\right) f\left(ipay^{e\,0}_{i\,(crypto)_i} - ireceive^{expected}_{i\,crypto} - \frac{W_{i(crypto)}}{1}, \forall\, i \in set(A)\right)$$ [189]

[186] Let us assume that the wallet contains the general platform cryptocurrency which is the underlying of the crypto products it issues

[187] A wallet does not yield interests, but we can treat the fiat gains due to revaluations as interests

[188] The "excess" gains over the total wallet value (i-1), weighted for the total Z(i-1).

[189] This is the easiest applicable formula: it requires the least steps from the initial data.

We can find the cost of debt comprehensive of crypto issuance by plugging the cost of crypto capital in the adjusted cost of debt for blockchain as:

$$R_{debt} = r_d = \left(\frac{r_{\frac{d}{b}}F}{B} + \frac{r_{d\,(crypto)in\,fiat}C}{B}\right)\frac{B}{D} + \frac{r_{d_{traditional}}T}{D}$$

Where $\frac{C}{B}$, $\frac{F}{B}$ refer, respectively to the portion of crypto financial products and the portion of fiat financial products over the total products issued on blockchain. We substitute and simplify to find:

$$R_{debt} = r_{d_{traditional}} + \frac{B}{D}\left(PD_{firm}LR_{traditional} + BRP - PD_{firm}\right) + \frac{CRP_{firm}C}{D}$$

The new cost of debt is a weighted average function of the old one, the cost of blockchain and the Crypto risk Premium of the firm.

3.3 Explanation and Modelling of cost of crypto capital

The cost of crypto capital refers to the cost of issuing crypto financial products on blockchain for a firm with a specific profile of risk management practices against exchange rate fluctuations.

The cost of crypto capital is a function of the cost of issuing financial products on blockchain and a "crypto risk premium" of the company: $r_{d\,(crypto)in\,fiat} = r_{\frac{d}{b}} + CRP_{firm}$

The crypto risk premium of the company encompasses the general "premium on cryptos" and a function of the company's exposure to unexpected changes in the fiat value of its crypto liabilities, hedged against through crypto holdings:

$$CRP_{firm} = Premium_{cryptos} + f\left(EPC_i - ERC_i - \frac{\Delta E_i^{unexpected} W_{i(crypto)}}{Z_{i-1}}, \forall\, i \in set(A)\right)$$

The $Premium_{cryptos}$ is the additional return required in debt markets for investing in crypto financial products. It is estimated by looking at general blockchain market prices and yield to maturities of fiat products and crypto products. It can be estimated in several ways.[190]

The company's exposure is an averaging function of the excess interest payments yields EPC_i that the company has to pay at certain dates for the issuance of crypto debt, the excess interests yields that the company receives ERC_i at the same given dates by its holding of financial crypto products, and the excess returns on the emergency wallet $\frac{\Delta E_i^{unexpected} W_{i(crypto)}}{W_{i-1(fiat)}}$ that it holds for crypto payments.

Since it is possible to rearrange CRP of the firm as:

$$CRP_{firm} = Premium_{cryptos} + \text{f}\,(\frac{\Delta E_i^{unexpected}}{Z_{i-1}}) f\left(ipay^{e\,0}_{i\,(crypto)_i} - ireceive^{expected}_{i\,crypto} - W_{i(crypto)}, \forall\, i \in set(A)\right)$$

Let us assume that for a set A of dates, $ipay^{e\,0}_{i\,(crypto)_i} - ireceive^{expected}_{i\,crypto} - W_{i(crypto)}$ are known.

Then, to calculate CRP_{firm} we need an estimation of the following:

1. $Premium_{cryptos}$: the premium required by investors for exposing to cryptocurrencies' values
2. $\frac{\Delta E_i^{unexpected}}{Z_{i-1}}$: the unexpected change in price of the underlying crypto over the total crypto amount of the company for both asset and liabilities.

Where $Z_{i-1} = C_{i-1} + H_{i-1}$ and $W_{i-1} \in H_{i-1}$. We suppose that W_{i-1}, H_{i-1} amounts are decided externally by company's policies.

3.3.1 Estimation of the Premium on crypto.

Pursuant to the assumptions made on the pricing of crypto products:

[190] See 3.3.1: estimation of the premium on crypto. below

$$YTMs_{crypto\ obligations} = YTMs_{blockchain} + f\left(E_T^{e\ 0}\left(\frac{fiat}{crypto}\right)_{at\ different\ Ts}, Maturities_{products}, Risks_{cryptocurrencies}\right) = YTMs_{blockchain} + Premium_{cryptos}$$

We define $Premium_{cryptos}$ as the average premium required on crypto products with respect to blockchain products on debt markets:

$$Premium_{cryptos} = YTMs_{crypto\ obligations} - YTMs_{blockchain}$$

Therefore, its estimation can be done in two ways:

- By looking at the YTMs of the market for fiat blockchain products and YTMs of crypto blockchain products. (Single parameter approach). Worse estimate.
- By modelling the returns of crypto products with multiple regressors depending on the expected exchange rate, the maturity, and others. (Multiple parameters approach). Better estimate.

The first approach involves regressing the returns of the fiat market's blockchain products with the returns of crypto products on blockchain using a dummy variable D that separates crypto from fiat:

$$D_i = 0 : fiat,\ \ D_i = 1 : crypto$$

$$r_{i\ (crypto)} = r_{i\ (fiat)}{}^{average} + \beta D_i + \epsilon_i$$

The beta would be the premium for cryptos and from the analysis it could be inferred whether it is statistically significant, how close it is to predicting the return on crypto products (by R^2 and other measures) and, through the use of other tests, whether the premium is sufficient or requires additional regressors.

A second, more comprehensive approach, could involve also looking at the risks of the expectations of exchange rate and the maturities of a particular crypto security:

$$r_{i\ (crypto)} = r_{i\ (fiat)}{}^{average} + \beta_1 \sigma\ (E_T^{e\ 0}\left(\frac{fiat}{crypto}\right)_i) + \beta_2 T_i + \epsilon_i$$

Where T_i represents the time to maturity of security and $\sigma\ (E_T^{e\ 0}\left(\frac{fiat}{crypto}\right)_i)$ represents the volatility of uncertainty of the expected exchange rate at the settlement time of the security.[191]

[191] This model has not been proven to work, it is just based on intuition

Overall, there are several econometric models that could force an estimate of $Premium_{cryptos}$. Some of these revolve around the discussion of log returns' modelling for the underlying cryptocurrency.[192]

3.3.2 Estimation of unexpected exchange rates' differences

The unexpected exchange rate differences measure the extent to which the cost of capital is exposed to the underlying cryptocurrency. If at a specific date the company is supposed to pay a certain amount of cryptocurrency to a crypto bond holder, then that certain amount was computed on the bases of the expected exchange rate for that date at inception. If there is a difference between the expected exchange rate and the realized one, then the company is exposed to the risk of paying more than it was planned. This affects the estimates of cost of debt and, therefore, the cost of capital. If the company, however, is supposed to receive an amount of crypto at that same date, then its exposure is reduced to some extent. This is included in the formula for the crypto risk premium as:

$$CRP_{firm} = Premium_{cryptos} + \frac{\Delta E_i^{unexpected}}{Z_{i-1}} f\left(ipay_{i\,(crypto)_i}^{e\,0} - ireceive_{i\,crypto}^{expected} - W_i, \forall\, i \in set(A)\right)$$

The unexpected exchange rate can be rearranged in the following way:

$$unexpected\ \Delta E_i = \ {E^{e\,0}}_{expected\ at\ i}\left(\frac{fiat}{crypto}\right) - E_{realised\ at\ i}(\frac{fiat}{crypto})$$

Assuming continuous compounding of the returns on cryptocurrencies:

$$E_i = e^{r_i} E_{i-1}$$

$$E_i = \prod_{j=0}^{i-1} e^{r_{i-j}}\ E_0$$

$$unexpected\ \Delta E_i = \left[\prod_{j=0}^{i-1} e^{r_{i-j}^{realised}} - \prod_{j=0}^{i-1} e^{r_{i-j}^{expected}}\right] E_0$$

[192] See 3.3.2.1: modelling of log returns

By using Tailor's expansion[193] we can substitute $E_i = \prod_{j=0}^{i-1} e^{r_{i-j}} \; E_0$ into a function of its logarithm to demonstrate that :

$$\ln{(E_i)} = \ln{(\prod_{j=0}^{i-1} e^{r_{i-j}} \; E_0)}$$

through Taylor's approximation:

$$\ln(E_i) = \ln(\,E_0) + \sum_{j=0}^{i-1} r_{i-j}$$

So that:

$$E_i = (E_0) \; e^{\sum_{j=0}^{i-1} r_{i-j}}$$

And

$$unexpected \; \Delta E_i = E_0 \left[e^{\sum_{j=0}^{i-1} r_{i-j}(realised)} - e^{\sum_{j=0}^{i-1} r_{i-j}(expected)} \right]$$

Since $e^{\sum_{j=0}^{i-1} r_{i-j}(realised)}$ for future forecasts is not known because the realized log return rates are unknown, we can approximate worst-cases scenarios through VaR, ES and MS functions and the returns estimates.

$$unexpected \; \Delta E_i = E_0 \left[e^{\sum_{j=0}^{i-1} VaR_{\alpha}(r_{i-j})} - e^{\sum_{j=0}^{i-1} VaR_{\beta}(r_{i-j})} \right]$$

Where α, β are arbitrary percentages which indicate a percentile of the distribution of the returns.[194]

Beta, β, is set so that the increases in exchange rate were the increases expected on which the pricing of the crypto securities were based. α is set so that it provides a potentially "bad" scenario for different end exchange rate value.

Therefore, in order to estimate these values, we need estimates and modelling of:

- Log returns
- VaR, ES, MS applied to log returns models

[193] See: Engsted, T., Pedersen, T. Q., & Tanggaard, C. (2011). The log-linear RETURN Approximation, bubbles, and predictability. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1655265

[194] See 3.3.2.2: VaR, MS and ES for cryptocurrencies' returns

The literature has found several ways to estimate future log returns of underlying cryptocurrencies.

A history of using these measures on cryptocurrency returns is in place.[195]

3.3.2.1 Estimation of log returns on cryptocurrencies

The modelling of the $unexpected\ \Delta E_i$ begins with the modelling of its return components:

Since $unexpected\ \Delta E_i = E_0\left[e^{\sum_{j=0}^{i-1} VaR_\alpha(r_{i-j})} - e^{\sum_{j=0}^{i-1} VaR_\beta(r_{i-j})}\right]$. A modelling of $e^{\sum_{j=0}^{i-1} VaR(r_{i-j})}$components is needed.

Historically, in comparison to more traditional assets, daily log returns of cryptocurrency denominated assets have been found to show very high differences between maximal and minimal values over one year, regardless of the year. Yearly standard deviations are higher than any other type of asset or security in any market, even higher lowest rated securities' markets.

However, log returns have been found to follow a trend. First of all, analyses show that testing for the zero average returns provide p-values that are significant (larger than 0.05) thus making the hypothesis that in the long run average returns then to zero, non-rejectable.

The distribution of log returns generally have fatter tails (higher kurtosis) and more positive skewness than the normal distribution. Because of this, they have been compared to most commonly used fat tails distributions (such as the Pareto, The Burr, the Weibull, The Fletchell, The T-distribution, The Lognormal and the Cauchy)[196]. Results from fit tests show that at the 5% significance level, the Cauchy and the T-distribution have been found to be a fit for the daily log returns distribution with the T-distribution being the best fit according to AIC/BIC and KS tests[197].

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[195] See right below

[196] Source: Grant, Gerry, and Robert Hogan. "Bitcoin: Risks and Controls." *Journal of Corporate Accounting & Finance*, vol. 26, no. 5, 2015, pp. 29–35., doi:10.1002/jcaf.22060.

[197] The Akaike Information Criterion, Bayesian information criterion and Kolmogorov-Smirnov are metrics used to test the goodness of fit of a distribution to a statistical model. AIC and BIC test for parametric fits, with the BIC being less lenient on additional free parameters. The KS test is non-parametric test that verifies distributional shapes. Source: *Akaike information criterion*. Akaike Information Criterion - an overview | ScienceDirect Topics. (n.d.). https://www.sciencedirect.com/topics/medicine-and-dentistry/akaike-information-criterion.

Trends within the log returns movements have been confirmed as null hypotheses stating that the time series were not stationary have all been rejected at the 5% significance level.[198]

For some cryptos such as Ethereum and Monero, hypotheses for weakly stationary time series have also been rejected, implying stronger perceivable trends. Regardless, daily log returns (time series) for all cryptos have been found to be mean reverting to zero and show clear signs of volatility clustering[199].

Despite the fact that we can assume that log returns follow a T-distribution with a mean reverting to 0 stationary process, the volatile behavior is quite different.

When in 2018 futures on Bitcoin started to trade on exchanges, the volatility dropped significantly, but its nature seems to be volatile on itself. Bitcoin, specifically, has been found to exhibit periods where the abnormal log returns (large and small) were coming together, in other words, periods where the volatility skyrocketed in a phenomenon called volatility clustering[200]. Due to this, models that strive to fit the log returns trends need to account for this very sensitive periods as well.

Most commonly, literature surrounding the study of the returns and the volatilities of Bitcoin has based its intuitions on the distributional behavior discussed above. In particular the fact that the daily log returns seem to follow a T-distribution and a mean reverting to 0 stationary process. The fact that there are clear signs of volatility clustering, moreover, indicated that, while the log returns could fit an ARMA, the volatility behavior could fit a GARCH process[201]. As the historical sample autocorrelation and partial autocorrelation functions confirmed volatility clustering, the GARCH process fit to the variance has been found to be (to a satisfactory significance level for most estimators) of the following nature:

$$\sigma_t^2 = \omega + \sum_{i=1}^{p2} \gamma_i \sigma_{t-i}^2 + \sum_{i=1}^{q2} \varphi_i \epsilon_{t-i}^2$$

Where the residuals $\epsilon_t = Z_t \sigma_t$ is generated here and cannot be predicted by the ARMA; Z_t being a noise term $Z_t \sim t(v)$ and following a student T distribution.

The mean model predicted through the ARMA is described as :

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[198] Source: Jo, Hoje, et al. "Bitcoin and Sentiment." *SSRN Electronic Journal*, 2018, doi:10.2139/ssrn.3230572.

[199] Volatility clustering refers to periods where daily returns would reach extreme peaks both downward and upward.
[200] See : Jo, Hoje, et al. "Bitcoin and Sentiment." *SSRN Electronic Journal*, 2018, doi:10.2139/ssrn.3230572.

[201] see: Jiménez, Inés, et al. "Risk Quantification and Validation for Bitcoin." June 2020

$$r_t = c + \sum_{i=1}^{p1} \vartheta_i r_{t-i} + \sum_{i=1}^{q1} \theta_i \epsilon_{t-i} + \epsilon_t$$

With both the autoregressive coefficient (AR) θ_i and the moving average coefficient (MA) ϑ_i found to be statistically different from zero within the scope of the whole model ARMA-GARCH.

For the purposes of this paper, it suffices to say that nowadays this is model has been found to be one of the most accurate in predicting volatility and returns oscillation (up to 100 days) and it has sustained Ljunx-Box and Arch LM[202] tests on the residuals revealing high reliability.

Many other models for estimations of returns and risks have been offered by the literature.

The second order moments (volatility) of the returns in economic and financial time series have historically been forecasted and modeled through the use of GARCH models as the one specified above. Although the mentioned above model seems to explain to a satisfactory extent the fluctuations, other models have been tested throughout the years to see whether they would be a better fit.

The GARCH-MIDAS models see the conditional variance decomposed into a short run component and a long one. These components behave differently: the short one evolves as a GARCH (1,1) while the long-term component is shaped by past values of realized volatilities.[203]

The realized GARCH model is based on assumptions of weak form efficiency of the market[204]. and sees the squared returns component replaced by the actual realized returns.

The GAS models (generalized autoregressive score) see the evolution of the volatility not only depend on its own past values but on the complete gaussian density of the distribution considering not only the second order moments but higher ones and shaping a more comprehensive and dynamic behavior. [205]

In a 2019 study by Carlos Trucios[206], the mentioned above models have been tested using parameters such as MSE, QLIKE, RLF values[207]. His results showed how, in every single case, the robust GARCH models

[202] See: Sjölander, P. (2010). A stationary UNBIASED finite SAMPLE ARCH-LM test procedure. *Applied Economics*, *43*(8), 1019–1033. https://doi.org/10.1080/00036840802600046

[203] See : Dash, Mihir. "Analysis of Bitcoin Returns Volatility Using AR-GARCH Modelling." 2020, doi:10.31124/advance.12124383.v1.

[204] Prices reflect all available past information

[205] Involves the use of skewness and kurtosis of the log returns' distribution in the time series modelling

[206] See Trucíos Maza, Carlos César, et al. "Value-at-Risk and Expected Shortfall in Cryptocurrencies' Portfolio: A Vine Copula-Based Approach." *SSRN Electronic Journal*, 2019, doi:10.2139/ssrn.3441892.

[207] See: Truccos Maza, Carlos CCsar. "Forecasting Bitcoin Risk Measures: A Robust Approach." *SSRN Electronic Journal*, 2018, doi:10.2139/ssrn.3189446.

mentioned above (GARCH-MIDAS and Realized GARCH) were always outperforming both the non-robust models and the traditional Gaussian GARCH for estimations of volatilities, further confirming the idea that outliers are important and must be considered when shaping a model.

The author, in fact, further emphasizes that in a bitcoin risk measure context, outliers must be accounted for through robust models in multivariate frameworks. Further confirmation of the models' reliability was achieved through the 1% VaR back testing[208]. The non-robust models have been found to underestimate the VaR. VaR is, in short, a high quantile of the distribution of losses for an investment.

Further considerations about the market can be derived from the studies by Dimitrios Koutmos[209] in May 2019 on market risks and bitcoin returns and by Antonios Kalyvas et al.[210] in June 2019 on price crash risks. In Dimitrios's paper the author assumes that, although Bitcoin price volatility does not seem to be influenced by the returns in aggregate market portfolios, the market for the crypto must be affected by the other asset pricing risk factors that are present in the general economy such as implied stock market, foreign exchange market volatilities and interest rates. In order to shape a model that accounts for such factors, he uses seven proxies: the US total market price index, the CBOE volatility index, the default spread, the relative 3 months treasury bill rates, the term spread, the inflation expectations, and the Deutsche bank FX volatility index. His findings show that the volatility of the crypto market has a strong positive correlation with the US total market index (CRSP) and strong negative correlations with the term spread proxy, the volatility index (CBOE), the FX volatility index and the default spread proxy. This study has strong implications on the nature of bitcoin market and other cryptos' markets, as it has been shown how there is a range of idiosyncratic risk factors that, other than operating in the greater economy, have specific impact here and are not considered by time series models and multivariate time series models that have been constructed by the literature. Moreover, the study underlines how foreign exchange volatility has a very strong impact on Bitcoin during high volatility regimes (A.K.A volatility clusters). This latest point implies considerable spillover related risks.

Antonios Kalyvas et. Al on Bitcoin's price crash risk further underlined the negative and significance relationship between general economic uncertainty and price crash probability of Bitcoin. In this paper it has been found that investors' behavioral factors observed in the greater economy do not have strong

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[208] See [61]

[209] Koutmos, Dimitrios. "Market Risk and Bitcoin Returns." *Annals of Operations Research*, vol. 294, no. 1-2, 2019, pp. 453–477., doi:10.1007/s10479-019-03255-6.

[210] Kalyvas, Antonios Nikolaos, et al. "What Drives Bitcoin's Price Crash Risk?" *SSRN Electronic Journal*, 2019, doi:10.2139/ssrn.3474550.

implications for the performance of cryptos' markets except for periods of high uncertainty in the underlying economy. Investors, often, are found to resort to cryptocurrencies securities in order to hedge during periods of high volatility in the stock and bond markets. Thus, although direct correlations between log returns of Bitcoins and other returns on the general market do not exist at significant levels, there are considerable quantifiable risks and effects derived from the underling economy, one of which is the spillover risk.

In a study by Toan Luu Duc Huynh[211] on spillover risks in crypto markets, there can be found confirmation that Bitcoin tends to be the recipient of spillover effects from the general markets and from other crypto markets, often in negatively correlated factors. Ethereum, however has been found to be quite independent, thus the author tested for contagion effects among cryptocurrencies using Student's T Copulas for joint distributions. The results suggesting that the extent of contagion risks increased the probability of joint extreme values of returns, implies that past and present value changes in cryptos do affect other cryptos and that Bitcoin seems to be the recipient of negative changes while Ethereum can be used as a hedge in this market, given its high degree of independency.

For the purposes of modelling $e^{\sum_{j=0}^{i-1} VaR(r_{i-j})}$ the following procedure should follow:

1. Analyze the behavioral distribution of the underlying cryptocurrency's log returns
2. Choose either a parametric or a non-parametric approach
3. Evaluate which kind of time series should be applied on the bases of the literature (such as the one cited above)
4. Employ back-testing techniques for reliability assessment
5. Implement VaR, ES or MS to select the boundaries of excess returns

3.3.3.2 VaR, ES and MS for cryptocurrency returns

Once a model for the estimation of returns of the underlying at each date has been implemented, it is necessary to implement VaR or similar tools for the estimation of the unexpected excesses:

[211] Huynh, Toan Luu Duc. "Spillover Risks on Cryptocurrency Markets: A Look from VAR-SVAR Granger Causality and Student's-t Copulas." 1 Apr. 2019.

$$unexpected\ \Delta E_i = E_0 \left[e^{\sum_{j=0}^{i-1} VaR_\alpha(r_{i-j})} - e^{\sum_{j=0}^{i-1} VaR_\beta(r_{i-j})} \right]$$

A 99% or a 95% confidence interval VaR requirement selects the daily (ordered) log return (loss) that coincides with the percentile given by the confidence level. The Basel Committee has recently proposed a new measure to assess risk that would replace this. VaR has been found to not capture to a satisfactory extent tail risk for distribution of losses that present high kurtosis (such as bitcoin). In its place, Expected Shortfall (ES) was proposed and defined as the average loss when the VaR is exceeded.[212]

Fantazzini et al.[213] in their paper developed a multivariate time series model to estimate simultaneously both market and credit risk for a cryptos portfolio. The market risk was estimated through VaR and ES measures[214]. The credit risk was estimated through the probability of default of the crypto in question, or the probability that it would be deemed dead academically or professionally. The proposed ZPP model contributes to the literature that studies market-implied credit risk measures of cryptocurrencies and is of interest to online data providers who strive to publish quotes of such risks. Though a model that shapes market and credit risk has seemingly been found for cryptos, the output it provides is expressed in terms of VaR exceedances and ES back tests, which are measures that have been found to either not consider high tails enough (VaR) or be too sensible to outliers (ES).

ES is extremely sensible to events that cause drops in value for the underlying (and thus returns) and when applied to risk models such as the ones mentioned above, could prove misleading as it strives to mitigate potential losses. Ines Jimenez et. Al[215] in a paper published on June 2020 proposes a new measure other than VaR and ES that would be more accurate and robust for bitcoin risk assessments. The proposed measure, the Median Shortfall (MS), considers the problems stemmed by the use of the VaR (high tail risk) while being less sensitive to shocks unlike ES which is an average. In order to show the application and validation of such measure, the author employs a semi-nonparametric approach to model Bitcoin's log return distribution, employs back testing techniques for risk assessment to then compare its MS findings with VaR and ES findings. He then concludes that MS is a valuable measure when applied along the others.

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[212] Liu, Wei, et al. "Forecasting Value-at-Risk of Cryptocurrencies with RiskMetrics Type Models." 17 Feb. 2020.

[213] See Fantazzini, Dean, and Stephan Zimin. "A Multivariate Approach for the Simultaneous Modelling of Market Risk and Credit Risk for Cryptocurrencies." *Journal of Industrial and Business Economics*, vol. 47, no. 1, 2019, pp. 19–69., doi:10.1007/s40812-019-00136-8.

[214] i.e., the minimum loss of a percentile of a distribution of potential losses that an investor can expect and the average of the losses in the same percentile.

[215] Jiménez, Inés, et al. "Risk Quantification and Validation for Bitcoin." June 2020.

He also argues that his employed SNP model[216] seems to perform better than traditional robust GARCH and GAS, but this is arguably the case.

Congruent to the modelling process listed above, the last two steps require:

5. Choose MS, VaR, or ES on the bases of their limitations
6. Choose α, β percentiles to express the confidence levels in function of the excesses:

$$unexpected\ \Delta E_i = E_0 \left[e^{\sum_{j=0}^{i-1} VaR_\alpha(r_{i-j})} - e^{\sum_{j=0}^{i-1} VaR_\beta(r_{i-j})} \right]$$

Such that $e^{\sum_{j=0}^{i-1} VaR_\beta(r_{i-j})}$ is the expected increase in exchange rate on which obligations' pricing processes were based and $e^{\sum_{j=0}^{i-1} VaR_\alpha(r_{i-j})}$ is a potential scenario in which the increase is different to some extent.

3.4 Cost of capital for Omega: a numerical example

3.4.1 Numerical example assumptions

Note that this example is not based on real data. Its purpose is to illustrate the model discussed in this chapter and to provide a potential example of its use. Because of the problems discussed in Chapter 1 and in this chapter, data nowadays are either unavailable or construct statistically insignificant samples. Moreover, this example starts with assumptions over general estimates and the ways they have been found. This is because, other than the data, there are multiple ways to model variables such as daily log returns of cryptocurrencies. This example does not provide any form of reliability for the model, rather tries to instruct on its application so that an interested user might follow the model in a clearer way.

3.4.1.1 Assumption : Company Omega

Assumptions 1-3 of the "general assumptions" [217]at the beginning of the chapter state:

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[216] Semi-non Parametric Model: see[70]

[217] See 3.0.2: general assumptions

1. Blockchain is introduced in a firm which is public and in the "going concern" phase
2. Blockchain is introduced at all levels to different extents and with a mix of every product discussed in chapter 1
3. It is possible to recognize amounts of debt, equity and assets that are on blockchain and that are floating with cryptos

We are assuming also that crypto products are introduced in investing, operating, and financing activities. Let us assume that we have a profile of the company in question and let us call it Company Omega.

Company Omega is an enterprise that operates in the medical equipment sector, it produces semiconductors and high-tech equipment that contributes to the value chain for machines that are employed in medical research, hospitals, and private medical institutions. Other than the B2B component, the company also sells directly to private consumers respiratory machines and other smaller scale end customer products. It has been in the going-concern phase for almost 25 years.

Omega has recently started to transact with both suppliers and customers on Ethereum blockchain, whenever its leased or sold machines need maintenance and whenever smaller components are sold, Omega employs the Ethereum blockchain for transactions. Omega has started to do this in order to decrease bookkeeping recording costs, transaction costs and human errors [218]when dealing with smaller payments both to and from other businesses. The employed blockchain also services the company in the timings of required services: some products (machines) directly request maintenance and place orders on the components ahead of time. This results in a higher coordination throughout the value chain that decreases overall administrative costs because it removes the managers' supervision to some extent.

This big enterprise holds powerful expertise in its risk management division that is able to hedge many risks regarding the timings of cash flows and the fluctuations of the underlying cryptocurrency that we assume to be Ethereum.

In the operating side of things, Omega records cryptocurrency denominated items by quoting their USD$ value and these are mixed with other non-crypto items. Crypto denominated items are present in the balance sheet under the following categories : "intangible fixed assets", "financial fixed assets and other non-current financial assets, in the working capital requirements under "inventories, payables and receivables" and under "provisions for risks and charges". The items can be found mixed with other fiat money denominated assets under the highlighted categories in Fig. 3.1

[218] See the benefits of blockchain in Chapter 1: introduction to blockchain

CATEGORIES	Crypto presence
Software, licences, other intangible fixed assets, fixed assets in progress and advances	x
Tangible assets(since 2020 non-current operating assets)	
Financial fixed assets (since 2020 non-current financial assets)	x
Other non-current financial assets	x
Non-current assets	
Inventories	x
Trade receivables	x
Other receivables	x
Current assets (A)	
Operating assets	
Trade payables	x
Other payables (2)	x
Provisions for risks and charges (current portion)	x

Table 3.1: The net working capital section of a fictitious balance sheet for Omega. The highlighted sections contain crypto financial products, their prices are quoted in USD by using Exchange rates quoted by major cryptocurrency exchanges. Source: the author.

The cryptos under "intangibles f.a." comprise a secondary Ethereum wallet that the firm holds for liquidity purposes. The ones under "financial fixed assets" are crypto securities denominated in Ethereum that the firm holds for hedging purposes. While the crypto items under receivables, payables, and inventories, are due to the transactions with other players in the value chain for the purposes mentioned above. Provisions for risks and charges also comprise the impairments of said items. [219]

Overall, the balance sheets (as well as the income statements) published to the general stakeholders do not differentiate between crypto assets and fiat denominated assets. [220]

CATEGORIES	Crypto presence
Net working capital (A) - (B)	
Derivative instruments (3)	x
Deferred tax assets	o
Deferred tax liabilities	o
Provisions for risks and charges (non-current portion)	x
Liabilities for employees' benefits (non-current portion)	
Loan fees (4)	
Other non-current payables(since 2020 non-current payables)	x

Table 3.2: liabilities of Omega. The highlighted sections show where the crypto financial products could be. Source: the author

[219] See Chapter 1: corporate reporting of financial products on blockchain
[220] See [27]

Furthermore, Company Omega holds some crypto derivative instruments (fig.3.2) for hedging purposes recorded in the log-term section of the balance sheet, these may also affect deferred taxes.[221]

Company Omega has also undergone an ICO to raise capital 5 years ago and the proceeds on Ethereum blockchain have not been entirely converted to USD$. The financing yielded an Ethereum wallet that was created from the emission of utility tokens. Omega has also issued crypto Ethereum bonds, futures, forwards, and options on Ethereum. These obligations are recorded along other fiat denominated obligations under "Net medium and long-term financial indebtedness" and under "Net short-term financial indebtedness" (depending on the time to maturity) in the balance sheet as shown by the highlighted categories in fig.3.3.

CATEGORIES	Crypto presence
NET INVESTED CAPITAL	
Group net equity	
Minority interests	
Total net equity	
Net medium and long-term financial indebtedness (4)	x
Net short-term financial indebtedness (4)	x
Total net financial indebtedness	
Lease liabilities	
Total Lease liabilities & net financial debt	
OWN FUNDS AND NET FINANCIAL INDEBTEDNESS	

Table 3.3 section of Omega's balance sheet the highlighted sections shows where issued crypto financial products could be recorded.

CATEGORIES	Crypto presence
Revenues from sales and services	x
Operating costs	x
Other costs and revenues	x
Gross operating profit (EBITDA)	

Table 3.4: portion of Omega Income statement: some of the revenues and costs of omega have been realized on blockchain through cryptocurrencies, they are quoted in USD at the exchange time. This shows the involvement of crypto products into the operating activities. Source: the author.

[221] See Chapter 2: summary of the impact of blockchain on cost of capital

Omega record some revenues from proceeds undergone in cryptos by quoting the value at the time of exchange events[222]. This affects the following categories: Revenues, costs, depreciations (shown in fig.3.4), Amortizations, impairments, Exchange differences and non-hedge accounting instruments, interest expenses, as well as profits (losses) (fig.3.5).

While the crypto portion of revenues and costs derive from the activities conducted with suppliers and customers, when it comes to depreciations, amortizations and the rest, the crypto portion of said items refers to the crypto portion of other items in the balance sheet.

In particular, Depreciations of cryptos refer to the wallet of cryptos under "financial fixed assets" and "other non-current financial assets". Amortizations and impairments, refer (partly) respectively to the cryptos that fall under "intangibles" and to the cryptos that are classified under "derivative instruments".

Exchange differences and non-hedge accounting instruments refers partly to the exchanges of cryptos[223]. Total interest expenses also include the payments linked to the security tokens and the Ethereum bonds.

CATEGORIES	Crypto presence
Depreciation and write-downs of non-current assets	
Amortization and impairment of trademarks, customer lists, lease rights and non-competition agreements and goodwill	x
Total Depreciation	
Operating profit (EBIT)	
Income, expenses, valuation and adjustments of financial assets	
Net financial expenses	
Exchange differences and non-hedge accounting instruments	x
Total Interest expenses	
Profit (loss) before tax **(EBT)**	
Tax	
Net profit (loss)	
Profit (loss) of minority interests	x
Net profit (loss) attributable to the Group	

Table 3.5 portion of Omega Income statement: the highlighted sections also include the expenses due to crypto financial products. Source: The Author

Overall, the way these financial reports are presented suggest no traceability of cash flows connected to cryptos. And that is the case for most companies when they construct annual or quarterly financial reports. Therefore, for the purposes of a numerical example, we make strong assumptions.

[222] If omega collects an X amount of Ethereum and exchanges that amount for dollars 1 hour later, when the exchange rate has changed since the collection period, the revenue will be recorded as the fiat value at the time of the exchange.
[223] The concerned part refers to the exchanges from the wallet of raw Ethereum general platform cryptocurrency.

We make the following assumptions to circumvent complications in the estimation of crypto impact on cost of capital:

1. Omega can provide detailed data on the amounts of cryptocurrency involved under any category of the Balance sheet
2. Omega can provide both the crypto amounts and the fiat value
3. Omega can provide the details of its crypto holdings' performances recorded under revaluations, amortizations, losses due impairments, gains etc.… under the income statement
4. Omega can provide the value of the crypto interests paid on issued crypto securities and the outstanding crypto debt
5. Time frame and amounts of all related crypto installments for Omega are given
6. We assume that future holdings of cryptocurrencies, and crypto financial products are decided based on external company policy

3.4.2 The blockchain risk premium for Omega

Let us suppose that Omega has issued, in the past, fiat denominated financial products on blockchain. Let us suppose that the price that these products had at inception made it so:

$$YTM_{security\ on\ blockchain} = f\left(YTM_{s(firm'securities\ not\ on\ blockchain)}\right) + BRP$$

We can, therefore, estimate Omega's BRP from the difference between the average of YTMs of Omega's issued products on blockchain and the YTMs of its other issued products at inception.[224]

Let us suppose that the $BRP = 0.014$ is statistically significant and is not extremely volatile.

3.4.3 Current Premium on crypto

The $Premium_{cryptos}$ defines the difference between the yields of a company's offered products on blockchain and the yields of their cryptos' issued products at inception. [225]

[224] See Chapter 3: the blockchain risk premium
[225] See Chapter 3: assumptions on the pricing of crypto products

$$
\begin{aligned}
YTMs_{crypto\ obligations} \\
&= YTMs_{blockchain} \\
&+ f\left(E_T^{e\ 0}\left(\frac{fiat}{crypto}\right)_{at\ different\ Ts}, Maturities_{products}, Risks_{cryptocurrencies}\right) \\
&= YTMs_{blockchain} + Premium_{cryptos}
\end{aligned}
$$

The current premium on crypto at the time of Omega's analysis is found by looking at the average difference between other companies' YTMs of products issued on blockchain and their issued crypto products averages. Table.3.6 shows the procedure. Firstly, the average YTMs of blockchain products are computed for each company, then their average YTMs of their crypto products are computed. Finally, the average of their differences is an estimate for the premium on crypto.[226]

Company	Average YTM of products on blockchain	Average YTM of crypto products
alpha	0.090	0.100
beta	0.110	0.170
gamma	0.100	0.170
z	0.100	0.150
f	0.120	0.130
fff	0.100	0.130
t	0.090	0.100
re	0.110	0.150
ded	0.100	0.160
lll	0.100	0.120
res	0.100	0.170
sap	0.110	0.130
call	0.110	0.170
bat	0.100	0.150
fif	0.120	0.180
sent	0.090	0.160
zeta	0.110	0.120
sigma	0.120	0.160
rarara	0.120	0.170
sant	0.110	0.130

Table 3.6: simulation of data for the estimate of the current premium on crypto. Source: the author

By subtracting the right column from the left column and averaging the results, we find that the current $Premium_{cryptos} = 0.03372$. Note that, as of 2021, it is very difficult to gather the YTMs at inception of

[226] See Chapter 3: estimation of the premium on crypto

products for each company involved with cryptos. Note also that the crypto YTMs have been computed based on future crypto prices' expectations.

3.4.4 Modelling of Omega's sensible excesses

Omega's sensible excesses refer to the set of $unexpected\ \Delta E_i$ such that they determine excess interest payments and excess returns on holdings of crypto assets[227].

$$unexpected\ \Delta E_i = E_0\left[e^{\sum_{j=0}^{i-1} VaR_\alpha(r_{i-j})} - e^{\sum_{j=0}^{i-1} VaR_\beta(r_{i-j})}\right]$$

We assume that Omega has modelled the periodic (daily) log returns of the underlying cryptocurrency (Ethereum)[228] by using an ARMA-GARCH-MIDAS model. [229] Each return at each date has a volatility and a distribution which shapes its possible values. Fig.3.7 on the left columns show the expected daily log returns and their volatilities according to the ARMA-GARCH-MIDAS model. For the sakes of simplicity, let us assume that the expected values are always 0.005.

periods	E (log return)	σ	VaR α	VaR β	E(α)	E(β)	ΔE
1	0.005	0.0020000	0.0060000	0.0054444	24000.0000000	23999.9994444	0.0005556
2	0.005	0.0020200	0.0060100	0.0054489	24144.6743108	24131.1297074	13.5446034
3	0.005	0.0020402	0.0060201	0.0054534	24290.4660648	24263.0853489	27.3807159
4	0.005	0.0020606	0.0060303	0.0054579	24437.3874314	24395.8731652	41.5142662
5	0.005	0.0020812	0.0060406	0.0054625	24585.4507577	24529.5000303	55.9507274
6	0.005	0.0021020	0.0060510	0.0054671	24734.6685712	24663.9728964	70.6956748
7	0.005	0.0021230	0.0060615	0.0054718	24885.0535836	24799.2987957	85.7547879
8	0.005	0.0021443	0.0060721	0.0054765	25036.6186935	24935.4848410	101.1338524
9	0.005	0.0021657	0.0060829	0.0054813	25189.3769898	25072.5382274	116.8387624
10	0.005	0.0021874	0.0060937	0.0054861	25343.3417554	25210.4662329	132.8755224
11	0.005	0.0022092	0.0061046	0.0054909	25498.5264703	25349.2762203	149.2502499
12	0.005	0.0022313	0.0061157	0.0054959	25654.9448153	25488.9756380	165.9691773
13	0.005	0.0022537	0.0061268	0.0055008	25812.6106757	25629.5720213	183.0386545
14	0.005	0.0022762	0.0061381	0.0055058	25971.5381447	25771.0729938	200.4651509
15	0.005	0.0022989	0.0061495	0.0055109	26131.7415272	25913.4862689	218.2552583

Table 3.7: Omega's sensible excesses exchange rates derivation. Each period shows the expected log return, its expected standard deviation and 2 different VaR values for its distribution. E(alpha) and E(beta) are computed on E(0) and the VaRs[230]. Their difference is shown in the last column.

[227] See Chapter 3: VaR, ES,MS applied to log returns
[228] See Chapter 3: assumptions on the company: Omega
[229] See above: 3.3.3.1
[230] See [75]

The volatilities influence the distributions of these returns at each date. Let us assume that Omega has chosen the VaR method of estimating the sensible returns at each date with arbitrary α , β that suit the company's needs in assessing probabilities of excesses. Fig.3.7 returns, on the columns in the middle, the VaR values at each date; also known, as the values of the return at specifics percentiles of their distribution, determined by α , β. Omega has chosen $\alpha = 25\% , \beta = 75\%$. So that $VaR(100\% - \alpha) , VaR(100\% - \beta)$ are constructed for each date.

Omega has then computed the expected alpha (High) Exchange rate and the expected beta (low) Exchange rate at each date. Then their difference to find the set of $unexpected\ \Delta E_i$ at the dates of interest. Let us assume that the price of Ethereum in USD is $E_0 = 24000$.

3.4.5 Omega's CRP

The Crypto risk premium is defined as[231]:

$$CRP_{firm} = Premium_{cryptos} + \frac{\Delta E_i^{unexpected}}{Z_{i-1}} f\left(ipay_{i\,(crypto)_i}^{e\,0} - ireceive_{i\,crypto}^{expected} - W_i, \forall\, i \in set(A)\right)$$

Let us assume that Omega will already know for a set of dates of interest all the activities that it will conduct that include crypto products (fig.3.8). It includes both investments, operations, and financing.

Let us assume that Omega's policies determine the amounts of holdings, crypto capital, and crypto wallet: H_i, C_i, W_i. In fig.3.9. note that $H_i + C_i = Z_i$. (Denominated in fiat).

Note that these data are not possible to gather in common enterprises by looking at periodic financial reports. We are assuming that Omega has clear crypto budgeting policies and forecasts. Holdings of crypto assets can fall under the categories of assets specified above. Their value is calculated subsequently to revaluations, amortizations and impairments registered. [232]

"Ireceive" refers to the interests the company is supposed to receive from investments in crypto financial products. "Ipay" refers to the (crytpo (Ethereum) table3.8) amounts that it is supposed to pay to debt holders

[231] See Chapter 3: The cost of crypto capital
[232] See Chapter 3: assumptions on the company: Omega

at certain periods (in Ethereum). The wallet refers to the amount of Ethereum that the company holds for operating and emergency activities.[233]

Note that if the company issues a crypto security, the proceeds do not go necessarily in the crypto wallet. They can be translated into fiat currency.

Omega				
Crypto activities				
		Denominated in crypto		
Periods		Ireceive	Ipay	wallet
32		2.0	4.0	1.0
31		2.0	4.0	0.8
30		0.0	4.0	0.7
29		2.0	4.0	0.1
28	Payment of crypto future	2.0	7.0	0.0
27		0.0	4.0	0.6
26	Acquisition of crypto option	2.0	4.0	0.8
25		2.0	4.0	0.7
24		2.0	4.0	0.7
23	Principal reward	0.7	4.0	0.7
22		0.3	4.0	0.6
21		0.0	4.0	0.7
20	Principal payment crypto bond	0.3	7.0	1.0
19		0.1	6.0	1.8
18		0.1	6.0	1.5
17	Acquisition of crypto bonds	0.1	6.0	1.3
16		0.1	6.0	1.0
15	issuance of crypto bonds	0.0	6.0	1.0
14		0.1	5.0	1.0
13		0.0	5.0	0.6
12		0.1	5.0	0.8
11	Start of coupon receivables	0.1	5.0	1.0
10		0.0	5.0	1.0
9	Start of deferred coupon payments	0.0	5.0	1.0
8		0.0	3.0	1.2
7	Acquisition of crypto bonds	0.0	3.0	1.2
6		0.0	3.0	1.9
5	Acquisition of Ethereum	0.0	3.0	1.9
4		0.0	3.0	1.4
3	issuance of crypto futures	0.0	3.0	1.4
2		0.0	3.0	1.2
1	issuance of crypto bonds	0.0	0.0	1.2

Table 3.8: Omega's future crypto activities. Source: the author

[233] See Chapter 3: the cost of crypto capital

For each period Omega provides a forecast of the holdings of Ethereum (table3.9). The holdings of Ethereum products comprise all assets denominated in Ethereum and the Ethereum wallet itself. The crypto capital, the amount that Omega has raised through crypto assets, depends on their financing activities (table 3.8).

crypto		ΔE (α-β)	E (α)	fiat	
Holdings	Crypto Capital	rate	rate (α)	holdings	crypto capital
2.0	10	1762.39931	28642.29517	85926.88552	286422.95175
1.8	10	1714.39883	28482.03088	74053.28028	284820.30878
1.7	10	1667.32175	28322.83468	67974.80324	283228.34682
1.1	10	1621.15060	28164.69701	33797.63641	281646.97008
1.0	10	1575.86825	28007.60840	28007.60840	280076.08397
1.6	12	1531.45792	27851.55950	61273.43090	334218.71402
1.8	12	1487.90317	27696.54109	72011.00684	332358.49312
2.7	12	1445.18789	27542.54405	93644.64978	330510.52862
2.7	12	1403.29627	27389.55937	93124.50186	328674.71243
2.7	12	1362.21286	27237.57815	92607.76570	326850.93776
3.0	12	1321.92248	27086.59159	97511.72973	325039.09910
3.1	12	1282.41027	26936.59102	102359.04587	323239.09222
3.4	18	1243.66166	26787.56784	117865.29851	482176.22118
4.2	18	1205.66236	26639.51359	159837.08152	479511.24456
3.9	18	1168.39839	26492.41987	143059.06730	476863.55766
3.7	18	1131.85601	26346.27841	131731.39207	474233.01145
2.4	18	1096.02179	26201.08104	89083.67552	471619.45864
2.4	18	1060.88253	26056.81965	88593.18681	469022.75371
2.4	14	1026.42531	25913.48627	88105.85331	362788.80777
2.0	14	992.63745	25771.07299	67004.78978	360795.02191
2.2	14	959.50653	25629.57202	76888.71606	358814.00830
2.4	14	927.02037	25488.97564	86662.51717	356845.65893
2.4	14	895.16701	25349.27622	86187.53915	354889.86708
2.4	14	863.93476	25210.46623	85715.58519	352946.52726
2.6	14	833.31212	25072.53823	95275.64526	351015.53518

Figure 3.9: Omega's Holdings, Crypto capita, Crypto Wallet. Both denominated in Ethereum and USD.

Note that the amounts of holdings and crypto capital denominated in fiat use the expectations of the exchange rate determined by $VaR(100\% - \alpha)$ (high). This is the expected worst-case scenario.

It is possible to compute:

$$CRP_{firm} = Premium_{cryptos} + f\left(EPC_i - ERC_i - \frac{\Delta E_i^{unexpected} W_{i(crypto)}}{Z_{i-1}}, \forall\, i \in set(A)\right)$$

Where $EPC_i = \frac{\Delta E_i^{unexpected} ipay_{i\,(crypto)_i}^{e\,0}}{Z_{i-1}}$, $ERC_i = \frac{\Delta E_i^{unexpected} ireceive_{i\,(crypto)_i}^{e\,0}}{Z_{i-1}}$

In Fig.3.10 the computations for each date are shown for EPC_i and $ERC_i + \frac{\Delta E_i^{unexpected} W_{i(crypto)}}{Z_{i-1}}$.

Their difference is shown in the last column.

The average difference: $f\left(EPC_i - ERC_i - \frac{\Delta E_i^{unexpected} W_{i(crypto)}}{Z_{i-1}}, \forall\, i \in set(A)\right) = 1.387\%$

So that: $CRP_{firm} = 0.03372 + 1.387\% = 5.107\%$

Alternatively, it is possible to compute the net crypto value at each date and multiply it by the delta exchange rate. The method used here, however, gives better insights on the fiat values and on the financial position, given that the firm might want to tweak its crypto investing and/or financing.Moreover, a scenario analysis of “ipay” and “ireceive” could be computed on the excesses by tweaking alpha and beta in the exchange rates computations.

EPC	$ERC + W_i \frac{\Delta E_i}{Z_{i-1}}$	$EPC - ERC - W_i \frac{\Delta E_i}{Z_{i-1}}$
0.01893	0.01420	0.00473
0.01911	0.01338	0.00573
0.01899	0.00332	0.01567
0.02056	0.01079	0.00976
0.03581	0.01023	0.02558
0.01549	0.00232	0.01317
0.01472	0.01030	0.00442
0.01363	0.00920	0.00443
0.01331	0.00898	0.00433
0.01299	0.00455	0.00844
0.01251	0.00282	0.00970
0.01205	0.00211	0.00994
0.01451	0.00269	0.01181
0.01131	0.00358	0.00773
0.01131	0.00302	0.00829
0.01121	0.00262	0.00859
0.01173	0.00215	0.00958
0.01142	0.00190	0.00951
0.01138	0.00250	0.00888
0.01160	0.00139	0.01021
0.01101	0.00198	0.00903
0.01045	0.00230	0.00815
0.01015	0.00203	0.00812
0.00985	0.00197	0.00788

Figure 3.10.: EPC, ERC+WDeltaE/Z-1, and their difference: Omega. Source: the author.

3.4.6 Omega's WACC

Let us assume that, before blockchain, Omega's cost of debt was 6% and its cost of equity was 11%.

Let us assume that the portion of Blockchain debt over the total debt is 20%. The probability of default of Omega is 3%, the traditional loss rate given default is 60%, and the portion of Crypto capital over the total debt is 5%.

Omega's new cost of debt after introducing blockchain and crypto products would be:

R_{debt}[234] $= r_{d_{traditional}} + \frac{B}{D}\left(PD_{firm}LR_{traditional} + BRP - PD_{firm}\right) + \frac{CRP_{firm}C}{D} = 6\% + 20\%(1.8\% + 1.4\% - 3\%) + 5\% * 5.107\% = 6.2953500\%$

Let us assume that debt over the total value of the company D/V is 60% and that the amount of equity issued on blockchain is 0%. Then the new WACC after introducing cryptos would be:

$New\ WACC_{omega} = \frac{R_{debt}(1-t_c)D}{V} + (r_e + BRP_{equity}\frac{B}{E})\frac{E}{V} = 6.2953500\% * 60\% * (1 - 35\%) + 11\% * 40\% = 6.855186500\%$

Both the introduction of blockchain and crypto products has increased both the cost of debt and the WACC. We are assuming no equity obligation is issued on blockchain and that the interest tax shields with corporate tax rate applies to the whole cost of debt which is certainly not the case given the volatile regulations surrounding crypto products and products on blockchain. These, however, are few of the many limitations of this model which employs many assumptions to derive approximations. We have assumed that no equity obligation has been issued on blockchain because of the uncertain nature of BRP (equity).[235]

Overall, this model can give intuitions on the impact of blockchain and crypto products on cost of capital, but it presents many limitations. These are discussed in the next section.

[234] See: Chapter 2: the cost of crypto capital
[235] See: Chapter 2: the blockchain risk premium

3.5 The crypto WACC model : Limitations and conclusions.

3.5.1 The scope of the model

The model constructed in this chapter aims to incorporate all the aspects of blockchain into estimates of cost of capital for a firm.

In chapter 1 blockchain and its products were defined and described in their unique characteristics. The trend of ICOs, tokens and general platform blockchain were laid out. Moreover, the corporate reporting of said items was explored in its inconsistent aspects.

Chapter 2 explained cost of capital and its determinants. It discussed how the issuance and the holdings of products on blockchain could affect it. It was inferred that the cost of capital was directly affected by the nature of the products on blockchain and by the nature of their returns in many ways. Both of these were explored and a thorough discussion of blockchain and crypto risks was presented.

Chapter 3 took all the risks, the caveats, the features, and the opportunities of products on blockchain and incorporated them into a WACC based model. The model strives in determining (fundamentally) the impact of financing through a wide range of blockchain products on a company's WACC by:

1. Determining (fundamentally) the direction of the WACC's response
2. Determining (fundamentally) the degree of the WACC's response numerically
3. Quantify the exposure to general platform cryptocurrencies' returns that the firm obtains

3.5.2 The limitations of the model

The main limitations of this model lie in the assumptions made to sustain it. Although made to be applicable to the most general case, the model requires fundamental assumptions that are not necessarily true.

In spite of all the assumptions based on financial literature (e.g., hurdle rates' estimation methods, rational agents' behavior, semi-strong and efficient markets, no barriers to entry, negligible transaction costs etc.…) and on mathematical and econometrical literature (e.g., Taylors' approximation, consistency in geometric Brownian motion series, etc.…), the model also makes strong assumption on:

- The nature of crypto products pricing
- The nature of investors' response patterns (linear BRP and premium on crypto responses).

Moreover, the model completely overlooks inconsistencies in the taxation regimes surrounding both regulated and unregulated financial crypto securities. This has strong implications in its reliability (such as tax shields calculations in the cost of debt).

3.5.3 Potential improvements and alternatives to the model

The model can be further improved by econometrics models, by the modelling of signals and by discoveries on crypto products regulations and taxation regimes.

The model itself is based on many assumptions as stated above. Parametric and semi-parametric models can provide better estimates of the variables used such as BRP and the premium on cryptos, the forecasting of the underlying cryptocurrency returns and the forecasting of yields to maturity of crypto products.

The signaling theory could be applied at all stages in order to better model the short-term responses of investors to these products' introduction into the firm's activities. The modelling of this behaviors can either emphasize the model's reliability or completely destroy it.

The long-term adjustment, although impossible to model nowadays, can be explored by looking at performance benefits and limitations derived by the blockchain and crypto usage. The change in firm's performance due to blockchain, could be directly incorporated into estimated of cost of equity's changes.

Subsequent clarifications on universal or national taxation regimes over products on blockchain can further improve the quality of the predictions over the impact on cost of capital caused by tax shields and other benefits.

Overall, the most immediate improvements consist in statistically proving the significance of the model's estimates and components.

3.5.4 Conclusions

Overall, I believe this paper to be helpful towards the literature that discusses costs of capital for alternative investments. It provides information on the market surrounding financial products on blockchain, it sheds light on the severity of the inconsistency in corporate reporting standards for the products in question, it summarizes the impacts the blockchain has on cost of capital in the most general of its applications, and it provides a fundamental WACC model which could be used for a multitude of purposes.

The information on the "cryptos" market, from chapter 1 and 2, provide a comprehensive look of the products and their features, the blockchain systems' risks, the underlying cryptocurrency's risks, and the behavior of investors. The info also includes trends in ICOs, distributional behavior of general platform cryptocurrencies and info from studies on signaling theory applied to crypto markets.

The severity of the inconsistent practices of blockchain products' reporting is made obvious through the challenges that are presented by the data gathering phases of analyses on the firms' costs of capital and/or financial position; it includes the challenges in identification of products, portions of crypto assets, holdings of cryptocurrencies and others. Moreover, the unclear taxation regimes present an ulterior obstacle to overcome in hurdle rates' estimations.

The impact of blockchain on cost of capital for a firm that introduces it in the most general way, is explained in chapter 2 on a fundamental basis. The basics of cost of capital are reviewed and its connection to blockchain's features, risks and benefits are made clear.

In this chapter these connections have been modelled under a WACC inspired model.

The model considers all the cost of capital's connections to the blockchain's introduction by introducing:

- The loss rate of securities on blockchain
- A blockchain risk premium
- A premium on cryptocurrency
- A crypto risk premium

The loss rate component accounts for the "unregulated" nature of tokenized securities on public blockchains. It is inferred by the fact that legally binding rights are not present (often) on tokens of various (financial product) nature.

The blockchain risk premium is the measure that accounts for the operational risks, the design risks, and the regulatory risks of blockchain as well as its benefits which include: transparency, ease of use, velocity, and security.

The premium on cryptocurrency accounts for the risks stemmed from the underlying general platform cryptocurrency in crypto financial products. These include the market, the credit, and the liquidity risks of the underlying currency.

The CPR or "crypto risk premium" is the measure of the company that explains its premium on cost of crypto capital as a function of the premium on cryptocurrency and its exposure to the volatile exchange rates. It considers that its future interest payments in crypto may have unexpected fiat values but it also considers the risk management practices of the company in tampering the unexpected losses.

The model, however, does not account for:

- Taxation regimes
- Future regulations on crypto products
- Identification problems
- The impact of blockchain on company's performance

It is possible to construct certain intuitions regarding these, and to model these factors using parametric approaches, but it is best to exclude them from the general model for now.

In conclusion, although purely fundamental, the paper explains how the WACC of a company might increase after the introduction of blockchain considerably.

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