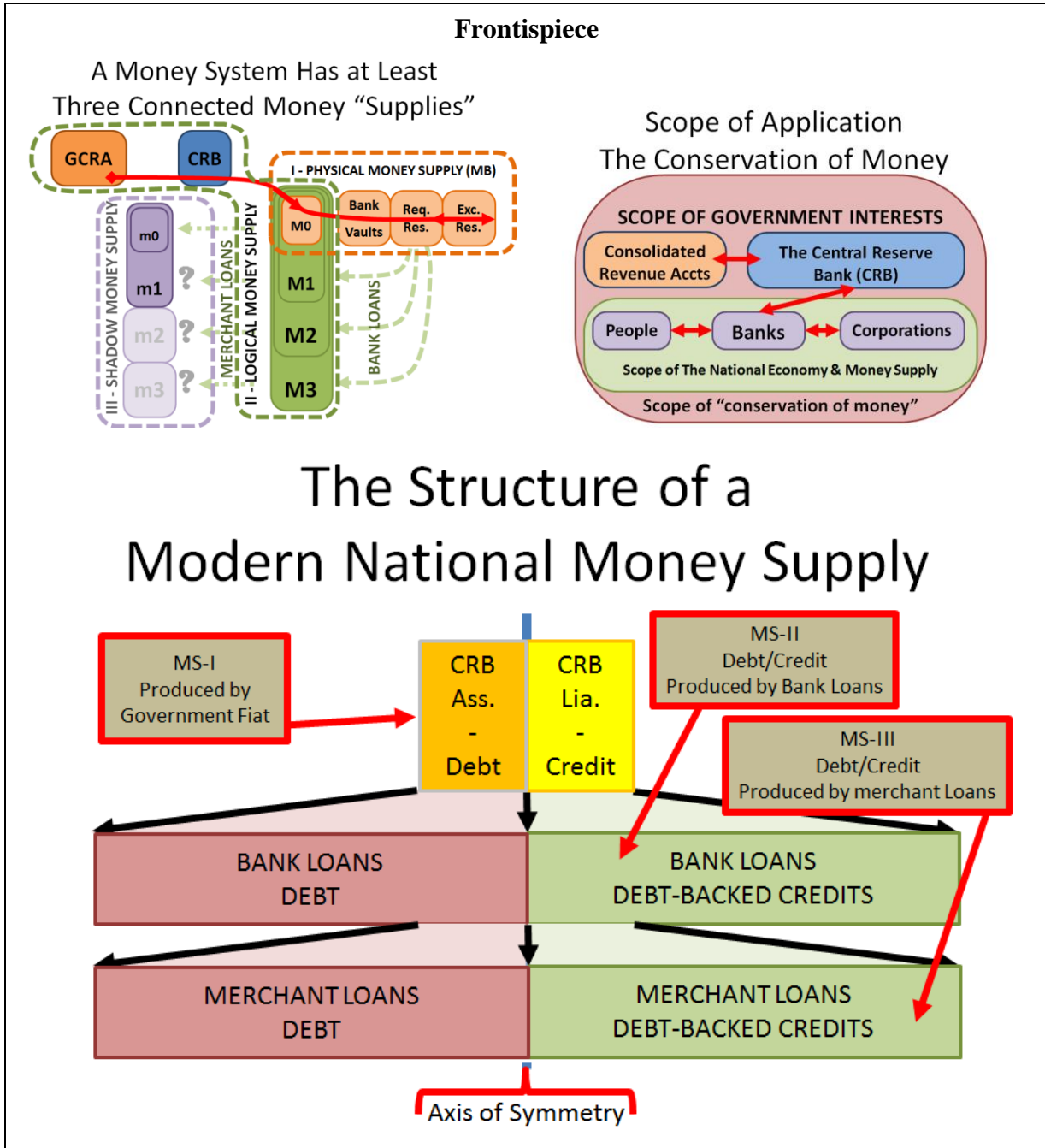NOTE TO FILE:
Garvin H Boyle
Dated: 160228   R2: 160304   R3: 160307   R4: 160309   R5: 160324 R9: 160330

1st Law of Econodynamics – Conservation of Money

Frontispiece

1 - References

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E. Wiki - Capital requirement.pdf
F. Wiki - Metallism.pdf
G. Wiki - Chartalism.pdf
H. Wiki - Double-entry bookkeeping system.pdf
I. Wiki - Modern Monetary Theory.pdf
J. Wiki - Standard of deferred payment.pdf
K. http://www.bankofcanada.ca/wp-content/uploads/2010/11/canada_money_supply.pdf
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O.

2 - Purpose

This is an attempt to understand the generation of modern money, how it can be created and destroyed, how money supplies can be expanded and contracted, and the events that might cause asymmetry in the money supply, if any.

3 - Approach and Structure of This NTF

Before going into the detailed study of what the money supply is and how it works, I will identify the references:
- Ref A is my NTF re how Odum's maximum power principle works to make modern economies evolve and function;
- Ref B is a Wikipedia article about the money supply, and my main source of inspiration and guidance when I started this NTF;
- Ref C is the site where I signed up for a course from INET;
- Refs D through J are Wikipedia articles read while preparing Ref A and this NTF.
- Refs K through N are other internet sites visited on specific topics

Ref A is a work in progress in which I develop a fanciful scenario describing the role of Odum's maximum power principle (MPP) in a modern society, and argue that we should be able to formulate a set of five "laws of econodynamics" that largely parallel the five "laws of thermo-dynamics".   As part of that exercise, I need to convince myself that the 1st law of thermodynamics, the law of conservation of energy, can be paralleled by a law of the conservation of money. To that end, I am interested in exploring when and how money is created and/or destroyed in a modern money system.

In addition, as part of the Ref A exercise, I posit that the money supply acts as a rather distinct platform on which the probabilistic dynamics of the 2nd and 4th laws can operate, somewhat in parallel, but also somewhat in addition to the thermodynamic activity, greatly enabling the self-organization of the modern financial economy. As a result, I posit the characteristic of being sufficiently-well conserved (in place of perfect conservation) to provide a stable-enough platform for the 2nd and 4th laws to do their magic.

Assuming that the money supply actually does provide such a posited platform, and understanding that the money supply is the means by which the financial and real economies interact, I want to characterize those aspects of the money supply that might provide insight into this interaction.

Ref B contains the most detailed worked example that I could find on how the various categories of money in a national money supply are handled, and how they interact, but it is far from complete. Based on the US reserve-banking system, it describes the changes to the money supply, itself, for each of several transactions, but does not provide the detail as to what is happening behind the scenes. Since my interests are in the creation and destruction of money, and the potential separation of debt and credit in the financial and real economies, I need to think through the existing processes to settle my questions, and Ref B, with a focus on M0-M2 types of money supply, is a merely good start.

Ref C is the course from the INET organization (Institute for New Economic Thinking) prepared and delivered by Dr Perry Mehrling as a MOOC (Massive Open Online Course). While taking this course I learned some techniques, borrowed from double-entry book-keeping, for untangling the trail of account changes associated with complex financial transactions. Admittedly, I will not be working with transactions that are terribly complex, but this exercise will give me a chance to practice those techniques. It is, sometimes, mind-boggling.

My approach to this study has been to read about monetary theory, as outlined in the Wikipedia and internet articles mentioned as references, and to take the online course which explores the "banker's view" of economics.

The structure of this NTF is as follows:
- In Section 4 – I explore several key concepts used throughout the rest of this NTF;
- In Section 5 – I describe how I initialized this exercise, and how a national money supply might be initialized;
- In Section 6 – I describe the basics of the physical money supply (MS-I);
- In Section 7 – I describe the logical money supply (MS-II), and its relationship to the other two money supplies;
- In Section 8 – I begin to explore the concept of a shadow money supply (MS-III), but with little detail (it needs an NTF of its own, I think);
- In Section 9 – I summarize findings; and
- In Section 10 – I think about what might be done to improve or extend this NTF.

4 - Some Key Concepts

There are a number of key concepts that developed as I wrote and re-wrote and re-wrote this NTF, in my attempts to understand what money is and how it works. Having taken the course by Dr Mehrling (see Ref C), I ultimately decided to take what he calls the "bankers view", and it seems to be coming together for me, at long last. In the banker's view, you set aside all concerns for flows of goods and services, prices of commodities, and other biophysical aspects of the economy, and focus on the flows of money and interactions of money managers and financiers. While such an idea flies in the face of my intuitions about the real biophysical economy, I think it does offer another perspective that is clearly NOT found in NCE theory, and is a fundamentally pragmatic and phenomenological approach to understanding the dynamics of the a key part of a modern economy. The following are the key concepts that are needed to understand the remainder of the NTF.

4.1 - Two Roles for Banks

I make a distinction between the "deposit-taking bank" and the bank as a profit-earning business. This may be somewhat artificial, but I think they are legally and functionally different roles, and so I make them different actors in this play.

The role of the deposit-taking institution is to use double-entry book-keeping (a meme or social invention of the Italian merchants of the Renaissance period; see Ref H) to ensure that money is meticulously accounted for with commonly acceptable precision (to the nearest penny). They

accept deposits, manage loans, and settle payments between their clients and the clients of other deposit-taking institutions.

On the other hand, the role of the banking corporation is to earn a profit by setting interest rates on loans, collecting interest and depositing it, charging banking fees and depositing them, etc. In this view of banks, the corporate bank is just another depositing customer of the deposit-taking bank with which it shares offices and personnel. You might say the deposit-taking bank just follows the rules given to it. The rules are set by the government (in laws and regulations), and by the corporate bank that owns it (in accounting policies). But, as I said above, this distinction is somewhat artificial, as the same banking staff will act in both roles.

4.2 - Categories of Money

There are many ways to categorize money, but usually those categories are woven together into a fabric called "the money supply". For my purposes, I break the money supply into three categories of money supply: the physical, logical and shadow money supplies. (See Figure 01.) Every country seems to define money supply a little differently. But, typically, they all have the following sorts of features:

- **M0** – They start with a category "M0" called "narrow money" which includes only cash in circulation in the form of bills and coins (which I herein denote as $c). This is the most liquid form of money, involved in transactions in which debt is created and settled within moments. It is the most ancient form of money, being an analogue of commodity money.

Figure 01 – Money Categories and Money Supplies

A money system seems to have three inter-connected money supplies: physical, logical, and shadow money supplies.

- **MB** – But M0 is also part of the set of all $c available to the country, including:
  - **M0** - $c in circulation;
  - **Vault Cash** - $c that have been deposited into bank vaults;
  - **Required Reserve Deposits** - $c that banks have transferred to the CRB for safe-keeping as reserves of $c against loans; to handle any run on the banks that may occur; and
  - **Excess Reserves** - $c that banks deposit in the CRB for safekeeping, and to earn interest on otherwise idle cash;
- **M1** – M0 plus all checkable accounts of various sorts, sometimes called checking accounts, or current accounts;
- **M2** – M1 plus all savings accounts of various sorts, which have restrictions on the frequencies and amounts that can be withdrawn, giving banks more flexibility in making longer-term loans. At this category it is no longer considered to be narrow money.
- **M3** – M2 plus all longer-term deposits which are frozen (cannot be withdrawn) for periods of time.

- **M4** – M3 plus very non-liquid deposits.

For this NTF I designate the three money supplies as MS-I, MS-II and MS-III. These are NOT accepted concepts by money authorities. I have made up these designations for the purposes of this note. It seems to me that MS-II is constructed out of MS-I. This seems to be a standard concept. But I include GCRA and CRB within MS-II. Then MS-III is constructed out of MS-II. That is a less standard concept. Note that, according to the Ref B article, most countries see an overlap between MB and the "money supply". That is logical but it does cause a wrinkle. So the standard "money supply" is MS-II – (CRB + GCRA).

Canada has a number of variations on this basic money supply concept shown in Figure 01, adding more little green rectangles such as M1+, M1++ that I don't go into. (See Ref K.) Many countries do not use the M4 category, so I don't show it here. Each country defines its money supply as it feels it needs to. However, the basics are MB with its four categories, and M0 through M3.

The goal of the M0-M3 categories seems to be to segregate monies of differing liquidities. My interests are different, as liquidity is not of great concern when considering the durability of money. I suppose the varying liquidity causes a kind of bias or asymmetry in behaviour. Highly liquid money causes debt to appear and disappear quickly, while the less liquid sorts create stable debt that lasts for long periods after it is created. But, again, that is not of consequence to this present exercise in which I am looking for breaches of conservation laws.

There are other kinds of short-term credit offered by merchants that would seem, in my view, to create yet another kind of money supply that I herein refer to as the shadow money supply. This money exists only as records of payables and receivables in the accounts of merchants and their clients. However, on the Ref C course I did learn that a so-called "shadow economy" is said to exist within the financial world, and a "system D", the global black market, is now said to be the second largest market in the world with a value of $10 trillion annually, which compares well with the US annual GDP of $14 trillion. So I would propose that the global markets, including the shadow markets and black markets, use this shadow money supply, in addition to the visible money supply. (See Ref L.)

There was a time when merchants used to issue their own money, for lack of suitable standard coin. Canadian Tire money is one of the few remnants of that phenomenon. But, nevertheless, I believe that there is a massive money supply hidden in merchant activities, that I here call it the shadow money supply.

4.3 - Profit and Loss versus Conservation of Money

As I revise this NTF I realize that there is a problem I have stumbled over again and again in previous versions, and I hope to get it right now, or, at least, handle it better than before. My economic experiences have taught me to think of assets and liabilities as including infrastructure, supplies, and real estate holdings, etc., in addition to money in the bank, or debts. Corporations often include human capital, depreciation, or good will in their balance sheets. Dr Mehrling advises, when looking at the financial economy, that one should take a "banker's view". In his mind, a banker has a focus only on the dynamics of the money, and does not consider the other

assets. So, in this NTF I am not worrying about price, quantity, value or any of those biophysical things that are affected by the money supply. I am only looking at the money supply. Profits and losses play little role in that perspective.

When a corporation counts its assets and liabilities, all of those non-money assets and liabilities get included. When a corporation determines its profits and losses, they are the net of such aggregate holdings. But, a corporation may suffer great losses, or earn great profits, without ever causing a breach of the proposed concepts of conservation of money. In a banker's view, an economic loss due to bad business decisions is totally different from destruction of money due to accident. Sure, both may lead to financial loss, but they may have very different effects on the money supply.

So the concept of the conservation of money is not about the conservation of assets, since only money is included. Nor is it about tracking profits and losses. That is where economic entropy starts to play a role, and that's 2nd law business.

4.4 - Physical Container vs Logical Value

There are two aspects to money in a real economy: the physical presentation of the money, and the role of the money based on some sense of value. I would like to explore this distinction between the physical container for money, and the logical value of money. One exists in the physical world, and the other exists only as a social set of rules, constraints, and practices that are almost universally respected.

Examples of the physical containers are shells, gold, silver (commodity money), coins, bills, pen strokes in ledger books, bits in computer files, and bits in communications protocols travelling across wires. When the two exist at the same place, we have what most people know as cash, or money. The physical container without the logical value is an empty container. When such a container is destroyed, the amount of logical money value does not change. But, when the container holds logical money, and it is destroyed, then the amount of logical money in the world is decreased by what was contained. Sometimes, two ledgers are maintained for debts and credits, such as two copies of a contract, or two sets of books – one for the debtor and one for the creditor. Then both containers must be destroyed to reduce the debt and credit by reducing the memory and evidence of the logical money. But, since the logical value is a matter of social contract, if the debtor and creditor still remember the debt and agree that it exists, then the ledgers or contracts can be reinstated from memory. Many debtor/creditor relationships may in fact exist only as promises between people of honour and conscience, without physical money.

How do physical and logical money come together? With commodity money, both parties in an exchange just happen to value the commodity similarly, and so the value is intrinsic to the money. With fiat money, the King, Queen or emperor holds a social monopoly on the right to make money, and stamps his/her image on a coin or bill. We might think of this as "commissioning" the money, or giving a worthless item the "nature" of money, by inserting the logical value into the otherwise worthless physical object.

I think this is an important concept with some odd implications. For example, you could consider money in a bank vault to be merely empty containers from which the value has been

transferred to the bank's ledgers. But, when you withdraw money as cash, the value is transferred back from the bank's ledgers back into the cash, and it remains joined as the cash circulates in the form of M0 money. So, a bank has this ability to denature and renature (decommission and recommission) money. I note that the CRB can denature money permanently before it is destroyed.

Money stolen from bank vaults, checks against checking accounts, IOUs between merchants and clients, and counterfeiting all cause wrinkles in this value/container concept. Cash is NOT a simple idea. It is a complex web of social understandings and agreements that require widespread social support if they are going to all work together. It is therefore surprising to me that the secular belief in the inviolability of money is so widely accepted, and so mercilessly enforced, when so few people really understand money.

4.5 - Redefined Definitions and Scope

In the several revisions of this note I have had to redefine some concepts, and alter the scope of others, in order to fit the schema used in my analysis of conservation of money. (See Figure 02.) In particular:

- Normally there is one money supply per nation. I am defining three closely related money supplies.
- Normally the money supply is confined to the national economy – the green area in Figure 02. I am expanding that to include all money within the purple area.

Figure 02 – Scope – Money Supply Vs Money Conservation

SCOPE OF GOVERNMENT INTERESTS

Consolidated Revenue Accts

The Central Reserve Bank (CRB)

People ⟷ Banks ⟷ Corporations

Scope of The National Economy & Money Supply

Scope of "conservation of money"

- This means that the scope of the proposed law(s) of conservation of money, as discussed below, is not the green area, but the purple area, i.e. the entire scope of government interests.
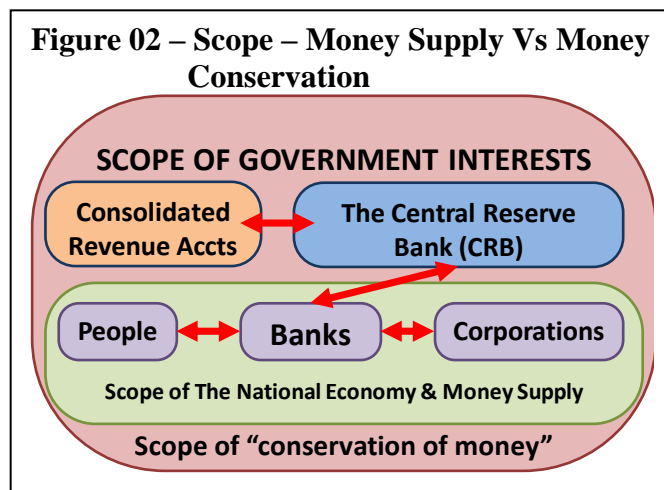
4.6 - Proposed Conservation Laws

I am not trying to show that the total money supply has a constant value. In fact it breathes larger and smaller as need requires. But, nevertheless, money is conserved at the buyer/seller interface in virtually all commercial transactions in which something is purchased. The concept I am working towards here is "sufficiently-well conserved" in place of "absolutely conserved". So, I want to understand how this breathing phenomenon and the phenomenon of the fundamental conservation of money at the buyer/seller interface interact. Here are the concepts that will be tested, each of which I have given a name and a symbol, for reference in this NTF:

Transactional conservation of money (TCM) – This is based on the concept of double-entry book-keeping. When two commercial agents exchange money, a double-entry is made in the books of both agents. For every asset change in the books of one agent a similar liability change must be made in the books of the other agent. This might be considered the atomic level of double-entry book-keeping. It requires a minimum of two such double-entries to fully record most real commercial transactions. The first double-entry creates a debt in the books of both

participants. The second double-entry records the payment and extinguishes the debt. The TCM describes one double-entry.

$$\Delta(borrower\ asset) = \Delta(lender\ liability) \qquad \text{Equ 01}$$

It may seem like a bit of a stretch but I think that, in every transaction, one of the agents can be considered the lender (e.g. a bank) and one can be considered the borrower (e.g. a client of a bank). This is a basic rule of symmetry. Whenever this rule is broken, the symmetry between assets and liabilities is broken.

So, my goal in this NTF is to figure out what kinds of transactions cause a breach in these concepts of conservation of money and conservation of money supplies.

Strongly Conserved Money Supply (SCMS) – In the following equation, lenders are typically banks, and borrowers are their clients.

$$\sum_{(accounts)} (depositor/borrower\ assets) = \sum_{(accounts)} (bank\ liabilities) = Constant \qquad \text{Equ 02}$$

In all cases the "assets" are ONLY money assets, and do not include other kinds of assets valued in terms of dollars. For every transaction, I want to be able to decide whether this law has been breached for any of the three money supplies identified in Figure 01. This law has been breached when any of the three terms changes value. This is why I call it "strong" conservation.

The standard accepted definition of "money supply" would correspond, I think, to the summation over all bank liabilities.

It is often tricky deciding which of the two participating agents is the one that contributes assets or liabilities. In many cases it doesn't matter. However, usually there is a chain of assets and liabilities that provide some hint as to how best to decide.

This condition of strong conservation is only valid, for each money supply, until it is not. That may not be a long time, or may be rare moments, or never.

I suppose I need to clarify how these work in each of the three types of money supply.
- **MS-I** – In the case of the physical money supply, or the Money Base (MB), the nominal value of the bills and coins is tracked, whether they are denatured or not. So, the issues are: are they conserved between commissioning and decommissioning, and does the total number change over time?
- **MS-II** – In the case of the logical money supply, the borrowers are usually clients of the commercial banks. Logical money in positive form is created by fiat, and destroyed by fiat. Logical money is also created by banks via loans, in both positive and negative form.

- **MS-III** – In the case of the shadow money supply, the borrowers are customers or vendors who purchase goods and services, and the lenders are the merchants who sell goods and services. It seems very peculiar indeed to consider the "payables" of customers to be assets, but you can view it this way, and it fits into the general schema. The vendor sells something on credit, to be paid for at the end of the month. The vendor has "loaned" the money for that duration, interest-free. So the buyer is the beneficiary of this transaction, and has the use of the asset (the money that should have been paid) for a while. Similarly, the "receivable" of the vendor can be viewed as a liability, as they are pretending they have money that they do not yet have. They do not have use of this "asset", so it is, temporarily, a negative asset, or a liability. So, shadow money is created and destroyed my merchants in the regular course of business.

Weakly conserved money supply (WCMS) – This is a much better description for any real-world money supply, but still not very likely to obtain very often, or for very long.

$$\sum_{(accounts)} (depositor/borrower\ assets) - \sum_{(accounts)} (bank\ liabilities) = Constant \qquad \text{Equ 03}$$

There is symmetry between the two summations. The magnitudes of each money supply can vary, but the status of the symmetry (the magnitude of the asymmetry) is maintained. This captures how most countries view their money supply as functioning. In this theoretical scenario, when the constant is zero all debts are paid off and all loans paid in full. But, in reality there are transactions that break symmetry, and when that happens the difference changes, and the law is breached.

Transactional conservation of the money supply (TCMS) – In this concept, all complex commercial transactions can be reduced to a series of transactions between agents two at a time (binary transactions), and each binary commercial transaction obeys this condition:

$$\sum_{(accounts)} \Delta(depositor/borrower\ assets) - \sum_{(accounts)} \Delta(bank\ liabilities) = 0 \qquad \text{Equ 04}$$

If this is true for all binary transactions, then money supplies are weakly conserved, so I suspect this is functionally the same as weak conservation. The advantage of this concept, however, is that I need only examine binary transactions, as implied by double-entry book-keeping entries, to determine if WCMS or SCMS are observed. That is the technique I use in my analysis.

5 - Initialization

There are two aspects of initialization that I need to think about:
- Initialization of my little economy used as an example in this exercise; and

- Initialization of a real national economy.

5.1 - Initializing My Exercise

I need to describe the agents, and the initial endowments they receive. I at first thought that would be a "no-brainer" exercise, but it has proven to be challenging:

5.1.1 - The Agents

This exercise will be based on a very small economy in which a few economic agents interact. The economic agents in this exercise, and their associated symbolic references, are:
- A government, in the role of the Government Consolidated Revenue Accounts (GCRA);
- A central bank, in the role of the Central Reserve Bank (CRB);
- The following concerned people: Andy, Barb, and Cole;
- The three deposit-taking banks that service each of these three people labelled Bank A (B_A), Bank B (B_B) and Bank C (B_C); and
- Three corporations that have the charter to operate these deposit-taking banks that I will call Corporation A (C_A), Corporation B (C_B) and Corporation C (C_C).

For each, I may use the short symbolic labels in the various tables when I need to make them more compact. Six of these I refer to as "persons" under the law: Andy, Barb, Cole, C_A, C_B, and C_C. Four are most often "lenders": CRB, B_A, B_B and B_C. The "persons" may also function in the role of merchants or merchant's clients.

5.1.2 - Fiat Money - Creatio Ex Nihilo

I am having some trouble figuring out where the money to start this all up comes from in the first place. There seems to be a chicken and egg problem. Gold coins need to be circulating before a bank can take deposits of gold coins. So, the money has to exist before the banks can exist. But, in a fractional reserve banking system, the money comes from the banks, so the bank has to exist before the money does. I solve this dilemma by jumping over it, and simply giving each of the "persons" a stack of fiat money to deposit as an initial endowment. I.e. I arbitrarily choose money first, then banks.

None of this fiat money is backed by gold or any other biophysical commodity. The government has created it using their monopoly for creating and destroying money. They printed polymer notes and minted base-metal coins having various face values, waved their magic wand to imbue them with a logical value of $25,000, and placed them in the care of the CRB that holds them as assets. The CRB counts the bills and coins ($c) by denomination, then puts them into their vault,

and enters the associated logical values in their ledgers as assets. By these actions they have created the containers that will be used in the physical money supply.

Then, the government spends $21,000 and directs the CRB to pay the bills, providing the initial

TABLE I – Initial endowments of financial stakes.		
The grants of cash were parcelled out as follows:		
Name	**Symbol**	**Amount**
Andy -	-	$ 1,000
Barb -	-	$ 2,000
Cole -	-	$ 3,000
Andy's bank -	C_A	$ 4,000
Barb's bank -	C_B	$ 5,000
Cole's bank-	C_C	$ 6,000
	TOTAL	$21,000 fiat

financial stakes, as outlined in **Table I**, as interest-free permanent loans, to each of the six persons. By this action they have initiated the physical money supply (MS-I) at $21,000 in $c and the logical money supply (MS-II) at $21,000 fiat.

I gave money to the corporations, and not the deposit-taking institutions themselves. The staggered amounts might help me keep track of sources throughout the exercise.

For reference in my graphs and charts, I identify actions that alter the distribution of money as steps with a three-digit number, in bold red, like this. In **Step 001** the government, by fiat, printed and minted $25,000 worth of $c and created $25,000 in the CRB assets. Note that the offsetting liability for Step 001 is absorbed into the GCRA, and must be/may be recovered in taxes, so this may be a breach of TCM, and a breach of the conservation laws, depending on Whether it is or is not recovered.

In **Step 002** some was spent and distributed to the "persons" (i.e. citizens and the banking corporations)

TABLE II – Assets (A) and Liabilities (L) after Step 002.

Step	Andy		C_A		GCRA	
	A	L	A	L	A	L
Prior	$0	$0	$0	$0	$0	$0
001						$25,000
002	$1000		$4000			
Post	$1000	$0	$4000	$0	$0	$25,000
Net	$1000		$4000		-$25,000	

Step	Barb		C_B		CRB	
	A	L	A	L	A	L
Prior	$0	$0	$0	$0	$0	$0
001					$25,000	
002	$2000		$5000			$21,000
Post	$2000	$0	$5000	$0	$25,000	$21,000
Net	$2000		$5000		$4,000	

Step	Cole		C_C	
	A	L	A	L
Prior	$0	$0	$0	$0
001				
002	$3000		$6000	
Post	$3000	$0	$6000	$0
Net	$3000		$6000	

Legend: A & L mean assets and liabilities. Prior means the account contents prior to these steps. Each step action is a double-entry delta in the accounts. Post means the account sum (prior plus deltas) after the steps. Net is assets minus liabilities. Col is a reference identifier for each column to aid discussion.

by the CRB, on behalf of the government, creating offsetting liabilities of $21,000. The state of both the physical money supply (MS-I) and the logical money supply (MS-II) after **Step 002** is entirely represented by M0, which is equal to $21,000 and is also equal to MB, M1, M2 and M3. The $4,000 of extra non-commissioned $c are not counted in either money supply.

Curiously, the assets and liabilities of the CRB do not seem to be normally included in the "money supply" of the economy. These seem to be considered to be external to the economy, as shown in Figure 02. But I choose to include the assets and liabilities of the government and the CRB within the scope of the proposed conservation laws. So, when the government created the money and gave the $c to the CRB, and then spent some, the money base (i.e. MB, or my MS-I) was created and came into being. Money created by government fiat is called exogenous money, as opposed to endogenous money. It is also called vertical money, or U-shaped money, as opposed to horizontal money, or C-shaped money.

The status of the money supplies is summarized in **Table III**:

TABLE III – Status of the Money Supplies – After Step 002

MS-I – THE PHYSCIAL MONEY SUPPLY

M0	Vault Cash	Required Reserves	Excess Reserves	Sum of Borrowers Assets	Sum of Lenders Liabilities
$21,000	$0	$0	$0	$21,000	$21,000

MS-II – THE LOGICAL MONEY SUPPLY

M0	M1	M2	M3	Sum of Borrowers Assets	Sum of Lenders Liabilities
$21,000	$0	$0	$0	$0	$0

MS-III – THE SHADOW MONEY SUPPLY

m0	m1	m2	Sum of Borrowers Assets	Sum of Lenders Liabilities
$0	$0	$0	$0	$0

Note: M0 is double-counted, since it is both physical money and logical money.

EFFECTS: The creation of the money base by fiat, out of nothing, in the form of polymer bills and base-metal coins, may have a different effect on the two involved money bases.
- **MS-I** - $21,000 worth of commissioned $c were creation ex nihilo, and was a breach of all four versions of the conservation laws.
- **MS-II** – If the $25,000 in the GCRA is recoverable in taxes, and if the $4,000 in non-commissioned $c is included, then there is no breach of any of the conservation laws. In that case, the government has NOT truly exercised its right of fiat money creation, but has merely transferred fiat value from taxed income to spending activities. That would seem to be the expected mode of operation of governments in modern liberal democracies.
- **MS-I and MS-II** – But, if the $25,000 is not to be recovered from taxes, then the government has truly exercised its right of fiat money creation, the $25,000 liability in the GCRA in **Table II** should be $0, and the non-commissioned $4,000 of $c should be disregarded as part of any money supply – either MS-I or MS-II. In that case, all four versions of the conservation law of money have been breached, for both MS-I and MS-II.

5.2 - Initializing a Real Economy

Before I move on, having dodged the issue of how to initialize my example by just doing it with government spending, I was forced to think about how a real-world economy becomes initialized. There is, of course, the historical view in which money evolved from something simple and common, to something complex. That history includes:
- Common durable commodities like sea shells (e.g. cowrie shells), Anatolian obsidian, Baltic amber, gems, etc.;
- Less common durable precious metals like copper, silver and gold in the form of jewelry;

- Hybrid commodity/fiat money in the form of malleable precious metals with images stamped upon them giving them status as coin of the realm;
- Hybrid commodity/fiat money in the form of "on demand" bills;
- Purely fiat money in the form of base-metal coins and "legal tender" bills backed only by the reputation of the issuer, i.e. the government; and
- Modern debt-backed money.

Some economies (e.g. in Europe, North America, or Asia) inherited an endowment of money of some form from centuries or millennia of historical developments as described above. I can imagine they simply inherited their money supply as they transformed and elaborated their money systems. Others are new-comers to the game. How they are initially endowed is a question for which I do not have a sensible answer. Given the fact that almost all nations in South America, Africa, and Southeast Asia have fallen very deeply into debt, I expect there is no sensible answer that is either fair or just or ethical in any way.

5.2.1 - Government Spending and Taxes

In the metallist view, money is found in the environment (shells, gold, and silver) and the business of fiat money creation is merely recognizing its value and stamping it to make it official. In that case, the money is endogenous. It would represent a significant widespread natural endowment to be had by prospectors, miners, looters, etc. This was certainly the way it used to work. In the chartallist view, the money has no value until the King stamps his image on a coin or bill. This seems to be the way it is now.

In the days of kings and emperors, the money was paid by the King to the people for goods and services, and that set prices, and that injected the money into society. A government would spend money into the money supply. Then the government could tax money out of the money supply. By these two means the money base (MB) could be controlled through these two levers. I can see how that would have worked in, say, the 1200s, when the physical limitation of gold supplies put the brakes on excessive spending in gold, and excessive collection of taxes in gold. That did not prevent collection and spending of taxes in kind. But during the Napoleonic era, when England, the Netherlands, and the Rothschilds were monopolizing the gold in Europe, the concept of budgets and overspending took hold.

Governments now do not have the luxury of overspending. Somewhere along the line governments released those levers of economic power and the banks, through the back door created by double-entry bookkeeping and reserve banking, took over the ability to create debt-backed money. Now, someone keeps track of how much the governments spend, and sovereign debts build up.

This is probably a far-too-simplistic idea, but it would seem that when governments spend more than they tax, the economy should grow; when governments tax more than they spend, the economy should shrink; and when the "budget is balanced", the economy should idle. So, money is spent into existence, and taxed out of existence again. Those who say that government should be "run like a business" with "balanced budgets" are, in fact, eroding the sovereign power of the government, and reducing it to the fate of the common citizen.

However, interest paid on sovereign debt is, I think, taxed largely out of the real economy, and spent entirely into the financial economy. So, I suspect sovereign debt is a source of imbalance between credits and debts. So, the reality is this – since governments got permanently into the red, they are, de facto, just another debtor caught in the grip of the laws of conservation of money.

In the view of many, it seems that taxes are merely viewed as the top of the right-most pillar of the U-shaped money flow. Spending pushes down on the left, and taxing pulls up on the right. But, as I said above, this no longer makes sense when governments are permanently in debt, and budget income and outflow are tracked using standard double-entry book-keeping rules. All money is conserved, including the debts, and they are locked in.

Figure 03 b) shows the two lungs of the M0 portion of a modern money base. The positive

Figure 03 – Initialization of Money Base

a) Fiat power creates no explicit obligation to pay; b) mere monopoly power creates implicit obligation to pay it back.

money (assets of borrowers, liabilities of lenders, or consumer credits) is shown to the right of the axis of symmetry, and the negative money (liabilities of borrowers, assets of lenders, or consumer debt) is shown to the left.

EFFECT: The government {spend, tax} regime would seem to have been in breach of TCM regime that is at the heart of double-entry book-keeping. All four rules respecting conservation of money were in breach for this form of money creation. However, the modern government regime of {balanced/unbalanced budgets} is not in breach of any of the four versions of conservation of money. That would seem to be a problem, as the government has given over control of the money supply to the corporate world. (??)

6 - The Physical Money Supply (MS-I) – MB

Since I am interested in how a modern money supply works, and not the historical money supply of the days of, say, King Henry VIII, I will proceed with an assumption of Figure 03 b). MB (the money base) consists of circulating cash (M0), cash in bank vaults, required reserve deposits, and excess reserves (see Figure 01.) As described in section 4.4, money has two parts: the relatively worthless physical container, and the invisible logical value that is poured into that container. In Canada those physical containers are, as I say, relatively worthless, but are nevertheless of fairly high quality. The bills are made of a polymer material that is difficult to destroy (making it more durable than paper money) and difficult to counterfeit. For this reason Canada prints bills for many countries around the world, and does a good business at that. Canadian coins are also of relatively high quality, with all sorts of pretty techniques possible (coloured enamel icons attached, holographic icons attached, bimetallic coin-ring combinations, or thinly electroplated blanks). Again, Canada does a booming business minting coins for other
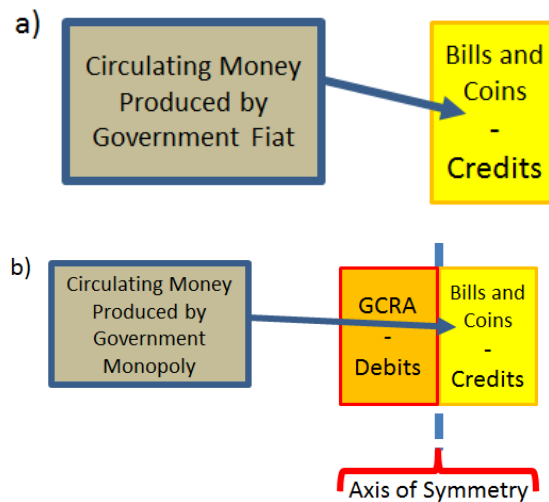
countries around the world in addition to minting its own coins. These bills and coins I represent in this NTF as $c.

The Canadian mint and the Canadian Banknote Company create the physical containers at the demand of the CRB. The CRB manages the stocks of such containers, and from time to time removes old worn-out $c from circulation and inserts new $c into circulation.

Before the $c go into circulation they are given fiat logical values according to the denomination of value they represent, and that value must come from somewhere else. As I said above, for this NTF I am assuming the second mode, using recycled fiat values, as shown in Figure 03 b).

At end of life, the worn-out coins are melted down, and the worn-out bills are burned, but the fiat value is carefully removed from such containers before they are destroyed, and such values are stored in CRB ledgers for later re-use.

It seems to me that such $c can have three different kinds of status, as money:
- Status I – Non-commissioned – these are $c that either have not yet been commissioned (have not yet had the value poured in, in my metaphor), or have been decommissioned (have had the value removed) prior to end-of-life destruction. There is $4,000 worth of non-commissioned $c in my example.
- Status II – Commissioned but de-natured – these are $c that are not "in circulation" but reside in bank vaults, in CRB required reserve accounts, or in CRB excess reserve accounts, but are not considered part of the nation's money supply. Perhaps it could be considered "potential money supply" similar to the concept of "potential energy". I need to think about that one!
- Status III – Commissioned and active – these $c are "in circulation" in some sense. They may, in fact be held in personal or corporate or international hoards which see little or no circulation. For example, I understand that 2% of the world's foreign reserve monies are held in Canadian dollars. Such dollars are clearly not circulating in Canada, or anywhere else. But most exist as $c in peoples wallets, pockets and purses, or in the cash registers of stores, and the tills of bank tellers.

What I am referring to, here, as MS-I, is the commissioned $c (Statuses II and III). In standard parlance, this is regularly called the money base, and designated as MB. (See Ref B.)   However, again in standard parlance, only the portion that is "commissioned and active" (Status III) is normally considered part of the "money supply".

6.1.1 - Understanding M0 – The Physical Side

In standard parlance, M0 is the category of money which is considered to be both part of the money base, and part of the money supply. That is, it is the only type of money that has both physical container and fiat value joined in one place. Quite reasonably, I can consider M0 to be part of both the physical money supply (MS-I) and part of the logical money supply (MS-II) at the same time. M0 consists of $c in circulation, and not in bank vaults.

6.1.1.1 - Destruction of $c

In **Step 003**, Andy has ten $100 bills. He accidentally burns one while playing with his lighter one evening at the pub. The MB, the M0, MS-I, and his personal net worth, just decreased by $100 (See **Table IV**).

TABLE IV – Impact of Andy's "accident".				
CRB $c	CRB Commissioned $c Assets (MB)	CRB Liabilities	Cash (M0)	Andy's net worth
$25,000	$21,000	Was $21,000 Is now de facto $20,900	Was $21,000 Is now de facto $20,900	Was $1,000 Is now $900

The Ref B document does not say what happens to the CRB liabilities (see salmon highlighting in **Table IV**), but I am assuming that a $100 bill is a demand note, and when the note is destroyed, the liability is de facto destroyed, even as the asset is destroyed. A bill represents a credit for Andy and a liability for the CRB. On the other hand, Andy owned this bill but there was no record of his ownership. The "bearer" had the right of ownership. There was no bank record that even gives indication of the existence of this bill, except for the CRB records that played a role in its creation and placed a serial number on it. It is not recorded as in a bank vault, in a required reserve deposit, or in an excess reserve deposit. Andy's destruction of the bill causes not the least reaction from the monetary system.

The money truly ceased to exist, both as a physical container, and as its logical content of $100 fiat. On the other hand, if the money had been in a bank vault when it burned, then the logical value would exist on some account in the bank, and the physical bill could be replaced by the CRB from its store of non-commissioned bills. The original physical bill would have been destroyed, but the $100 fiat dollars would still exist, and could be associated with a new bill. But, given that the CRB is unaware of the destruction of the bill, it will affect the symmetry between the assets and liabilities in the entire money system, when the accounts of the CRB are included.

6.1.1.2 - Counterfeiting of $c

Suppose, instead of Andy burning his $100 bill, some very highly skilled person is able to create counterfeit $20 bills that are undetectable even by the best experts. This nasty person passes five counterfeit bills to Andy in exchange for his $100 bill, supposedly to buy beer, at the same pub. This has the opposite effect as the destruction of a bill. The net worth of the nasty person has risen by $100, as has the de facto liability of the CRB, but, due to the quality of the counterfeit bills, Andy's de facto net worth is unchanged. The counterfeiter has infringed upon the government's monopoly on creating fiat money. (See **Table V**.)

TABLE V – Impact of Nasty's Counterfeit Bills.				
CRB $c	CRB Commissioned $c Assets (MB)	CRB Liabilities	Cash (M0)	Nasty's net worth
$25,000	$21,000	Was $21,000 Is now de facto $21,100	Was $21,000 Is now de facto $21,100	Was $X Is now X + $100

6.1.1.3 - Hoarding

Hoards would include piggy banks, change jars in bedrooms, coin collections, treasure chests full of coins and bills, tourists' souvenirs, and ==sovereign foreign reserves== (?). Such hoards have an impact through reduced velocity of money.

Velocity of Money – If you take the total debt extinguished by a dollar, and divide by the time involved, you get a ratio called the velocity of money. Typically, the velocity of money is calculated as $V_m \equiv (debt\ extinguished)/(dollars\ of\ currency \times time)$. For example, suppose Andy, Barb and Cole are all sitting at a bar and they realize that Andy owes Barb $100, and Barb owes Cole $100. Andy pays Barb, and Barb immediately pays Cole, using the same $100 bill. The velocity of this $100 bill is V = $200 / ($100 x 6 seconds) = $10 / $-minute. A $100 bill has extinguished $200 in debts in one tenth of a minute.

If Andy takes a $100 bill and goes shopping and spends the money in one day at ten stores, and all of those stores deposit the money into their checking accounts at end of the day, the money has been "circulating" for one day. But some of Andy's $100 may have been passed to other clients of those stores, and spent in yet other stores, before being re-deposited into a bank. On a busy shopping day, the velocity of this $100 may be substantially greater than $1 / $-day.

On the other hand, if Andy puts the $100 bill into his mattress "for a rainy day", along with several other such $100 bills, then it has been "hoarded". Its velocity becomes $0 / $-day for as long as it remains in the hoard.

There are, of course, many kinds of debts (purchase of goods, services, financial debts), many kinds of money (coins, bills, checks, barter), and many units of time (day, month, quarter, year) that might be of interest. So there are many different ways to define velocity of money. Usually velocity of money is a macro-level concept applied to the money supply as a whole. But, it seems to me that the velocity of money, when applied to a particular assortment of $c, can describe the effectiveness of that part of the market in which it is involved prior to its ultimate re-deposit in a bank. Each dollar used for Andy's shopping spree had a velocity of at least $1/$-day, because it was immediately flipped by Andy. On the other hand, each dollar that went into Andy's hoard will have a velocity of $0/$-day for as long as it stays in the hoard, which might be forever. A velocity of zero has an equivalent effect on the money supply as destruction of money. So, hoarding may temporarily or permanently impair the effective size of the physical money supply (MS-I) along a continuum determined by the velocity of the particular hoard.

For each dollar withdrawn from a bank we have a continuum of velocities from zero up to well over 1 (say ∞). I.e. V ∈ [0, ∞). I wonder what the distribution of these velocities would be. There would be a large number of small fast transactions, and a small number of large slow transactions.

EFFECT: Destruction, counterfeiting, and hoarding of $c have a direct effect on M0, which is simultaneously part of MS-I and MS-II (see Figure 01). These actions directly or effectively cause a breach of SCMS, since the sum of associated CRB liabilities no longer matches the sum of effective money in circulation. In fact, because a person has altered an asset without changing

an associated liability, this is in violation of all conservation rules.   Hoards have an asymmetric impact only if the CRB is unaware of their existence, or their effective velocity.

6.1.2 - Vault Cash

When currency (i.e $c) is deposited into a "deposit-taking institution" such as a bank, it is placed into a checking or a savings account (see sections 7.2.1 and 7.3.1 below.) The logical money remains a part of the logical money supply (MS-II), but is effectively separated from the bills and coins, which remains a part of the physical money supply (MS-I). The logical money is recorded in the account of the depositor. The physical $c are counted by denomination and go into the bank's vault.

Although this $c is denatured, it acts as a token for fiat money that is in the logical money supply, and is used, under the reserve banking system, or its replacement, to manage the size of the logical money supply. In all activities it is managed via double-entry bookkeeping and so its conservation, while within bank vaults, is carefully managed and probably 100% unbreachable.

But, it can be removed from vaults in two ways:
- It can be withdrawn as $c by a client, within the rules of double-entry book-keeping.
- It can be stolen by a bank robber.

When $c are stolen from a bank, they are, effectively, immediately re-natured. I.e. the logical and physical forms are immediately re-united. The MS-I does not change in size. But, the logical value now belongs to the bank robber, when it was already assigned to a bank's client. This means MS-II immediately rises in size, because there is an asset (in the hands of the robber) not balanced by a liability. I would guess that the corporate bank must assume a liability for stolen cash, so the deposit-taking institution would mark a liability against its corporate self, and so preserve the integrity of the money supply.

In any case, all of this variety in Figure 02 is based on the MB category. It is of particular interest to me, as I think it somehow represents a floor below which the money supply cannot fall. In some sense, then, it is related to the economic equivalent of what is called, in thermodynamic parlance, absolute zero. I need to go back to this when I think through the 0th law and the 3rd law.

EFFECT: While the $c are in bank vaults all transfers between bank vaults and into/out of vaults adhere to double-entry bookkeeping standards, and the physical money supply is conserved. If $c are stolen from banks, and if the corporate arm of the bank takes on a liability for the missing $c, then both the physical and logical money supplies are conserved. If the corporate arm of the bank does not take on a liability, then the physical money supply is conserved (no $c were created or destroyed) but the logical money supply increases in size by the amount of the robbery.

6.1.3 - Deposits, Reserves, and Excess Reserves

The natural course of currency is to be deposited in either a checking account or savings account (see sections 7.2.1 and 7.3.1), to be placed in the vault, and then to be used to back loans by the bank to other clients.   This process is called the reserve banking system. For each loan, the bank

is required to place a small percentage into a reserve deposit account with the CRB. Money which has not yet been used to back such a loan can be deposited, in turn, by the bank with the CRB.

I describe this process in greater detail when I address bank loans, below, in section 7.4.1. But, the important thing to note is, as I said above, all transactions and transfers with the other banks and with the CRB are managed using double-entry book-keeping with backup copies of all records, so there is zero probability that any of the conservation laws will be broken.

EFFECT: The handling of physical money among the CRB and all of the deposit-taking institutions is a well-oiled machine managed using double-entry bookkeeping rules. Except for the issues of theft, which I cover in section 6.1.2 above, and, possibly the issue of interest, which I cover in sections 7.3.2, 7.4.2 and 7.4.3.2 below, there is no chance that physical money will not be conserved.

7 - The Logical Money Supply (MS-II) – M0 Through M3

This section addresses what happens within the area with the dotted green boundary in Figure 01. My goal is to understand if any actions taken by economic agents within that boundary can create or destroy money, or alter the implied symmetry of endogenous money creation by banks through loans. I get to the curious example of bank loans somewhat later in section 7.4, at which time I will need to revisit the way the reserve banking system works. While the examples are drawn from US finances, much is equally applicable to Canada, or other countries.

7.1 - Understanding M0 – The Logical Side

This section is about M0, as is section 6.1.1 above. M0 is part of both MS-I (the physical money supply) and MS-II (the logical money supply). Currency destruction, counterfeiting, and hoarding affect both MS-I and MS-II.   I covered it pretty well there, I think. I will say no more here.

7.2 - Understanding M1

M1 includes the logical content of the M0 category, plus all of the logical money in so-called checkable bank deposits. M0 money can be used to create and extinguish debts immediately. It can attain very high velocities. It is therefore considered very liquid. In contrast, checkable accounts require more time to extinguish debts, and are considered less liquid. M2 and M3 are each less liquid that the previous category. So, M1 is the next most liquid category, after M0.

7.2.1 - Checkable Accounts

In **Step 003**
- Andy deposits his $1,000 into a transactional account (also called his "checking account" or "current account") at his bank, B_A.
- Barb deposits her $2,000 into a transactional account at her bank B_B.
- And each of the three corporate banks deposit their assets into transactional accounts each in their own respective depository institutions – C_A into B_A, etc.
- But Cole did not deposit his $3,000 into a checking account.

Vault cash increases by $18,000.
MB (or MS-I) does not change, as it includes M0 plus the vault cash.
M0 decreases by $18,000 and now includes only the $3,000 that belongs to Cole.
M1 does not increase, as it already included M0.
M2 and M3 do not change.

I need to examine this more closely using the techniques of Dr Mehrling (see Ref C). I am going to focus on one depositor, to see how it affects the various money supplies. (See **Table VI**.)

Table VI – Andy Depositing Cash into a Checking Account.

Step	Andy's A&L		CRB's A&L		B_A	
	A	L	A	L	A	L
Prior	$1,000 (M0)	$0	$1,000	$1,000	$0	$0
003a		$1,000 (M0)			$1,000 (M0)	
003b	$1,000 (M1)					$1,000 (M1)
Post	$2,000	$1,000	$0	$0	$1,000	$1,000
Net	$1,000		$0		$0	
Col	A	B	C	D	E	F

Legend: A&L means assets and liabilities. Prior means the account contents prior to this step. Each step action is a double-entry delta in the accounts. Post means the account sum – prior plus deltas – after the step. Net is assets minus liabilities. Col is a reference identifier for each column to aid discussion.

I can break Andy's **Step 003** actions into two steps, each of which is a double-entry bookkeeping event. In **Step 003a**, Andy turns his cash over to the bank B_A, and two accounts are adjusted. In this case Andy is the lender, and B_A is the borrower. I show this as a liability (category M0) for Andy in column B and an asset (category M0) for B_A in column E. The bank puts the cash into its vault (not shown here) and strips off the logical fiat dollars. For **Step 003b**, in column F

it enters those logical fiat dollars into a checking account ledger as a liability (category M1) and into Andy's own personal accounts (which he maintains at home, maybe in a bank book) as an asset (category M1) in column A.

TABLE VII – Status of the Money Supplies – After Step 003

MS-I – THE PHYSCIAL MONEY SUPPLY

M0 (B ass.)	Vault Cash (B ass.)	Required Reserves	Excess Reserves	$\sum(B\ ass.)$	$\sum(L\ lia.)$
$3,000	$18,000	$0	$0	$21,000	$21,000

MS-II – THE LOGICAL MONEY SUPPLY

M1 (B ass.)	M2 (B ass.)	M3 (B ass.)	$\sum(B\ ass.)$	$\sum(L\ lia.)$
$18,000	$0	$0	$18,000	$18,000

MS-III – THE SHADOW MONEY SUPPLY
Unchanged.

The logical money is recorded in entries in ledgers that are associated with the depositor's account. Andy's transaction is a typical exchange in which two "double-entry" entries are made, for a total of four entries. Five out of six persons deposited their $c, so Step 003 involves a total of 20 account entries.

A cash withdrawal by a person from a checking account would run this process in reverse. So, deposits and withdrawals are complementary opposite actions.

EFFECTS: the effects of deposits into banks (and withdrawals from banks) are complicated due to the fact that these actions have an effect on both S-I and MS-II:

- TCM is observed in each double-entry bookkeeping action.
- Thinking of the physical money (MS-I) SCMS, WCMS and TCMS are all observed, because no physical money was created or destroyed.
- Thinking of the logical money supply (MS-II) SCMS, WCMS and TCMS are all observed, because no logical money was created or destroyed.
- However, the physical and logical forms of the money have become separated, the physical denatured form going into vaults, and the logical form going into clients' accounts.
- Bank robbery would seem to be a possible source of asymmetry in the money supply, depending on how it is recorded.

7.2.2 - Reserves for Checkable Accounts

When the reserve banking system was first set up, banks had "reserve requirements". (See Ref D.) In recent times that has been replaced by a different protocol called "capital requirements". (See Ref E.) Under the old (pre "capital requirement") system, the banks are allowed to use the "excess reserves" as the basis for bank loans to clients. It was required that a percentage of the value of the loan be held in reserve. For example, if the required % was 10%, and a client wanted a loan of $X, then the bank had to have at least (10% of $X) in "excess reserves" or it could not make the loan. When the loan was made, the required reserves were segregated, and (possibly) transferred to the CRB. In addition to (or instead of) the requirement that 10% be held back, there is also now something called a "capital requirement" that will adjust the amount that can be loaned, but that calculation is very complicated and, for my purposes, amounts to the same thing. I.e. government policy places limits on how much of a bank's deposits can be put at risk through re-investment, and how much must remain in the bank's vaults, or, at least, on the liquid side of its books.

In **Table VIII** I show the accounts of the five depositors after they have deposited their money into checking accounts in the deposit-taking institutions, and the banks have identified the excess reserves. (See salmon-coloured cells in **Table VIII**.) Note that Cole has not deposited his $c.

TABLE VIII – DEPOSIT-TAKING INSTITUTIONS' STATUS – AFTER STEP 003							
Deposit-Taking Banks	**Accounts**				**Vault Cash ($c)**	**Required Reserves ($c)**	**Potential Excess Reserves ($c)**
	Clients' (Persons') Accounts			**Bankers' Liabili-ties**			
	Account Holders	**Account Types**	**Clients' Assets**				
B_A	Andy	Chk (M1)	$900	$900	$4900	$0	$4900
	C_A	Chk (M1)	$4000	$4000			
B_B	Barb	Chk (M1)	$2000	$2000	$7000	$0	$7000
	C_B	Chk (M1)	$5000	$5000			
B_C	Cole	-	$0	$0	$6000	$0	$6000
	C_C	Chk (M1)	$6000	$6000			
					$18000	$0	$18000
				Column	**A**	**B**	**C**

I do note, however, that this switch from "required reserves" to "capital requirements" happened shortly after the time that Biophysical Economics theories say that the bottom started to fall out of Western economies (i.e. after 1972). Known as the Basel Accords, they were released in 1988 (Basel I), 2004 (Basel II), and the latest one formulated following the 2008 global economic crisis (Basel III) is scheduled for implementation very soon. Each of these protocols is dramatically more complicated and sophisticated than the previous protocol, to handle dramatically more complicated types of financial transactions. This is in line with my Ref A arguments of the role of the MPP in causing the separation of the financial economy from the real economy.

But, these reserves and excess reserves, however calculated, are sitting idle, and not earning profits for the banks, so the banks have an option: they can put the money into interest-earning accounts called (in the US) Federal Reserve Bank credit accounts. For this NTF I'll call them CRB Credits. But, I won't discuss such accounts here. I will deal with all types of interest below (see Sections 7.3.2, 7.4.2 and 7.4.3.2
). So, Column C in **Table VIII** is meant to indicate the limit on what can eventually be transferred to excess reserve accounts, and not what has been transferred so far.

7.2.3 - Checks

Continuing from Step 003, I am now at **Step 004**. Andy writes a check for $400 and gives it to Barb in payment of a debt. Four sets of accounts are now affected – those of Andy, Barb, B_A, and B_B.

Priors: Andy and Barb start with assets of $1,000 and $2,000 respectively. Banks B_A ($4,000) and B_B ($6,000) have liabilities associated with deposits by C_A and C_B as well. They have assets as $c in their vaults.

Transaction: In Step 004a Andy and Barb note the check each in their respective check books. In Step 004b Barb deposits it in the bank

Table IX – Andy Writes a Check.

Step	Andy's A&L		B_A's Accts	
	A	L	A	L
Prior	$1,000	$0	$4,000	$4,000
004a		$400		
004c			$400	$400
Post	$1,000	$400	$4,400	$4,400
Net	$600		$0	
Col	A	B	C	D

Step	Barb's A&L		B_B's Accts	
	A	L	A	L
Prior	$2,000	$0	$6,000	$6,000
004a	$400			
004b			$400	$400
Post	$2,400	$1,000	$6,400	$6,400
Net	$2,400		$0	
Col	A	B	C	D

Legend: A&L means assets and liabilities. Prior means the account contents prior to this step. Each step action is a double-entry delta in the accounts. Post means the account sum – prior plus deltas – after the step. Net is assets minus liabilities. Col is a reference identifier for each column to aid discussion.

B_B and bank B_B records it as an asset (check in hand) and a liability (owed to Barb). In Step 004c, bank B_A updates Andy's account, recording the check as a liability (must pay to other bank) and an asset (owed by Andy).

7.2.3.1 - Link to MS-III

There are other sequences, other stories, I could use to describe this set of events, but the results are the same. I like this one because there is a potential pause between the time when Andy and Barb note the debt as paid, each in their own check books, and the time when the banks actually record the transaction in the records of the MS-II money supply. If there is a pause, the check effectively is invisible to the banks, and can be used in lieu of money in the MS-III money supply, the shadow money supply.

The banks are not involved until Barb deposits the check, but Andy has removed (or committed) the money from his check book. M1 money only includes what the banks can see, as indicated by the deposited money in the accounts. A check that has been written against such an account, if not certified in some fashion, is invisible to the bank until "cashed" or deposited in another account and settled. But such an uncashed check has the potential to act as a substitute for cash, if Andy has a great reputation. I would guess that a check from Bill Gates would be as good as cash, when used for an alternate to cash. Suppose Andy writes this check and the recipient, Barb, endorses the check (by signing on the back) and gives it to someone else, call him George01, in payment of a debt. Then George01 uses it as partial payment of a debt with George02, who passes it to George03, all of the way to George10. The entire cascade of Georges know Andy and know he is good for it, so they accept the endorsed check. George10, then decides to deposit it into his checking account, and it gets settled, and M1 money merely moves from Andy's account to George10's account. During the 10 intervening transactions the endorsed check is behaving like cash, and has in fact increased the volume of currency in circulation, but is not included in the M1 tally of liquid assets in the economy. This is a kind of shadow money, and is part of the shadow money supply that is invisible to the banking system, and invisible to the government.

Government of Canada checks are like this, and have long been used as "as good as cash" until recently. That practice is now discouraged, since people often forge an endorsement, and so steal the government check belonging to someone else.

EFFECTS: Checks are normally written, passed, cashed and settled within the simple framework of a few double-entry book-keeping entries. But, sometimes they are endorsed and used in place of cash to settle other debts not directly related to the purpose of the check.
- A check that is deposited and settled immediately has no effect on the conservation of money in MS-II or MS-III.
- A check that is written and marked as "committed", but never cashed, reduces the liquidity of MS-II until that money is released again.
- A check that is endorsed and used in lieu of cash to settle other debts has a double effect of reducing the MS-II liquidity while it is in circulation, but expands MS-III until it is finally deposited and/or cashed.

7.2.3.2 - Link to MS-I

When a check is used, there are repercussions for MS-I as well. When the logical assets move from Andy's bank to Barb's bank during the settlement of the check, the physical $c in the vault must follow. The way it used to be done was a regular settling of net shifts of gold at the end of each day. So if $4,000 had to go from B_A to B_B, and $3,000 from B_B to B_A, then only $1,000 went from B_A to B_B. I have not shown such a shift here, but $400 worth of $c must go from B_A to B_B. But if the accounts of both debtor and creditor are in the same bank, no $c need be shifted.

EFFECTS: If $c is shifted between banks using the tools of double-entry book-keeping, the MS-I money supply will be conserved. I.e. SCMS of MS-I will be observed.

7.2.3.3 - Debit Cards

A debit card transaction functions like a check, but very quickly. Logical money is removed from the assets of a debtor, and placed into the account of the creditor. At the same time net amounts of $c must move from bank vault to bank vault, if the two accounts are in different banks. However, debit cards have such a fleeting impact on MS-III that it can be ignored. Banks are able to settle transactions over computer networks in seconds, and there is no functional pause between the decision by the debtor to pay, and the settlement between banks, as there may be for checks.

EFFECTS: The use of debit cards follows the rules of double-entry book-keeping, and should not affect the conservation of money for any of the three money supplies.

7.3 - Understanding M2/M3 – Savings Deposits

7.3.1 - Savings Accounts

In **Step 005** Cole puts his $3,000 into a savings account.

Normally, savings accounts are not included in M0 or M1, but are included in the less narrow categories M2 and M3. I think M3 is similar to M2, so I don't give it special attention. M3 is less liquid savings deposits, and, when it exists, M4 is yet less liquid. But M4 contains M3, which contains M2, which contains M1, which contains M0.

MB does not change, as it previously included M0.
Vault cash increased by $3,000.
M0 decreases by $3,000 to $0.
M1 decreases by $3,000 to $0.
M2 does not change, as it included M0.
M3 does not change, as it included M0.

7.3.2 - Interest on a Savings Account

Cole had placed his initial endowment into a savings account which pays interest. In a sense, the client is loaning the bank some money, which the bank can then invest in longer-term activities. The client is paid for some loss of liquidity (restrictions on withdrawal frequency) by interest payments.

I am going to go through this is some detail, somewhat for practice, but also because there are some wrinkles that I need to think through. First, we need to return to Step 003, in which the corporate bank (person) C_C put its $6,000 into a

Table X – Cole Deposits Savings and Gets Interest.

Step	Cole's A&L		B_C Accounts for C_C and Cole	
	A	L	A	L
Prior	$3,000 (M0)	$0	$0	$0
005a		$3,000 (M0)	$3,000 (M0)	
005b	$3,000 (M2)			$3,000 (M2)
005d	$150 (M2)			$150 (M2)
Post	$6,150	$3,000		
Net	$3,150			
Col	A	B		

Step	C_C's A&L			
	A	L		
Prior	$6,000 (M0)	$0		
003a		$6,000 (M0)	$6,000 (M0)	
003b	$6,000 (M1)			$6,000 (M1)
005c		$150 (M1)	$150 (M1)	
Post	$12,000	$6,150	$9,150	$9,150
Net	$5,850		$0	
Col	A	B	C	D

Legend: A&L means assets and liabilities. Prior means the account contents prior to this step. Each step action is a double-entry delta in the accounts. Post means the account sum – prior plus deltas – after the step. Net is assets minus liabilities. Col is a reference identifier for each column to aid discussion.

checking account in the deposit-taking institution under its own control, i.e. in bank B_C. I show this here as Steps 003a (deposits the $c) and 003b (opens an M1 checking account). That was past history and I am just catching up the books here. Now, Cole puts his $3,000 in $c into bank B_C in Steps 005a (deposits the $c) and 005b (opens an M2 Savings account). It sits for a year, and one year later, the corporate bank owes Cole 5% interest on his savings account, which amounts to $150. Since this is all done at one deposit-taking institution, there is no inter-bank settlement needed. In Step 005c the bank C_C removes $150 from its checking account, and in Step 005d it pays its debt to Cole, by putting the money into his savings account.

So, there is a net movement of money from borrower (in this case C_C) to lender (in this case Cole).

7.3.3 - Non-Reversibility

In all of these effects, they are logically reversible, in detail, but non-reversible in practice, because they are linked or engaged in some fashion with the real biophysical economy in which the so-called arrow of time, the second law, drives all economic activity in one direction. So most savings are eventually spent, and do not accumulate and generate a lot of interest. And those savings that do accumulate are loaned out again at a higher interest rate, thereby creating a reverse flow of money from banking clientele (in the real economy) to banks (in the financial economy). So, the overall effect is to create a flow of money from the real economy to the financial economy.

Here, **Table XI** is an update to **Table VIII**. In it I show the status after all $c has been deposited into deposit-taking institutions. I have restored the assets of all persons to the state in which they were initialized, for the sake of simplicity of following arguments.

TABLE XI – DEPOSIT-TAKING INSTITUTIONS' STATUS – AFTER STEP 005							
Deposit-Taking Banks	**Accounts**			**Bankers' Liabili-ties**	**Vault Cash ($c)**	**Required Reserves ($c)**	**Potential Excess Reserves ($c)**
	Clients' (Persons') Accounts						
	Account Holders	**Account Types**	**Clients' Assets**				
B_A	Andy	Chk (M1)	$1000	$1000	$5000	$0	$5000
	C_A	Chk (M1)	$4000	$4000			
B_B	Barb	Chk (M1)	$2000	$2000	$7000	$0	$7000
	C_B	Chk (M1)	$5000	$5000			
B_C	Cole	Sav (M2)	$3000	$3000	$9000	$0	$9000
	C_C	Chk (M1)	$6000	$6000			
					$21000	$0	$21000
A	**B**	**C**	**D**	**E**	**F**	**G**	**H**

The three deposit-taking banks are identified in column A, and the accounts of their six clients are identified in columns B, C and D. The related bank liabilities are listed in column E. The standard concept of money supply corresponds to column E plus M0. MS-I assets are outlined in column F, and these determine the potential for required and excess reserves, in columns G and H. Since no loans have been made yet, column G is zero.

EFFECTS: The effect of depositing cash into an M2 account is to reduce M0, and M1 but leave M2 and M3 as they were. Again, the physical cash goes into the vaults, and remains a part of the physical money supply (MS-I) or the money base (MB), but is no longer part of the logical money supply. The logical part of the money goes into the accounts as a banker's liability, and so remains part of the logical money supply. Because it is in a savings account it is M2 and M3, but not M1 or M0.

The integrity of MS-I and MS-II are both maintained because all transfers are managed according to double-entry book-keeping rules.

7.4 - Expanding the Logical Money Supply – Loans

7.4.1 - Bank Loans

Continuing with the exploration of M1 money, in **Step 006,** B_C makes a loan of $2000 to Cole. I will handle this according to the "reserve requirement" protocol. According to **Table XI**, B_C starts with $9,000 in vault cash, but must put 10% of each loan into the CRB as "required reserves". So, it can make loans up to ($9,000 / 0.10) = $90,000. A loan of $2000 is well within the allowed amount, requiring only $200 be sent to the CRB as reserves. It will still have $8,800 in excess reserves after this loan is made.

The M1 category of money increases by $2000 when the loan is made because the money is deposited into a checking account. This M1 money is created, apparently, out of nothing. *Creatio ex nihilo*. See **Table XII** below.

I consider this loan to be between the corporate arm of the bank C_C, and Cole, with the book-keeping done by the deposit-taking institution B_C. So, the loan involves three economic agents, to start with. I do this because, eventually the bank will collect interest on this loan, and the interest is profit that goes to the corporate arm, C_C, and not to the non-profit book-keeping activity.

Here is the logic of a bank loan, the way I have separated the two roles of the bank:
- Cole has prior assets of $3,000 in a savings account; C_C has prior assets of $6,000 in a checking account; but B_C is holding both of these as deposits, totaling $9,000 in deposits.
- C_C negotiates a loan with Cole at 6% per annum, not compounded, payable at ½% per month:
  - First, in **Step 007a** C_C has money removed from its checking account and placed into Cole's checking account.
  - In **Step 007b** Cole agrees to pay the money back by signing a loan document that creates a liability for him, and an asset for C_C.
- B_C, in a parallel process, negotiates an interest-free loan with C_C to fund the above loan using its ability to conjure up funds creatio ex nihilo:
  - In **Step 007c** the deposit-taking bank B_C gets involved, tidying up its own paperwork. The additional M1 funds are recorded as a liability against the assets of C_C, thus making the increase in the size of the M1 category of money visible to itself and the government monitoring processes.
  - In **Step 007d** the deposit-taking bank B_C finalizes its paperwork, for this end of the loan, by entering the loan as an asset (receivables against the loan) and a liability for C_C.

When Cole makes payments of principal against this loan, the money will flow from him to C_C to B_C, extinguishing a part of the debt as it flows through the books. On the other hand, interest payments will not extinguish the debts associated with the principal. That needs a different look.

TABLE XII – Accounting of a Loan

Step	Cole		C_C		B_C	
	A	L	A	L	A	L
Prior	$3000 (M2)	$0	$6000 (M1)	$0	$9000	$9000
007a	$2000 (M1)			$2000 (M1)		
007b		$2000 (L)	$2000 (L)			
007c			$2000 (M1)			$2000 (M1)
007d				$2000 (L)	$2000 (L)	
Post	$5000	$2000	$10000	$4000	$11000	$11000
Net	$3000		$6000		$0	
Col	A	B	C	D	E	F

The prior assets of Cole are the $3000 deposited into a checking account in B_C. The prior assets of C_C are the $6,000 deposited into a checking account with B_C. As the loan is

established, the net of A&L of any of the participants has not changed, but the total liabilities of B_C have increased. The two parts of MS-II have expanded in size, but the difference has not changed. Also, the net of A&L for Cole have not changed, and yet, Cole immediately has $2,000 more to spend.

Why do I do it like this? I am trying to distinguish the two roles of the bank. B_C loans money to C_C, and then C_C loans the money to Cole. C_C takes the business risk. B_C keeps the nations books accurate. As C_C it takes a risk, loans money to Cole, uses its own resources to fill Cole's checking account which is immediately available, and will collect payments with interest to eventually extinguish Cole's debt, as long as Cole can pay. As B_C it merely does the book-keeping for Cole and C_C and the government. The actual process is probably more simple than shown. However, interest collected on the loan payments can be counted as revenue for C_C, rather than B_C, and accounted separately.

Here is where the "logical money supply" seems to get weird. I note that:
- Of the eight "$2000" entries in the above set of transactions, only one modifies the logical money supply, and that is the bank liabilities in column F. Apparently only the liabilities for B_C matter and, as a deposit directly into a checking account, it counts as M1. (See column F.)
- This "deposit" into column F is, in my view, some kind of pseudo-deposit, and not a real deposit, since no coins or bills are ever exchanged between Cole and his bank. The net vault cash does not change. Only logical cash is involved in the transaction, although theoretically, there is vault cash in reserve to back up the loan. I suppose I could imagine that they handed Cole a bag of cash which he immediately deposited into his checking account.
- Cole's new A&L are not counted as part of the money supply, even though that is the point of contact with the real economy. E.g. Cole can immediately buy a new stove, or needed vegetables. $2000 has been apparently created in the money supply out of nothing, without intervention of the CRB.
- I suppose the difference between Cole's new asset, and his new liability, is the time-scale on which they have an effect on the economy. The asset has a fast-acting impact as Cole goes on a buying spree and injects it into circulation. The liability has a slow-burn impact as it and appropriate interest payments are withdrawn from circulation over extended time periods. This dynamic asymmetry in time creates an opportunity for increased flows of money from sector to sector.
- M1 is increased by $2000 to from $21,000 to $23,000, as is M2 and M3. M0 and MB are not changed.

All of the above leads me to this view of the

Figure 04 – Structure of Money Supply
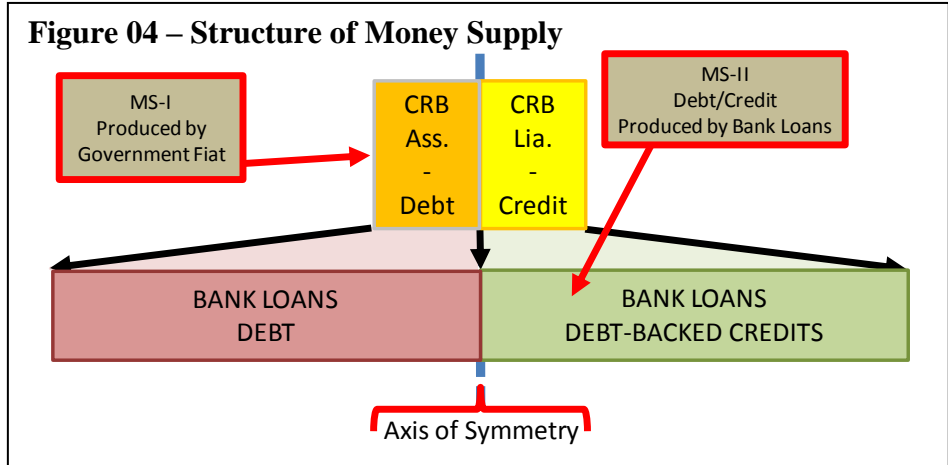
structure of the money supply, as shown in Figure 04. The Ref B article, however, just deals with the right-hand side of the structure. It includes the money base (MB) and the loans that are supposedly based on the reserves of such money. They do not address the negative money to the left of the structure.

EFFECT: Bank loans can expand the money supply dramatically, in this case by a factor of as much as 10. The green box in Figure 04 represents the credits which are counted as part of the money supply, but which are recorded in the bank accounts as liabilities of the bank. The symmetric pink box on the left is a pool of debt that is not counted as part of the money supply. However, this symmetry between credit and debt is the basis of the equations of conservation of money, as shown in Equations 01 - 04.

7.4.2 - Interest on a Bank Loan

There is an enigma that has bothered me for many years, ever since I first heard of the concept of the "time value of money". Where the H--l does interest come from? If money in conserved in the micro-actions of an economy, where does this extra bit of money that we call interest come from? If money transactions are a zero-sum game at every instance of interaction, someone must be losing when interest is paid! The most common answer you will get, if you ask, is that is comes from natural growth in the economy: agricultural growth, industrial growth, cultural growth, etc. But, that doesn't really explain it. When a money system grows, its either because the government has printed more \$c or taken on more debt, or because banks have issued more loans, and persons (corporations or people) have taken on more debt. These sound like zero-sum sources. So, I have a particular interest in understanding interest. ☺ For that reason, I go into this in excruciating detail.

In **Step 008**, Cole has had his loan of \$2,000 for a month, and must make an interest payment on the loan. Let's say that Cole owes the interest to the corporate bank C_C, at a rate of 6% per annum, payable monthly at ½ % per month, or \$10 per month. I know this is not very realistic but I am interested in where the interest comes from, and what the impact in on the money supplies, so it does not need to be realistic.

In **Table XIII** I look at the account changes associated with payment of the interest. **Step 008** proceeds as follows:
- The loan agreement was between C_C and Cole, and B_C is merely the disinterested book-keeper of the accounts of both parties to the loan agreement. C_C has sold services to Cole, and now wishes to collect a deferred payment.
- Priors: the various entries from the previous table, recording the two loan agreements (C_B → C_C, and C_C → Cole) are shown as priors.
- In **Step 008a** C_C puts \$10 debt on Cole's "TAB", and informs Cole that payment is due. This all happens off the official books, and the debt is not actually due yet. So Step 008a is not in **Table XIII**.
- In **Step 008b** Cole writes a check and gives it to C_C, in payment of the debt, and commits the funds in his check book.
- In **Step 008c** C_C processes it and the check is immediately "settled" as the \$10 moves from Cole's checking account to C_C's checking account, and the debt in Cole's TAB is extinguished.

In **Table XIII** I have used -$10 in two places as it is easier to understand than the other option which is to show them on the opposite side of the A&L divide, which is where they should be.

The outcome of all of this book-keeping is this:

- The total net worth of Cole and C_C has not changed, being $2090 + $6010 = $9000.

- The size of the logical money supply (MS-II) jumped by $2000 when the loan was issued, but the interest

TABLE XIII – Interest on Cole's Bank Loan

Step	Cole's A&L		B_C Cole's Accounts	
	A	L	A	L
Prior	$3000 (M2) $2000 (M1)	$2000 (L)		$3000 (M2) $2000 (M1)
008b 008c	-$10			-$10
Post	$5000	$2010 (L)		$4090
Net	$2090		-$4090	

Step	C_C's A&L		B_C C_C's Accounts	
	A	L	A	L
Prior	$6000 (M1) $2000 (L) $2000 (M1)	$2000 (M1) $2000 (L)	$2000 (L)	$6000 (M1)
008b 008c	$10			$10
Post	$10010	$4000	$2000	$6010
Net	$6010		-$4010	

payment did not diminish it or change it. It is still $4090 + $6010 = $11000 (counting only the B_C liabilities).

- The payment of the $10 in interest looks exactly like a transfer of funds between a buyer and a vendor, with this exception – the funds have moved from the real economy (in the hands of Cole) to the financial economy (in the hands of C_C).

So, my questions, again, and answers, are:

- Did the money supply change when interest was charged? Apparently not at all. This is a bit of a surprise to me, as I expected some effect. But, perhaps that is just because I supposed that Cole paid the interest when it was due. If he had been late on his payment, and if that late payment had been added to the principal of the loan, then the logical money supply would have immediately grown by that amount.

- Did the money base change? No. And no money shifted vault to vault. This all happened within the logical money supply (MS-II).

- Did the total debt and total credit change within MS-II? The debt did not change, as no principal was paid on the loan, but the credit shifted from the real economy (Cole) to the financial economy (C_C).

- What is the effect of interest payments on sovereign debt? This is a one-way transfer of funds out of the real economy into the financial economy.

7.4.3 - Bank Loans, Reserves and Excess Reserves

7.4.3.1 - CRB Deposits

Having looked at bank loans and bank interest, I think I can now look at the workings of the money base (MS-I) in more detail. Suppose, in **Step 009**, all three depositing institutions have moved a portion of the unused $c assets in their vaults back to the CRB, either as required reserve deposits or as excess reserve deposits:

- Priors: In Step 004 Andy paid Barb $400 by check, and that necessitated a shift of vault contents. All other activities had no effect on vault contents. Loans, interest on savings accounts, interest on loans, and other such activities within the scope of a single deposit-taking institution do not have an effect on vault contents.
- In Step 009a all deposit-taking institutions deposit any required reserves into "required reserve" accounts with the CRB. Since, at this point B_C is the only such bank that has made a loan of $2000, and since the required reserve rate is 10%, B_C must deposit $200 into such an account with the CRB, and the other two need do nothing.
- all of their required reserves to accounts in the CRB (Step 010a), and a portion of their excess reserves as well (Step 010b), the accounts of the banks might look like this (including changes from steps 007-009):

		Step	Vaults A&L		CRB Reserve Acct		CRB Excess Reserve Acct	
			A	L	A	L	A	L
B_A	1	Prior	4600	0	0	0	0	0
	2	009a						
	3	009b		4000			4000	
	4	Post	4600	4000	0	0	4000	0
	5	Net	600 ($c)		0 ($c)		4000 ($c)	
B_B	6	Prior	7400		0	0	0	0
	7	009a		0	0			
	8	009b		7000			7000	
	9	Post	7400	7000	0	0	7000	0
	10	Net	400 ($c)		0 ($c)		7000 ($c)	
B_C	11	Prior	9000		0	0	0	0
	12	009a		200	200			
	13	009b		7800			7800	
	14	Post	9000	8000	200	0	7800	0
	15	Net	1000 ($c)		200 ($c)		7800 ($c)	
	16							
Totals	17	Net	2000		200		18800	
Columns			A	B	C	D	E	F

TABLE XIV – DEPOSITING INSTITUTIONS' MB STATUS – AFTER 010

The rows are numbered, and the columns are labelled.

- The $400 check of Step 004 needed to be settled, so cash came out of the vault of B_A and into the vault of B_B during the priors, adjusting the contents of each vault.
- The required reserve associated with the $2000 loan appears as a vault liability at cell B12 and a reserve account deposit at cell C12.
- The actions of Step 010a all lead to transfers of cash from vaults to the CRB at cells B3, B8 and B13, reflected in cells E3, E8 and E13.

- Each of the three banks have a small remnant of holdings in cells A4, A9 and A14 to address requests for cash withdrawals from the checking accounts, but most people use checks for that, so a lot of cash is not really needed in vault holdings.
- The total $c holdings is found as the sum of row 17, and is $21,000, or the money base (MB). This is the size of the physical money supply, that I call MS-I.

Ref B goes on to talk about foreign exchange, but I want to avoid that for now. I am interested in what happens inside a single economy run on fractional reserve banking.

7.4.3.2 - Interest Paid on CRB Deposits

In previous sections I have looked at interest on savings accounts, and interest on loans. In both cases it seems that interest payments are merely transfers of logical money from the borrower to the lender.

If you look at the green patch in Figure 01, it seems that the GCRA and CRB are usually considered outside of the economy. So, from that perspective, it would seem that interest paid by the CRB to banks would be an inflow of money into the economy, and interest paid by banks on loans from the CRB would be an outflow. I suspect that economists see it that way. I cannot find a reference that makes it clear.

But, if you take the view that the government is locked into the same money cycle as the rest of us, due to the interest it must pay on its sovereign debt, then the entirety of Figure 01 is the economy, and these interest payments are no different from others. They are simply transfers of logical money from borrower to lender, or from buyer to vendor.

7.4.4 - Banking Fees

Banks charge for all kinds of financial services, as do insurance companies, trust companies, tax preparers, etc. Now even my grocery store offers banking, savings and loan services. Again, these services would be similar to interest payments on loans in their effect on the various accounts, I think, but I wonder if there is a biophysical difference. Banking fees associated with giving me financial advice, or with actions taken to manage my investments, or with actions taken to cash my checks and settle accounts with other banks – these fees are all associated with physical efforts. In all of these cases the bank DOES something and gets paid to do something. This is akin to growing and selling vegetables.

But in the case of interest paid, whether to the bank or by the bank, nobody is doing anything. The interest accumulates and is paid without something being done. This, I think, is called the "time value of money", and I find it hard to understand, and wonder if it is a delusional concept. I cannot seem to prove it's delusional.

Back to the topic. I don't think banking fees, other than interest payments, are much different from vegetable sales, and so I don't need to describe them in detail. It is just a transfer of funds from buyer to seller.

7.4.5 - Debt Write-Off

Debt write-off happens all of the time. Every time an agent goes bankrupt, when liabilities exceed assets and the creditors force the debtor to pay what it can, and extinguish some portion of the debt, the rest of the debt is written off. Suppose Cole is found to be unable to pay back his $2000 loan, ever. He has written a check for $5000 to someone, the check has been settled, and those the credits now belong to someone else.

Then the various book-keeping entries that recorded the loan can be removed from the books, but the credits continue to exist somewhere else in some other agent's accounts. There was a time when such bad debts lived forever, or until the debtor died somewhere in debtor's prison. Sometimes the heirs had to pay the debts of the dead. In modern society, we have instituted the concept of bankruptcy, whereby such bad debts can be extinguished without payment.

Based on all of the previous discussion in this NTF, I believe that, in the to and fro of competitive capitalism, the weak conservation of money law is always observed, except in the cases of fiat money creation, and of bankruptcy. But, bankruptcy is fairly common.

In **Step 010**, Cole declares bankruptcy, and his loan gets written off by the bank. Compare this to **Table XII** in which Cole's loan was detailed. I have retained the entries from that table as priors, in bold red, to show which items get written off:

- Priors: Cole paid the first interest payment of $10, reducing his checking account from $2000 to $1990. Cole then transferred his savings of $3000 to checking, giving him a total of $4990 in his checking account. He then wrote a check for $4990 to buy a beater of a car that immediately broke down permanently, and he cannot get the money back. He now has assets of 0$ and liabilities of $2000 (L).

- Priors: The corporate bank C_C has assets of the original $6000 endowment plus the $10 that Cole paid for interest on his loan. It no longer has the $2000 (M1) that was advanced to it from C_B since that was, in turn, advanced to Cole, who spent it on the beater. So, they have assets of a $2000 (L) (worthless) loan agreement with Cole, and liabilities of a $2000 (L) (still good) loan agreement with B_C.

- Priors: B_C had $9000 in $c but had to settle with some other bank for Cole's check for $4990, and now has assets (in $c) of only $4010. It also has assets of $2000 (L) for the still good loan agreement with C_C. In its role as the guardian and keeper of the books for the national logical money supply (MS-II), it cannot take a loss. The risk was taken on by the corporate arm, and must be born there. In addition, it did allow C_C to use M1 money in that loan, and is still carries a liability for that money.

- In **Step 010a**, receivables recorded against Cole's loan are written off by C_C. The M1 money cannot be repaid. It is not marked as paid, but simply is removed from Cole's account. This is shown in **Table XV** as one red circle with an X. Note that this is only half of a double-entry. This is a breach of TCM.

- In **Step 010b** the loan agreement is cancelled, and the corresponding assets and liabilities are removed from Cole's own paperwork, and from C_C's account. This is shown in **Table XV** as two red circles with an X.

- In **Step 010c**, C_C digs into its own M1 checking account that existed prior to the loan (the $6000 endowment) and pays $2000 down the amount outstanding on the loan from B_C.

- In **Step 010d**, C_C and B_C agree that the loan is paid off and close it out.

I have recorded Steps 010c and 010d as reversals in the books, to make it more clear what is happening.

TABLE XV – Accounting of a Debt Write-Off

Step		Cole		C_C		B_C	
		A	L	A	L	A	L
Prior		$0 (M1)	$2000	$10010 (M1)	$4000	$4010	$4010
010a	1				~~$2000 (M1)~~		
010b	2		~~$2000 (L)~~	~~$2000 (L)~~			
010b	3		-$2000	-$2000 (L)			
	4			**$2000 (M1)**			**$2000 (M1)**
	5				**$2000 (L)**	**$2000 (L)**	
010c	6			-$2000 (M1)			-$2000 (M1)
010d	7				-$2000 (L)	-$2000 (L)	
Post	8	$0	$0	$6010	$2000	$4010	$4010
Net	9	**$0**		**$4010**		**$0**	
Col		A	B	C	D	E	F

Legend: Priors include the entries made in red. Post is the sum of priors plus black entries. Red items which are circled were written off. Red items not circled were prior commitments that had to be met to close off the series of loans. Post numbers are the sum of prior positions, plus black entries. Net is assets minus liabilities.

EFFECTS: The effects of debt write-off are:
- Cole went from a net worth of -$2000 to $0 – an increase.
- C_C went from a net worth of $6010 to $4010 – a decrease.
- B_C, of course, by design, had no change in net worth.
- The credits that Cole spent on the car are now with another bank, and are still part of the positive part of the logical money supply MS-II.
- But the debts associated with Cole's bad loan have been cancelled, leaving an imbalance in the two sides of MS-II.
- A debt write-off seems to be a net transfer of money from the lender to the borrower's sector of the economy, if not directly to the borrower. The lender has lost money. Someone is ahead.

7.4.6 - Credit Write-off

Credit write-off is the other side of the coin, in a manner of speaking (☺). Is it ever possible to lose all of your credits?
- I suppose that if you deposit all of your money in a bank, and you do not have a bank book, and the bank burns with all of its records, then there is no proof of the existence of your credits.
- I suppose, the bank could fake its records and simply zero out your credits.
- Or, a person could die with unidentified bank accounts, and eventually, the abandoned money would go to the bank.

EFFECTS: If such a thing could happen, it would have the opposite effects:
- The net worth of the borrower would decrease.
- The net worth of the corporate bank would increase.
- There would be no change to the debt side of the MS-II money supply.

- The credit side of the MS-II money supply would increase.

But, there are laws and social constraints that prevent that from ever happening, and people and banks have back-up ledgers. So, in general, I don't think credits ever get lost, cancelled, or written off, in the normal or abnormal run of business.

8 - The Shadow Money Supply

8.1 - Merchant Loans

In this section I want to examine some of the transactions that might be involved in the shadow money supply that I previously labelled MS-III.

Step 011 proceeds as follows. If Andy was purchasing, say, vegetables at a market, at a cost of $12 he might:
- Select the vegetables;
- Ask them to put the $12 on his monthly tab;
- Take them home to eat.
- Pay the "Tab" at the end of the month.

This is only barely different from a bank loan:
- When Andy picks up the vegetables, he implicitly owes the $12.
- The grocer implicitly loans Andy the $12, and creates a loan agreement that the $12 will be paid back at the end of the month. The physical evidence of this loan agreement is the entry in the grocer's tab, and the corresponding entry in Andy's note book at home.
- Then Andy immediately uses the $12 that was implicitly loaned to him to pay for the vegetables on the spot, before leaving the grocery store with them.
- By this means, a micro-facsimile of a standard bank loan was made between Andy and his grocer, but this loan if "off book" in the sense that it does not get into the banking records of either participant until Andy sends a check, and the debt is settled between Andy's bank and the grocer's bank.

My questions, then, are:
- Did the money supply change as transaction happened?   Yes. Money that Andy did not spend immediately could be used to purchase other things, so, until the end of the month, there was, effectively, $12 more circulating in the economy. The money supply did rise between the time the debt was incurred and the time it was paid, but not in a way that would be reported by the banks. (See Figure 03.) The merchant has evidence of receivables that would allow it, for example, to take out short-term loans, or win the trust of suppliers, etc. So, while the bank accounts don't show a rise in money supply, the debt short-term debt increases the liquidity of the supply chain for vegetables, and has the same effect as a greater money supply. I suppose, perhaps, that it increases the implicit velocity of money.
- Did the money base change? No. Though cash may have moved from vault to vault when the debt was paid.

- Did the total debt and total credit of the logical money system (MS-II) change   No. It just shifted about. Whatever balance existed between credit and debt within MS-II has been maintained throughout the period of this loan.

Such merchant-to-buyer short-term debt is often the product of terms of payment, that may be monthly, or 30-days, 60-days or 90-days. Some of this kind of debt is formalized in financial instruments called T-Bills, commercial paper, or bankers' acceptances. The line between the unofficial sort of commercial debt, like the grocer's tab that I used as a micro-example, and the

Figure 05 – Three Money Supplies – Showing Symmetry

formal sort, such as bankers' acceptances, is a confusing one that I don't understand. But, I do presume that there is a line.   I would make this distinction. As soon as such an instrument appears as a liability in the accounts of a deposit-taking institution, it enters the logical money supply (MS-II). Those that are not, or not yet, entered into a banker's account books are part of what I am referring to as the shadow money supply (MS-III; see Figure 05).
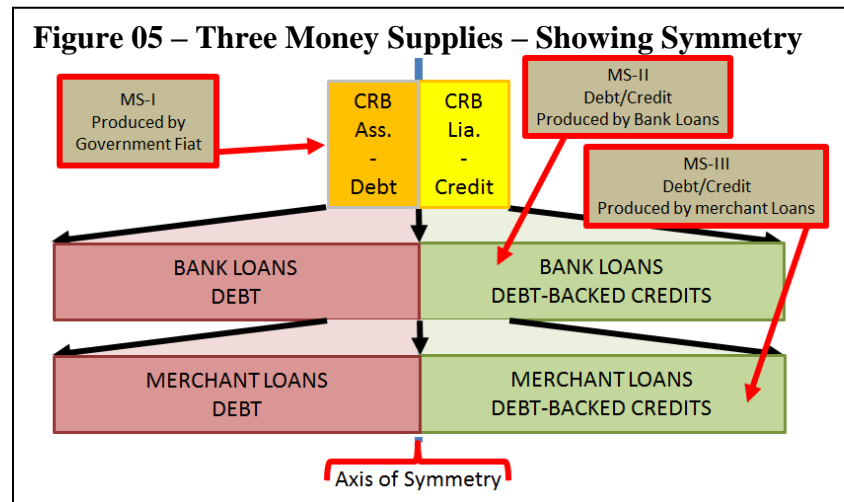
Such a shadow money supply adds greatly to the liquidity of money, and the velocity of money, and also greatly reduces the need for bankers and merchants to be handling volumes of money all day. The smooth operation of such a monetary system requires a lot of trust between participants, so the reputation, or credit rating, of the participants becomes important. Bankers' acceptances, for example, are a means by which merchants can access money using their banker's reputation.

I don't know how big such a shadow money supply might be, compared to the logical money supply that governments track, but I would guess that it is quite large.

8.2 - Credit Cards

My credit card has no overt banking fees, and charges no interest if I pay monthly. This is a grand-fathered agreement that I have to be careful to maintain, as I have had this deal since 1972. That puts me, as a consumer, in the same circumstance as a merchant. I can spend, spend, spend all month, and just settle once a month. So, I can use such a pure credit card as an example for merchant loans.

Such credit cards, along with standard commercial terms such as 30-day, 60-day or 90-day terms, produce an invisible river of mid-term credit and debt. Like a stream of electrons torn free of their moorings and flowing over the rocky bottom stream bed of fastened-in-place protons, loans are created monthly, the credits and debts implicitly springing into existence, intermingling, and ultimately extinguishing each other again, even as new ones spring up. Or,

perhaps, the better analogy is quantum foam in which positrons and electrons spring into existence, each go their separate ways, only to collapse into complete annihilation when they meet some other member of their cohort of nemeses.

Bank credit cards, then, would seem to have two effects on money supply. They provide an added measure of liquidity in the daily transactions of consumers such as me – a kind of liquidity that retailers have enjoyed for decades, or longer. But, also, they make some part of this invisible branch of the money supply visible to the banks. The banks, in their role of settling accounts between multitudinous debtors and creditors, they take these otherwise invisible short-term loans onto their own books as assets and liabilities, and add them to the logical money supply (MS-II).

On the other hand, I suspect that merchant's credit cards, such as a Canadian Tire card, or an Esso gas card, would be part of the shadow money supply, only being tied to the banks' accounts when the bill is paid monthly.

8.3 - Stocks and Bonds

A bond is a loan agreement between a person with assets to loan, and a corporation that want to take on debt to finance its activities. This would seem to be part of the shadow money supply (MS-III). Double-entry book-keeping is used every step along the way, and so money involved in the bond market would be, I think, conserved at least as WCMS.

A stock is also a loan agreement between a person with assets to loan, and a corporation that wants to use sales of equity to finance its activities. The twists and turns of stock sales, however, are beyond my ability to analyze in any cursory fashion, and so I am uncertain whether this part of the shadow money supply conserved the integrity of money.

8.3.1 - Markets for Stocks and Bonds

Ditto here. I cannot say for certain that markets for stocks and bonds maintain the integrity of the shadow money supply. I believe it to be in accordance with WCMS, since double-entry book-keeping is used in all transactions, and therefore at least, transactions are in accordance with TCM, but I cannot say for certain.

8.3.2 - Dividends

I think this would be vaguely similar to interest payments. The money-lender (the stock-holder) purchases an interest in the possible productivity of the stock, and collects interest when that productivity is realized, but, otherwise, does not. This is merely a sharing of credits earned by the corporation that issued the stock. It should not affect the balance between credits and debits, nor should it affect the money supply.

8.3.3 - Discount Markets for Stocks, Bonds, Mortgages and Other Loans

Stocks, bonds and mortgages are all kinds of loans. This would include government "war bonds" and their modern versions such as treasury bills. They all behave differently, and some are very complex, but my basic question is this: do they change the balance between debt and credit? Another way, perhaps, to ask the question is: Is there any kind of transaction in which the associated profits and losses, in $, are not equal. Suppose C_A sells Andy's loan to C_C at

1% discount. This is a self-referential sale, as I am selling dollars for dollars. It might proceed as follows:
- Bank C_A writes a check for 0.99*$2000 = $1980 to bank C_C.
- Bank C_C deposits the check into its associated bank B_C, and settles it with bank B_A.
- Bank C_C transfers Cole's loan to C_A and informs Cole.
- Bank C_C writes off the $20 of unrecoverable interest on the bad loan to Cole.
- Bank C_A garnishees Cole's wages for the full amount, plus interest.

So, I think all discount markets for financial instruments involve some sort of write-off.

9 - Summary

Figure 05 shows my view of what the structure of the money supply is.

Equations 01-04 are the mathematical basis of a law of conservation of money. But they need to be carefully interpreted and carefully applied. In particular, the meaning of bank, lender, depositor and borrower has to be carefully understood for each of the three different money supplies.

In the case of Equation 01, it seems to be not relevant which participant in a binary exchange is termed the lender, and which is the borrower. For the other three equations, the definition of roles is a little more important. For MS-I, the bank is the CRB, and the depositors/borrowers are usually other deposit-taking banks. For MS-II, the banks are the deposit-taking banks other than the CRB, and the depositors/borrowers are non-banking economic agents. For MS-III, the "banks" are vendors, and the depositors/borrowers are buyers of stocks, and bonds, goods and services.

After fairly careful, and rather tedious, examination of as many examples as I can think of, it seems that the following statements are true:
- The modern money supplies have a very distinctive symmetric structure as money is created, and, if there were perfect conservation of both positive and negative money, the net worth of the money system should be zero.
- However, there are two clear instances in which the symmetry can be broken:
  o When the government uses its fiat powers to "print money" without taking on a liability at the same time.
  o When bad debts are written off during bankruptcies, or in similar circumstances, and a bank takes a loss. This seems to cause a transfer of funds from the banking sector to the non-banking sector. I suspect that this is a very significant flow.
  o When lost or forgotten credits in abandoned bank accounts are absorbed by the banks. This seems to cause a transfer of funds from the non-banking sector to the banking sector.
- Interest payments do not break the symmetry of the money supplies, but they do divert positive money across the divide between lenders and borrowers, in whatever circumstance this happens. I suspect that this is a very significant flow that counter-balances the flow due to written-off debts.
- The size of the money system, if measured as $|\sum credits| + |\sum debits|$ is not conserved in any money supply. MS-I is probably the most stable, changing from time to time as the CRB

releases new $c. In fact, for the other two money supplies, this sum probably fluctuates ever-so-briefly with every financial transaction. So, SCMS may be observed in MS-I for periods of time, but is probably never observed in the other two money supplies.
- On the other hand, I believe that WCMS and TCMS are both observed for all three money systems, except for the fiat creation and credit/debt write-off. I.e. for the vast majority of transactions, WCMS and TCMS are observed, and money is conserved.

All that being said, I would propose that there is a concept of "sufficiently-well conserved" quantities. Sufficient for what? Well, sufficient to be a base for 2nd law and 4th law dynamics to do their work and cause thermodynamic or non-thermodynamic entropy to be produced, and to cause dynamic systems to self-organize:
- Energy is the "poster child" for a sufficiently-well conserved quantity, and it is the basis on which probabilistic dynamics produce thermodynamic entropy, and cause the self-organization of systems. The breach in energy conservation is related to mass/energy conversions, which are rare and usually associated with fission or fusion.
- Atoms of a given element are sufficiently-well conserved to be the basis of stable rules of inorganic chemistry, in which Gibbs found plenty of evidence of thermodynamic entropy at work.
- Within an organism, genes are sufficiently-well conserved to be the basis of stable rules of organic chemistry.
- Within an ecosystem, alleles of genes are sufficiently-well conserved to be the basis of self-organization of ecosystems into evolving species.
- Within an ecosystem, members of species are sufficiently-well conserved to be organized into trophic webs.
- Within a society, memes and modes of behaviour are sufficiently-well conserved to be the basis of self-organization of complex societies.
- Then there are many bases of economic behaviour that are, in some sense, sufficiently-well conserved to act as stabilizing rungs on which very complex economies can be built. Our three current inter-connected money systems are one example. Or, there is real-estate, by type of land, or gold.

So, is money perfectly conserved? Absolutely not. Is it sufficiently-well conserved. Absolutely yes!

I have one other observation and many questions. MS-I and MS-III are the remnants of a very resilient and very ancient set of practices by merchants and kings. MS-II seems to be a relatively modern invention, rising from the concept of double-entry book-keeping. This new concept has been placed between the two ancient concepts, and has created a new kind of economy, that can be called the financial economy, in place of the real-world economy. There is clearly an important dynamic between these two economies, and that dynamic dominates our modern world, but is not seriously analyzed or discussed, as far as I know. For example, interest causes a flow of positive money from the real economy to the financial economy, and debt write-off causes a flow in the other direction. One upsets the balance, but the other does not. This raises questions like:
- How serious is the modern imbalance between debt and credit?
- Does the debt pool in places like sovereign debt pools?

- Does the credit pool in places like pension plans?
- When governments started issuing bonds, did they de facto give up their monopoly on fiat creation of money and allow the banks to replace it with creatio ex nihilo via loans?
- I know, from my work in EiLab and from Dr Yakovenko's work, that positive money self-organizes into a Boltzmann-like entropy-determined distribution. Does the negative money also redistribute itself in this fashion?

10 - Yet-To-Do

What might I do to extend or improve on the ideas in this NTF?
- Possibly talking to somebody in the banking system might help me.
- The shadow money supply is not well developed here. Perhaps a new note on that topic would be useful.
- The flows of money between the real and financial economies could be converted to differential equations. That might be interesting. For example, as a result of this exercise I suspect that all interest payments into the financial economy from the real economy are paid for by a flow of money back into the real economy caused by bankruptcy. That is a nasty thought.
- The arguments around the mathematics of the 1st law of thermodynamics should be reviewed with a thought to how they might apply to a 1st law of econodynamics, with this idea of "sufficiently-well conserved" in place of the "almost perfectly-well conserved" concepts around energy.
- If any of the original symmetry between credit and debt has been maintained historically, then there must be large oceans of debt out there somewhere. Or has it all been eaten up through bankruptcies? The relative growth and movement of credit and debt within the economy would be an interesting study.
- Who is the "Center for Financial Stability", in New York, and what is the "Divisia" formula for calculating money supply?
- What is the distribution for velocity of money within a money supply, and does the concept work for negative money as well as positive money?
- Does the thermodynamic concept of absolute zero have an analogue in economics, and what role might the physical money supply play in determining that?
- Do differences in the time dynamics of the two sides of a bank loan affect the asymmetry of the money supplies?
- Are excess reserves in any way analogous to "potential energy", since they are in fact "potential money supply".