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CHAPTER 7

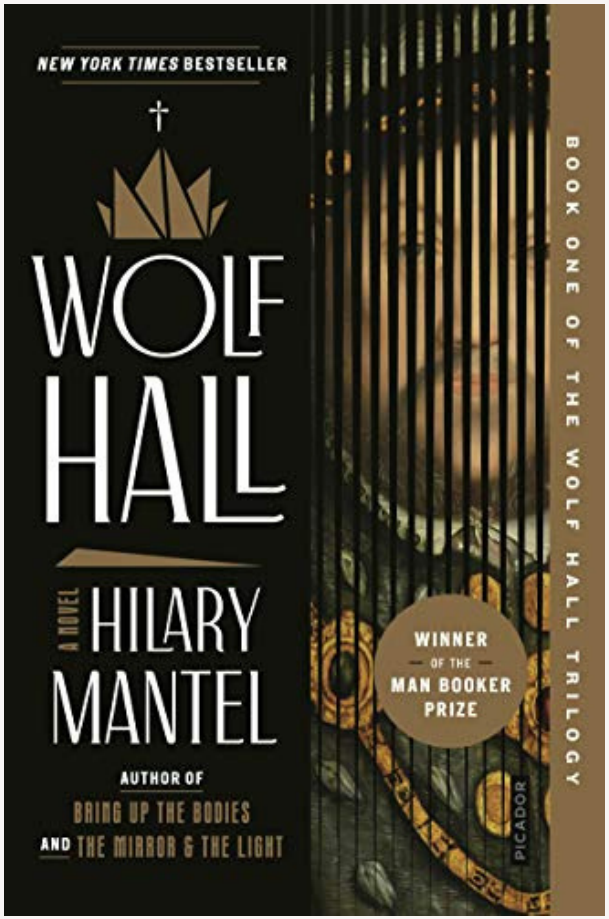
Cryptocurrency, Distributed Ledger Technology and Blockchain Tokens

Section 1: Introduction to Blockchain and Distributed Ledger Technology

Chapter 7 introduces blockchain tokens and distributed ledger technology. This may seem like a fringe topic since it is closely tied to the recent collapse of cryptocurrency prices.

Cryptocurrencies remain a steady fixture in the news, with a well-known example being Bitcoin. They function using distributed ledger blockchain technology. The aim of Section 1 is to become familiar with this new technology. This enables understanding of how Foodprint tokens, which are a cryptocurrency, can function to facilitate governance of common pool resources, as discussed in Chapter 4. The most important point here as we learn more about cryptocurrency, blockchain, and distributed ledger technology, is that the Foodprint token is not a form of money to be exchanged for goods.

Source: Satheesh Sankaran, CC BY-SA 2.0 <https://creativecommons.org/licenses/by-sa/2.0>, via Wikimedia Commons.



There are 3 main aspects to blockchain and distributed ledger technology. The first is how the technology functions, that is, the computer programming underlying blockchain. We are only covering this superficially, since our focus is not computer science per se. The second is how blockchain and distributed ledger technology provide a new way to organise currency systems. Thirdly, we explore the types of cryptocurrency functions. These are augmented considerably beyond both standard physical currencies, such as euros and dollars, and their digital means of being passed between accounts.

Let's proceed step by step. First, consider the concept of **Distributed Ledger Technology**, commonly referred to as DLT. This technology can be demystified by thinking of it as an accounting system. Accounting is a discipline in itself: managing accounts and keeping financial records is fundamental to any political economy. (For a dramatic account of this significance see Hilary Mantel's 2009 historical novel *Wolf Hall* about Thomas Cromwell's leading role under King Henry VIII). A ledger is a record of accounts. Banks keep records of our accounts, acting as our accountants, so that users may access a copy of their financial records.

Distributed Ledger Technology has a specific feature unlike typical ledgers. For example, a standard ledger from a bank is centrally administered. We do not expect that we can alter our bank account directly by personally updating transactions. DLT is precisely that: distributed, and not centralised. This means that it can be updated by all of the partners participating in a ledger system. This is made possible by a peer-to-peer (P2P) computer network, and any update to the system is acknowledged as legitimate by all using the network. Rather than having one central authority oversee and register all changes to the ledger, permissions are distributed over the network of actors. Every actor in the network can alter the ledger and record, for example, through a transaction, but the update must be agreed on by consensus of all the actors on the network. The key to making this distributed ledger accounting system function securely is blockchain technology.

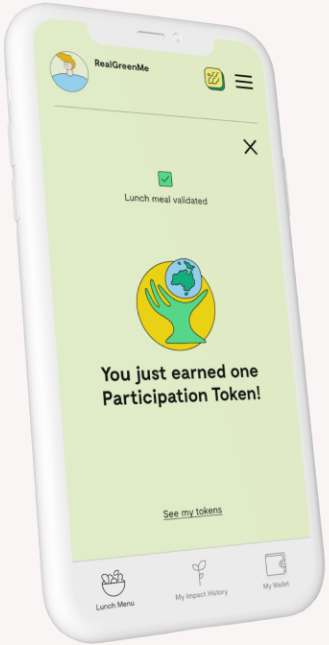
Blockchain provides a high level of security from fraudulent changes to the ledger to make this multi-party ledger updating possible and safe. Blockchain provides a means to implement a distributed ledger, but is not itself equivalent to a distributed ledger.

To learn more about DLT, see the video "Blockchain technology": https://www.youtube.com/watch?v=4sm5LNqL5j0

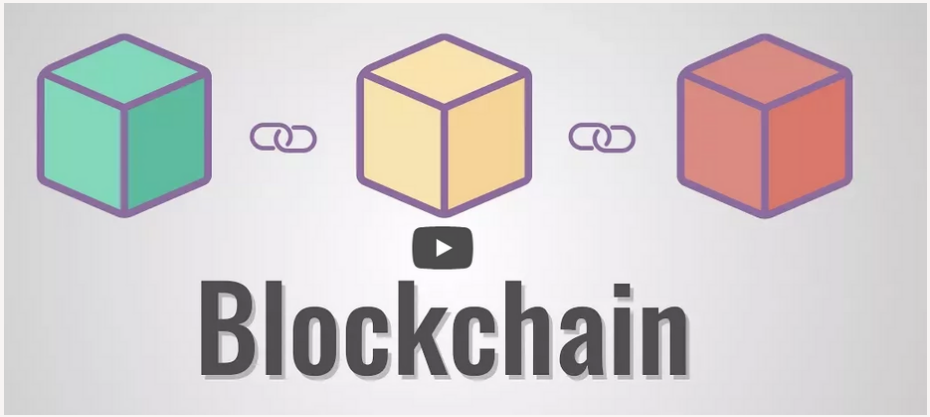
Artist Username: LuckyStep.

Next, let’s consider the pioneering **blockchain technology**. Recall that the function of the blockchain is to provide the infrastructure for a distributed ledger system. Blockchain has several different elements, mainly blocks of data containing the history of earlier transactions that are identically available to every user on the network. Blockchain technology provides a means to secure that the data is valid, provided all of the users on the system use appropriate protocols to update data. On this point we can cite an example from the Food Futures App which mints and distributes Foodprint tokens in a graduated scale according to individual and collective contributions. The current transaction validation method relies on individual reporting and double-checks a transaction (the double-checking is centralised, but eventually this, too, will be decentralised).

As long as the recorded transactions are valid, then once they are imprinted into the blockchain data, they will remain as a permanent record of all individuals’ contributions. All users on the network receive notice of their transactions in the permanent Foodprint tokens issued to users’ digital wallets.



Bitcoin was developed by the person or group using the name Satoshi Nakamoto in 2008-09, and was the first use of blockchain. The vision was to create a fully electronic currency that would not need the oversight and policing of a central authority. Once the currency system was set up, actors could exchange standard currencies (euros and US dollars) for units of the limited supply of Bitcoin. These accounts are managed on a DLT system whereby anyone, without being a member of a bank, can make exchanges using Bitcoin, and maintain their accounts.



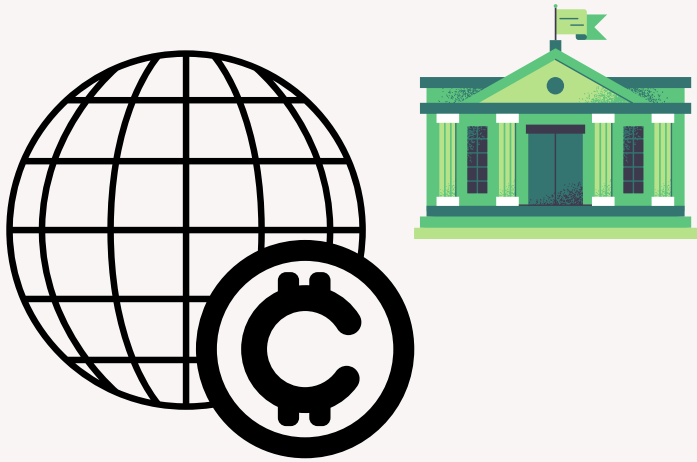
"How does a blockchain work - Simply Explained." Source: https://www.youtube.com/watch?v=SSo_EIwHSd4

Blockchain represents an innovative way to maintain public accounts. Over time, its effective use to manage large scale common pool resources without a central government will likely be demonstrated. Specifically, it is well-suited to work within voluntary, opt-in communities that have an identifiable membership group. As well, it provides a means to record activities. The Food Futures App relies on blockchain to implement the measure, record, validate system to acknowledge individuals' contributions, and to provide data to visualise the collective impact.

For more, see blockchain video introduction "How does a blockchain work - Simply explained": https://www.youtube.com/watch?v=SSo_EIwHSd4

Cryptocurrency is a particular application of blockchain technology, much as blockchain technology is a way to implement a distributed ledger. The most famous cryptocurrency is Bitcoin. However, if you watched the video “Blockchain and Distributed Ledgers” you saw that there are currently about 1,000 cryptocurrencies. These currencies all function in unique ways specified by their developers. Bitcoin, and other cryptocurrencies, attempt to serve the same function as money. In the modern era, monetary systems are state-operated systems that control the amount of money in circulation (otherwise everyone could print their own money). Cryptocurrency systems that seek to play the same role as standard money must therefore have a means to control their money supply. But, since their advantage lies in using DLT and blockchain, they are not controlled by a central authority. Instead they function in computer protocols and algorithms that use computer programs to enforce the rules the system designers set up to regulate the currency.

Bitcoin has received a bad reputation because people have sought to get rich by investing in it, instead of treating it as a currency like any other currency. Certainly it is possible to make money by speculating on the rise of one currency’s price against other currency prices. (This is what George Soros did in 1992, by betting against the Bank of England and making approximately one billion US dollars.) Financial tools will always be subject to speculation. However, the strength of cryptocurrency lies both its decentralised nature, and its high level of security against fraud and theft achieved by blockchain technology.



Ether is a cryptocurrency whose blockchain is generated by the Ethereum platform. Artist Username: Quatrox Production.

One liberating feature of cryptocurrencies, in addition to their decentralised character, is that they can fulfil unique purposes within the different communities that use them. Bitcoin attempts to replace standard money for some market transactions. However, the function of cryptocurrency is much broader than standard money.

Food Futures offers a community cryptocurrency in the form of blockchain Foodprint tokens. These are in the Ethereum standard, and are awarded to users of the Food Futures App who have made sustainable choices. Over time this community currency system may be expanded so that tokens will serve a utility function to receive donated surplus goods (these are non-rival in character because they would have been wasted otherwise). Since Food Futures is built on the concept of anti-rival value, with the externalities produced from sustainable choices, the Foodprint token itself is anti-rival. This means there is not a limited total supply. Tokens are minted when positive externalities are measured and recorded. They serve to indelibly and permanently recognise individuals' contributions toward achieving lower GHG emissions.

The future of human civilization hinges on whether people learn to collectively manage the atmospheric commons. The Food Futures community cryptocurrency provides a tool to achieve this aim, consistent with Elinor Ostrom’s principles of managing common pool resources. Think of the insignificant items we pay small amounts of cash for on a daily basis. We can appreciate that the value of contributing to achieving net carbon gas neutrality has more value than the pennies we spend on trivial items, such as chewing gum and pastries. Yet we have detailed accounting systems for these petty consumables, and as yet no currency system to measure, record, and validate the far greater value of living together sustainably.

Candy Shop in Sweden. Source: Guillaume Speurt, CC BY-SA 2.0 <https://creativecommons.org/licenses/by-sa/2.0/deed.en>, via Wikimedia Commons.

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Section 2: Double-Entry Bookkeeping Versus Triple-Entry DLT Record-Keeping

Just as with our discussion of DLT, blockchain and cryptocurrency, we do not expect to become experts on double-entry bookkeeping through this book. However, we can respect the role that this accounting technology has played in the rise of modern capitalism. Our goal is to understand how record-keeping, as an innovation in itself, can be revolutionary.

First, let's imagine doing basic calculations using Roman numerals. This number system was used throughout Europe into the 1400s. Try completing the sum of CDVII plus XCII. Imagine needing to keep track of quantities of items exclusively using Roman numerals. We will leave that aside for the reader to calculate as an exercise if they wish. Science and engineering would be held back by such a numbering system. The mere symbolic representation of concepts itself therefore is a type of technical innovation.

Individual decimal places

	Thousands	Hundreds	Tens	Units
1	M	C	X	I
2	MM	CC	XX	II
3	MMM	CCC	XXX	III
4		CD	XL	IV
5		D	L	V
6		DC	LX	VI
7		DCC	LXX	VII
8		DCCC	LXXX	VIII
9		CM	XC	IX

Roman numerals. Source: *https://en.wikipedia.org/wiki/Roman_numerals*

Luca Pacioli. Source: https://commons.wikimedia.org/wiki/File:Luca_Pacioli_in_the_Summa.jpg

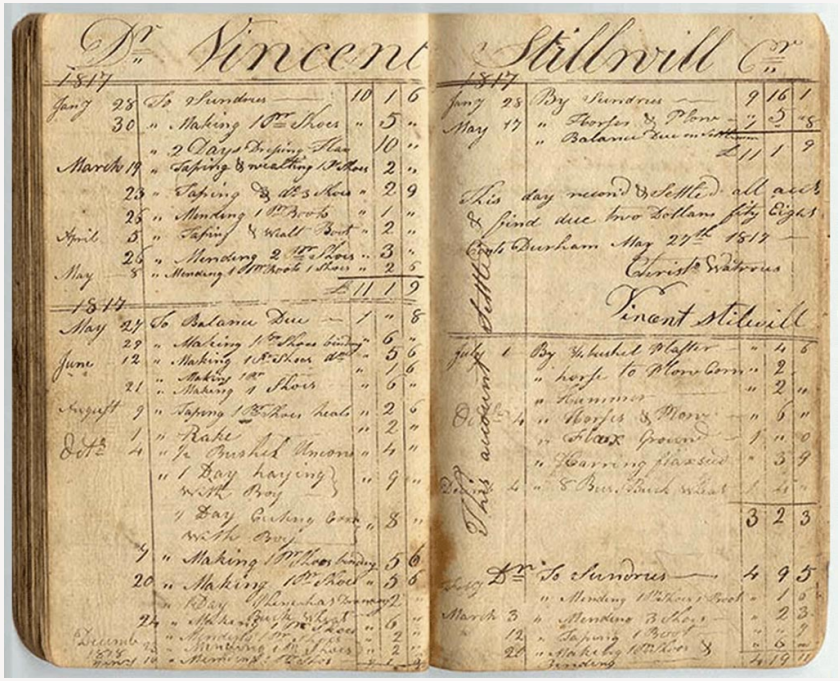
One basic element of the breakthrough into the principles of **double-entry bookkeeping** was the gradual cultural adoption of the Arabic number system used throughout the world today. Before modern accounting methods (“modern” is used in the historical sense dating from Early Modern Europe between 1450 and 1789), records show that people kept diaries of their possessions, detailing inflow and outflow of traded goods.

The breakthrough of double-entry record keeping was sufficiently profound that observers at that time recognised its significance. We are aware of this breakthrough because an Italian monk, Luca Pacioli, codified the method as it was used in Venice. Earlier incidences of this new technique date back to the 13th century in Provence. Pacioli took an action vital to the advancement of knowledge. He wrote an encyclopedia about mathematics in 1494 with an article about double-entry bookkeeping. Due to the newly invented printing press, his encyclopedia was mass produced. Today Pacioli remains known for his entry on accounting.

The innovation of this new accounting practice was the concept of balancing credits and debts, and devising a method to rigorously keep track of these numbers. The term “double-entry” thus refers to treating every transaction as an exchange. If I go to the store and buy and orange for one euro, then the euro is debited from my account, and I receive the orange in return (which is valued at one euro). The consequence of this record-keeping system means that if I am running a shop selling oranges, I can keep the following accounts (shown in the table on the right). These entries reflect that I purchase oranges for 0.5 EUR each, and I buy 20 oranges, for 10 EUR in total. Then I sell the oranges for 1 EUR each, and receive 20 EUR. This type of calculation, as well as the entire conceptualisation of economic exchange, is so basic to us that we barely think of it as a fundamental innovation in the history of human civilization.

	Debit	Credit
Cash for 20 oranges	10 EUR	
Receipt of 20 oranges		10 EUR
Sale of 20 oranges	10 EUR	
Receipt of payment 20 oranges		20 EUR

This method of accounting makes it straightforward to grasp the profitability of buying and selling oranges for this vendor. Such accounting enables comparing the revenue flows of different products. It records the value of an item in terms of the amount of money paid for it. An aspect of the double-entry system is that merchants can match their accounts, and there should be no discrepancies. If I record receiving 10 EUR from you, then you should record a debit of 10 EUR to me.



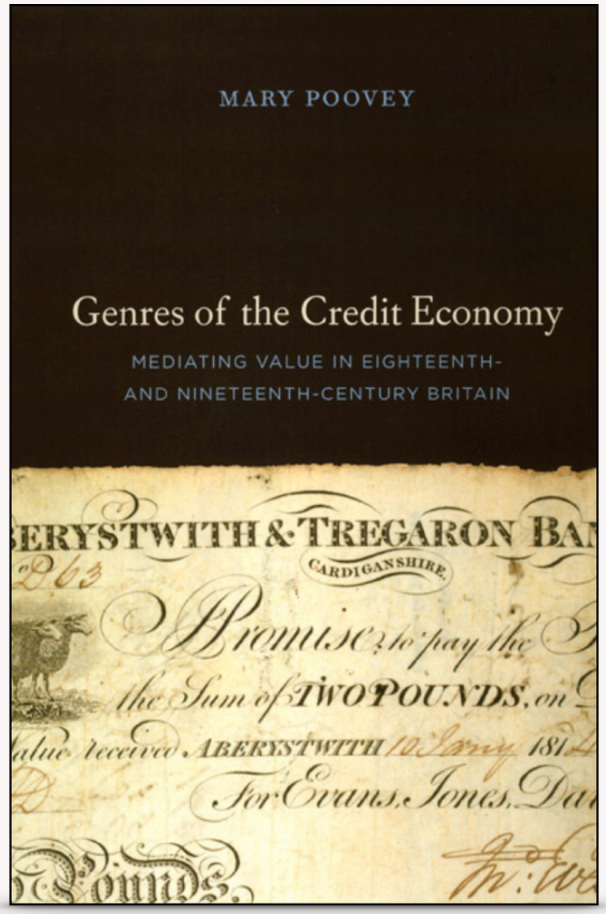
Debits on the left, credits on the right—the hallmark of double-entry accounting. Every financial event brings two transactions, a debit in one account and an equal, offsetting credit in another account. Photo: Christopher Watrous' account book, Debits and Credits for Vincent Stillwill accounts*, Durham, Connecticut, 1817. Source: "Double-Entry Bookkeeping Accounting Systems: Double-Entry vs. Single-Entry Systems," Business Case Website, Solution Matrix LDT. https://www.business-case-analysis.com/double-entry-system.html*

Double-entry bookkeeping conceptually intersects with the dawn of what would become the conservation principles of physics. Coupled with the cultural assimilation of Arabic numerals, and the spread of double-entry bookkeeping throughout Europe, this process took place over centuries. Double-entry bookkeeping is based on the following principles:

- Accounts (credits and debts) must balance.
- The money in circulation must be constant (unless a sovereign state issues new currency, but it must be accounted for, i.e. how much new money is put into circulation).
- All money paid out must be exchanged for goods and services of that value which become an asset on hand (in the orange sale example above, what is paid out is exchanged for goods of that same value).
- This accounting method enables the calculation of profit: profit is the surplus value after all expenses are paid for production.

Double-entry bookkeeping may now be revolutionised by a new chapter in accounting: Distributed Ledger Technology (DLT). This brief historical overview is provided to ignite our imaginations about the possibilities of a potential breakthrough in accounting. DLT can be viewed as **“triple-entry bookkeeping.”** This system maintains the credit and debit balance crucial for the double-entry method, but adds publicity to all records, meaning that transactions are not only recorded in private ledgers, but are maintained in a distributed manner by all of the participating nodes of the system.

Double-entry bookkeeping keeps account of debits and credits to everyone’s account. An aspect of this which we are familiar with is that the buyer and seller of a good each (in contemporary times) maintains their own accounting record of any transaction. In this way, accounts can be checked against each other. For an easy example, consider your own personal bank account. We take it for granted that what I put into the bank, in the form of cash or a digital deposit, is credited to my account. We assume that our records, which we also rely on the bank to maintain, ar identical to the bank’s records. We do not expect to have more or less credit in the account than we deposited, or deducted when we paid for goods.



Historian Mary Poovey’s book on the history of financial instruments, Genres of the Credit Economy*, 2008.*

DLT maintains a triple-entry accounting system. This third entry, beyond credits and debits, refers to every transaction recorded on every node of the networked peer-to-peer system.

The third entry is the public nature of the record. The transaction is not only recorded between buyer and seller in their own double-entry records, it is also recorded publicly. The entire blockchain system typically used to implement DLT also keeps track of all the currency units in circulation. This additional concept introduces the next section on the functions of money. This idea refers to that, for example, in Bitcoin exchanges, not only are transaction records made public to all participants supporting the Bitcoin network, but the transaction records keep track of individual transactions against the total amount of Bitcoin tokens in circulation. The blockchain system supporting Bitcoin has the information of all of the Bitcoin in circulation.

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Section 3: Brief History of Money and Monetary Functions

The aim of this section is to give a panoramic overview of the history of money and introduce the functions that money serves. Money is a large topic, with intimate relevance to most of us, hence this section serves to help us to understand the new innovations in monetary systems made possible by cryptocurrency. Recall that cryptocurrency is one application of blockchain, which is one means to implement distributed ledgers. We focus on the use of DLT and blockchain to generate community cryptocurrencies.

Money developed as a means to conduct trade more easily. Pre-historic peoples, who lived before 1200 BCE, initially traded goods either as a form of gift-exchange, some type of debt obligation, or by barter. Barter is the closest form to contemporary monetary exchanges. This is because it involves two goods being traded having equal value. Barter evolved into a form of exchange we now refer to as **“commodity money.”** This is relatively simple. Certain goods needed by everyone, such as basic food substances like grain, have a value to everyone.

"Olaus Magnus - On Trade Without Using Money." Source: https://commons.wikimedia.org/wiki/File:Olaus_Magnus_-_On_Trade_Without_Using_Money.jpg

Thus, some items could be routinely used for exchange. These needed to be easy to carry around and store. The complexity of finance even in the ancient world is evident from the Code of Hammurabi. This is the Babylonian text dating from 1755-1750 BCE, carved into a stone pillar of basalt for Babylonians (see Horne, 1915). This code discusses the obligations of debtor to creditor, and the forms of acceptable payment. Payment could be in kind (giving back what one took, or a replica), an item of common value, such as an animal, or in terms of labour.

Part of the code of Hammurabi. By John Ross. Source: https://www.flickr.com/photos/37351539@N05/3681068075/

The forms of commodity money that developed historically were easy to exchange, and could be in the forms of gold, silver, barley, or shells. Coins, as a form of money, are dated to 500 BCE, and there is evidence they developed in three cultures: Lydia, India, and China (see Heymans, 2021, p. 4). The invention of money is argued to have had a revolutionary effect on social relations, and on the ability of cultures to advance (Heymans, 2021). The early invention of coins shares with cryptocurrencies that they served a particular function to the specific communities using them. Early coins did not have universal value in themselves (although the substance of which they were made held value as a commodity, with value in use), but coins developed within communities as a means of payment. As such coins were issued by a sovereign who stamped an identity into an otherwise amorphous piece of precious or semi-precious metal. They could have different denominations, for example, 1-unit and 10-unit coins.

The first known example is attributed to the King of Lydia, in roughly 600 BCE, who established the Lydian stater coin. Early coins had value in terms of the precious metals they were made of, but acquired an additional value from being state-sanctioned. The coins' minting by the sovereign, with the sovereign's imprint, served to guarantee that their composition was of the appropriate quantity of precious metals.

Ancient Lydian coins made of electrum, a naturally occurring mixture of silver and gold. Source: Classical Numismatic Group, Inc. http://www.cngcoins.com, CC BY-SA 3.0 <http://creativecommons.org/licenses/by-sa/3.0/>, via Wikimedia Commons.

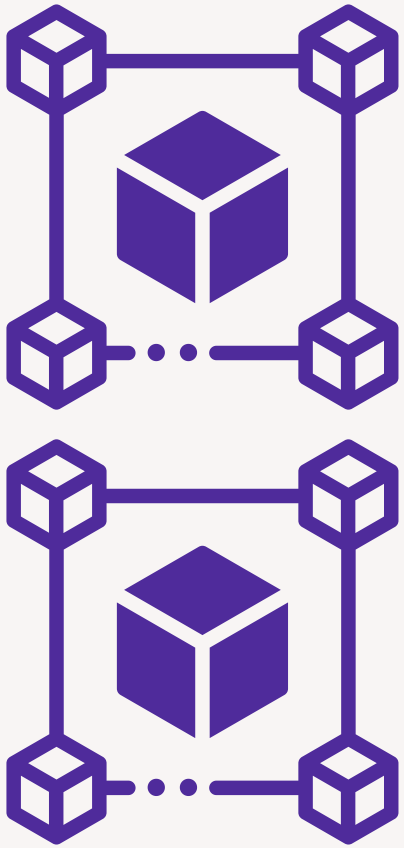
This invention had the advantage of providing a means to trade value with three functions that are now defined to be characteristic of money. Money plays three roles: as a medium of exchange; a unit of account to measure value; and a store of value that does not deteriorate over time. The first forms of money as coins had an intrinsic value due to their substances. Over time a derivative form of money developed that strictly had value because it was backed by a sovereign. This is the paper form of money we are familiar with today.

Paper money obviously does not have intrinsic value, as do coins made out of precious metal. Since their invention, first attributed to Chinese authorities in the 13th century CE, paper notes have gone from being backed by precious metals to merely having value “by fiat.” This phrase “by fiat” refers to holding value by law, and in principle means that these notes can be used to pay taxes levied by the sovereign government. As well, when owed money as a creditor, and needing to take a debtor to court for failure to replay a loan (which is evident in the Code of Hammurabi), the law stipulates that these paper notes minted by the sovereign government must be accepted as legal payment of debts. Up until 1971 the US dollar was backed by a gold standard. This meant that the up until 1971 holders of US dollars could trade their paper dollar bills for gold. After 1971 only faith in the value of the US dollar maintains its value globally.

Money has become increasingly abstract, evidenced by the transition of coins made of valuable metals to global currencies backed by faith and the sovereign's decree that it be used to pay taxes and debts. It can be hard to pin down the source of its value, other than by referring to its value lying in the faith in its value. Today, monetary sums are often exchanged digitally, without a physical record of transactions in the form of physical money. Despite this abstract quality of the value of money in today’s economy, it enables global trade and makes advanced commerce possible.

In this chapter we have focused on DLT, blockchain, and cryptocurrency as a possible next step beyond the historical barter systems and fiat monetary systems combined with double-entry bookkeeping to a new generation of functions. Recall the three functions of money: medium of exchange, unit of account, and store of value. It must be limited in supply because it tracks the value of rival goods.

For more information, see "Money creation in the modern economy": https://www.bankofengland.co.uk/quarterly-bulletin/2014/q1/money-creation-in-the-modern-economy



Consider also the properties that money must have to serve these functions. It must be durable in order to serve as a store of value. It must serve as an acceptable payment, which is enabled by the sovereign law backing it up as legal tender to repay debt. It must be portable so that people can take it with them to buy goods. As well it must be fungible, which we studied in Chapter 3. This means it must be divisible with uniform indistinguishable units.

When we consider cryptocurrency, and Bitcoin as the best-known example, it can function as a medium of exchange, a unit of account, and a store of value. It is durable so long as digital systems continue to exist. It is portable because people can have access to payment over virtual connections. Bitcoin is also designed to be fungible. If it were not, each of its units would be unique and distinguishable from another unit.

We conclude this section considering the broader range of functions of cryptocurrency. Cryptocurrency exists as blockchain tokens, for example, such as one unit of Bitcoin. The key point is that cryptocurrency can serve more complex purposes than standard physical money, or even its digital representation that we currently use.

The figure on the right compares the functions of standard physical and digital currencies against the contemporary expansion of monetary forms to cryptocurrency blockchain tokens. A token is one unit of the blockchain currency. The left column represents standard currency. Remember that money is defined to serve the functions of unit of account, medium of exchange, and store of value. Its acceptability is supported by the sovereign state that issues the currency as a means to pay tax. Examples are the euro, the US dollar, and the UK pound sterling.

Money vs. Blockchain Token

Comparing Money & Token Functions

Currency	Token Types	Token Functions
Unit of Account	Utility	Transferable
Medium of Exchange	Currency	Negotiable-Liquid
Deferred Payment	*Investment-Security	Standardized
[Payment of Tax]		Comparable to stock or bond

“equity rights in a company, voting rights, dividends from future earning, or rights to have an other form of access to future proceeds of the company” (Gurkov 2021) ; ICO image: https://www.chipin.com/blockchain-ico-guide-explained/;
Coin image: CoinInvest GmbH, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons

Cryptocurrency tokens as they have come to be used in the 21st century can also serve the functions of holding utility, serving as a currency (with all of those functions), and serving as an investment security. Due to the programming that makes cryptocurrencies possible, they can have added functions made possible by their executing code. (The latter relates to operational function as “smart contracts,” which is not explored here.)

The new functions of cryptocurrency expand how money could be used in the future. Returning to the first section of this chapter, this is because a blockchain is updated by consensus across all participating nodes, and has a high level of security guaranteeing the accounting information it contains.

In summary, cryptocurrencies can serve a function of utility, which means that they can serve as a ticket for a particular kind of good only offered to holders of those tickets. Thus, it could serve as a membership pass, or access to an event. Cryptocurrency can serve all of the functions of a traditional currency, and there is speculation over how popular a nationally backed cryptocurrency could be. China released its digital Yuan in January 2022, leading to speculation over its further development as blockchain, which is not yet the case (Raud & McKinnon, 2022). Cryptocurrency can also serve directly as an investment tool, operating as a investment stock.

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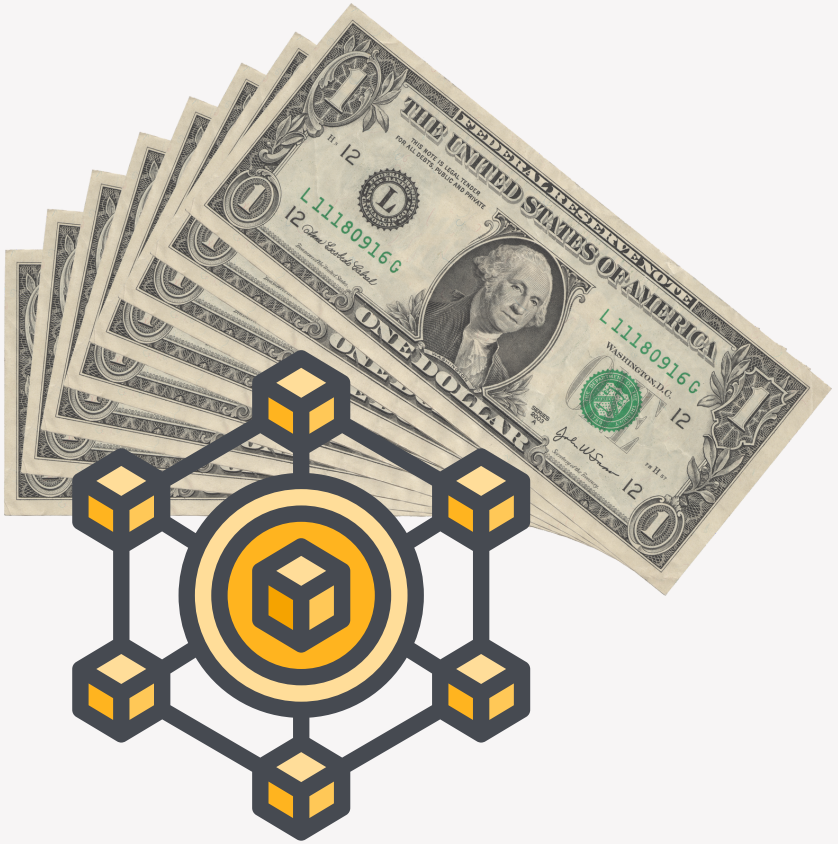
Section 4: Positive Externalities, Anti-rival Goods, and the Tragedy of the Commons

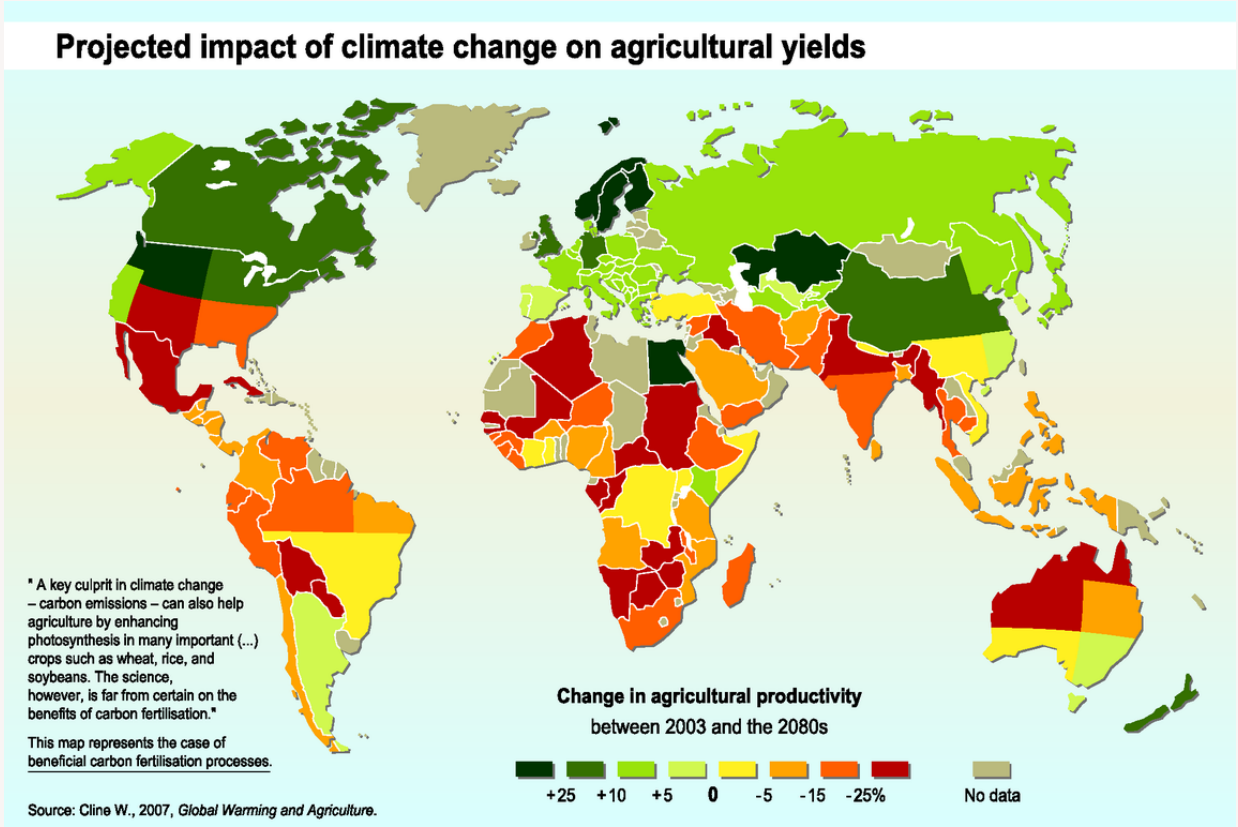
DLT, blockchain, and cryptocurrency are revolutionary new ways to maintain financial records, circulate currency, and give new functions to tokens (formerly coins or bills in standard monetary systems). We have discussed the advantages of the new currency systems. Their ledgers can be decentralised, and simultaneously updated by consensus on the ledgers kept by all participants. They provide a secure way to maintain currency systems due to the blockchain technology: once one block of transactions has been mutually confirmed and updated by all participants, it cannot be altered. Finally, the currency units—tokens—can serve many more functions.



We now go more deeply into the additional types of functions made possible with blockchain tokens. Blockchain tokens have all of the functions of standard money: unit of account, medium of exchange, and store of value. Leaving aside their potential new function as an investment tool (such as a share of stock), we focus on their additional utility function: they can be offered to give access to a particular good or service that only holders of the token can obtain. Blockchain currency systems can be tailor-made to serve the needs of particular communities. Those communities can determine which functions the tokens of their currency should have.

To link the use of blockchain as a community currency to the major theme of this book we can ask: how do we solve the environmental tragedy of the commons?

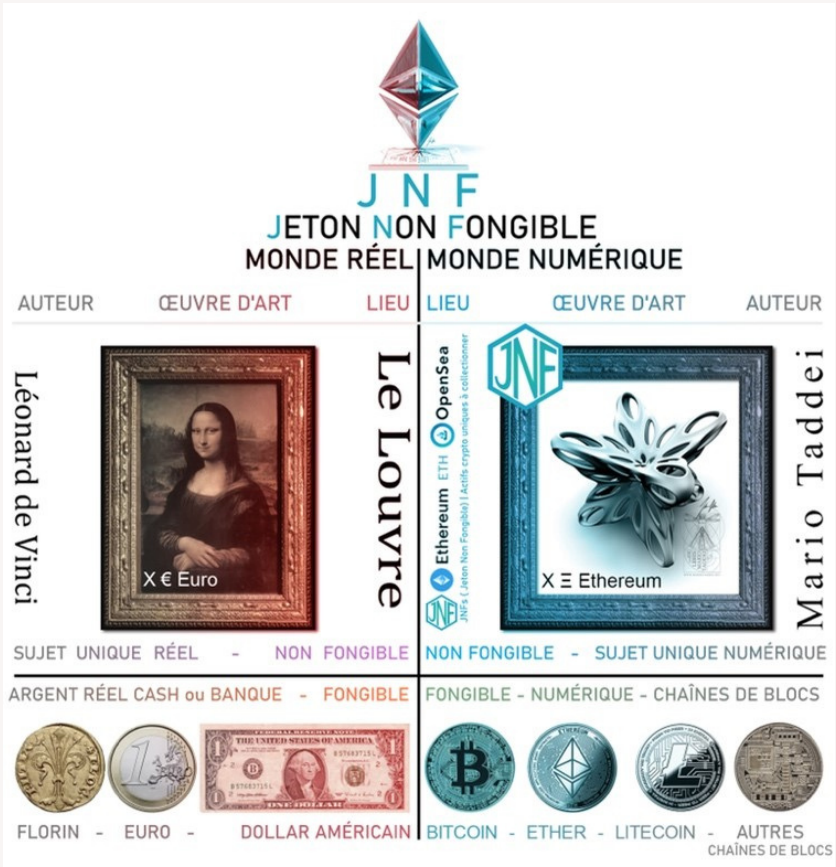
We return to the concept of externality. Negative externalities are those harms to bystanders that can arise from the exercise of private property rights. One example is air pollution, through excessive GHG emissions. Positive externalities are those that benefit bystanders, such as how a public education system makes everyone in that society better off.



Disparate impact on agriculture across the globe projected from 2003 to 2080. This is based on predictive modeling and shows differential impact of climate change; greener areas may benefit (note projected impact on the Nordic region), and those marked red may suffer from decreasing agricultural productivity. Source: European Environmental Agency. https://www.eea.europa.eu/data-and-maps/figures/projected-impact-of-climate-change/trend09-1m-soer2010-eps

As we discussed in Chapter 6, externalities are often anti-rival in their impact on bystanders. The example related to the defacement of public property demonstrated this property of an anti-rival negative externality. Excessive greenhouse gas emissions, at least until the time when we have achieved net carbon neutrality and capped the total amount of atmospheric CO2e gasses under the 1.5°C threshold, also exists as an anti-rival negative externality. This is because, for example, when individuals and corporations in developed countries have high carbon footprints, not only are members of their nations confronted with dangerous weather conditions, but so are citizens of developing nations who are already more vulnerable.

Given the anti-rival nature of the harms produced by excessive GHG emissions, especially because they place us on a trajectory to an unsustainable environment, we can see that reducing GHG emissions is an anti-rival positive externality. This is much like in the case of defaced public property, everyone benefits when the damage caused is repaired. Recall that standard money serves as a medium of exchange of market goods. These are scarce, rival, and subtractable. To serve as a medium of exchange for rival goods (what one person owns, no one else can own), money must also be scarce, rival, and subtractable. However, given the new functions of cryptocurrencies, tokens can be designed to circulate and record anti-rival value, as well as rival value. This means that anti-rival cryptocurrency tokens can be designed to measure, record, and validate the generation of anti-rival positive externalities.



Conveys different types of currency, including one-of-a-kind, non-fungible Ethereum tokens. Source: HypersiteOriginal: MarioTaddei, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons

Money vs. Blockchain Token

Comparing Basic Money & Token Functions

Money	Anti-Rival Fungible Token	Anti-Rival Nonfungible Token
Unit of Account	Measure value/contribution	Indicate value/contribution
Medium of Exchange	Medium of sharing: Shared tokens are not deleted	Medium of sharing: Shared tokens are not deleted
Store of value	Each token has unique data; Units are standardized	Each token has unique data; Units are not standardized
[Payment of Tax]	Utility function could confer rights to owner	Utility function could confer rights to owner

*Tokens can be rival, non-rival, and anti-rival; **we only consider anti-rival tokens here**. These are **not limited** in their total sum, and are minted whenever new value is generated. Contributions can be measured; they are recorded on the blockchain when tokens are issued, they can be shared at a later time, and thus serve to store value in the recognition they offer to holders.

Before discussing how this measure, record, validate system works in the Food Futures App with Foodprint tokens, consider the range of functions that cryptocurrency can have. The table on the left illustrates these new functions.

We are now combining the concepts of anti-rival goods and cryptocurrencies created to serve the function of tracking the value of anti-rival goods. Traditional currencies only track the value of scarce and limited goods. They have a limited supply. When we consider anti-rival value, this is unlimited, and the more it increases, the more of the anti-value is generated. As an analogy related to our example, imagine if it were possible to track all of the times passersby were not disturbed by damage to public property because it had already been repaired: the total amount would keep growing every time a person looked at the building. Cryptocurrency makes it possible to develop a system to measure, record, and reward these contributions of positive externalities.

To understand the power of cryptocurrency to keep track of how value circulates in a community, consider an abstract example based on vaccine distribution, and the concrete example of Food Futures. Imagine a cooperative effort to develop a vaccine for a new disease. If this vaccine were to be open-sourced, it would need crowdfunding where many participants join to give relatively small amounts of capital. In order to avoid being an investment with an Initial Coin Offering (subject to regulation), people who contribute could be given a Vaccine Fund Token for contribution—these could be fungible, reflecting the amount of this contribution, or non-fungible, reflecting any threshold amount set by the community. These tokens could then later serve the function of giving contributors access to the vaccine, once developed.

Vaccine distribution and take up provides positive externalities in helping everyone in a community jointly to achieve so-called herd immunity and to collectively suffer less harms from an illness that could otherwise be devastating.

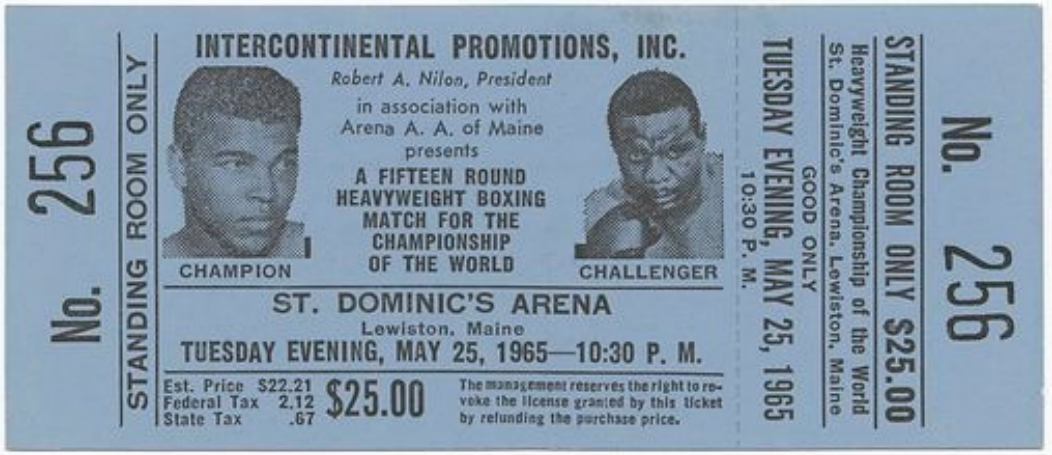
Source: "Congresswoman Mary Scanlon has partnered with Rite Aid and Union Memorial Church in Darby to host a COVID-19 vaccine clinic," https://yeadonborough.com/one-day-vaccine-clinic-in-darby-wednesday-march-31/

The Food Futures App with Foodprint token balance.

Food Futures developed the cryptocurrency Foodprint token. All tokens are on a spectrum from being fully fungible, like money, to each token being wholly unique, such as contemporary non-fungible tokens representing artwork (see Mitchell, 2022). Foodprint tokens are fungible in the sense that they are issued in denominations and can be aggregated. They serve to measure, record, and reward individuals' contributions of the positive externality of lessened CO2e emission. The Food Futures index provides data on the relative sustainability of meal choices. This enables Food Futures App users to have information about the sustainability impact of their meal selection. By validating a meal selection, that choice and its impact is recorded into the blockchain system. The blockchain system then issues cryptocurrency Foodprint tokens that serve to recognise individuals' meal selections, as well as the sustainability impact of those choices. This is how the Foodprint community currency operates to measure, record, and validate the value of the positive externalities contributed by Food Futures App users.

In the future, the Foodprint tokens can be shared for donated surplus items. These are non-rival in the sense that they are surplus, and would go to waste if not used. Examples are magazines that would be destroyed if they do not sell, or tickets to cultural events that result in empty seats. The concept is that, using participants' input, an anti-rival sharing space would be developed that would offer donated surplus items on a shared basis for Foodprint tokens. These might be issued through a lottery, first-come first-serve, or an auction system. The key aspect is that possessors of Foodprint tokens received through the measure, record, validate system would share tokens: they retain a permanent record of the kilograms of CO2e gasses not emitted, and share their token with the donor who would then be able to show their Foodprint token account balance publicly to show how many kg of CO2e gas they donated goods to recognise and sponsor.

This system acts proactively. Rather than the cap and trade system that promises an offset after the negative externality has been committed, in Food Futures, the positive externality may be recognised subsequently.



Example of a ticket to a cultural event. Source: Public Domain, accessed https://www.lookandlearn.com/history-images/YSH000712/Ticket-for-boxing-match-between-Muhammad-Ali-and-Sonny-Liston

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Section 5: Conclusion—Using Tools to Construct 1.5°C Lifestyle Individually and Collectively

As you can tell from the amount of press coverage blockchain tokens from Bitcoin to NFTs are getting in today's media, DLT, blockchain, and cryptocurrencies are ready to revolutionise money and accounting practices (see Tett, 2022). But there is a more orthodox and more revolutionary way to understand their innovative potential.

Source: Stably https://medium.com/stably-blog/history-of-money-and-currency-in-the-world-5942b3554f5f

The more mainstream interpretation of the breakthrough of cryptocurrencies is that they can substitute for normal anti-rival money. In the Stably blog, from which the image on the previous page was copied, the history of money we discussed in Section 2, included commodity money, money as precious metals, paper money with and without backing of precious metals, digital money forms, and cryptocurrency. Stably is a particular kind of cryptocurrency that holds its value and is backed by precious metals. This backing is designed to overcome a major problem with rival cryptocurrencies: their values can move up and down in extreme variations. Stably refers to other obstacles in the widespread adoption of cryptocurrencies: their difficulty to use, difficulty of denominations that scale to large and small transactions, and resistance from well-entrenched financial corporations and practices (see Stably, 2020).

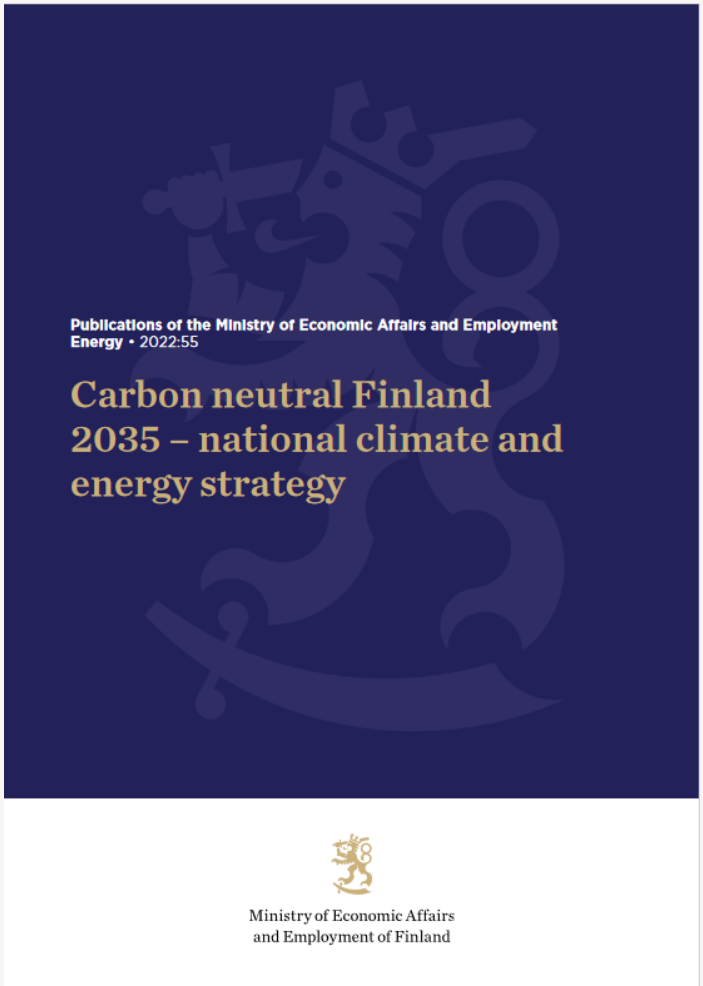
These standard obstacles to the development and application of cryptocurrency do not apply to Food Futures and the Foodprint token because this is a cryptocurrency developed initially within partnership with Unicafe in Helsinki, Finland. Food Futures takes advantage of the ability to create a local currency with particular functions. A more visionary view is that cryptocurrency may offer a means to empower individuals to exchange and share value in local networks (see Laurin, 2018). The advantage of these local networks is that they keep value within the network, instead of perpetually extracting units of resource to accumulate at the top of the socio-economic pyramid of wealth.

Stably cryptocurrency representation.

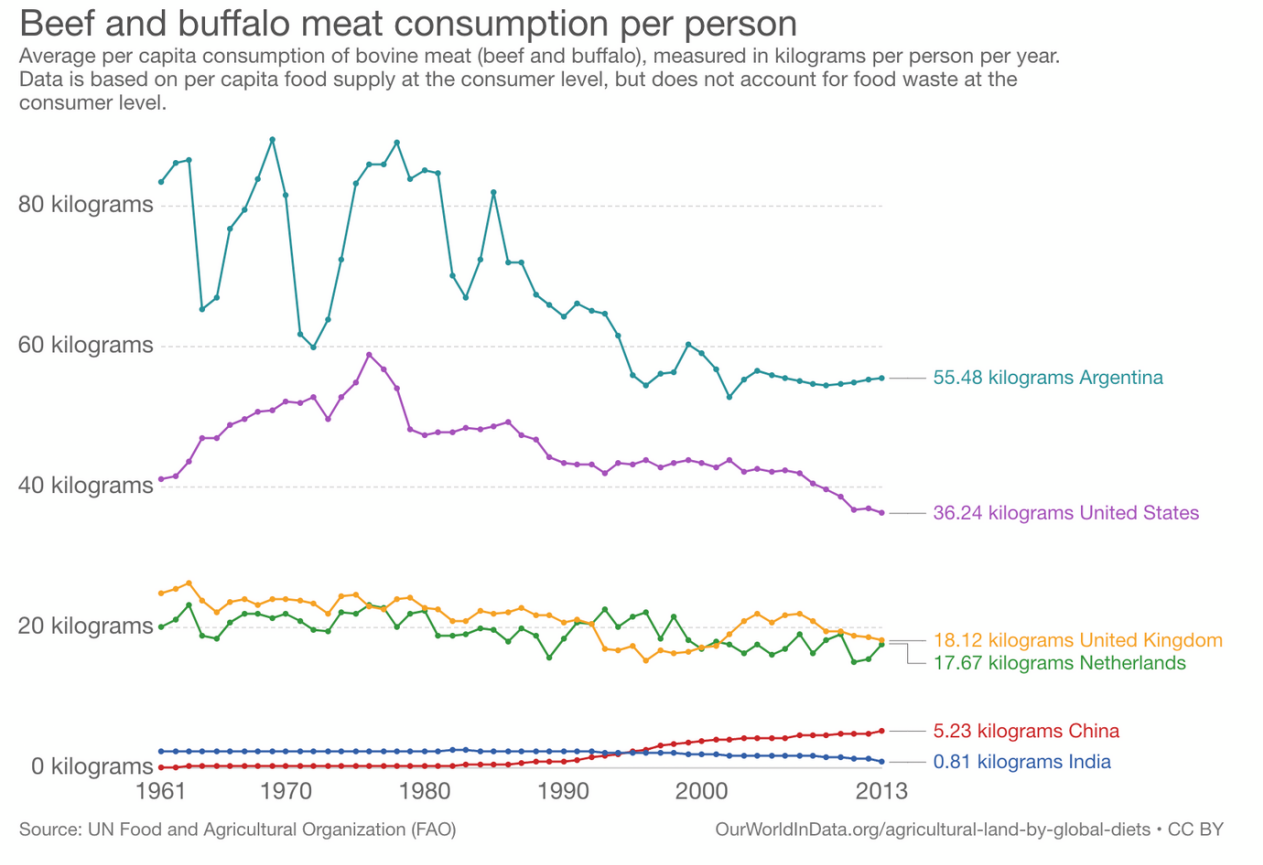
Source: Image from https://kemlaurin.medium.com/the-graeber-effect-the-rise-of-the-barter-economy-the-death-of-bs-jobs-ee6f9fd17add

We close Chapter 7 and this book on sustainable consumption, by bringing together the themes of the global environmental tragedy of the commons, positive externalities, and Elinor Ostrom's design principles for polycentric governance. Additionally, the breakthrough technologies of DLT and blockchain community currencies provide a tailor-made way to measure, record, and reward positive externalities. Chapter 4 pointed out that agents have different motives. Some actors may seek to use as many resources as possible, despite how this affects everyone else. Some actors may prefer to cooperate with others, but worry that they will be taken advantage off. Even more significantly, most of us probably realise that even though consumers are sovereign and generate market demand, no single consumer can change runaway greenhouse cases by changing personal consumption patterns.

Finland has the stated public policy goal of achieving net carbon neutrality by 2035. This is a statement of the democratic will of the Finnish people. Yet we know that the Finnish per capita carbon footprint is currently about 8 metric tonnes. Diet is the easiest set of consumer choices to change with respect to the technological innovation required (as opposed to transportation and the energy sector). Two percent of Finns are reported to be vegan, and thus consume food in the most sustainable way. An additional 10% are vegetarian.To give an idea of the change in consumption patterns that could add up significantly, Finns could reduce their meat consumption to avoid imported beef products, which are currently approximately 4 kg/person annually; and they could reduce cheese consumption by half to 12 kg/person/year. At its lowest feasible number, producing one kg of beef emits 19 kg of CO2e gas; 1 kg of cheese emits 13 kg of CO2e gas. Given the per capita numbers, this reduction in consumption would come to 0.4 million metric tonnes less for beef consumption, and 0.86 million metric tonnes less for cheese consumption, for a total of 1.2 M metric tonne reduction annually. This is a modest shift that helps restore net carbon neutrality for land use in Finland, which currently has a carbon footprint of approximately 2.2 M metric tonnes per year.



Source: https://julkaisut.valtioneuvosto.fi/handle/10024/164323

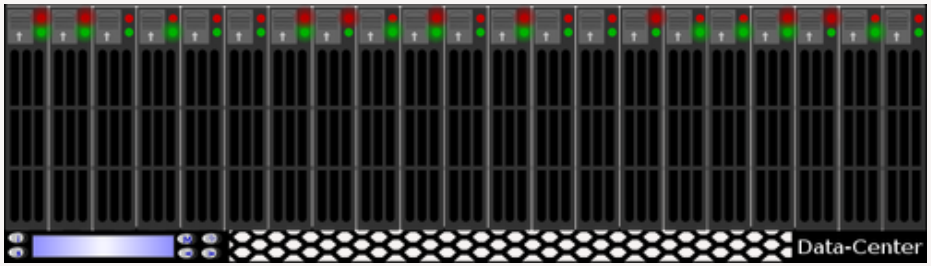


Source: Our World In Data, CC BY 3.0, <https://creativecommons.org/licenses/by/3.0>, via Wikimedia Commons.

Dietary change, while the easier to achieve technically, meets resistance because supply chains and individuals' habits are entrenched. Producers do not have a motive to alter their products unless consumers' demand patterns change. Yet consumers have little motive to alter their dietary habits because each, acting alone, cannot make a difference. The common pool resource of the atmospheric commons thus faces collective tragedy as individuals' consumption patterns produce negative externalities of excessive CO2. The heavier carbon footprints are those of consumers in advanced capitalist societies with more money to exercise consumer sovereignty.

However, if citizen consumers value a 1.5°C lifestyle, which many reportedly do, then we can build voluntary virtual communities to realise this goal. Steps on this path include the steps taken in *Sustainable Consumption*: gathering data and information to make appropriate choices. We need a means to counter the tragedy of the commons, and the anxiety that none of us can make a difference alone. We can implement a means of measuring, recording, and validating individual contributions. Any reduction of CO2 emissions toward the global goal of maintaining a 1.5°C temperature rise is surely as worthy of keeping track of as is the exchange of pennies for trivial consumer goods. These positive externalities that anti-rival cryptocurrency systems can measure, record, and validate, amplify to empower the individual and collective achievement of environmental sustainability and security.

Our final note is to point out the video explaining the new environmentally friendly way to mint blockchain tokens. Cryptocurrency and blockchain have received a bad reputation because the means of achieving security in updating the blockchain for Ethereum currencies was "proof of work." This required solving a mathematical problem requiring enormous computing power. However, in the new "proof of stake" method, those minting blockchain additions are recognised as providing valid updates because they have invested in the value of the cryptocurrency. See the video "Proof-of-Stake (vs proof-of-work) here: https://www.youtube.com/watch?v=M3EFi_POhps



Source: https://publicdomainvectors.org/en/free-clipart/Data-center-vector-illustration/13239.html

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