Informational money, Islamic finance, and the dismissal of negative interest rates

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Abstract

The Islamic Finance Requirements as formulated in [1] induce the notion of an IFR-compliant financial system. IFR-compliance provides an axiomatic approach to Islamic finance. In order to deal with potential mismatches between IFR-compliance and Islamic principles, IFR-compliant financial systems are referred to as Crescent-Star finances and IFR serves as axioms for Crescent-Star finance. Literally following that approach negative interest rates are to be avoided in a Crescent-Star financial system just as well as positive interest rates. W.r.t. Islamic finance Crescent-Star finance may admit false positives, i.e. IFR-compliant models of finance that nevertheless fail to qualify as sound from an Islamic perspective, but there won't be false negatives.

A weaker version Crescent-Star$_n$ finance is formulated which formally permits negative interest rates, and a strengthening of the requirements of Crescent-Star finance to Crescent-Star$_{pls}$ is defined in which it is always required that profit and loss sharing takes place in connection with lending. It is argued that if only informational money is taken into account, Crescent-Star$_n$ finance prevents the occurrence of negative interest rates. It is shown that the situation is quite different for physical monies.

Crescent-Star$_{pls}$ finance excludes negative interest rates as well as positive interest rates.

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1 Introduction

In Bergstra [1] the notion of an IFR-compliant financial system is proposed. The requirements making up IFR-compliance may be considered axioms for class of a financial systems. I will

assume that all systems of Islamic finance[1] (hereafter IF) are IFR-compliant. It is quite a different matter, unresolved for the time being, however, to establish (or to disprove) the converse.[2]

In order to deal with the eventuality that some IFR-compliant systems are not judged to be in compliance with principles of Islamic finance that failed to be captured by the requirements listed as IFR, I propose to refer to the class of IFR-compliant financial systems as Crescent-Star finances. Thus the Islamic Finance Requirements that together define IFR-compliance may be viewed as the axioms for Crescent-Star finance. In this manner we find an axiomatic approach to a class of financial models that includes Islamic finances.

Crescent-Star finances are approximations, or models if one so wishes, of Islamic finances within a risk-averse methodology of comparing and analysing financial systems. The risk to be avoided is that a financial system is deemed "Islamic" on insufficient grounds. By not insisting that all Crescent-Star finances are Islamic finances that risk is dealt with. In terms of modelling Islamic finance Crescent-Star finance may feature false positives but it is unlikely to feature false negatives.[3]

1.1 Terminology for monies and money-items

It is useful to distinguish physical money (PM) from informational money (IM).[4] Unfortunately contrasting PM and IM is too simplistic. A distinction needs to be made between money-items and monies. A money comprises an entire circulation of money-items. A money may feature different classes of money-items.

1. A money refers to an entire design of (categories of) money-items and its circulation mechanisms, rather abstractly. Alternatively "a money" may refer to the current contingent state of affairs for an instance of a money meant abstractly.

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[1] I will use the concept of "Islamic finance" in an informal manner only and I will try to avoid any definitive claims on what is or what isn't an adequate financial system according to Islamic principles, thus leaving room of different interpretations if the concept.

[2] In Niekamp [23] it is argued that many different designs of conventional financial systems exist, no natural order of money dictates a design in all detail, and I assume that a corresponding conclusion holds for Crescent-Star finances and for Islamic finances as well.

[3] Islamic finance (IF) as it is known today arose around 1930 and it required some 50 years of further development until a full-fledged financial system had been created. In its strict dismissal of (positive) interest rates IF might be considered an extreme view on finance. As a manifestation of extreme thinking IF is obviously non-violent, just as creationism is a non-violent form of extreme thinking within Christianity. Now one may wonder why IF is so recent and what might have caused its surfacing. A remarkable perspective may be borrowed from Valkhoff [25] where it is indicated that in the development of Christianity the awareness of an increasing distance between God and individual persons induced a heterogeneous development of conceptually extreme views. Those developments took place over 500 years ago, but it is worth investigating if the development of extreme views, may it be in connection with money or otherwise, in Islam in the last 150 years, has in a similar manner been triggered by an increased feeling of distance from God in the Islamic world. Extrapolating the views of Valkhoff [25] from Christianity to Islam suggests counterintuitively and surprisingly that some extreme views in Islam may in fact occur as a consequence of its conceptual modernization.

[4] One may think of PM as being outdated or nearly outdated. That is wrong in my view because the specific package of features provided by PM in terms of (i) authentication and anonymity provided for different partners in a transaction, (ii) independence of internet infrastructure, independence of the power grid, and (iii) prevention of fraud, may not yet have been matched by any design for an IM.

2. In case of ambiguity in need or clarification one may optionally add type information by writing $money_a$ for the abstract reading of money, and $money_c$ for the concrete (instantiated) reading of it, the latter taking its temporal status as a dynamic system into account.

   For instance:

   (a) the Euro is a $money_a$, (it is based on the Maastricht treaty),

   (b) the Euro is an undervalued $money_c$ against the USD,

   (c) the amount of Euro's in circulation is at an all time high, and therefore:

   (d) the Euro is an inflationary $money_c$,

   (e) according to Bergstra [2, 3] it is open for debate whether Bitcoin, as specified in Nakamoto [21], is an informational $money_a$ (the issue of architectural adequacy), while Bitcoin is currently not an informational $money_c$ although it might be the case that Bitcoin is a candidate informational $money_c$ (the issue of evolutionary adequacy).

3. Each $money_c$ is one of the possible realizations of a $money_a$. However, when taking an empirically observed $money_c$ (say M_X) as a point of departure it requires the design of a theory of money to develop a (description of) a $money_a$ that may serve as an abstract account of M_X. There is much freedom in designing the abstraction, just as there is much freedom for finding a concrete realisation when given an abstract description. Money-items of a $money_a$ are formal descriptions of money-items of its concrete version as a $money_c$. When speaking or writing of specific money-items with spatio-temporal existence one needs to refer to a $money_c$ rather than to a $money_a$.

4. A money goes with the notion of a money-item (also money-thing). Some monies allow a diversity of classes of money-items. Two classes that may both have subclasses are: IMI (informational money-item) and PMI (physical money-item).

5. A money may have both PMIs and IMIs. Conventional monies like EUR and USD have both.

6. A physical money (PM) is a money that features physical money-items (PMIs) only.[5]

7. PMI_a's and IMI_a's play a role in theoretical work about monies M_a. When considering an existing money, by default PMIs and IMIs are meant concretely.

8. An informational money (IM) is a money that allows informational money-items (IMIs) only.[6]

9. A money-item for an IM is referred to as a QoIM.

10. A group or package of QoIMs is denoted as a QoIMp (quantity of IM pack).

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[5]Probably monies started in the form of PMs but PMs seem not to exist anymore. A PM_a has PM_c's as its realisations.

[6]If Bitcoin is considered a money (which I don't) it is an IM.

11. Different monies may be distinguished with subscripts $X, Y, Z, ..$ Then a money-item for IM_X is a $QoIM_X$, and a package of those is a $QoIMp_X$.

12. As the phrase term quantity of money is often used for a universal aggregate we write $v(Q_\mu(IM_X))$ for the aggregate value of all existing $QoIM_X$'s according to a valuation metric μ which produces a value in terms of the money of account (MoA_X) that comes with M_X.

13. I will alternatively refer to a PM as a PM only money (though speaking of a PMI only money would be more systematic in this case),

14. A PMI for PM_X is a PMI_X. A package of those is a $PMIp_X$

15. An IMI for an IM is a QoIM, (and an IMI for IM_X is $QoIM_X$).

16. An IMI_X for a money M_X that is not an IM is not a a QoIM.

17. An item class for a money is a class of technically similar money-items, for instance: coins, banknotes, checks, and electronically loaded RFID cards constitute four different item classes each consisting of PMIs only), while private bank accounts, and reserves held at a central bank are item classes exclusively made up of IMIs.

18. A wide spectrum money (WSM) features "many" item classes. The item class family of a money may be dynamically changing. Currently an IM is by definition not a WSM, but that may change.

19. A mono-item class money features just a single class of money-items. If Bitcoin is considered an IM then it is a mono-item class IM.

20. A money M brings with it a money of account MoA, with its unit: UMoA. Each money-item of M is valued as q UMoA with q some positive rational number.

21. A money M_X brings with it a money of account MoA_X, with its unit: $UMoA_X$. Each money-item of M_X is valued as q $UMoA_X$ with q some positive rational number.

22. The distinction between a MoA_a and a MoA_c arises if one intends to analyse the relation between a money M and a MoA in general.[7]

23. By definition q $UMoA_X$ is not a money-item, though it may constitute a description of the value (in terms of MoA_X) of some money-item for M_X.

24. With Crescent-Star^{im} I will denote the class Crescent-Star financial systems that make use of informational money items only (i.e. that are IMs).

25. The distinction between Crescent-Star$_a$ and Crescent-Star$_c$ and the distinction between Crescent-Star$_a^{im}$ and Crescent-Star$_c^{im}$ is useful as well. Below I will only discuss abstract versions of such monies.

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[7]Assuming that Bitcoin is an IM_a (Bitcoin$_a$) as wel as an IM_c (Bitcoin$_c$), it determines a MoA_c, (say denoted as MoA[Bitcoin]$_c$). Abstracting from the state of development of Bitcoin$_c$ one finds an MoA_a: MoA[Bitcoin]$_a$. The question how MoA[Bitcoin]$_a$ compares with MoA[Euro]$_a$ is a relevant conceptual question which seems to be entirely open. One may guess that MoA[Euro]$_a$ is more similar to MoA[USD]$_a$ than both are to MoA[Bitcoin]$_a$ but at this stage I don't see a sound argument for that guess.

1.2 Interest prohibition: having interest rate zero at all times

Now the prohibition of interest, axiomatic for Crescent-Star finance says nothing about its sign and I conclude on purely formalistic grounds that negative interest rates as as well as positive interest rates are considered undesirable in Cresent-Star finance. I will assume that not having any interest coincides with interest being zero at all times.

A weaker version of IFR, written IFR_n is persmissive, at least in principle by not explicitly excluding it, of negative interest rates while not being permissive of positive interest rates. The corresponding class of finances will be referred to as Crescent-Star$_n$ finances, the subscript n denoting that the interest prohibition axiom is restricted to positive interest rates.

1.3 Five axioms for Crescent-Star Finance (CSF)

I will refer to [1] for a listing of the five requirements making up IFR-compliance. These are considered the axioms for Crescent-Star finance. Here I will only briefly recall the titles of these five requirements, without further explanation:

1. interest prohibition,

2. no misleading,

3. true entity requirement,

4. gambling prohibition,

5. mandatory donation.

It follows from the third requirement that an amount of money may only be bought in exchange for the same amount of money. Otherwise either party in the transaction could get something for free.

1.3.1 Crescent-Star$_n$ finance: weakening the axioms for CSF

The axioms for Crescent-Star$_n$ finance (CSF_n) replace the first axiom by the prohibition of positive interest only. This is a weaker set of requirements on an economy which, when considered as a specification of Islamic finance is less likely to feature false negatives, and of course more likely to feature false positives.

By using CSF rather than IF as a tag for the axioms systems false negatives as well as false positives may occur, and may be found to exist in a later stage, without the terminology being compromised beyond repair.

I failed to find any expositions about the admissibility of negative interest rates from an Islamic perspective and for that reason my exposition is somewhat experimental. A candidate positive reply, that is a suggestion for an argument taken from Islamic finance that dismisses negative interest rates more directly than Crescent-Star$_n$ finance does, may run as follows: let PLS abbreviate profit and loss sharing, and by imposing PLS negative interest rates are ruled out. This leads to a useful strengthening of the axioms for CSF.

1.3.2 Crescent-Star$_{pls}$ finance: strengthening the axioms for CSF

The interest prohibition axiom can be strengthened by stating that all payment in connection with any loan must take place in the context of profit loss sharing (PLS). In [18] one finds an argument that these stronger requirements are in fact plausible for leading done by financial intermediaries and banks. This stronger set of axioms, however, may dismiss financial models that are considered Islamic by some authoritative bodies. The stronger axiomatization is referred to as Crescent-Star$_{pls}$ finance (CSF$_{pls}$).

It seems that Islamic finance lies in the logical interval between Crescent-Star$_n$ and Crescent-Star$_{pls}$. For the present paper the gap left open between these two axiom systems matters a lot as Crescent-Star$_n$ is indeed permissive of negative interest rates, a fact to be established below, while Crescent-Star$_{pls}$ demonstrably dismisses negative interest rates.

1.4 PLS is independent from CSF

Now CSF need not imply a practice of or a preference for PLS. To see this one may understand providing a zero-interest loan as a gift. Here I assume that providing loans against zero interest complies with CSF if providing the loan is not instrumental for acting in contradiction with the other four axioms of CSF. Such loans without interest are given by A to agents B from whom A expects positive attitudes in return in a later stage of its life. The economy of giving as it has been formulated in Weijland [26, 27] may be applied as a description of an economy based on such particular kinds of gifts. I am confident that at least in theory an economy of giving (including the provision of zero interest loans) may be designed within the constraints of a Crescent-Star finance. Such an economy contradicts PLS. So CSF and therefore CSF$_n$ need not imply PLS.

1.5 Organizing assertions about Crescent-Star finances

Here is a survey of assertions (hypotheses, results, and conjectures) and questions, which provide an outline of the arguments that I wil make.

1. SOUNDNESS OF CSF$_n$: CSF$_n$ is sound w.r.t. Islamic finance, in other words: each design of a financial system which is valid from an Islamic point of view constitutes a Cresent-Star$_n$ finance.[8]

2. PLAUSIBLE CONJECTURE: Crescent-Star$_n^{pm}$, that is the class of Crescent-Star finances making use of PM only, admits designs of a financial system that may run into a perpetual state of negative interests. (In other words Crescent-Star$_n^{pm}$ is strictly included in Crescent-Star^{pm}.

3. WORKING HYPOTHESIS: in the absence of PM, the costs of storing and protecting one or more QoIMs (quantities of informational money) is flat rather than proportional

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[8]Soundness of CSF w.r.t. IF is an assumption from [2] where, however, negative interest have not been taken into account. By interpreting CSF as excluding negative interest rates the possibility arises that a financial system can be designed which is deemed valid from an Islamic point of view but which, by featuring negative interest rates, is not a Crescent-Star finance.

to the nominal value of the amount being stored and protected and by consequence such costs don't qualify as negative interests.

4. AUXILIARY RESULT: in the absence of PM negative interests must be explained by the policy making of a bank, or more realistically of a central bank (CB). CB by imposing negative interest rates can force individual banks to (i) impose negative interest rates on its customers holding sight deposits or savings accounts as well, and/or (ii) to provide negative interests to customers who are borrowing money.

5. DISCLAIMER: there are many designs possible for the interaction between agents, banks, and a central bank. There seems not to be any "natural" organization of this financial machinery. Current practice may in many cases be understood as a dematerialized version of classical processes dating back to times before modern IT entered the scene. In some cases there are four levels, with a top-level bank (like ECB or FeD) coordinating the work of a number of (national) central banks.[9]

6. VALIDITY OF NEGATIVE INTEREST PROPAGATION: If a bank, say A, borrows money from CB against negative interest rates it is Crescent-Star$_n^{pm}$- compliant for bank A to claim negative interest rates from their customers as well.

7. WELL-FOUNDEDNESS OF THE INTEREST EXPLANATION CHAIN: Proving (or rather arguing for plausibility) that no conceivable hierarchically organised banking system working with informational money only, can produce negative interests at any level without imposing such negative interets by way of taxation at some level makes use of a well-foundedness assumption: the chain of interest payments starts with a first instance of negative interests (in a causal sense), or of simulated negative interests.[10]

8. ASSUMPTION: violations of Crescent-Star$_n$-compliance in connection with negative interest rates are to be found in mechanisms playing a role at the top of the banking hierarchy rather than at its bottom. The well-foundedness principle indicates that "somewhere" a sub-mechanism can be found producing negative interest rates which is not caused by yet another such sub-mechanism (assuming that a financial system requires negative interest rates to be paid by some participant).

9. RESULT: Crescent-Star$_n^{im}$ finance equals Crescent-Star^{im} finance (in other words, by dismissing positive interest rates, and in the absence of PM and given the context of the

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[9]In the four main currency areas the architecture of the financial system is pairwise different. A survey of various mechanisms for the interaction between banks and central banks is given in Gray [16]. An explanation from first principles of coordination between banks is provided by Mallett [19]. For uninitiated readers it would be very helpful, however, if policies are explained, as in [16], from a position where mechanisms have been explained in a policy-independent manner, as in [19].

[10]In the case of the ECB a major mechanism is the so-called main refinancing operation (MRO), see [12]. An MRO involves buying bonds (bank assets) and selling back the same bonds later for an agreed price. In this manner, by selling back for a higher price a negative interest on the loan of the bonds is simulated. This is done specifically in a way which even seems to be valid from an Islamic point of view. However, the degree of freedom in choosing a price for a bond, and even in choosing different prices for the selling and buying of the same bond, is connected with the bond producing a (positive or negative) interest rate, which is at odds with Crescent-Star finance.

On its site the ECB indicates its normal business of monetary policymaking as the regular setting of three different interest rates (so-called key interest rates), each of which might be negative in principle.

remaining axioms of Crescent-Star finance, negative interest rates are dismissed as well; this assertion will be argued below.)

10. COROLLARY: DISMISSAL OF NEGATIVE INTEREST IN IF: from the above assertions it follows that it is plausible that in the absence of PMIs (that is in an IM) negative interest rates are to be dismissed in Islamic finance.

11. QUESTION ON COMPLETENESS OF CSF_{pls} (left open): are all Crescent-Star$_{pls}$ finances valid from an Islamic point of view. (Providing an affirmative answer to this question amounts to confirmation of the completeness of the axioms of Crescent-Star$_{pls}$ finance for Islamic finance. This completeness holds true even if CSF_{pls} is not sound, that is, its requirements are too strict w.r.t. IF.)

12. QUESTION ON COMPLETENESS OF CSF (left open): are all Crescent-Star finances valid from an Islamic point of view. This question arises only after completeness of CSF_{pls} has been confirmed.[11]

2 Negative interest rates in a hypothetical PM

When considering negative interest rates in any financial system, or model of it, some conception of an entire money circulation becomes mandatory. In the simplest and nowadays hypothetical, case there are only physical money-items (PMIs) and no informational money-items. I will look into this case in some detail.

2.1 Partially explaining away negative interest rates as cost

A world in which all agents make use of the same PM_X the existence of negative interest rates may be understood as follows:

- the unit of the money of account (MoA_X) corresponding to PM_X is denoted with UMoA_X.

- assume that an agent B owns an amount of money valued at p UMoA_X, and suppose that B expect to continue its ownership during an episode Δt,

- now assume that B implements its ownership of the mentioned amount by being in possession of an physical amount P with value $p = val(P)$ UMoA_X,

- during time interval Δt, B must protect P against loss and theft say at cost r_P,

- Now B may avoid part or (perhaps even all) of these costs by lending P to another agent, say A, who is then in possession of it (though not becoming its owner), and who is able to preserve and protect it in a less costly manner, say against cost $s_P < r_P$.

- In this way an advantage may arise for B, and B may be willing to provide a premium q_P with $s_P < q_P < r_P$ to A for its cheaper preservation of the money.

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[11]If CSF_{pls} turns out to be sound for IF, that fact, however, implies that CSF must be incomplete.

- By averaging out over different PM configurations with value p and by market competition between different potential holders of such amounts an expected cost of holding an amount with value p UPM will come into existence, which works as a a negative interest rate expressed in terms of the MoA.

- It is reasonable that r_P is proportional to p.

- Indeed B may subtract q_p from its borrowed holding P valued p UMoA$_X$ and B may return to A after expiration of episode Δt, an amount P' with reduced value $p - q_p$ UMoA$_X$.

To the extent that storage of money brings real cost, emanating from real work, and indeed requires the provision of a real service, such cost may be considered acceptable and may not be viewed as an interest payment but rather as a transaction cost that comes with the preservation of money.[12]

This kind of economy seems to be unstable as all savings are concentrated at the most effective storehouse of money. However, different storehouses may compete in terms of price (keeping negative interest low in absolute value) as well as with regard to risk management (keeping the risk of loss or theft low). An agent B may prefer splitting its savings over a number of different storehouses each of those being relatively cheap with a significant risk of loss or theft. Thus the number of storehouses need not shrink to just one.

2.2 Financial black holes supporting sustained negative interests

One may imagine a large volume of money held by a single agent A owning and running a storehouse for PM, say H. A is indebted to many of its customers. The situation may be such that none of that money is more cheaply stored outside H. Thus money can't escape from H and H possibly permanently attracts money to it. H has become a black hole for PM, a possible form of a liquidity trap in Keynesian jargon.

Nevertheless H's owner A must pay support staff and facilities for protecting its holdings and for maintenance of H. Thereby A, while running H, "evaporates" some money to the outside world. This money is likely to be taken by A from its holdings in H as cost of storage (and in the light of the above remarks such withdrawals may but need not necessarily be considered negative interest imposed by A on its customers and may in part or in total be considered legitimate costs). In the black hole comparison, which should not be taken too seriously, that outflux of money may be compared to the famous Hawking radiation. This comparison suggests that unless there is a permanent influx of new debt to A for storage in H, on the long run H will be emptied.

If a fraction of the costs of the storage of money with a storehouse can be considered a premium for the fact that storage in H is less risky than private storage of cash outside a

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[12]It seems that Bitcoin has such transactions cost as well. If none of the holders of Bitcoin intend to perform any transactions the collection of owners is still well-advised to perform fake transactions on a regular basis in order to keep the mining and validation system in good order. Negative interest then arises from the fees imposed by miners for validating the fake transactions, and at the same time the creation of new Bitcoin has an inflationary effect that works in the same (downward) direction.

storehouse, and in particular if a storehouse may ask a premium in excess of its costs given a competition between its prospective clients, that premium may be considered an instance of negative interest, even if real cost of storage are not counted as interest.

In an extreme situation an economy contains merely a number of storehouses for money and the dominant economic activity is related to keeping the storehouses in good order. Whenever an agent not owning a storehouse accumulates too much money it has no other option than to ask a storehouse owner to take care of it. In this manner one obtains a somewhat depressing picture of a stable economy with persistent negative interest rates. Leaving aside the somewhat artificial attempt to maintain the black hole analogue, it seems to be the case that an economy with sustained negative interest rates is conceivable. But this form of circulation of money may fail to be IFR-compliant because agents may fail to comply with the requirement of mandatory donation.

However, introducing mandatory donation by all owners of holdings of accounts with a storehouse seems to be consistent with the given picture, from which it follows that (assuming a PM only system) a financial system with sustained negative interest rates that complies with the other four IFR requirements is conceivable.

This kind of example economy being hardly realistic we are left with the consideration that an economy may begin cooling down by de facto permanent storing of an increasing percentage of circulating PM. And after cooling down negative interest rates constitute a stable feature and a turning point towards economic expansion and re-use of stored money need not arise, that is not necessarily in some extreme and wholly unattractive circumstances.

2.3 Compromising the PM only regime

I conclude from the above that Crescent-Star finance may in fact be compatible with sustained negative interest rates in the case of a PM. Now of course if only a small fraction of the monetary circulation consists of IMIs the situation will not change much. In order to find different circumstances it must be assumed that most if not all money in circulation takes the form of IMIs. In such circumstances cost of storage, production, and maintenance of PMIs (if present as a low fraction of the circulation) is understood as transaction cost that comes along with the technical form of an amount rather than as negative interest which is proportional to the size of an amount. For simplicity I will assume an IM only financial system below.

3 Three views on money: operational, intentional, and mechanical

Money is surprisingly difficult to understand. And why that is the case is hard to understand also. Money is a topic of daily experience for most people and making use of it is so hard to avoid that even contemplating the idea of not understanding what money is seems entirely foreign to most people.

I will now provide three views on money which in combination may provide some understanding of it.

3.1 An intuitive operational view

In the intuitive operational view one knows how to make use of money in order to support one's daily existence. Given a money M (as identified with its MoE, money of exchange), with its associated MoA and given some agent A the following may be noticed:

1. The direct use of M_c as an MoE_c by exchanging (ownership of) a PMIp for (ownership of) an object that is for sale or for (the temporary or permanent use of) some service, constitutes the primary functionality of M.

2. Earning money through work, sales, or subsidies, constitutes the converse process to the direct use of money. This earning process is most well-known, applying M both as an MoA (how much do I earn) and as an MoE (these are last months earnings).

3. Having too many PMIs (too large a PMIp) at hand is impractical and depositing a PMIp in a bank while receiving access to an account containing an equivalent value in terms of an IMIp (without reserving any right to receive precisely that same PMIp back upon request) is standard.[13]

4. Conversely at cash points access to an IMIp may be used to withdraw money, that is to convert an IMIp into a corresponding PMIp. Correspondence means that the value of both packages as measured by MoA is approximately the same.

5. When placing an IMIp on a bank, care must be taken that interest rates are sufficiently high, that access is permitted when needed, that the bank will not fail, or that if it fails some external guaranties will work out well.

6. A shortage of disposable money-items for M is either an incentive to take a loan (that is to borrow some money-items), or an incentive to cut planned spending, or an incentive to collect more earnings.

7. Saving money and thus having it incorporated on a bank account is considered good practice.

3.2 An intentional and rationalizing view of money and its use

In addition to the operational view one may entertain the following views which give expressions to one's perspective on what money is for and how it ought to be used for that reason.

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[13]At this stage one may notice some room for more precision. A PMIp that might be "too large" in practice is a $PMIp_c$ rather than a $PMIp_a$. However, one may easily ignore or forget the difference between two coins of the same value. Or one may abstract from the identification numbers of banknotes. It is plausible to view $PMIp_c$ as being descriptive of PMIp's at a level of abstraction where such distinctions don't count. In some cases a view with higher resolution may be needed, however, and the use lower levels of abstraction may be required: for banknotes one may speak of a PMI_{cii}, that is the PMI_c understood inclusive of its informational identity (which might be a fraud), and for coins as well as for banknotes a PMI_{cpi} which captures the physical identity as well. Using this convention, a DNA trace on a coin might be found on a PMI_{cpi} rather than on a PMI_c, and if two banknotes are the same when viewed as a PMI_{cii} then at least one of the two PMI_{cpi}'s at hand must be an instance of counterfeit money.

1. In general it is considered a good thing if agents save money for their future. item The idea of money is clear and the money one uses is an implementation of such ideas. The implementation may have some flaws but the objectives of the system are clear and are well expressed by the classical summary: MoE (means of exchange), MoA (money of account), and MSoV (money as a store of value).

2. Because a money M serves as an MoA for itself, they is no need to distinguish both functions of money.

3. Easy access to one's holdings of IMIs is of paramount importance.

4. Possession and ownership if PMIs and IMIs can be distinguished. Both a PMIp and a IMIp can be stolen, leading to the thief being in poison of money that (s)he fail to own, and one must be aware of how to prevent such disappointing events.

5. Although the development of one's assets as specified in terms of money-items is often considered in nominal terms it is rational to take a greater interest in the development of its value in real terms, that is taking inflation, deflation, and the effects of cumulative interest into account.

6. It is rather obvious that storage of digital money-items (that is of an a IMIp) is simpler and for that reason cheaper than storage of physical money-items (that is of a PMIp). This differential increases when the value of the quantities increases.

7. As an alternative to storing money one may invest it, which means that one buys goods which according to one's expectation in due time can be sold for a reasonable price. Preferably the goods produce some income during time of ownership, and moreover they can be sold at a price in excess of the price of acquisition.

8. Inflation is the most prominent enemy of an owner of money. Inflation causes the value of saved money to decrease in real term even if it increases in n nominal terms.

3.3 A mechanical and deductive view of money and its use

Instead of complementing the operational view that all users of a money share to some extent with the intentional/rational view, one may complement it with a mechanical understanding of how a money works. Rather than to depart from a rationale of what a money is or should be one deduces from facts or assumptions about the architecture of a money which proporties it may have. A highly complicating factor for the mechanical view is that there are som many different organisations of financial machinery and that the inner workings of seemingly the same money are changed time and again.

Doing so is difficult and it requires one to introduce abstractions, and any mechanical view must be based on a some theory of money and its circulation. A mechanical view (of some financial system FS) explains how money flows or may flow through the modular structure of

a hierarchical banking system with all steps equipped with a description that is meaningful from the perspective of modular double entry bookkeeping.[14]

1. One may be aware that rigorously using M_c as a MoA_c for itself fails to explain that in some circumstances a $PMIp_c$ consisting of one or more coins may exceed its nominal value (that is it may be exchanged for other PNIs or IMIs as if its valure were above the nominal value). This may happen with coins that provide access to a vending machine.[15]

2. One may hold that savings and debt are complementary, i.e. that money is a zero sum game so that the suggestion that we better all save for the future is meaningless.

3. One may hold that at a system level saving money for the future is a logica impossibility and that for that reason no degree of slowing down the economic development of the entire system can be motivated in terms of being careful with one's money.

4. Acquiring a mechanical understanding of the current ECB driven monetary system in a part of the EU is difficult. Even finding a mechanical (operational) characterisation of interest payment is difficult, see Bergstra & Middelburg [7] where an attempt to formulate such a characterisation is made, in order to support a precise definition of the idea of interest prohibition.

5. One may understand negative interest (if any) claimed by a bank on IMI deposits as the consequence of central bank policies which come very close to taxation on one's holdings. Such negative interest payments cannot be connected with there real cost of storing the deposited amounts and for that reason must express the influence of another cost factor.

6. One may understand positive interest rates as form of subsidy (the opposite of taxation) rather than as an expression of the effects of a competition for money on a market of borrowers competing for scarce resources in terms of access to funds.

7. One may understand PMIs as an advanced technology for MoE and MSoV which is insensitive to negative interest levels, which permits a supporting level of anonymity for buyers and sellers involved in transactions and which provide a most wanted expression of freedom of choice.

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[14]It seems that one can't avoid the introduction of banks and a central bank. Now following Goodhart [15] the definition of banks is not self-evident and so is the true role of a Central Bank which he considers an evolutionary outcome of the banking system. The distinction between banks and non-banks is portrayed as an economic one, not a logical one, although as he states a bank primarily invests in non-marketable (or at least non-marketed) assets. Mettenheim [17] uses a so-called minimal definition of banks: accepting deposits and extending loans, with the provision of payment services being of secondary importance only. This minimal definition serves the purposes of our paper quite well. The implications of double entry bookkeeping are not easy to grasp either. In Fischer & Braun [13, 14] the point is made that when approaching a double entry bookkeeping based economy from the perspective of statistical mechanics it appears that equilibria will arise only if an upper bound to the amount of money is imposed in advance. This is a non-trivial conclusion from an economic point of view which implies that the boundedness of the entire money circulation is a cause rather than a consequence of the existence of a market equilibrium. Such bounds must play a key role in each circulation model, and for that reason in any mechanical perspective on money.

[15]Similar issues may occur if one has lost the password for a password protected $IMIc_c$. Its accounted value may instantly drop below its nominal value.

8. One may be worried about metrics for inflation and deflation that don't take into account the earning models for pension funds who depend on the fate of investments which are often not measured by such metrics. One may hold that such discrepancies are so important that it may prove self-defeating to manage the money system in terms of these notions.

3.4 Fluctuating between an intentional and a mechanical view

A mechanical and deductive view of money may undermine assumptions that underly the intentional view based on one's own rationalisation of the concept of money. Still giving up one's rationalisation in favour of a mechanical view that may be based in part on defective conceptual modelling is problematic.

I hold that both views are bound to lead to inconsistencies and that the way a person may deal with those inconsistencies is to switch back and forth from the intentional view to the mechanical view, while using paraconsistent reasoning patters to combine both views. Both views will evolve in time but it is unwarranted to expect that a consistent picture will emerge.

3.5 A comparison with the logic of fractions

In Bergstra & Bethke [4] it has been outlined that for the notion of a fraction two views may be distinguished, an expression oriented view and a value oriented view. Both views in combination lead to inconsistency. Bridging both views may be done by means of the chunk and permeate paradigm for paraconsistent reasoning that was proposed in Brown & Priest [11].

In [4] it is suggested that a person's perception of fractions oscillates between an expression oriented perspective and value oriented perspective in a manner which may be compared with the oscillating 3D interpretations of the 2D picture of the so-called Necker cube as discovered by Necker in [22] (see also Mortensen [20]). The 2D picture might be linked with an operational view of fractions that all persons share and which focuses on "what to do when..." without attempting to provide explanations in terms of one ore more concepts of number or in terms of one or more concepts of validity for an assertion that is made up from expressions.[16]

One may understand the operational view of money as a 2D view, and both extension views as competing 3D views that add an explanatory dimension in different ways: via intentions (requirements capture for a money) and rationalisation of a concept of money, and via architectural reconstruction and modelling combined with deductive analysis including the use of computer simulation if probabilities are to be be estimated. One may provide some substance to the 2D versus 3D metaphor by considering space/time and volume as the two dimensions of the 2D picture and intention/working as a third dimension.

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[16]In [8, 9] different attempts are specified to find a middle ground between an expression oriented view of fractions and a value oriented view of fractions. But at closer inspection it appears that in the setting of both papers the contrast between an expression oriented view and a value oriented, two views that logically defeat integration, view persists.

4 On the structure of positive and negative interest rates

This section contains an attempt to describe how loans and deposits compare in a regime of positive interest and in a regime of negative interest. A major difficulty seems to be that the classical story of fractional reserve banking, which to some extent explains how it can be that the system works at all with positive interest rates, needs to be complemented with a detailed description of the interaction between banks and their (unique) central bank. That description takes requirements into account which differ between currency different zones thus making the whole story far more complex than with just one single central bank.[17]

In any case it appears that high (in an absolute sense) negative interest rates can only be explained as the effect of central bank policies that intend to make the money unattractive for investors from outside its scope and at the same time aim at stimulating economic activity by rewarding borrowing and subsequent spending while imposing taxation on savings for agents within its scope. With this explanation in mind one may consider high positive interest rates as a CB issued subsidy on saving and a simultaneous penalty on spending.

4.1 Client borrows money at a positive interest rate

Let A be a client who borrows an amount p at a bank B where A is known as a client. Assuming that for say one year of deposit B charges A an amount r as a positive interest payment. Assuming that the bank only takes deposits and extends loans, but refrains from other investments, one may explain r as the sum $r = r_{opp} + r_{adm} + r_{ins} + r_{mg}$ of four components as follows:

1. The opportunity cost incurred because B might otherwise have added p to its reserves with CB, for CB would have paid B some interest say r_{opp}.

2. Administrative cost (r_{adm}), including transaction fees as well as ongoing cost for maintaining the organization of B. In case of an IM such cost are independent of the size of p.

3. Insurance cost (r_{ins}) for taking care of the risk that A won't be able to return p or all of p when due.

4. A margin (r_{mg}) that B may charge in view of the competition between its current and prospective clients, many of whom are willing to borrow scarce money against a positive interest rate. The higher the margin, the higher the cost for the client.

It seems fair to say that in this particular transaction only $r_{ins} + r_{mg}$ contributes to the notion of interest to which IF may object. Instead r_{opp} is for B an unavoidable consequence

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[17]In particular if trade policy considerations, which in turn are often driven by concerns about unemployment, constitute an incentive for a central bank (say CB_X) to strive towards a lower exchange rate for its currency against currencies of competing economic zones, and if the artificial engineering of risks that will deter foreign investors in the currency of say CB_X fails, making ownership of the currency unattractive by means of negative interest rates may be of help. It follows that in an open economy CB's of a risk avoiding economy will be inclined to impose negative interest rates before CB's of high risk economic zones do the same.

of the mechanism at hand and v unavoidable comes with the loan as an event taking place in space and time.

4.2   Client deposits money at a positive interest rate

Next consider the case that client A deposits amount p with B and is required to pay r to be in view of a negative interest rate. Now one finds a formula $r = r_{cb} - r_{adm} - r_{mg}$, where:

1. The interest (r_{cb}) B receives from CB when depositing p as an addition to its reserves.

2. Administrative cost (r_{adm}), including transaction fees as well as ongoing cost for maintaining the organization of B. In case of an IM such cost are independent of the size of p.

3. There is no risk that the bank won't recover its deposits to CB. And if that risk exists it is a systemic risk against which insurance will not work.

4. A margin (r_{mg}) that B may charge in view of the competition with other banks for clients who are willing to deposit money against a positive interest rate. The higher the margin, the lower what is paid to the client.

Here the part r_{cb} constitutes a subsidy paid by CB as an incentive for saving.

4.3   Client borrows money at a negative interest rate

Let A be a client who deposits an amount p at a bank B. Assuming that for say one year of deposit B charges A an amount r as a negative interest payment. One may explain r as follows $r = r_{cb} + r_{adm} + r_{mg}$ with:

1. Profit r_{cb}: this is either avoided negative interest at deposit to CB (that is the negative interest not paid by B to CB because p is withdrawn from B's reserves) or obtained negative interest from CB if B borrows p from CB to extend the loan to A.

2. Administrative cost (r_{adm}), including transaction fees as well as ongoing cost for maintaining the organization of B. In case of an IM such cost are independent of the size of p.

3. Insurance cost (r_{ins}) for taking care of the risk that A won't be able to return p or all of p when due.

4. A margin (r_{mg}) that B may charge in view of the competition between its current and prospective clients, many of whom are willing to borrow money with the benefit of a negative interest rate. The higher the margin, the lower the yield for the client.

Here one finds that the primary mechanism that allows B to transfer negative interest to its borrowing clients lies in the CB producing negative interest payments on it loans. Moreover the part r_{cb} constitutes a subsidy from CB to the clients of banks as an incentive for borrowing (that is not saving).

4.4 Client deposits money at a negative interest rate

Next consider the case that client A deposits amount p with B and is required to pay r to be in view of a negative interest rate. Now one finds a formula $r = r_{cb} - r_{adm} - r_{mg}$.

1. If B is forced to hold p as an overnight reserve at CB B pays a negative interest r_{cb}, otherwise if B may simply keep it it its database without being charged by CB $r_{cb} = 0$

2. Administrative cost (r_{adm}), including transaction fees as well as ongoing cost for maintaining the organization of B. In case of an IM such cost are independent of the size of p.

3. There is no risk that the bank won't recover its deposits to CB. And if that risk exists it is a systemic risk against which insurance will not work.

4. A margin (r_{mg}) that B may charge in view of the competition between clients who are willing to deposit money against a negative interest rate, with a preference for minimising that negative interest rate (in absolute terms). The higher the margin, the more is charged from the client.

Now we find that the margin may be used to deter non-clients from becoming clients by depositing money with B which is felt as a problem by B. Further if p must be put in reserve with CB after all daily transactions have been cleared, it is the negative interest policy of CB that is driving the mechanics, whereas if the bank need not ask CB to take care of the money, there is no room fro high negative interest rates (at deposits) as banks will be keen to accept deposits at marginal revenues which hardly exceed transaction costs.[18]

5 Arguments against negative interest rates

Different arguments can be brought forward against the phenomenon of negative interest rates as a feature of a Crescent-Star$_n$ finance, and as a feature of an Islamic finance. Before listing such arguments I will provide an account of what may constitute positive interest.

5.1 On dismissing negative interest rates and payments

This is an attempt to provide a complete listing of arguments, or forms of argument, against negative interest rates and payments, which can be either derived from the axioms of Crescent-Star$_n$ finance or which can be read of from explanations of Islamic finance as constituting plausible system preferences for IRF-compliant financial system designs.

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[18]At this point banking regulation becomes important. By being able to attract more deposits B may be allowed to borrow more money from CB, which results in higher reserves allowing to extend more loans against (somewhat lower) negative interest. It seems that a rather comprehensive understanding of the interaction between B and CB as well as the regulations that impose limitations on amounts and ratios is essential to understand the particularities of this aspect of negative interests. One also finds that negative interest on client deposits arise already if positive interest payments by CB approach zero.

The payment for nothing argument against a negative interest payment: A qualitative argument against negative interest rates using g the axioms of Crescent-Star$_n$ finance runs as follows.

Supposing that an agent A borrows p from agent B for the time duration Δt, then in a context with negative interest rates, B is entitled to an additional premium, say q to be paid by A which is proportional to p and which is in the first order also proportional to Δt with the (now negative) rate of interest as a coefficient. From the perspective of B the amount q is created from nothing, and it is in no way earned by B through some form of work. Therefore A's payment of an amount q to B contradicts the true entity requirement (IFR no 3.)

Applying the payment for nothing argument in the setting of an IM: In the setting of an IM, or of any money for which the PMIq's are small in total in comparison to the total volume of IMIq, the occurrence of negative interest rates must feature with banks accepting deposits against negative interest only. Now the cost of storing an IMq is minimal an unrelated to the size, in terms of MoA, of stored IMIq's (unlike the case with PMIs or with gold). Assuming that banks will not send away clients unnecessarily, it follows that negative interests claimed by banks over the deposits held by their clients must be caused by central bank (CB) policies.[19] In particular the unique CB responsible for surveying and interbank clearance of a commercial bank itself claims negative interest rates on the reserves held overnight by a bank.

Finally upon adopting a mechanical view, and assuming as a working hypothesis this form of influence of a CB as a cause of negative interest rates one may find that a CB receives a negative interest payment in a context where no justification in terms of cost can be found and the primary argument applies in full force.

The cooling down to turning point argument: A world with an IM where interest rates are perpetually negative may be considered impossible or may be considered extremely unlikely. In other words after a period of cooling down, the cause of negative interest rates, an economy must always reach a turning point. This argument is supposed to apply in a Crescent-Star$_n$ finance.[20]

The persistent fluctuation argument: This argument is also an economic argument which is supposed to apply in a Crescent-Star$_n$ finance. One may argue that interest rates cannot be or unboundedly often negative, returning to zero equally often, but without episodes of positive interest occurring as well. In other words, sign fluctuations must run through the entire range from positive, zero, to negative.

In a world with perpetual negative interest rate, deflation is likely be perpetual as well. Perhaps hyperdeflation occurs and PMIs with lower values must be introduced time and again. Such a system incorporates a systematic incentive for consumption. It is hard to

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[19]I will assume that negative interests are created or promoted by the CB, or any other authority in charge of the production and maintenance of the volume of money-items, and of incentives for and against the creation of money by banks, in order to counteract an unwanted shift in the economic equilibrium of the community for which it carries responsibility.

[20]This is not obvious, given the fact that there seems to be no objection against the assumption that interest rates are perpetually positive. In section 2 it was shown that a cooling down argument need not apply in the case of a PM dominated world.

imagine that at no stage people will start to consume to such an extent that no measures are ever needed to prevent consumption from growing too fast.[21]

The profit-loss non-sharing argument: As was mentioned above in Section 1.5 item 1.4 negative interest payment demonstrates a case of the absence of profit-loss sharing (PLS). Although the need to apply PLS does not follow from the axioms of Crescent-Star$_n$ finance its non-application might be considered to constitute a deliberate and problematic avoidance of a preferred option from a point of view of Islamic finance.

The PMI preservation argument: PMIs constitute obvious specimen of money-items the demise of which might be considered both counter-intuitive and counter-productive from a perspective of Islamic finance. In a world permissive of negative interest rates a CB finds an incentive to discourage or even to disallow the use of PMIs. This negative pressure against PMIs, as resulting from the occurrence of negative interest rates, may be put in reverse and thus considered to provide an argument against being permissive of negative interest rates.

The renaming argument: One may cast all subsidies and withdrawals made by CB as the result of taxation and refunding of excessive taxation (in hindsight).

Negative interest rates may be understood as a taxation on an institution's reserves held at a CB very much like like Gesell's money based on demurrage (*Freigeld*). Positive interest rates constitute a taxation of not holding reserves with the CB.

Now it seems that positive interest rates can't entirely disappear by speaking of taxation because banks can impose positive interest rates on clients competing for funds in times money is scarce. On the other hand, CB driven negative interest rates can be explained away in terms of taxation entirely. Here it is an assumption on the mechanics of money that the existence of market competition alone can't explain why a bank would impose a negative interest rate on a deposit held by a client. Under that assumption speaking of negative interest payments can be avoided in favour of "taxation-talk". If that is possible its seems reasonable from an Islamic point f view to do so, though not implied by IPR$_n$.

5.2   Flipping the coin: advancing cryptographic informational monies

With negative interest becoming unsurprising in so-called conventional finance several conventional aspects of it are turned upside down. For instance PMIs become much more important because a PMI, at least in today's form, is not vulnerable for negative interest rates.

1. PMI may be restructured in the style of Silvio Gesell's demurrage. Gesell's proposal uses a downgrading mechanism for specially designed banknotes that gradually diminishes

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[21]Without having performed any theoretic economic analysis I suggest that a system which features negative interest rates at some stage will on the long run show fluctuating interest rates, and more importantly interest rates with fluctuating signs. I will assume by way of a working hypothesis that a financial system which features negative interest rates must also be capable of featuring positive interest rates. From this hypothesis it follows that a financial system which dismisses positive interest rates must also dismiss negative interest rates. However, the unfeasibility of ongoing negative interest rates in an IM using economy requires further scrutiny.

the buying power of each banknote by means of so-called stamping. Metallic coins can't be dealt with under Gesell's scheme. Demurrage was invented in order to speed up the circulation of money in a local economy by discouraging the hoarding of money. It may be completed with narrow geographical restrictions on the validity of stampable banknotes. Adoption of demurrage based PMIs constitutes a very consequential modification of conventional money. One may imagine that stamping and demurrage are much more easily applied to IMIs.

2. PMIs may be abandoned altogether. That step, however, is at cost of a significant virtue of PMIs namely their facilitating role in carrying out anonymous transactions.

3. PMIs and conventional IMIs (and perhaps PMIs held in bank safes) may be allowed to have different prices for the same nominal values. The implications of such a step are significant because all price indications will split in accordance with the resulting variety of money forms (price equivalence classes). This step seems to be equivalent to abandoning PMI and at the same time introducing a second money that constitutes a PM which is then connected to the original, now less wide spectrum, money by way of some form of currency board.

4. However, and perhaps more importantly, a Bitcoin-like candidate money may replace the role of conventional PMIs thus rendering the introduction of a PM besides a reduced conventional money redundant.[22]

5. Yet another method is to limit the amount of PMI that is available for holding per capita, or as a percentage of one's total holdings.

6. I recall the viewpoint of Bergstra [1] that a Bitcoin-like informational money may profitably be used within an IFR compliant financial system. The arguments in favour of a Bitcoin-like system as a carrier of an IFR-compliant system make use of its disincentive for positive interest rates in combination with the idea that Bitcoin is not supportive of lending and borrowing. Therefore Bitcoin gives no incentive to negative interest payments either. With negative interest rates becoming an increasing problem for savers, Bitcoin-like (candidate) monies become more interesting.

Much can be proposed, none of it conforms the rules of the financial game that were considered self-evident until recently. Remarkably, for each of these scenario's it seems obvious that a financial system purely based on informational money (for instance with Bitcoin-like coins for intentionally anonymous transactions) may be more easily adapted to a setting with negative interest rates.

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[22]Doing so, however, by means of Bitcion in its current form, is not so plausible in view of the fact that Bitcoin provides anonymity only poorly and not by design and authentication not at all. This state of affairs underlies my assessment in Bergstra [3] that Bitcoin is not architecturally adequate for moneyness, or if one so prefers not evolutionary adequate for moneyness.

6 Concluding remarks

My conclusions from looking into the issue of negative interest rates in connection with Islamic finance and with an eye towards the coming into prominence of informational monies are these:

1. A detailed design of terminology and notation on monies and money-items has been proposed and used in this paper.

2. There are reasons to believe that negative interest rates will be dismissed in the world of Islamic finance just as positive interest rates are dismissed already. These reasons become stronger if the role of physical money-items decreases.

3. The question as to whether Crescent-Star$_n$ finance is equivalent to Crescent-Star finance is sensitive to the role of PMIs. In the absence of PMIs, that is for any IM, CSF$_n$ and CSF seem to be equally restrictive.

4. With negative interest rates becoming prominent for conventional monies the role of cryptographic informational monies may increase, such monies may take the role played by PMIs in a conventional money, those PMIs being phased out because a central bank can't impose negative interest rates on its holders.

5. The idea of a Crescent-Star informational money is coherent (that is not inconsistent), it may emerge within a few years. Bitcoin may serve as a source of inspiration for it, but Bitcoin is not sufficiently mature to play the role of that kind of system system already. In particular it must be improved concerning facilitating customised anonymity for trading partners as well as customised authentication (the opposite of anonymity). Moreover as I argued already in [1] the mining system merits revision.[23]

Many questions remain. I mention some:

1. It is unclear to what extent an IM may provide a substitute for the use of PMIs. It is not even clear if the use of PMIs is on the way up or on the way down. A fractions of the economy depends on the ability of agents to engage in anonymous transactions. It is unclear how important that fractions is, both in terms of its size and in terms of its role.[24]

2. It is unclear to what extent Crescent-Star finance axiomatizes the concept of Islamic finance. It may not be sound if one needs to accommodate cases of an Islamic finance that are permissive of negative interest rates, and it may not be complete in view of the fact that it does not provide an decisive incentive to make use of profit-loss sharing as a substitute for loans against interest.

3. It is unclear if negative interest rates can be discussed at all without taking due consideration of different and competing currency zones, each regulated by their own CB.

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[23]When setting up a Bitcoin-like CSF supporting IM, it is no problem if it becomes a so-called. It market capitalisation could be easily lifted above that of Bitcoin at its very beginning. Moreover including some form of asset backing against a basket of existing conventional monies is probably very useful, though it will require state of the ar AI to determine the scope of that basket automatically.

[24]It is possible that, counterintuitvely, a Bitcoin-like money substitute conventional IMIs rather than conventional PMIs.

References

[1] Jan A. Bergstra. Bitcoin and Islamic Finance.
University of Amsterdam, Informatics Institute, Report TCS1406, April 2014, `http://www.science.uva.nl/pub/programming-research/tcsreports/TCS1406.pdf`, also on `vixra.org/1501.0021`, (2014).

[2] Jan A. Bergstra. Bitcoin: not a currency-like informational commodity.
University of Amsterdam, Informatics Institute, Report TCS1406, April 2014, `http://www.science.uva.nl/pub/programming-research/tcsreports/TCS1406.pdf` also on `vixra.org/abs/1501.0005`, (2014).

[3] Jan A. Bergstra. Architectural adequacy and evolutionary adequacy as characteristics of a candidate informational money. `arXiv:1504.07184 [cs.CY]`, (2015).

[4] J.A. Bergstra, I. Bethke. Note on paraconsistency and reasoning about fractions. To appear in J. of Applied Non-classical Logics, `arXiv:1410.8692v2 [cs.LO]`, (2015).

[5] Jan A. Bergstra and Karl de Leeuw. Bitcoin and Beyond: Exclusively Informational Money. `arXiv:1304.4758v2 [cs.CY]` (2013).

[6] Jan A. Bergstra and Karl de Leeuw. Questions related to Bitcoin and other informational money. `arXiv:1305.5956v2 [cs.CY]` (2013).

[7] J.A. Bergstra and C.A. Middelburg. Preliminaries to an investigation of reduced product set finance. *JKAU: Islamic Economics*, 24(1):175–210 (2011).

[8] J.A. Bergstra and C.A. Middelburg. Division by zero in non-involutive meadows. *Journal of Applied Logic*, 13(1): 1–12 (2015). Also `arXiv:1406.2092 [math.RA]`.

[9] J.A. Bergstra and A. Ponse. Division by zero in common meadows. *In de Nicola, R. and Hennicker, R. (eds.), Software Services and Systems*, LNCS 8950, pp. 46–61, (2015). Also `arXiv:1406.6878 [math.RA]`.

[10] Jan A. Bergstra and Peter Weijland. Bitcoin: a money-like informational commodity. `arXiv:1402.4778`, (2014).

[11] B. Brown and G. Priest. Chunk and Permeate, a paraconsistent inference strategy. Part I: the infinitesimal calculus. *Journal of Philosophical Logic*, 33, pp.379–388, (2004).

[12] Monetary policy decisions. ECB website. `https://www.ecb.europa.eu/mopo/decisions/html/index.en.html`, (accessed on May 17, 2015), (2015).

[13] R. Fischer and D. Braun. Nontrivial bookkeeping: a mechanical perspective. *Physica A*, 324: pp 266–271 (2003).

[14] R. Fischer and D. Braun. Transfer potentials shape and equilibrate monetary systems. *Physica A*, 321: pp 605–618 (2003).

[15] C.A.E. Goodhart. Why do banks need a Central Bank? *Oxford Economic Papers, New Series,* 39 (1), pp 75–89 (1987). (2012).

[16] Simon Gray. Central bank balances and reserve requirements. *IMF Working Paper*, `http://www.imf.org/external/pubs/ft/wp/2011/wp1136.pdf` , (2011).

[17] K. Mettenheim. Back to basics in banking theory and varieties of finance capitalism. *Accounting, Economics and Law*, 3(3): pp 357–405 (2013).

[18] Moshin S. Khan and Abbas Mirakor. The financial system and monetary policy in an Islamic economy. *JKAU: Islamic Economics*, 1:39–57 (1989).

[19] Jacky Mallet. Description of the operational mechanics of a Basel regulated banking system. `arXiv:1204.1583 [q-fin.GN]`, (2012).

[20] Ch. Mortensen. An analysis of inconsistent and incomplete Necker cubes. *Australasian Journal of Logic*, 4, pp. 216–225, (2006).

[21] Satoshi Nakamoto. Bitcoin: a peer-to-peer electronic cash system. `http://Bitcoin.org/Bitcoin.pdf` (2008).

[22] L.A. Necker. Observations on some remarkable optical phenomena seen in Switzerland: and on an optical phenomenon which occurs on viewing a figure of a crystal or geometrical solid. *London and Edinburgh Philosophical Magazine and Journal of Science*, 1 (5) pp. 329–337, (1832).

[23] M. Niekamp. Eine Integrative Philosophie des Geldes, Versuch einer Metaethischen Rekonstruktion von Negativzins und Schwundgeld. (In German) PhD Thesis Univ. Osnabrück. `https://repositorium.uni-osnabrueck.de/bitstream/urn:nbn:de:gbv:700-2015011913002/1/thesis_niekamp.pdf` (2014).

[24] T. Swanson. The anatomy of a money-like informational commodity, a study of Bitcoin. `https://s3-us-west-2.amazonaws.com/chainbook/The+Anatomy+of+a+Money-like+Informational+Commodity.pdf`, (2014).

[25] R.J. Valkhoff. Een genealogie van twee moderniteiten: Jean Bodin en Michel de Montaingne en het verval van een teleologisch wereldbeeld. (In Dutch) PhD Thesis Univ. of Amsterdam. `http://dare.uva.nl/document/2/53425` (2007).

[26] W.P. Weijland. Mathematical foundations for the economy of giving. `arXiv:1401.4664 [q-fin.GN]`, (2014).

[27] W.P. Weijland. A general equilibrium theorem for the economy of giving. `arXiv:1411.1929 [q-fin.GN]`, (2014).