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A graph representation of the financial relations in a given monetary structure is proposed. It is argued that the graph of debt-liability relations is naturally organized and simplified into a tree structure, around banks and a central bank. Indeed, this optimal graph allows to perform payments very easily as it amounts to the suppression of loops introduced by pending payments. Using this language of graphs to analyze the monetary system, we first examine the systems based on commodity money and show their incompatibility with credit. After dealing with the role of the state via its ability to spend and raise taxes, we discuss the chartalist systems based on pure fiat money, which are the current systems. We argue that in those cases, the Treasury and the central bank can be meaningfully consolidated. After describing the interactions of various autonomous currencies, we argue that fixed exchanged rates can never be maintained, and we discuss the controversial role of the IMF in international financial relations. We finally use graph representations to give our interpretation on open problems, such as the monetary aggregates, the sectoral financial balances and the endogenous nature of money. Indeed, once appropriately consolidated, graphs of financial relations allow to formulate easily unambiguous statements about the monetary arrangements.

JEL codes: E42, E50, E52, E58, F33, F34

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Introduction

Understanding the fundamental nature of money is paramount for macroeconomic models. Indeed, over the past century, the description of money was central to the building of simplified models of macroeconomics, and monetary economics became a field of macroeconomics in itself. The *classicals* first postulated that money was neutral and avoided the need for any suitable description. The *new classicals*, and most prominently the monetarists (Milton Friedman) reached a milder version of this statement with the quantity theory of money, stating that money was neutral in the long run. Again, the debate was not on the structure of the monetary system but rather on its implications for macroeconomic theories. The debate between neoclassicals and Keynesians led instead to theories of money being descriptions of the monetary system, but these are in fact restricted to theories of interest rates, with mainly the theory of liquidity preference for the Keynesian approach and the loanable fund theory for the neoclassical approach, and these are often summarized and popularized in the IS/LM models of the neoclassical synthesis. In general, the urge for economists to provide guidance for politicians and central bankers forced them to avoid questioning the structure of the monetary system. In the tradition of classical economics, economists were more interested in finding microfoundations for their models in a reductionist perspective, that is to deduce them from microeconomic behaviours, rather than unveiling the complex structure of the monetary system in a top-down approach.

There is certainly no unique theory of money, since money is not a universal concept. Indeed, any monetary arrangement in a society is different and leads to a specific description. We should indeed rather describe the various possibilities of *monetary systems* rather than talk about a unique *theory of money*, including those which have been or are realized, but also allow for the description of possible systems which are not yet realized in practice, as required by the general democratic debate. This is nicely summarized by Minsky (1996, p1): *"[...] relevant theory is not a compendium of propositions derived from axioms assumed to be universally true: economic theory is not a subdivision of mathematics. Relevant theory is the result of the exercise of imagination and logical powers on observations that are due to experience: it yields propositions about the operation of an actual economy"* .

Descriptive approaches thus prefer to focus first on the different possible monetary systems, before drawing conclusions which are necessarily restricted in their scope. They can be gathered so far in two major categories: metallism and chartalism. Oversimplifying, one can say that metallism is the description of monetary systems in which

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money is backed by a real asset, often gold, whereas chartalism is the description of monetary systems based on pure fiat money that originates from the state's ability to raise tax (see Bell (2001) for a historical perspective and Knapp (1924); Lerner (1947); Mitchell-Innes (1913) for seminal papers). Since the end of the Bretton Woods system in 1971, which was already a remote form of convertibility, this latter descriptive framework has received renewed attention and is often named neochartalism in that respect (Wray, 1990). Following these two general categories, the debate is often about knowing if money is exogenous or endogenous, as the question of its fundamental nature arises, and one wants to know how to use monetary and budget policy to influence the economic situation of a given monetary area.

All fields of human knowledge had to develop a suitable formalism from which the results are presented in their simpler form. For instance rephrasing mathematics with symbols and equations rather than in full sentences helps enormously in its formulation and its communication. But rather than a replacement of the general language, it is an enrichment, and even in books of mathematics or physics, the major part is written in the general language, even inside the proofs of theorems. The formalism is indeed only used when it clarifies, and never to obfuscate. In this article, we develop a graph representation of the structure of monetary arrangements, based on the fact that accounting is performed with double entry balance sheets. Such graphs are rather common in representations of flows in macroeconomics, but are generally absent for the description of stocks, although they have already been extensively used to study the systemic risks in networks of commercial banks [see e.g. Sheldon & Maurer (1998); Upper & Worms (2004); Wells (2004)]. To phrase it shortly, graphs are often used to explain how things evolve, but not to detail how things are organized at a given time. Given the complexity of the monetary systems, a graph description leads to a much simpler visualization. Nearly all debates about the structure of the monetary system can be rephrased in a very compact form using such graphs, as it allows to represent all balance sheets at the same time while consolidating sub-sectors.

We thus argue that this is the natural language in which the discussions about the nature of monetary systems should be carried out. By representing a complex structure in a very compact form, it thus carries a much clearer information, just like a very deep equation carries a powerful meaning in just one line. Using this language we then discuss the various possible monetary arrangements and how they are related. This opens then possibility to discuss on a clear basis the major topics associated with the monetary system which are

- the monetary policy (money creation and interest rates setting);
- the budgetary policy (debt issuance);
- the interaction of various autonomous monetary systems (international monetary relations).

Not only do graph representations simplify these discussions, as they help in the formulation of the various possible monetary arrangements, but they also facilitate the communication with non-experts, and this should be a major concern in democracies, for any choice of monetary arrangement is a choice of society.

This article is organized as follows. We first review in § I how graphs are usually used to represent flows in a given unit of account between different members of a financial system. The use of graphs for stocks will then appear as a natural generalization, and we explain in § II how we can build a simple graphical representation for the representation of the asset-liability relations in a financial system. We also discuss the introduction of a state in the representation, from which we start to discuss the monetary and budgetary policies in § III. A general picture of a system with several currencies is also rephrased using graphs in § IV. Finally, we discuss some controversial issues in § V, such as the European Monetary Union (EMU), the monetary aggregates, the sectoral financial balances, and finally reconsider the debate about the exogenous vs endogenous nature of money.

I. USING GRAPHS FOR FLOWS

In this section we review how flows of funds are typically represented by graphs (in the sense of *graph theory*), and we assume that there exists a unit of account (e.g. \$ or €) in which these flows are expressed. We postpone the discussion about the origin of such unit of account, and simply assume it exists.

A typical flow a funds between n actors, can be summarized by the numerical entries of an antisymmetric matrix or table , which is simply the set of a_{ij} with $1 \leq i \leq n$ and $1 \leq j \leq n$ such that $a_{ij} = -a_{ji}$). Indeed, if actor i pays a given positive amount $a_{ij} > 0$ to member j, it can also be considered that actor j pays the negative amount $a_{ji} = -a_{ij} < 0$ to actor i[1]. Furthermore, an actor cannot emit a payment to himself so $a_{ii} = 0$. An immediate consequence is that there are at most $n(n-1)/2$ payments for these n members. However, in a typical set of payments corresponding to a given period of time, there are much less bilateral payments than the maximum allowed. This is because actors have only economic interactions with a subset of all actors. This implies that most entries of the matrix of payments are vanishing.

[1] Note that because economics is often expressed in the general language, it is reluctant to use relative numbers, that is which can be positive or negative. It prefers to state that somebody receives a positive amount than pays a negative amount. Similarly, assets and liabilities are always positive quantities, but it is implied that a negative asset is a liability and a negative liability is a positive asset.

In this context, it appears much more enlightening to use a representation based on a weighted graph (see Fig. 1). The n vertices of the graph are just the n members of the economic system, and the edges which connect these vertices are related to the non-vanishing entries of the matrix of payments. If a_{ij} is positive (respectively negative), then we can even say that the edge is oriented from i to j (respectively from j to i), and in either case the weight of the edge from i to j is given by a_{ij}.

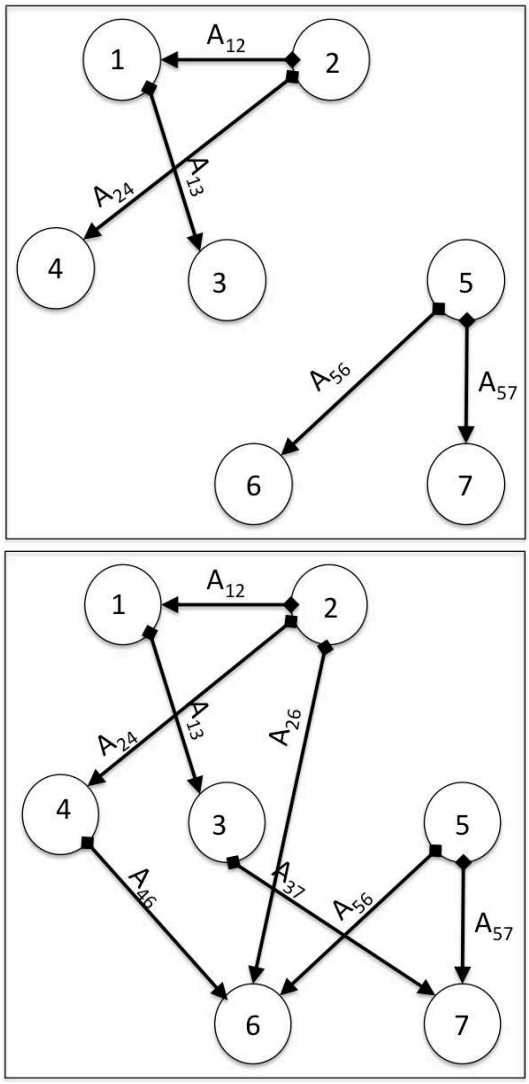

FIG. 1 Top: disconnected graph of payments with no cycle. Bottom: connected graph of payments with two cycles.

First, we will disregard graphs which are not fully connected, since each of its connected parts can be decomposed into a superposition of connect graphs. Each subgraph represents just the payments inside a community. A very general result is that a connected graph with n vertices, and m payments with $m \geq n$ necessarily possesses cycles. This result can easily be obtained by induction. If there is a cycle, this means that unnecessary payments are made, since for instance we have a pattern where member 1 is paying member 2 which pays member 3 which then pays member 1. It is then sufficient to subtract the same amount from all these payments inside a cycle such that one of the edges vanishes and thus be removed from the graph structure of payments. A typical arrangement inside a connected graph can thus be reduced to a graph with n members and at most $n-1$ payments (see Fig. 2).

In order to achieve a practical graph of payments where the number of transactions is minimum, we notice that a tree with one member being the root and all other members being leaves which are connected individually to the unique root, is also a graph with n edges and $n-1$ vertices. It is no wonder that this is in general the pattern which is found to settle the payments. One member acts as a banker and centralizes all the payments from other members as well as payments to other members. Rather than a general connected graph, the payment structure takes then the form of a tree. In its simplest form, it is a tree with depth unity (that is all leaves are directly connected to the root banker). Each individual i but the banker (labeled by i_B) is thus paying p_i to the banker in the relative sense (paying if positive and receiving if negative), given by

$$p_i = \sum_{j=1}^{n} a_{ij} \,, \tag{1}$$

such that $\sum_i p_i = 0$ given the property $\sum_{ij} a_{ij} = 0$. By construction, the banker receives what is he is owed, as it is simply

$$-p_{i_B} = \sum_{\substack{i=1 \\ i \neq i_B}}^{n} p_i \,. \tag{2}$$

This means that the typical organization of a payment structure is to go from a disorganized graph with many cycles, to a tree graph with no cycle at all. This self-organizing feature can be done completely to lead to a tree graph of depth unity, but it can also be partial, with a few cycles remaining. In this latter case, then there are several bankers each one of them organizing the payments from and to a subset of the members, but these bankers organize their payments in a disorganized graph with cycles. If the bankers decide to remove the cycles as well, they can also organize around a preferred bank, which would then act as a central bank. The central bank could be one of the banks and one would reach a payment tree structure with depth 2. This is illustrated in Fig. 3.

Since stocks are the results of the integration of flows over time, it seems natural to represent the structure of stocks with similar graphs, and this is the central point of this article. Eventually one would like to be able to represent both stocks and flows in a compact and readable form.

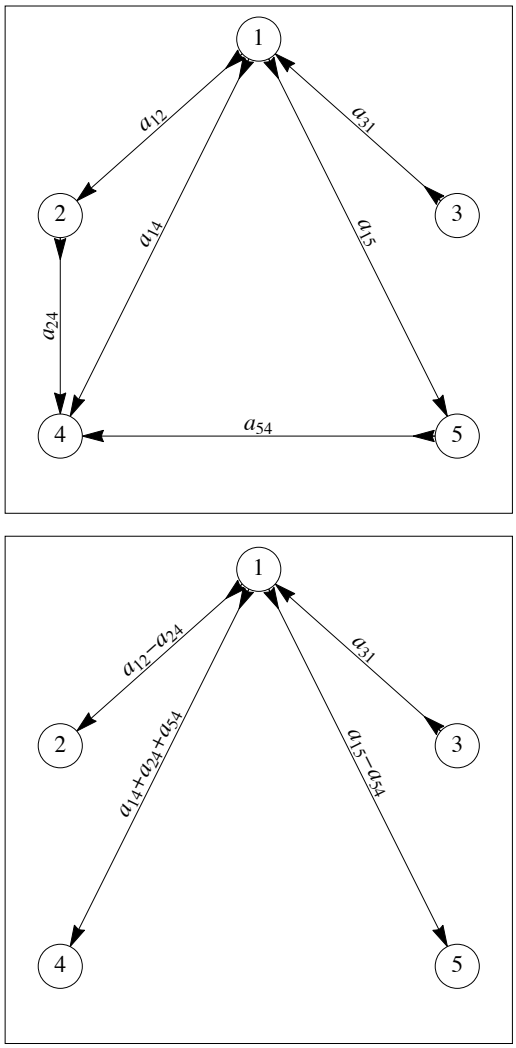

FIG. 2 Top: typical graph with two cycles. Down: after removal of the cycles, there are less edges than vertices.

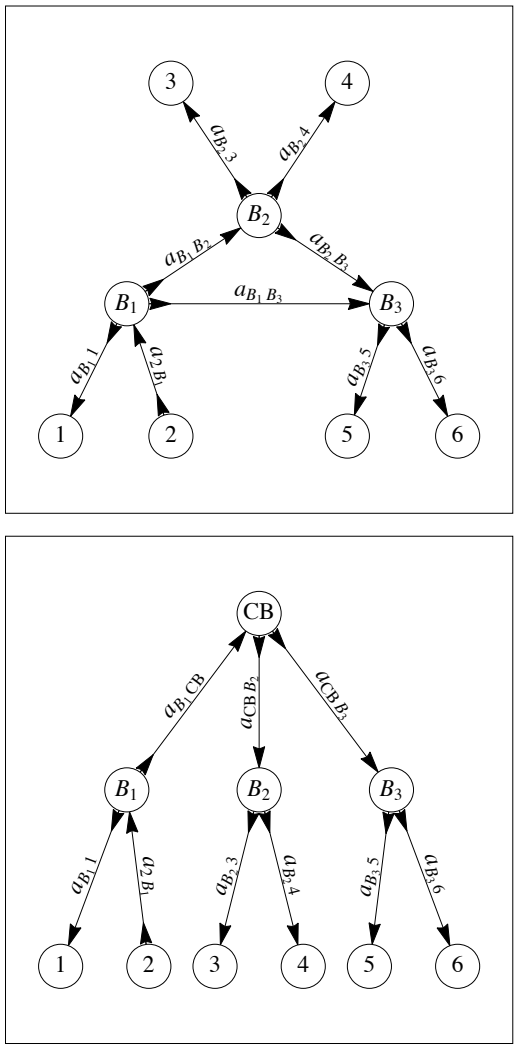

FIG. 3 Top: typical graph of payments with a network of bankers. Down: typical graph of payments with banks acting through a central bank.

II. GRAPHS FOR STOCKS

A. Unit of account

Before turning to stocks, we must specify what is exchanged. In the graphs representing the flows of payments, it was assumed that the payments were made in some unit of account, without specifying what it could be. There are essentially two features which are necessary[2] to define a unit of account.

- A given unit of account possessed by a member must refer to something which is completely indistinguishable from what is referred to by the same amount of unit of account used by another member;
- What is referred to by the unit of account must be something which can be possessed by any member, and the payment corresponds to a change in its ownership.

If the unit of account is a general commodity, then the unit of account is rather straightforward to define. It is any unit in which it is natural to measure the commodity. In the most simple case of gold, then it is sufficient to use for instance a unit of mass. As long as it refers to something which is invariant, a given amount possessed by somebody is completely equivalent to the same amount possessed by somebody else. In that respect, an amount of gold is a good unit of account since gold is invariant through economic space and economic time, but it is clearly not possible to use a given amount of land as different domains are not comparable. Land can be possessed, but two equal areas of land are not equivalent.

[2] We emphasize that a necessary condition is not a sufficient condition, so it is not a defining list of conditions.

In general, we must thus distinguish between real assets which are distinguishable, and real assets which are indistinguishable. In the former case, only a share of ownership of a given asset can be used as a unit of account since each real asset is different from another one. This is in general of limited use, unless the real asset is very large and we can thus define many small shares of ownership. For instance a share of ownership of a large company can be used as a unit of account. In the case of a real asset whose nature is to be indistinguishable, that is a general commodity, it can be readily used as a unit of account once an invariant and unambiguous measure has been agreed upon.

B. Representing commodity ownership

For flows the key feature in a graph representation is the *change of ownership* of the unit of account. However, for stocks, a key feature which must appear is the relation of *ownership itself*. We thus represent each commodity (by this we mean the totality of this existing commodity) or each real asset on a single vertex, and the ownership is represented by an edge which links it to the different members possessing a part of it. On the edge, we draw an outgoing arrow from the commodity vertex or the real asset vertex to stress that it is a liability, and an ingoing arrow on the members which have ownership, to emphasize that it is an asset. It is thus an oriented edge, and the amount written on the edge is then the amount of asset for the owner and the amount of liability for the commodity or the real asset, expressed in the unit of account. In that representation, a commodity can be considered to be completely stored in a vault, and the liability of the commodity can be viewed as the liability of the vault itself. Since the vault is nobody's, the corresponding assets of members are net assets as they are not the liability of somebody else. If the concept of a vault is not a purely theoretical simplification, and if the commodity is really stored somewhere with a guard, then we can reach a more complicated structure of ownership, where it is the vault keeper which acts as a bank safe and possesses all the commodity, but in turn issues liabilities to the customers who have brought the commodity there for safety reasons. The members of the system can thus in general either possess directly the unit of account, or own it indirectly through a bank, and we would typically say that they have a (positively credited) account in that bank. In that case, we say that the bank issues an *I Owe You* (IOU), as a record of the gold which has been placed into the vault. In the first case the members of the system need to physically exchange the commodity, and in the second case they only exchange the ownership certificate, that is they exchange the IOUs. A possible extension is then to reach a system in which this indirect ownership is made through several banks. See Fig. 4 for a graphical illustration of commodity ownership.

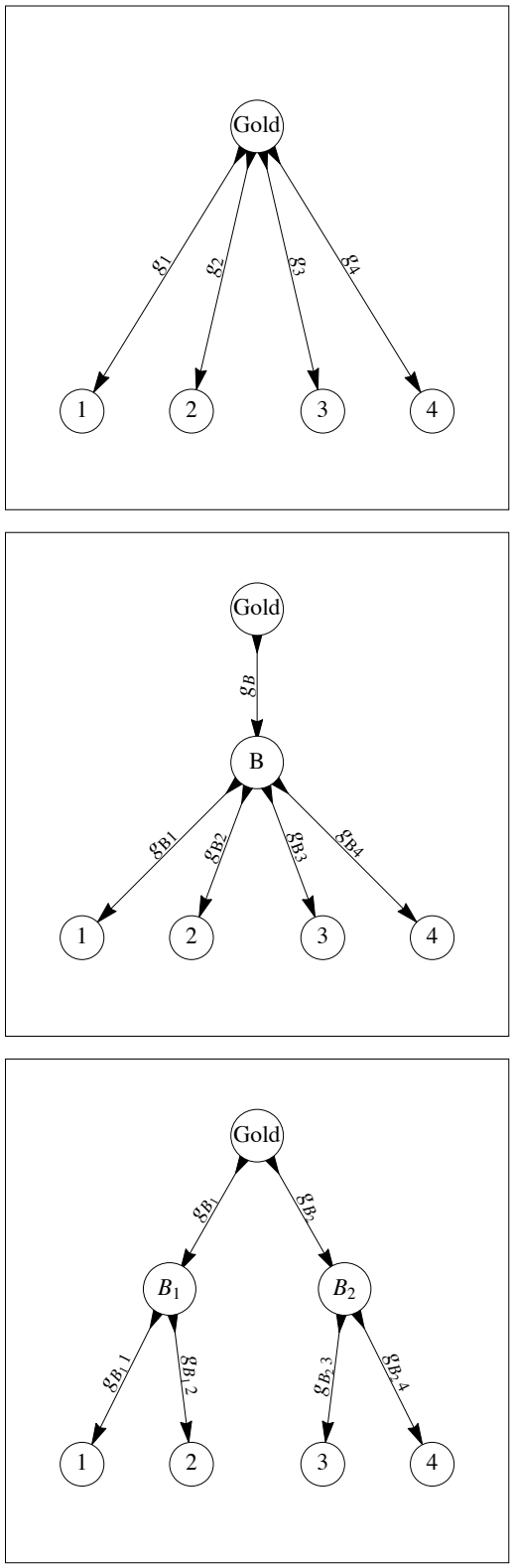

FIG. 4 Top: direct ownership of a commodity. Middle: indirect ownership of a commodity through a single bank. Bottom: indirect ownership through several banks, with each bank owning directly the commodity.

C. Centralized and decentralized banking

The system of keeping track of ownership with the actual commodity stored in a vault is a primitive system of bank, and it is likely that there will be the appearance of several bankers. Depending on the degree of cooperation several configurations are bound to appear once customers of different banks start to interact in the economic world and need to exchange (that is to settle payments).

- *Independent banking.* The banks can ignore each other. This would force every customer to have a bank account in each bank. Or at least once a person needs to accept a payment from somebody else having its assets in a given bank, this person would be forced to open a bank account in the same bank, so as to be able to transfer the liability. Eventually we just have several copies of the same system, which could be merged (all banks gathered to one, and the bank account of a given person in the different banks can then be summed).

- *Decentralized banking.* In an intermediate system of cooperation, each customer would still have only one bank account in a given bank, but the bank themselves would possess a bank account in other banks. In this system, a bank A owes gold to its customer, either because it has gold in its vault, but also possibly because another bank B owes gold to bank A. There could be an extreme case where a given bank has no gold at all, but other banks owe gold to it. In this decentralized system of banking, all banks have to keep tracks of the claims they have on other banks, and will for sure be reminded what they owe. This can become very inefficient for a large number of banks, because with this system of mutual debts, we will recover the same structure as we found for payments before applying any simplification. There will be several loops in the graphs of debts and claims between the banks, and the system will not be transparent enough.

- *Centralized banking.* By the same argumentation, it can become optimal to simplify as much as possible the networks of debts and claims among banks, that is to remove all the loops. In order for this to be permanent, one would thus need to organize the banks in a tree structure (with depth one for simplicity), with one of the bank acting as a central bank. Instead of all banks keeping positions with all banks, the banks keep only a net position with a central bank. For N banks the number of debts scales then as N rather than N^2 and this system is more transparent, simpler to operate, control and regulate. In a last round of cooperation, the banks can decide to send their gold in the vault of the central bank, and keep a claim on it, so as to optimize the cost of gold keeping.

Note that in the case of independent banking and decentralized banking, there is actually a central structure hidden through the possession of gold. First, in decentralized banking, if all banks settle their debts, they are back to independent banking, but all are united through the claims they have on the commodity. So even if there is no central bank, or no central system, the fact that only one commodity is used is functionally close to a system with a central bank. Gold acts as the center of the system. The centralized banking system is just there to avoid displacing physically heaps of gold through the storage of everything in the central bank. We thus see that the use of gold, with its physical exchange, is rooted in the lack of a central organization, as it effectively replaces it.

This sequence of cooperation is essentially what has been followed in all developed countries from the invention of banking to the creation of central banks in the very short period where gold was the counterpart of liabilities, that is around the XIXth century. The final result after this phase of integration, is that we have obtained a 2-tree (a tree of depth 2), with the central bank at the root, the commercial banks at the first level, and the customers on the leaves. We postpone a more general discussion about the history and evolution of the monetary structures to §II.F, as it happens to be much more complex than this simple story.

D. Payments in a tree structure

Once the tree-structure of claims and debts has been clearly identified, then payments are made extremely easy. For nearly each payment between customers, there is a unique loop created, because the payment at this stage is the addition of a new debt. Indeed we remind that a tree with N vertices, has $N-1$ lines. When one line is added as a result of a new debts/claim between customer due to economic activity, there is necessarily one loop (any graph with N vertices and N lines has necessarily one loop). In order to maintain the tree structure and to avoid direct claims between customers or between banks the new loop needs to be removed. In order to remove a loop we subtract the amount of the payment in all lines of the loop, and this will remove automatically the latest payment line. This is illustrated in Fig. 5. It is of course similar to a simplification of a graph of payments, except that now we have simplified a graph of debts and claims (or assets and liabilities), that is a graph of financial stock. For this we have considered that a payment is a new pair of asset/liability which needs to be incorporated in the graphs of stocks. At any time step, there will be payments, and by successively incorporating them in the graphs of stocks, we effectively build the graph of stock as the result of the temporal integration (in the mathematical sense of differential calculus) of payments from an initial condition. Rephrased differently, the graphs of payments at a given time is the

time derivative of the graph of stocks at that given time. Graphs of stock are the position of the monetary system, and graphs of flows are their variation.

Note that the removal of the loop might involve the full tree (if the customers are not in the same bank for instance) but it can involve only a sub-tree (e.g. if the customers are in the same bank). But in any case, a payment requires to know what is the fundamental tree structure of assets, in order to identify clearly the loop that needs to be eliminated. This is why when a customer a pays a customer b, it needs to provide its bank A with the name of the bank B of customer b.

E. Gold withdrawal

A customer might as well ask for its asset to be converted into central bank's gold. Indeed under this model, the central bank owns gold and owes it to commercial bank who in turn owe it to customers. This can be modelled in a graph representation by considering that a customer has two bank accounts. One in a commercial bank, and one which reflects its direct possession of the gold commodity. There are several ways to represent and thus to understand the operation. A simple one is to consider that this is equivalent to the creation of a loop which goes from the gold commodity to the customer and then goes back to the gold commodity following the tree of commercial banks. This is depicted in Fig. 6. One can also consider that this is not a true loop. Indeed we have represented the two different bank account on the same vertex. If we had represented the two different bank accounts as two different vertices (but now vertices do not correspond identically to customers), then there is no more loop and the operation is just the result of a standard payment from one account to another. Either we want to stick to a structure where there is no unsimplified loop, but the price to pay is that a customer might have several bank accounts (one in gold, one in commercial banks), or we do not fear to have loops as long as they are not fundamental loop since all lines of the loop are not denominated in the same thing (even though it can be with the same unit of account).

F. From commodity to fiat money

Before we go any further, a comment is in order about the history of monetary systems. The story we presented for the integration of banks in a network is only a pedagogical story, and is by no means *history*. First it cannot be history, because there is absolutely no reason for the different countries and epochs to have followed the same paths. One story cannot be history. Furthermore, questioning the story of monetary arrangements is nearly equivalent to questioning the origin of money and currencies. The presentation adopted here would imply, if taken at face value, that there was first barter, then in a sophistication, there was exchange of commodities, and only after came a mild form of fiat money as a claim

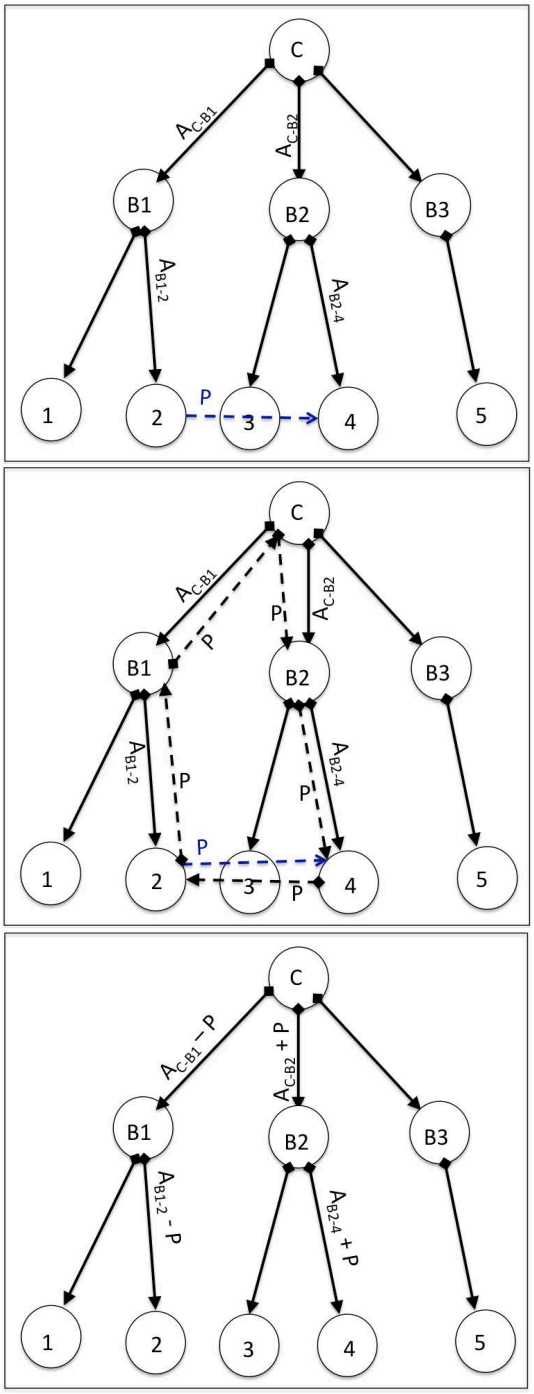

FIG. 5 Top: a new short-term debt is added as a result of a payment between customer 2 and customer 4. A cycle going from customer 2 to customer 4 to bank 2 to the central bank to ank 1 and back to customer 2 is created. Middle: we identified the cycle which has to be removed. Bottom: after the cycle is removed the tree structure is recovered, and the new balances of debts/claims have been adjusted. Note that the arrows do not depict payments (flows) but assets/liabilities which are stocks.

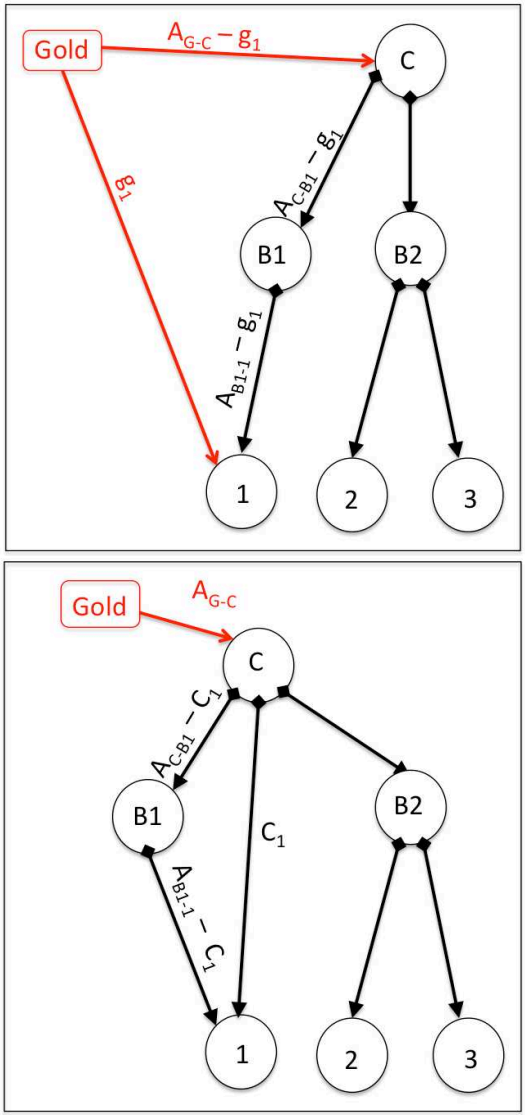

FIG. 6 Top: as a result of the requirement that the customer should hold directly a part of its wealth in the commodity, there is now an irreducible loop in the monetary system. Indeed as a result, the customer holds directly gold but also holds claims on gold through the commercial banks. Bottom: an intermediate requirement would be for the customer to hold directly a claim on the central bank. In that case, given that the customers has also two banks accounts, one which is directly at the central bank, and one in its commercial bank, this is also equivalent to the creation of a loop. Bank accounts at the central bank take the form of paper bank notes (which are thus anonymous), and this operation is equivalent to *cash withdrawal*.

on commodities (gold) toward banks. This story implies that there is a positive historic movement toward liquidity, but where the value of claims is backed by gold. This point of view is essentially the *metallist* point of view or the *commodity theory of money*. If this might have been true for some societies at some times, there is no proof that this is has been a general feature.

Actually it is argued by Graeber (2011) that this is rather the exception in history, and that the most generic type of money is credit money which finds its origins in the quantification of moral debts in units of accounts. The gold standard money appears in that perspective as an exception driven by the industrial revolution, and ended in 1971. These general ideas are actually not new, as they are rooted in the *chartalist* description of the origin of money, where the unit of account for the debts is actually set by the state. The chartalist description of money dates back from Mitchell-Innes (Mitchell-Innes, 1913) who emphasized that money is a standard of deferred payment. As the state spends in a chosen and arbitrary unit of account, it also sets that this unit of account should be the standard unit of account for debt repayment, as all individual debts toward society which take the form of taxes have to be redeemed in that state unit of account, which is a pure fiat money. In that case, the fiat money does not derive its value from the market as a commodity, but rather is credit money whose value is initiated by the sovereign states. These ideas have been further developed by Lerner (1947) and Knapp (1924) and are currently revived under the name *neo-chartalism* (Wray, 2004).

In order to shift from a commodity money to a pure fiat money we just need the central bank to give up on its commitment to convert its IOUs into gold. There is a vault full of gold, but the key has been lost. In that case, any customer can ask for its assets to be converted into central bank's IOUs but not into gold (on Fig. 6, only the bottom configuration is possible). The *chartalist* theory of money argues that everything would behave as usual as long as the state continues to tax in that unit of account. It thus argues that taxation is a *sufficient condition* to impose that the state IOUs are the unit of accounts for debt repayments. The true amount of commodity inside the state issued coins does not matter, as long as the state has the monopoly on coinage and the ability to tax in this unit. The power of states lies in their ability to tax and neo-chartalists thus refer to such a fiat money system as a *sovereign currency*.

Forstater (2003) [see also Cottrell *et al.* (2009)] has recently explored the monetization in colonies by colonizing countries, and showed that it was performed exactly following that logic. The colonizing countries have spent their currency in the colonies, and enforced its use by promising to tax in that same currency, so as to enforce the power of the colonizing country. When the US landed in Europe, they wanted to impose such a chartalist monetization, and it was strongly opposed by the French government in exile until this idea was given up, precisely on the ground that this would amount to colonization (de Gaulle, 1959) and not liberation.

This controversy about the nature of money is extremely pregnant in the macroeconomic debate. But as we have argued already, there is no unique theory of money. There have been societies at some given time that have evolved using a commodity money, and other

societies at other times that have developed a chartalist system. In general, one could say that whenever a state collapses, the corresponding society reverts to a commodity money, whereas when a society self-organizes around a strong central power, it shifts toward a chartalist system based on debt money initiated by the state ability to tax (Graeber, 2011). Given that the gold convertibility of the Bretton-Woods agreement has been abandoned in 1971, there is no doubt that the current international system is a chartalist system. If this is still debated, it is only because this can be considered as being rather recent from a historical point of view. We explore in greater details the debt nature of money in § II.I.

G. Paper money and cash withdrawal

For our purpose here, which is to understand the general structures of monetary systems, it is sufficient to remember that we have achieved a pyramidal, or a tree structure of claims and debts. But the question is then to know what is owed, when there is no more commodity to owe. At least what is preserved is the possibility to transform a claim on a commercial bank, to a claim on the central bank. This is what is done each time one withdraws banknotes. It is as if one transfered money from a bank account at a commercial bank to a bank account at the central bank, with the additional sophistication that the bank account at the central bank for customers is materialized in paper notes, and is thus anonymous. So in a sense, once the convertibility to gold is removed, the ultimate form is not a commodity, but a paper printed by the central bank, which is as good as gold.

Again this operation is equivalent to the introduction of a loop as explained in Fig. 6. It is very similar to a withdrawal in gold, except that now the ultimate form preferred by the customer is the IOU of the central bank. This is usually called cash and takes the form of paper bank notes for customers. A payment between two customers using these paper bank notes, is equivalent to a very simple loop which is actually just a triangle between the two customers and the central bank, but as it is anonymous, it needs not be registered by the central bank. Indeed, the peculiarity of paper bank notes is that it breaks the two sided accounts which is otherwise central in the monetary system. That is for any arrow, an asset/liability relation, both the asset and liability sides have a written record somewhere of their relation. However with paper bank notes, only the one possessing the asset keeps track of its possession of the asset. On the central bank side, only the total number of bank notes is kept into the ledgers. Anonymity and flexibility comes however with less security.

Would everybody ask to convert its assets into IOUs of the central bank, if the central bank allows for it, everybody will end up with its assets in the form of central bank IOUs. In practice however, the central bank IOUs for customers take the form of coins and notes, and not formal bank account in ledgers. But if everybody was allowed to hold a proper checking account at the central bank, and not just paper money, we would in fact reach a very simple system for payments. That would be equivalent to the merging, or consolidation - see next section - of all the commercial banks with the central bank. Indeed, this would be a simple 1-tree structure, with the central bank at the root of the tree, and all customers placed below it at the first level.

H. Conservation laws

The concept of oriented graphs, with local conservation of charge has long been known in physics (Kirchhoff, 1847). It is used in electric circuits, with conservation of current at internal vertices, or in Feynman graphs, with conservation of momentum at internal interaction vertices. The same concept applies here to graphs of monetary arrangements. At every vertex, the sum of all lines should vanish. Or if we separate into assets (claims) and liabilities (debts), the sum of assets at one vertex should be equal to the liabilities of that vertex. The assets are similar to positive charges whereas liabilities are similar to negative charges, and vertices have to be financially neutral. The double entry book-keeping of any company or bank is thus designed to preserve this neutrality. Following this analogy, every arrow (called an oriented edge in graph theory) joining two vertices is similar to a charge displacement or a polarization, as it is a liability on one side (a negative charge) and an asset on the other side (a positive charge). This means that any immediate payment or any new debt/claim relation conserves the financial charge, as it is simply a displacement.

The major consequence is that we can consolidate any subsector of the monetary system. Let us draw a closed line in the monetary graphs. This define a region of the monetary system. We assume at first that there are no customers sitting inside. Since all vertices inside this region are by construction neutral, and since we can ignore the internal financial relations as they net out, we can replace the subregion by a single vertex whose assets and liabilities are given by the incoming and outgoing lines of the region. In practice, it means that if we do not need to consider the internal financial structure inside the region, we can ignore it and simplify the graph. In accounting, this is called a *consolidation* and helps in reading the structure of graphs. One can for instance decide to consolidate the financial sector, and thus to reduce all banks to just one bank like in Fig. 7. Actually nearly all interesting graphs are consolidated, so as to show a specific feature of the whole system.

I. Going into debt

What if a customer sees his asset going negative? After a payment, nothing prevents this in principle. As a

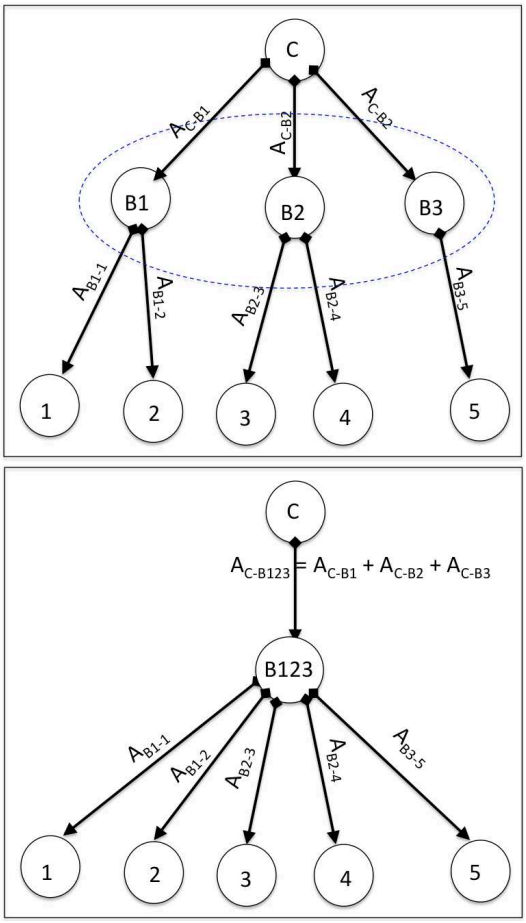

FIG. 7 Top: we identify a closed curve for a consolidation of banks located inside. Bottom: the result of the consolidation.

result, it is not the customer which has a claim on its bank, but then it is the bank which has a claim on the customer since the arrow is not going from the bank to the customer, but in the opposite direction. And we see that this would then be tempting to make more payments than the assets owned, and this infinitely[3]. There are several possibilities to prevent this from happening. The simplest one is to simply forbid spending if it leads to negative assets. This is clearly too simple, and there are several reasons for allowing people to go into debt. In the Marxist analysis of capitalism, we need for instance to spend first by borrowing in order to buy materials, components, in order to create afterwards more sophisticated products, sell them, create a profit, and finally reimburse the loan. So the possibility of going into debt is rooted in the creation of wealth. The usual solution to allow for people to go into debt, but still keeping control of it, is to charge interests. There are several ways one can charge interests. But they are all based on the same principle which is to lend an amount and to ask for a higher repayment on an agreed future time delay (the maturity). The difference between the initial amount lent S, and the repaid amount can be converted into an interest rate I using usual composition of interests for the duration of the maturity D. It can sometimes be more convenient to work with a log-interest rate defined by $i \equiv \log(1+I)$. The amount to be repaid is then $S \times \mathrm{e}^{D\,i}$. Of course if I and D are small, the amount to be repaid is approximately $S(1+Di) \simeq S(1+DI)$. A more complicated loan can always be considered as a set of independent loans (e.g. for a mortgage where the repayment has to be made every month in say 240 month, it can be considered as the addition of 240 independent loans), all with the same interest rate, but with different maturities, which have been arranged such that the repayments are always kept constant. For the sake of understanding the nature of debts and interests, we will thus always ignore complex schemes like this and consider a single maturity for an amount borrowed. In our graph representation, we now need to indicate a debt by (S, i, D) where S is current amount, i the interest rate and D its maturity (the time delay with which it must be reimbursed). Equivalently, one could decide to represent the current amount owed, the maturity, and the higher value at maturity. After every unit of time, (S, i, D) is replaced by $(S \times (1+i), i, D-1)$, and when the maturity becomes null, it is transformed into an immediate payment of amount $S \times (1+i)^D$ whose loop needs to be removed as described in § II.D.

So far the IOUs of the bank, once we have removed the reference to an underlying gold convertibility, are just the promise to convert them into IOUs of the central bank. And no matter at what time this conversion is made, this will be realized with the same amount of central bank IOUs. These financial assets are equivalent to interest-less debts. By introducing the possibility to have debts which bear interests, that is for which the issuers of the debts is committed to reimburse more in the future, we see that we will have a mixed system in which we have tow categories of IOUs. In the first category, we have the IOUs of the central bank, and the IOUs of commercial banks which are promises to deliver IOUs of the central banks, and in the second category we have the IOUs of customers who have borrowed and which promise to realize a payment in the future using IOUs of the first category. Throughout this paper we will make a distinction between *money* and *net money* when referring to these IOUs:

- money consists in the financial assets, and it is the reflection of IOUs of commercial banks and of the central bank toward customers;
- net money consists in money from which we subtract the liabilities, that is it is made of financial assets minus financial liabilities, or net assets.

All amounts are expressed in the same unit of account,

[3] In physics, when quantities are not bounded by below, bad things happen, and ghosts haunt the theory.

e.g. the national unit of account (e.g. \$ or €) which is the one of the central bank.

J. Loans and deposits: hens and eggs

An everlasting debate is about knowing whether or not deposits allow customers to borrow, or if it is because customer borrow that there are deposits. This question is reminiscent of the debate about who was first there between the egg and the hen. We will tell two stories, one where it is the egg in this section, and one where it is the hen in the next section, which will then allow us to conclude that these stories are harmless as long as they help thinking the possible underlying mechanisms, but they are not fundamental at all.

When a banker grants a loan, it is equivalent to the addition of two arrows going in opposite directions. One is going from the commercial bank to the borrower and corresponds to an increase of its assets (of its money), which is decided by the banker. But in exchange of this, the other arrow is the debt going from the borrower to the bank (see Fig. 8). It has the same amount, but it bears interest up to a maturity, meaning that the borrower is committed to repay back the loan and the interest associated to it. Of course the borrower has his own agenda, which is to spend what he has borrowed by paying another customer (say of the same bank for simplicity). We see that the total of the assets possessed by a customer in his bank has increased, but of course the total of its liabilities has increased as well at the same time by the same amount. Even after the borrowing customer has paid the other customer of the same bank, if we sum all their assets and liabilities toward the bank, it has remained the same. But since we have decided to call money the financial assets of customers, and not the net assets, we can say that there has been money creation as a result of the act of borrowing. So we must always remember that there is no net creation of assets because if we have increased the assets, we have also increased the liabilities. In other words, if we were to consolidate the customers into only one customer, then the total net assets, that is the total debt of the banking sector toward the consolidated customer is unchanged. If we consider only money and not just net money, that is if we consider only the financial assets of customers, we are looking at the polarization of the money sector, which results in the displacement of money up to the point where there is negative money, that is liabilities of the customers. This is often called the *endogenous* nature of money and we discuss it further in § V.F.

To conclude, in this story, it is the loan which has made the deposit. It has created money but since it was just there to polarize into equal amount of assets and liabilities it has not created any net money. We can also see that some simple fundamental questions arise. What if all customers with positive assets ask to convert these assets into the central bank IOUs? What if the borrower pays somebody in a different bank and not in the same bank? Before answering these questions, we will answer and even more important question. What if the borrower fails to reimburse?

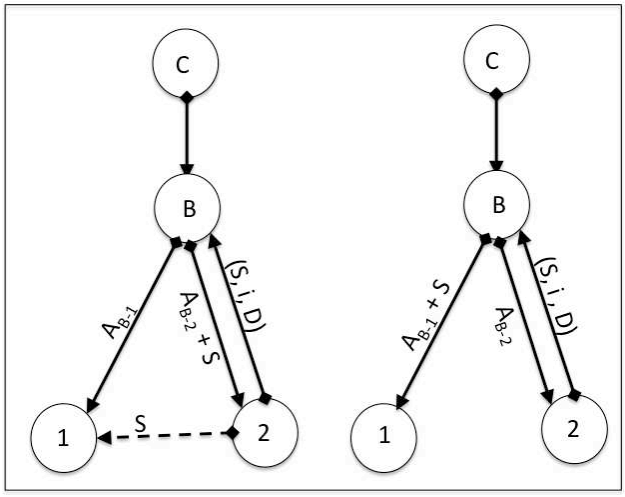

FIG. 8 Left: the customer contracts first a loan for an amount S, with interest rate i, with maturity D. We showed in dashed arrow, the payment he intends to make with the amount borrowed. Right: after payment to the other customer for a service or an investment, he is left with the same asset, but has an extra liability. The other customer has an increased asset. There is a creation of assets and liability, but both compensate. In this story, the loan has preceded the creation of a deposit.

K. Net worth of bankers

Indeed, the borrower thinks that he will be able to repay in a future because he is going to exchange his work against money, that in turn he will use to reimburse. There are then obvious reasons why the borrower might not be able to work to find the money needed. This ranges from losing his job, having an accident, or simply being dead, among many other reasons.

From a graphical point of view this would be equivalent to a unilateral removal of the debt from a customer to its bank. However, our formalism starts to be inconsistent if we allow for such possibility, because at the bank vertex, there will be no more neutrality since the removal of the debt (which is an asset for the bank) would mean that it is no more there to compensate for the corresponding liability (in Fig. 9, one can say that the corresponding liability is toward the customer which has been paid by the borrower). In order to guarantee the neutrality of all bank vertices in a graphical representation of a monetary system, one thus needs to consider the *net worth* of the banker.

So far the bank was just a node or a vertex in the graph structure. Maybe it needed some ressources to operate, that is it needs a little workforce of clerks to keep

track of all the assets entering into it and all the liabilities exiting, but if we ignore this, it is essentially empty, and is just an accounting artefact. Now, in reality, if a borrower fails to reimburse, it would be the banker who should do it for him. This mean that the banker, the physical person[4], is one special customer of the bank. In order to differentiate him from other customers, it is useful to draw him on a different level, but formally it is similar to a customer. We will to refer to it as the bank *net worth*. If a customer defaults, then instead of just removing the corresponding line of the debt, we will then consider that it is the banker which (unvoluntarily) pays the borrower, and that once the loop of the payment is removed from the graph, it is equivalent to remove the debt of the customer, but also to reduce the assets of the banker, that is to reduce its net worth. Conversely, when the borrower reimburses but also pays interests, it does so to the banker and this means that the bank net worth increases by the same amount. With this notation, the bank vertex is by construction always neutral, and the risk of defaulting together with the benefit of charging interests, are reported on the bank net worth. This bank net worth might be at the beginning zero, but laws might ask this to be a positive quantity from the beginning. In that case its value would be given by the capital which has been brought by the newcomer. A new banker, after asking the authorization of being a banker, will ask to convert its assets in commercial banks into direct central bank IOUs, and will use this as a positive initial net worth. Then he will start lending to customers who will both owe and have money in the bank, and this by creating assets and liabilities out of thin air. Formally it is not lending its initial capital, but rather uses it for safety reasons in case some borrowers would default. Any loss is incurred on the net worth and thus is taken from the initial capital invested in the bank. Banking comes with a risk, and the hope is to gain more interests in the net worth than what is lost by defaulting borrowers.

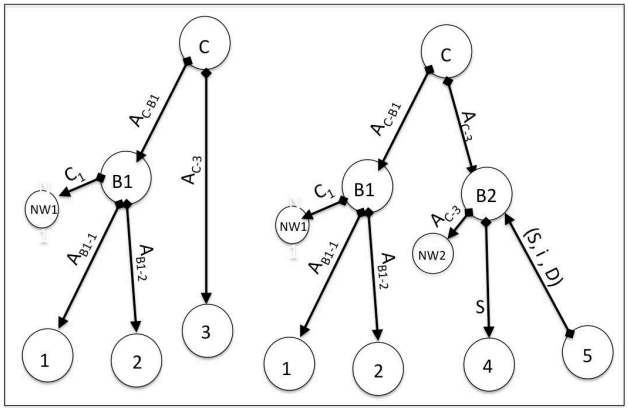

FIG. 9 Left: customer 3 has asked for its assets to be converted into central bank IOUs. Right: he then uses these central bank assets as an initial capital to create a bank and starts creating loans out of thin air. He might also receive deposits from new customers (not shown on the graph).

This notion of net worth is the same as the usual notion of net worth for companies, among which banks are just a special type. Indeed, any company can be considered as an abstract vertex, which has a financial position with respect to the rest of the system (e.g. clients owe it money and it owes money to suppliers). It also has a net worth, which is the sum of the initial capital brought by the creator, on which benefits have accumulated (this is similar to the interests charged by the bankers, which are just a given type of service). From a legal point of view, stockholders all possess a fraction of this net worth. The stockholders can ask to leave it as it is, to spend it in investment, or to transfer a subpart onto their own bank account, and this happens when a coupon is paid.

The notation of consolidation has to be extended to take into account the net worth of banks or companies. The net worth in a sense is nothing but the total charge of a bank or of a company, that we have put outside of the central vertex, to comply with our habits of neutrality at vertices. If we draw a closed region that we want to consolidate, we just need to add all the values of the net worths which are inside, and they will add up to the equivalent net worth, as when we integrate the electric charge density in a given region in order to compute the total electric charge in it.

L. Hens and eggs revisited

We cannot ignore the possibility that individuals borrow directly from other individuals. Understood in a broad sense, this is common if we see a company borrowing to individuals, as individuals (the stockholders) borrowing to individuals. As mentioned above, the wealth of a company is contained in its net worth which in turn is possessed by the pool of stockholders. So it is sufficient for simplicity to examine the case of an individual borrowing to another individual. In that case it is in appearance different from the hen and eggs story that we have talked about when banks have created a pair deposit/debt out of thin air. But as we shall see, it is just apparently different. As we revisit the problem exposed in Tobin (1963), we find that the representation in graphs actually clarifies the explanations about the monetary arrangements which are made at each step.

An individual will only be able to lend what he has. Lending will take the form of a payment to the borrower, and the borrower and the lender would agree on the debt, meaning that we also need to draw in our graphs the debts agreed upon, with amount, interest rate and maturity. This looks like the first step of the bank lending. We write two arrows going in opposite directions, one for the payment of the lender, and one for the debt recog-

[4] More realistically the physical group of persons made of stockholders. But throughout this paper we symbolically describe these as *the banker*.

nition. The difference with the bank story is that the payment needs to be settled by a loop removal as a usual payment, whereas in the case of the bank, it was directly in the tree of the monetary system. If both the lender and the borrower are in the same bank, the resulting situation is depicted in Fig. 10 (left plot). As a final step, the lender might find it extremely risky to have a debt of another customer, and might decide that bankers are precisely made for taking such risks. And he also would like to possess assets with shorter maturity. So he is going to sell this debt to the banker. The banker in turn will be willing to accept only if there is something to compensate the risk. As a compensation, he is going to ask for a part of the interest rate or a part of the amount owed, or both. As a final position, we have now reached a situation where the borrower needs to reimburse the bank which needs to reimburse the first lender. But the banks transfers only a part of the reimbursement and keeps the difference in the net worth. And of course at some point the borrower might perform a payment, for instance to the lender, but it could be to anybody, as his plan was to borrow in order to spend. The final situation is similar to situations where customers have all their assets in accounts for which the bank serves an interest. And the banker earns its life by the difference between the interest it asks on its assets and the interest it serves on its liabilities. Following this analysis without considering this extreme case, it is tempting to drape words around it, in saying that some customer savings have been used to generate loans for other customers, and the intermediation of the banker is retributed by the difference in interest rates. In that case, it is customary to call this a financial institution and not a bank, since in this point of view, it serves only as an intermediation between customers who lend to each other. But we must be clear that the initial situation of Fig. 10 (left plot) which was added for the purpose of our nice story, actually never exists, as only the final situation is realized, blurring even more the difference between a bank and a financial institution. The only real difference would be that, once the loan has been used to pay a customer outside of the bank/institution, a commercial bank traditionally owes above, that is to the central bank, what it is owed from below by the borrowers, whereas a financial institution owes below (to the savers) what it is owed from below by the borrowers. Since this requires to describe interbank payments, we discuss this below in §II.N and illustrate it in Fig. 12. Additionally, one should not forget that for a financial institution the maturity of the liabilities toward the customers is in general much smaller (1 or 2 years) than the maturity of the assets it holds (5 or 10 years) (Minsky, 1992), so that the customers might at some point decide to withdraw their assets. This would force the institution to borrow from above (to banks or to the central bank), and the financial institution would then have a balance sheet resembling the one of a bank.

In order to gain an additional insight on the problem, one can also consider a simpler case, where we do not refer at all to the first customer, and consider that it is actually the banker who is lending what is on its net worth. If we follow in details the different graphical situations, then at the end we find simply that this is equivalent to the simple situation where the banker keeps entirely the interest for him. Before lending, his net worth was a claim on the central bank bearing no interest, and after lending, when the money lent is spent outside the bank, the net worth has not changed value but it has changed of nature, as it was replaced by a claim on the customer to whom he has lent with interest. In this extreme case where the banker has kept the whole benefit of the interest rate for him because he used his own net worth for lending, we see again that the final situation is in every respect similar to the case where the banker has created the loan and the debt out of thin air. It is completely equivalent to saying that he is lending his net worth and receives a claim on a debt in exchange, or that he created a loan and a deposit out of thin air.

So the conclusion is that the order does not really matter. As long as we look at time scales which are not too small, the effective theory is the same, as the final situation is similar. In this second story we have just found a nice way to explain why interests can be served on saving accounts, but this could equally have been added independently.

If we really want to resolve the apparent paradox of the moment of money creation (the hen and the egg), we need to realize that the right moment in which money is created is when a double arrow is written, one for an immediate debt with no interest and one for the debt. When a bank grants a loan, then at the very moment when it increases the balance of the borrower, it also recognizes an exactly compensating long term debt. It is at this very moment that we should consider money is created. Then when the borrower is actually spending, we are already beyond money creation, and the problem is to get it accepted. On Fig. 8 we have clearly written this status in the first graph. However, for the second story we have not written in the first graph the immediate debt of the lender, but rather we have started directly with the result of the loop simplification which follows immediately after. We should instead consider that this moment is the creation of money. With this formal agreement, money creation is not made before or after a loan. It is made exactly when the loan is made, when the compensation between an immediate and a long term debt is written. This is just a formal solution to the apparent paradox, nothing more. What is important to take home, is that no net money is created, whatever the process considered.

Even though this debate might appear extremely simple once rephrased in small graphs, I should insist that this debate still permeates the economic literature, and even accounting rules insofar make the distinction between banks and financial institutions. When the first ones lend first *out of thin air*, the second ones are supposed to lend the deposits of their customers to other customers. But in practice the final result is completely

similar, especially if banks start to serve an interest on the deposits[5]. One might argue that a possible difference lies in the fact that the financial institution cannot lend more than the deposits it has received. But the amounts which are lent are spent, and eventually it increases the deposits and thus the possible loans made out of it, so the limit is just an apparent one. Furthermore, as mentioned above, the savers might withdraw their assets because they have a shorter maturity.

In practice, financial institutions guarantee the payment of an interest once an amount is transferred to an account in the institution. They then look for possible ways to lend, in order to ensure that the net worth will receive enough interests, so as to enable this retribution. In that sense the deposits create the loans for financial institutions, because they trigger the need for the institution to actually realize a loan, so as to be able to pay the interests owed. A famous French example is the *Livret A* institution. Customers transfer sums between their deposits in commercial bank to this saving account in the institution. Independently the institution looks for ways to lend money, usually for construction schemes at higher interest rates. Since construction schemes are usually not enough, it then needs to find other ways to lend the money which it has received. The final situation is that there are liabilities for the institution on which it serves a small interest rate, and then there are assets which are the loans made, on which it receives a higher interest, just like for a usual bank.

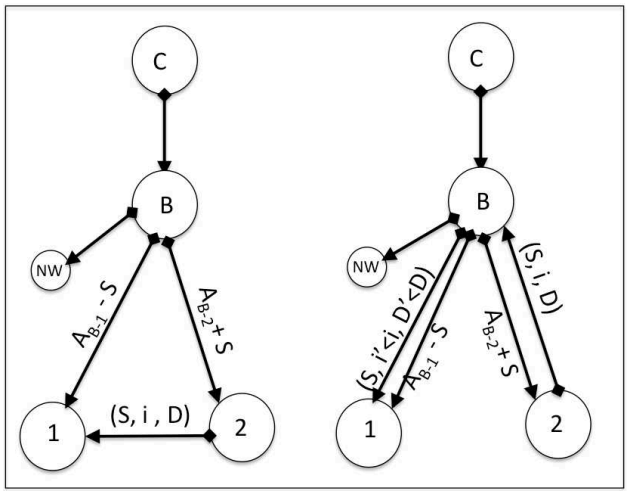

FIG. 10 Left: position after the first customer has lent an amount S to the second customer of the bank. Right: position after the banker has bought the credit owed to the lender, taking part of the interest in exchange for taking the risk.

[5] The only question which matters is to know what would happen if the net worth of the institution goes negative, and for this we should rather look at the size of the institution than at its legal nature, to try to guess the reaction of the central bank, that is to guess whether or not it will step in as the lender of last resort.

Now what is interesting in the story where one customer lends to another one, at least in the story that we have told, is that there was a stage in which the debt of the borrower was directly to the lender, and not indirectly through the bank vertex as when the banker has decided to buy the credit. Of course these operations are agreed upon from the beginning, so either situation might happen. If it is clear that the debt will remain a direct debt from a borrower to a lender, then what we have is the issuing of a bond. If the customers are actually considered as companies, the situation is the one of a company that issues a bond to finance e.g. an investment, and no bank wants to take the risk in its net worth. Or from another point of view, the lender is willing to fully take the risk in order to ask for a higher interest rate. Given that this debt was not integrated in the fundamental tree structure, its nature starts to shift. For instance, if the debt goes through the bank vertex, the lender has a claim on the financial institution that he can ask to transfer to another institution, or to convert into central bank IOUs. But when the claim is directly onto the borrower, the only hope is to find somebody willing to buy it, that is to exchange it for IOUs of banks. This is the point in our graphs where we will start to consider that there are different levels of debts. Those which are always transferable or convertible into central bank IOUs are part of the fundamental tree structure of the monetary arrangement. But the assets which are directly corresponding to the debt of a borrower, should be drawn in a different color to emphasize their different nature. The IOU of a bank is as good as the central bank IOU, because there is a commitment to always swap one for another. But the IOU of an individual or a company is not as good because there is no commitment to perform such exchange.

As a comment, note that sometimes a bank reverses its role of taking risks, and instead sells the credits (Wray, 2010). That is it starts by granting loans, creating liabilities out of thin air, but then sells the credit to customers so that the final situation is the left plot of Fig. 10. In that case, the customer is fully taking the risks and does not benefit from the lender of last resort insurance provided by the central bank. The bank only makes a small profit for charging the service of intermediation. Everything happens as if the customer was a banker, with the difference that quite often he is not even aware of it, since it is a pension fund which has bought the credit for him. This was widespread practice before 2008 as the banks sold credits, hidden in *asset backed securities* to individuals who were only contributing to their retirement plans.

M. Bank runs and the nature of money

What if we reintroduce for a while the possibility that eventually, the central bank IOUs are the promise to pay a commodity (gold). In a monetary arrangement, then thanks to conservation of charge at each vertex, the sum

of the leaves of the tree, that is the sum of IOUs possessed by all customers, reflects all the IOUs issued by the central bank. But it is the total sum of leaves, including assets (claims on the banks) and liabilities (debt toward the banks) which is the net money and reflects the total commodity in the central bank's vault. If there is no debt at all, and customers have only assets, then everybody can ask at the same time to convert their wealth into gold. The entire tree would vanish, and we would be back to a situation where everybody has a share of the commodity. But if we allow for debt among the customers then we must be careful with the fact that money (positive assets) is not net money. If we allow all positive assets to be converted to gold, then we have more claims on gold than gold itself, and the system fails. How is it possible if we have been so careful to ensure charge conservation at every stage of our monetary system? It is extremely simple and reflects the true nature of money with respect to net money. Money is now partially claims on the gold of the central bank, and claims on the debts of the borrower. It has shifted from its *commodity nature* to its *debt nature*. In order to see this we need to look at the outside vertices of the monetary structure. This includes the assets of the customers but also their liabilities to the system. And these debts are not available immediately since the borrowers have to work to be able to pay. This is illustrated in Fig. 11. So essentially money is now partially a right to get gold, and partially a right to ask for the borrowers to work by purchasing their workforce. Indeed when a customer with positive assets pays a borrower in exchange of work, the reduction of the loop reduces the assets of the payer, and reduces the liabilities of the borrower. Again there is no net money destruction. However there is money destruction.

It is because of this incompatibility between money and net money, the fact that the first one is only partially a claim on the assets of the central bank, but also partially a claim on the future workforce of borrowers, that convertibility to gold must be abandoned. By allowing customers to go into debt, but by incorporating these debts in the monetary structure, we have shifted the nature of the IOUs, in an irreversible manner which calls for the end of convertibility. Conversely, if no bank had accepted to polarize money, that is to generate endogenous money, and if loans where made by customers to customers in the form of bonds that would not be encapsulated into the tree structure, then the IOUs of the banks would still be claims on the central bank gold reserves. One would have two types of currencies. One would be the IOUs of banks which are eventually redeemable in central bank assets (gold), and then the IOUs of individuals that we could also exchange to settle payments. In some cases we would exchange claims on gold, and in other cases claims on future workforce, but we should be aware that nothing guarantees that they would be traded at par. By incorporating the loans, or at least a major part of the loans in the fundamental tree structure, we have obtained a much more liquid system, at the price of

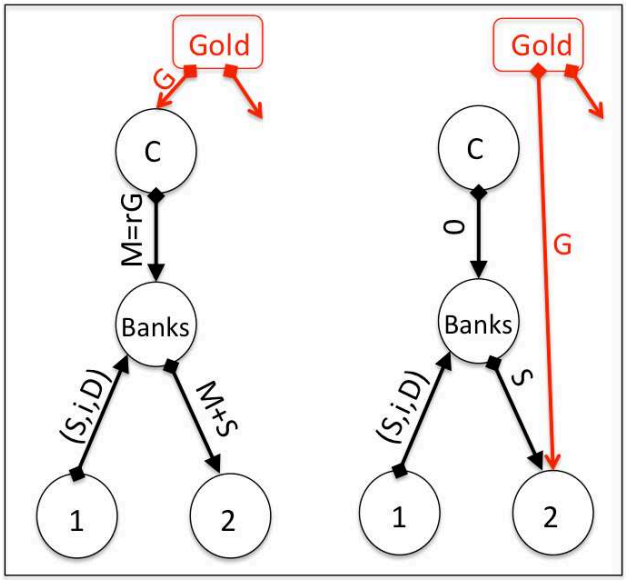

FIG. 11 Left: the total assets of customers are reflected partially by the gold held at the central bank, and partially by the debts of the borrowers. Right: if customers ask to convert their assets into gold, they cannot convert all of it, since part of these assets are the debts of the borrowers. At some point, the central bank needs to stop the convertibility.

abandoning the convertibility. As we will see further, the same process happens in currency which are pegged to an external currency. The external currency acts like gold. Allowing to convert money instead of just net money in the external currency, contains the same internal contradiction leading to an unavoidable breakdown of the currency peg.

N. Interbank payments

Up to now we have considered only customers who would pay each other easily as they have accounts in the same bank. What if after borrowing, a customer spends by paying someone in another bank? To find the answer we follow the same procedure. The payment creates a loop in the fundamental tree structure, and it is the cancellation of this loop which results in the actual payment. But if we do this, we realize that the bank of the borrower will then be possibly in debt toward the central bank. If it is not the case then there is absolutely no problem and the assets of the first bank at the central bank have decreased while those of the second bank have increased.

However if the first bank has not enough central bank money, there are two possibilities. *i)* Either the central bank allows for the first bank to be in debt, and it will charge interests for this. Then the central banks acts with banks as a bank acts with its customers. This is not a surprise since this is the purpose of the underlying tree structure; *ii)* or the central bank does not allow for such

possibility. Then instead of removing the loop through the central bank, that is instead of settling the debt of the first bank to the second bank though the central bank, the second bank has to accept the direct debt of the first bank. After a while we are then back to a system in which all banks have debts toward other banks, in what looks very much like a decentralized system of banks. The interbank payments are depicted in Fig. 12.

The way the monetary system works is actually a mix of the two. First, the central bank guarantees the payment of an interest on the deposits (possibly zero) of commercial banks at the central bank. But it also guarantees that the commercial banks can borrow from the central bank at the discount rate which is of course higher than the rate paid on deposits. This means that no commercial bank would loan its excess of central bank money at a rate lower than the deposit rate, and at a rate larger than the discount rate. The central bank thus defines a corridor of rates in which the commercial banks can negotiate interbank loans. The rate at which they loan to each other on a daily basis is the interbank rate, and it is this rate that the central bank tries to control with its monetary policy (see § III.B). The discount rate is just meant to safeguard against a dysfunctional interbank market and guarantee that commercial banks can always borrow to settle interbank payments.

We realize that the power lies in the institution which allows to be indebted. When a bank goes into debt, it has to borrow from the central bank under the conditions set by the central bank. So in a tree structure, we have a hierarchy in the structure and those at the upper vertices hold a form of power on those situated below. The power to allow the others to go into debt is far from insignificant. We will see that in the international system, this tree structure still appears with strong currencies at the top of the tree, benefiting from the right to grant loans.

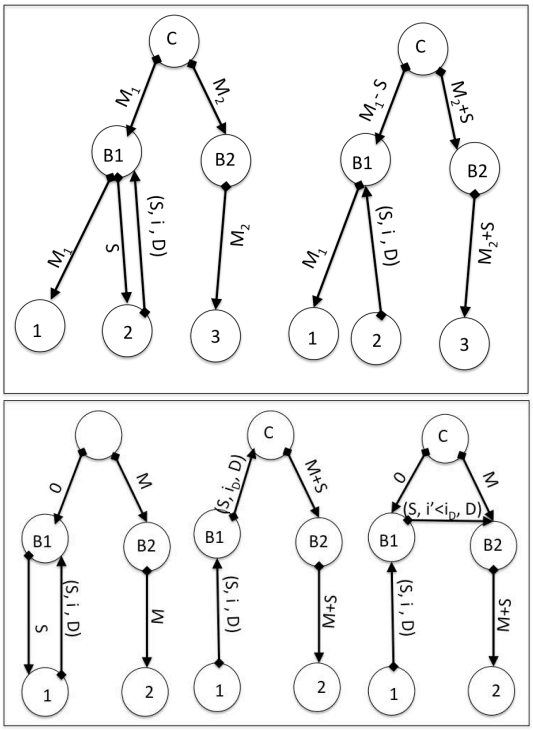

FIG. 12 Top left: the banker, who has already received the deposits of some customers, grants a loan to a given customer and writes the double arrow, one for money creation and the other one for the debt. Top right: the customer spends in another bank, and if the amount lent is less than the deposits received earlier by the bank, it still holds a claim on the central bank. This way of lending falls in the category of the financial institutions, has it has mainly assets and liabilities below.Bottom left: the banker grants a loan, but has never received any deposit from any saver. It makes sure to ask for an interest rate higher than the discount rate. Bottom middle: the borrower spends in another bank, and in order to settle the payment the bank had to borrow at the central bank at the discount rate. This is typical of bank lending as it has assets below and liabilities above. Bottom right: since the second bank now has a lot of central money which bears no interest, it might prefer to lend directly to the first bank this excess at an interest rate lower than the discount rate, so that the first bank owes directly to the second bank and not to the central bank. In all cases, we have not shown the net worth of the bankers for simplicity and we have assumed a simple case in which they vanish, but the will evolve as the repayments due plus interests are carried out.

III. INTRODUCING A SOVEREIGN STATE

So far we have considered an extremely simple system in which we have banks and customers, and a central bank. Companies where not mentioned so far, but they can be incorporated easily. Since we have shown that gold convertibility cannot be maintained when credit is included into the system, and given that it has now been abandoned for all currencies, we will assume in the remainder of this article that there is no more gold conversion possible. We thus considerate only a system with pure fiat money. However, until now we have ignored the presence of a sovereign state and this is much more crucial. Or at least, we have only considered its ability to organize the banks around a central bank and to organize the conditions of borrowing (the monetary policy), but have completely ignored its ability to borrow, tax and spend, that is we have ignored the chartalist nature of money in our graphs. It is however for this part that the graph representation becomes most advantageous. We will first develop our formalism to represent the presence of the state in its full form, and this will then allow to discuss at length the budgetary tools of sovereign states.

A. Public spending and public borrowing

1. Borrowing methods

The state has a bank account at the central bank, and in all literature this is referred to as the *Treasury*. It feeds

this bank account, which is thus held in central bank money, by forcing the payment of taxes by customers (which in that occasion are called taxpayers). Any taxpayer, creates a new loop when he is asked to pay the Treasury, and by the usual removal of the loop described in § II.D, the Treasury account at the central bank increases, whereas the customer's account and the account of its bank at the central bank decreases. It is formally equivalent to paying somebody after withdrawing cash. The customer converts its assets into central bank IOUs and gives them (he pays his taxes) to the Treasury. From the chartalist perspective, we can say that this taxation drains central bank IOUs out of the private sector. We remind that in the chartalist interpretation, it is the fact that eventually taxes are paid in central bank IOUs which makes the central bank IOUs widely acceptable as the main means of payment. Asking to pay tax liabilities in central bank IOUs is certainly a sufficient condition for its acceptance as the central means of payment since the customers need to ensure that they hold enough of these IOUs, either directly from the central bank in paper bank notes, or indirectly by holding IOUs of commercial banks, to be able to pay their taxes.

By contrast, public spending goes from the Treasury account to individuals, e.g. by paying the salaries of civil servants or through social spending. Now when the state wants to tax more than it spends, this is easy. It is hard for taxpayers, but there is no technical reason why this could not happen. However, if the state wants to spend more than what it taxes, we need more. There are several possibilities that we are going to review in details

- *Money printing*: This is the easiest possibility. It consists in increasing unilaterally the amount on the Treasury account. If there is no more convertibility this is fine, because the IOUs of the central bank are not exchangeable with anything anyway. If there is still convertibility, this might be equivalent to a debasement of all IOUs. But anyway we have already seen that as soon as we allow for debt, and this debt is encapsulated into the monetary system, convertibility should be abandoned.

- *Directly borrowing from the central bank*: Another possibility would be not to print money, that is to put it on the Treasury account out of thin air, but to lend it to the Treasury. This is exactly as when money is printed, except that now the state also issues a bond that it gives to the central bank, and if it feels like it, it might decide to add a maturity and an interest rate. Such a situation can only really work if both the Treasury and the central bank obey the same sovereign power, so that the state actually controls both sides of the deal. The consequence is that if this is the case, then it can borrow as much as it wants. This is fundamentally different from a country borrowing in a foreign currency, and it is the essence of a sovereign currency. And when it needs to reimburse, it can just borrow again what is needed. This would be equivalent to writing in red ink on the bond issued ten years earlier that it should be extended another ten years. Eventually, as the bonds remain and are extended or replaced by similar bonds, this is equivalent to money printing. The process of directly borrowing from the central bank is depicted in Fig. 13. What we realize is that initially the net money of customers and bankers is M and after the Treasury has borrowed and spent S, the total net money of customers and bankers is $M+S$. This increase can be traced to the central bank as we see that the liabilities of the central bank toward the commercial banks now include the spending of the Treasury. Everything happens as if the Treasury bonds were the new gold from which the central bank originates its liabilities. If we consider the consolidated state, which would be the Treasury and the central bank merged, there is certainly an increase of the net money, or money creation.

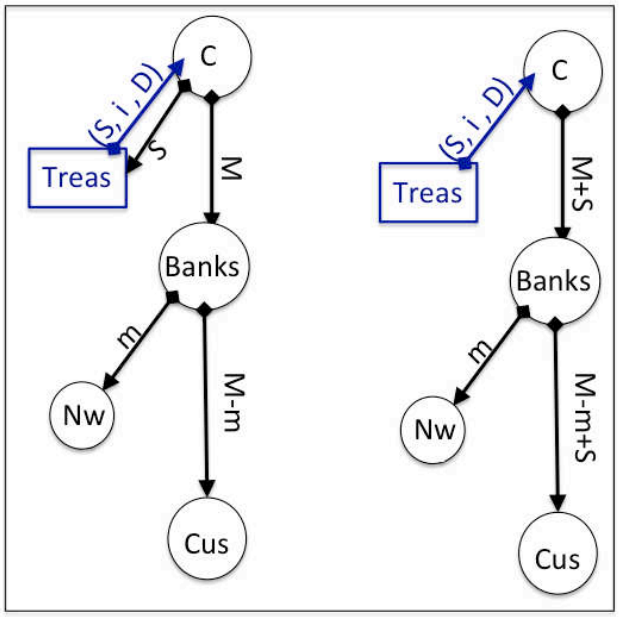

FIG. 13 Directly borrowing from the central bank leads to an increase of the total net money of customers and bankers.

- *Borrowing from the banks*: In this last case, the state is forbidden to borrow directly from the central bank, and it thus needs to borrow what is needed from banks. This process goes through essentially the same steps as when an individual borrows from another. The result is that in exchange of a payment to the Treasury, the state will issue a bond, that is an IOU toward those who have paid the Treasury. It can be individuals, but it is not very common. Commercial bankers perform such operations, e.g. using their net worth if it is positive, or simply borrowing from the central bank what they want to lend to the Treasury. This latter

method is slightly more complicated as we should not hide the fact that the commercial bank needs to provide a collateral, for instance a previously owned Treasury bond, when borrowing to the central bank. The loan thus takes the form of a repurchase agreement. At first the commercial bank sells a bond to the central bank against a smaller amount of central bank money, and then it buys it back at its value, the difference between the two amounts being effectively an interest paid. This is functionally the same thing as loan, apart that the collateral is there to make sure the bank will repay the loan it has contracted in one form or another. Either it repays by buying back the collateral it has previously sold, or it defaults and the central bank keeps the collateral. This collateralized loan is illustrated in Fig. 14.

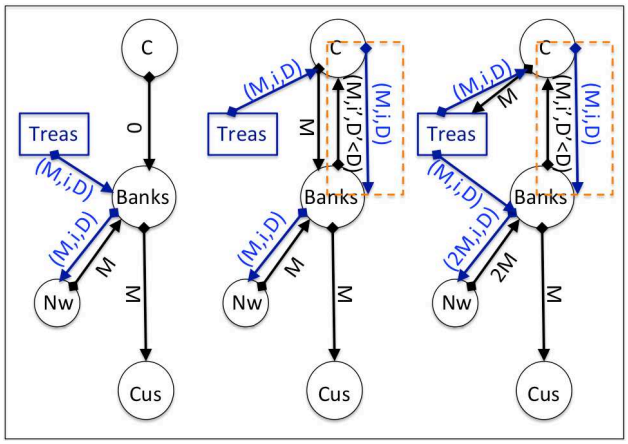

FIG. 14 Left: initially the bank already has a Treasury bond in its assets. Middle: the bank uses it as a collateral to borrow from the central bank. The maturity of the loan is smaller and for this to be interesting, the interest rate needs also to be smaller than the interest served on Treasury bonds. The repurchase agreement is enclosed in orange dashed lines. Instead of holding directly the collateral, the commercial bank holds a claim on it. Right: after lending to the Treasury, the commercial bank receives a new Treasury bond. The subsequent spending of the Treasury is depicted below in Fig. 15.

2. Net money and financial wealth

When the commercial banks pay the Treasury, they accept to decrease their net worth, or to increase their liabilities toward the central bank, but their net worth will then receive immediately the bond of the state as a compensation. The amount of IOUs possessed by the bankers remains constant, but the nature has shifted from central bank IOUs which promise nothing, to Treasury IOUs which promise central bank IOUs in the future with interests. If the bank had to borrow the amount lent to the Treasury, it must only make sure that the interest received is larger than the interest paid. Nearly immediately after this, the Treasury spends in the monetary system the amount of central bank money it has borrowed. This situation is depicted in Figs. 15. This new Treasury bond held in the banks net worth can then in turn be used as a collateral for further borrowing at the central bank, and further lending to the Treasury, without any theoretical limit.

In order to grasp what happens after the Treasury has spent what it has borrowed, it is useful to contemplate the special case in which the net worth of the bankers was initially vanishing. This does not forbid the bankers to lend to the Treasury, given that what they lend are the assets they have at the central bank, or provided they have a suitable collateral they can borrow at most at the discount rate the central bank money they need. What we realize in the last graph of Fig. 15 is that the total net money of customers has increased by the amount spent by the Treasury. And we can now see a double origin for this net money. Some comes from the liabilities of the central bank, and some comes from the liabilities of the bank sector net worth. But the net worth of the bank sector remains unchanged since it also receives the IOUs of the Treasury. What the monetary system has done is that it has used the net worth of the bankers to convert the IOUs of the Treasury to IOUs which are redeemable in central bank money. Finally, we conclude that when the Treasury borrows directly from the central bank, the Treasury bonds are converted into net money by the central bank, whereas when the Treasury borrows from a commercial bank, this conversion is made by the commercial bank net worth.

In order to visualize more thoroughly the difference between these two cases, we can consider the consolidated state (the Treasury and the central bank merged). The total net money of customers has increased by the amount spent by the state. In the first case the Treasury IOUs are internal to the consolidated state, whereas by borrowing to banks, the Treasury bonds now leak out of the consolidated state sector as they enter the bankers' net worth. Now the discussion about the creation of money is a discussion about the net worth of bankers. Should we look only at the total net money of customers, ignoring the structure of the bankers' net worth? If yes, then we conclude that there has been money creation, which finds its origin in the bankers' net worth. Both the central bank and the commercial banks are responsible for the total net money of customers. But if we consider that there is no reason to separate the net worth of the bankers, which are just a special type of customers, then we need to subtract the amount owed by the net worth to the bank vertex, and this amount exactly compensates for the increase of assets in the customers sector. However, we should not forget that there is another part in the net worth, which is an asset for the bankers, and which consists in the Treasury bonds. So in this second interpretation, we would conclude that the total net money originated by the central bank is the same as

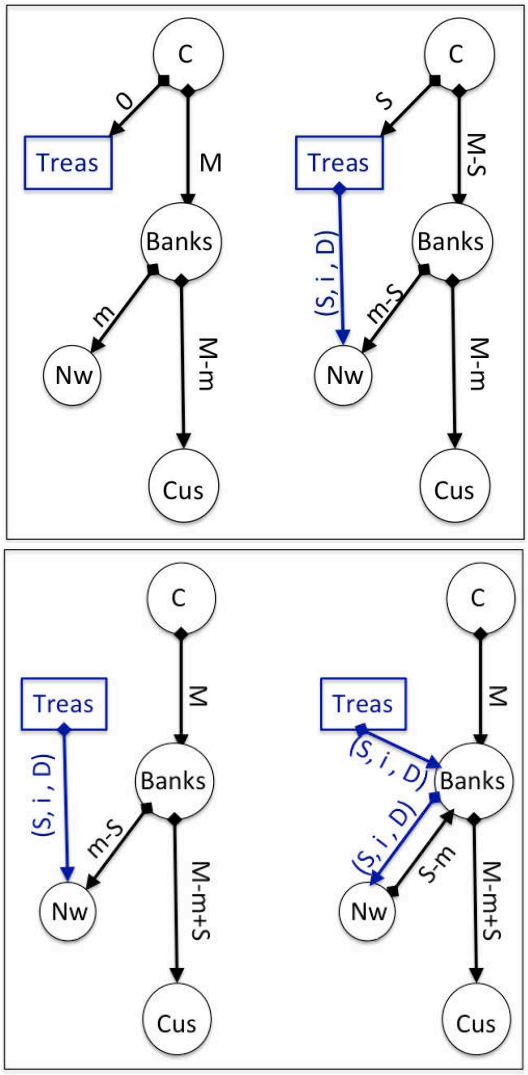

FIG. 15 Top left: the simplified monetary system with a consolidated bank sector and a consolidated customers sector, where the net money of the customers and the bankers is M. Top right: the Treasury borrows an amount S to the banks. Bottom: the state then spends what it has borrowed. Left and right are two equivalent representations of the final result. If the initial net worth of the bankers is initially $m = 0$, we realize that now the net money of the customers is $M + S$ instead of M initially. If we consider both the customers and the net worth of the banks sector, the net money made of IOUs which are convertible in central bank money has not increased, but the financial wealth has increased as the net worth of banks is also made of Treasury bonds.

initially - it is a reflection of the central bank liabilities which are unchanged - but the system has been supplemented by Treasury bonds which have a financial value as well. With this interpretation, one would say that no net money has been created, but the financial wealth has increased. In Fig. 16 we illustrate with graphs the process of Treasury borrowing from banks and spending in the private sector, but also the possible interpretations which can be made, depending on the consolidations chosen. We see on this example, that the choice of the consolidation used to read a given financial arrangement is often a reflection of our underlying ideology, as it leads to draw apparently contradictory conclusions. But the graph representation helps in formulating unambiguous statements, as it helps to clarify what is exactly meant by the word *money*.

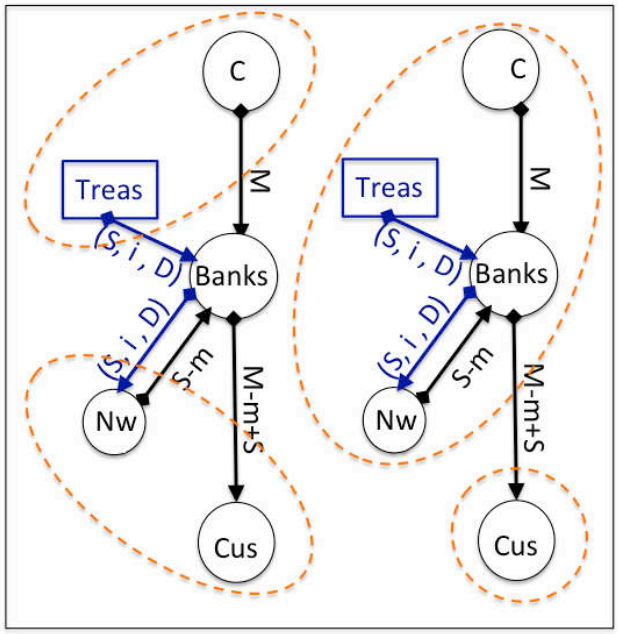

FIG. 16 Several possible consolidations schemes lead to different interpretations. Left: if we look at customers but also the net worth of bankers, there is no net creation of money induced by the public debt, but the financial wealth has increased as the net worth of bankers is made of Treasury bonds. Right: if we look only at the customers, there is net money creation induced by the new public debt.

3. Discussion

We would live in much more democratic states if the Treasuries were allowed to borrow directly from their central bank, given that state institutions would then have to be ruled by the governments. By electing a government on a program, we would know what spending out of taxing it is ready to make and thus how much it will be willing to print, which in the long run is a debate about the possible level of inflation. But recently, the idea that democracy should stop at the entrance of the central bank has won, as it has been argued that decisions made on democratic grounds might be unstable as they are affected by elections. By not allowing the central bank to be under democratic control in the interest of everybody, and by asking it to be independent, then it is just serving the interest of a few, namely the commercial bankers as we will argue in the next section. So the

debate about inflation has been removed from elections, and central banks have been made independent with a target on low inflation, so as to guarantee the value of the assets held by savers.

B. Open market operations

In practice however, as part of the monetary policy, the central bank buys and sells bonds in open market operations. At least it is always doing so with short term Treasury bonds as part of the conventional monetary policy, and it might decide sometimes to do it as well with longer maturity Treasury bonds as part of the unconventional monetary policy. Let us ignore in this section the long term bonds emitted by the Treasury. Due to the conventional monetary policy, the lined is blurred between a model where the central bank directly finances the Treasury, and a model where this is done by commercial banks. When the central bank buys a bond possessed by a banker, the final result is the same as if the bond had initially been emitted toward the central bank. That is in the initial situation, the Treasury owes central bank money to a commercial bank, and in the final situation, it owes central bank money to the central bank itself, and the central bank owes its own IOUs (central bank money) to the commercial bank.

So the commercial bank has accepted to get rid of an IOU which bears interest, that is which promises to be worth more in the future, in exchange of a central bank IOU which bears no interest. But the Treasury will never default on its debt, because the state also runs the central bank and thus the central bank can buy an infinite amount of Treasury bonds if it is asked to. Said differently, if the interest rates for short term Treasury bonds start to increase as the commercial banks become more and more reluctant to buy these, the central bank needs to buy as many short term bonds as necessary to ensure the short term interest rates on Treasury bonds remain at the targeted level. In fact, using these open market operation a sovereign state running a sovereign currency has the means to ensure that the banks are always willing to buy Treasury bonds. When Japan entered deflation in 1990, its public debt kept increasing, without causing any problem to the monetary structure. Indeed it has reached and overtaken 200% of GDP, but since all of this debt is in the national currency, it did not raise any problem. The only problem it could have generated at some point was that it could have fostered inflation, but that is precisely what Japan needed and wanted to achieve.

As we argue now, this system is intrinsically flawed. First when the commercial bank bought the Treasury bond, it had to pretend that it was worried the state might never reimburse, so as to ask for interests rates which are at least slightly higher than the interest rate at which they can borrow from the central bank, and make a profit on the difference. Of course the banks knew they would always be reimbursed, because the central bank always stands ready to buy bonds. As the interest rates departed from the target chosen by the central bank, the latter bought short term bonds to prevent the short term rate from increasing. Indeed, in order to convince a commercial bank to get rid of a financial instrument which is not risky and which bears interest, the only solution is to pay more than the current value of the bond, which amounts to a decrease of the interest rate on those bonds. The bank thus makes an immediate profit instead of a larger profit later. Indeed this difference goes directly into the net worth of the banker and amounts to money creation.

To conclude, we reach the same stage as if the Treasury had sold directly its bond to the central bank, except that now we have increased by a small amount the net worth of the bankers. By first selling the bonds to the commercial banks, instead of selling directly to the central bank, the bankers were able to realize a small profit. But this profit is an immediate and easy one. So they have on one side to pretend they do not like when the Treasury goes into debt, so as to be able to ask for the highest possible interest rate, and secretly enjoy it since either they make a profit when it falls due, or even better immediately if the central bank buys the bonds to control the interest rates. This shift between directly financing the Treasury, and financing through the banks dates back in France to 1973 and it has been continued thanks to the subsequent European treaties. Given that the commercial bank sector has a direct interest in it, commercial bankers never ask for changing this system. Instead they have to play a game which consists in claiming they do not like public debt, so as to be able to make simple profits out of their unnecessary intermediation. In sovereign states, where the central bank obeys the logic of the government, the deficits can be huge and still the interest rates paid on short term bonds are indirectly controlled by the central bank as it buys a huge amount of what is issued toward commercial banks. Actually, the central bank must buy whatever is necessary to control the interest rates of the short term bonds, as part of the monetary policy.

The commercial banks will always end up with a part of their assets denominated directly in central bank money, which bears no interest, and Treasury bonds, which bear interest. If we adopt a consolidated state point of view, where we merge the Treasury and the central bank, then the commercial banks have two types of accounts. Deposits which bear no interests, and saving accounts which generate interests, just like everybody. In order to control the interest rate, the central bank shifts the amounts from the interest-less to the interest-bearing account and vice-versa.

C. State consolidation and sovereign currencies

This point of view of consolidating the Treasury and the central bank is rather natural for the neo-chartalists. However it goes against the habits of most economists,

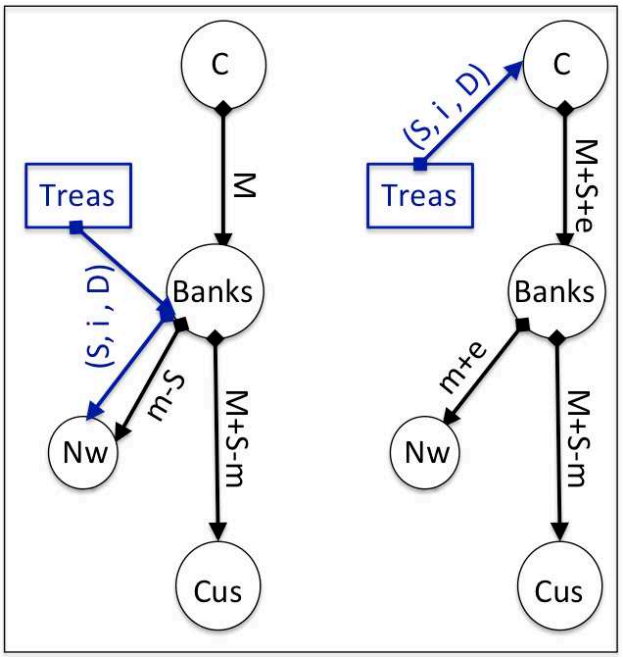

FIG. 17 Left: the commercial banks have bought the Treasury bonds. Right: they have accepted to sell to the central bank.

since they are reluctant to consider that the central bank is a creature of the state, even though it must react automatically whenever a new public debt is issued. Here we must be sure to know whether we talk about what it is, what it could be or what it should be. To us, it seems reasonable to consider that the Treasury and the central bank should be consolidated in sovereign states. Or to state the obvious, we should be able to consolidate the two, in situations where this is possible, that is in states where the central bank does everything to control the short term interest rates of bonds by buying bonds in open market operations, and acts coherently with the government. Indeed, we must recall that there are two types of short term interest rates that the central bank can control

1. the interbank rate (called the Fed funds rate in the US), which is the rate at which the banks can borrow with collaterals at the central bank. This is depicted in the middle of Fig. 14. It is necessarily capped by the discount rate which is the maximum rate at which they can borrow, and above the rate paid on commercial bank deposits, if it exists;

2. the short term bonds rate which is affected by open market operations.

If a bank decides to control the short term bonds rate, then when conducting outright purchases of short term Treasury bonds, it will also increase the central bank liabilities (central bank money), which will decrease the interbank rate, that is the rate at which the banks can borrow. Furthermore, the interbank rate is capped by the discount rate. So controlling the short term bonds rate implies to control also the interbank rate.

However, a central bank can decide to control only the interbank rate and not the rate on short term bonds. For this, it will only conduct repurchase operations, or collateralized loans to commercial banks. This would affect the rate at which the commercial banks can borrow, but in general it will not affect directly the rate of the short term Treasury bonds. Indeed, the Treasury would then borrow like any customer, and banks are free to set the conditions. Nearly all developed countries, except the Eurozone, control both rates and run what we call *sovereign currencies*. Indeed, the European Central Bank (ECB) has virtually amputated its right arm voluntarily, by abandoning the possibility of controlling interest rates on Treasury bonds. This is why the ECB performs only repurchase agreements to control the interbank rate, but does not control the short term rate on bonds via outright purchases of Treasury bonds, contrary to the Fed monetary policy. Indeed, as there are several types of bonds, each one of them issued by a different government, the ECB cannot decide which one to buy as it would amount to a form of financial solidarity between the various European states, and this is intentionally avoided in the European Union construction. As the various Treasuries are not helped by the ECB to issue low interest bonds, everything happens as if they were borrowing in a foreign currency, where the interest rates are set by the bankers, just like for any standard customer. Indeed, the bankers lending to the Eurozone Treasuries decide what should be the markup rate, that is the difference between the rate at which they borrow, which is effectively the interbank rate set by the central bank, and the rate at which the lend to the various Treasuries. On the contrary, the United Kingdom (UK) or the USA are in the configuration where the central bank buys whatever is necessary to control the interest rate on bonds, and things are as if the Treasury was borrowing from the central bank, except for the small profit made by bankers due to their intermediation.

To conclude, if the Treasury borrows directly from the central bank, it makes sense to consolidate the Treasury and the central bank. If it borrows from commercial banks, but the central bank controls the short term interest rates on the bonds, the effective theory is nearly the same, and it still makes sense to consolidate the Treasury and the central bank. We must also mention that so far we have considered only short term bonds. First, the Treasury could perfectly issue short term bonds only. That would certainly work fine if the Treasury was borrowing directly from the central bank. And if the Treasury needs to borrow to commercial banks, it would be sure to pay the standard rate as the central bank needs to control the interest rate on short term bonds and must be prepared to buy whatever is needed to achieve this goal. But it is a reality that Treasuries also issue longer term bonds. Since the commercial bankers need to protect themselves from the risk of higher short term interest

rates, which is the rate at which they borrow, there is necessarily a markup rate and long term bonds always have a higher interest rate. But this might precisely be what the government could try to achieve. Indeed the long term bonds are not repaid at once at the end of their maturity, but instead the interests are paid in coupons gradually, with the principal repaid only at the end. So by buying these, the banks have a way to predict and control a substantial part of their future cash flows. Issuing bonds of various maturities is thus a way to stabilize the banking sector and to smooth the issuing of bonds.

However, if like in the Eurozone the central bank stops controlling the interest rate on bonds but controls only the interbank rate, the Treasury is treated like a standard customer, that is it is treated by the central bank as if it was a foreign Treasury. We say that this is not a sovereign currency. Note that in that case, the governments might find it more convenient to issue only long termTreasury bonds, so as to postpone the repayment after the next general election. The consolidation might still be possible formally, since any consolidation can be made as it is just an accounting simplification, but it hides some salient features. Sometimes the commercial banks would add only a small markup rate to the Treasury bonds and one would not see the difference, but in case of crisis the markup rates can start to be huge, on all maturities, even reaching the point where the commercial banks stop buying Treasury bonds like in the recent Eurozone debt crisis.

D. Should it stay or Schuld it go: the clash

We have seen that when the Treasury borrows and spends, it increases the financial wealth of customers and bankers. But it is subject to interpretation in order to decide if it increases the net money or not. It depends how we consider the net worth of bankers. There is thus a huge debate on the nature of money and the nature of debt. Essentially, apart from the fact that Treasury bonds bear an interest, they have an intrinsic difference with central bank IOUs, which is that they have a maturity, and are thus bound to disappear through the reimbursement of the Treasury's debt. But we have seen that for the customers, the monetary system has resulted in an apparent conversion of the Treasury's IOUs into normal bank deposits for customers. Let us take a simple case where 20% of the net deposits is a reflection of the central bank IOUs, and the rest comes from government debt. The good news is that since this mixing between the different origins has been made possible thanks to the banking system, it means that by construction the customers have always more assets than the debt of the state. So the state could always, at least in theory, run a huge temporary tax on capitals which would reduce the assets of customers and increase the Treasury account. For an order of magnitude this would be one year of GDP since nowadays public debts are of that order. With this it would then be able to reimburse the pending bonds. See Fig. 18 for an illustration. As a result, the net money would be reduced by that amount. But if initially around 80% of the customers net financial wealth was the reflection of public debt, then it means that the financial wealth on deposit and saving accounts has been reduced by the same amount. If we imagine that people will feel poorer they will stop consuming and this will cast the economy into an extreme recession initiated by a deflation. But the Treasury could be proud of having eliminated all of its debt. Since 2011, this is what has been done in countries, mainly European countries because of Germany, where it has been decided to reduce the public debt. And that is where macroeconomics starts to be a social science. People could be fine with the reduction of their financial wealth, being prepared that in the long run prices should decrease, or even changing their saving habits so that it does not happen. There is in principle nothing wrong and one could imagine that some countries might cope with it in happiness. But we think that it is more likely that the private sector sticks at least partially to its previous saving habits, meaning that everybody tries to spend less, causing deflation and possibly after recession. So by ignoring this, the goal of debt reduction can be extremely harmful to the economy. Actually whenever a state runs a surplus, this never lasts more than a few years (Wray, 1990, 2004), and then recession enters the game to generate new deficits. If public debts have been reduced when compared to the GDP during some period of history, they are nearly always constantly increasing in nominal value, because the total net money of customers needs to go more or less at the same pace as GDP growth plus inflation to satisfy the habits.

However, all our preconceived ideas run counter proper thinking. For instance, in Germany money is named *Geld*, and it is a derivative of *Gold*. It thus carries a meaning which goes beyond the real nature of money where convertibility has been abandoned. On the contrary, debt is called *Schuld*, but this is the same word which is used for guilt or fault[6], depending on how we translate. So the denomination hampers a proper thinking, since as the Germans pronounce the word *debt*, they immediately mean what they should do about it, that is getting rid of it, as it is morally bad. By drawing the consolidated graph structure, we are able to remove the words which convey too much ideology, as only asset/liabilities relations of different types appear.

E. A horizon definition of money

In the end, the debate is about what we think the debt will become in the very long run. Indeed, in a system

[6] As noticed and analyzed in Graeber (2011), this is also the case in many ancient languages (Sanskrit, Hebrew, Aramaic).

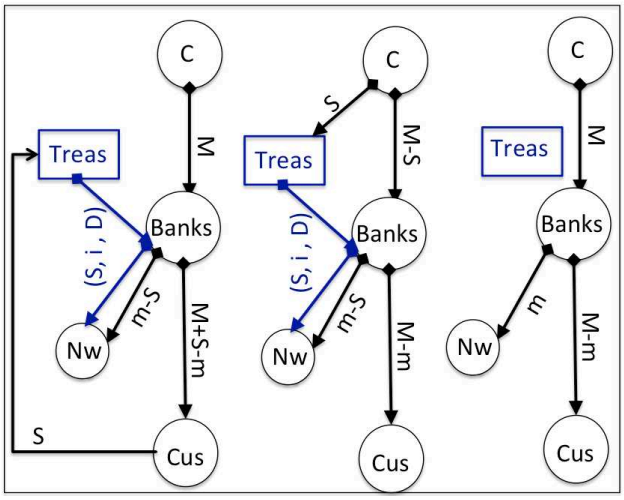

FIG. 18 Left: the state levies a huge tax. Middle: the tax is effectively paid to the Treasury. Right: The state settles its debts and gets clear of all debts.

which has abandoned convertibility, central bank money is an eternal debt. The central bank owes gold, but it owes it in an infinite time because it has stopped the convertibility of its IOUs into commodities. It would thus be tempting to define money as a debt which is never reimbursed. Interestless money in that definition would thus be just one type of money. A concrete example to apply such definition is to consider the paper debts which have been issued by the US federal government during the civil war. At that time, paper notes were issued having the status of a debt, in order to finance the war. But they kept being exchanged and were subsequently considered as currency, without being redeemed into gold, but being used to pay taxes.

The problem with such definition of money is that it is not local in time. Indeed, we need to know the full future of the debt to deduce if it was actually money or if it really was a debt which has been reimbursed[7]. The drawback of the definition is thus that we do not know what will be the infinite future, since this is fundamentally impossible. So we have to rely on a lighter and imperfect definition, where we would consider that a debt is money if there is a consensus among customers that it will never be reimbursed (or reimbursed by issuing an equivalent debt). This deeply depends on the point of view. For any debt issued by the Treasury, there are thus always two extreme point of views. For the ones who believe that since states always run deficits, it is for sure a type of money. We call this point of view the *should* point of view since in this point of view we should run deficits, at least in pace with growth and expected inflation. Conversely, for those who think that debts should and will be reimbursed, no matter the state of the future economy, the public debt cannot be considered as money. We can call this point of view the *Schuld* point of view. The debate between *should* and *Schuld* is reminiscent of the debate about rational expectations. If the state issues a new debt, does it mean that there is an actual debt of the customers toward the state? Those who think that this debt exists no matter what are in the *Schuld* sector, whereas those who ignore such possibility, by arguing that people do not look at national accounting for the personal wealth, are in the *should*. The *Schuld* point of view was first formulated formally as the Ricardo-Barro equivalence, according to which taxpayers exactly anticipate future taxes from current deficits. The two point of views are summarized in Fig. 19. If the Ricardo-Barro equivalence is invoked, the financial wealth of customers and bankers always remains unchanged, even when the Treasury borrows, and remains M, that is the total liabilities of the central bank, whereas if the equivalence is ignored (as we think it should be), the financial wealth is increased by public deficits and is thus $M + S$, where S is the total debt.

We must say it is hard to be convinced by the argument that people will take decisions thinking about a possible debt they owe to the Treasury. We think that in order to find a convincing answer in this debate we must look at the past behaviour of major western states. And what we find is that, apart for a few years, they run constant deficits and the sovereign debts keep growing in nominal values. Only on some occasions, some governments manage to run a surplus but this never lasts very long. For the US history, this is certainly the case, where there was just occasional years of surplus in an ocean of deficits (Wray, 2004). Even Germany, which is patronizing the rest of Europe, was in deficit up to 2015. So the conclusion when we look at history, is that deficits are typical rather than unusual as they allow for an increase of the financial wealth of customers which goes along GDP growth and inflation. But again economics is a social science. Nothing prevents a given society at a give time to suddenly feel the need to enforce the Ricardo-barro equivalence.

F. Monetary policy

In the next section, we present the essential features of the current conventional monetary policies, and then treat afterwards the main differences brought by the unconventional monetary policies

1. Conventional monetary policy

The instruments of the monetary policy are very complex and can be very different from one country to another. It is by no means the goal of this paper to present

[7] This construction is thus similar to the definition of horizons in General Relativity, where the definition relies on the full future of the spacetime solution.

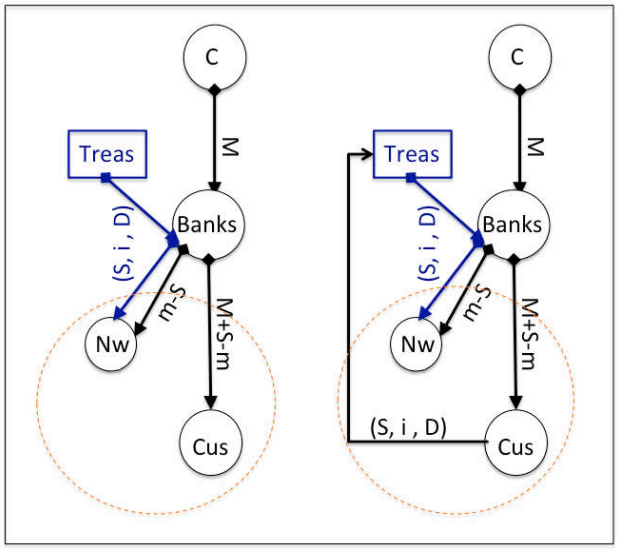

FIG. 19 Left: the point of view that when the state issues a debt the customer do not feel the need to reimburse it. Right: For any new debt, the customers anticipate that they have a debt toward the state, with the same value, interest and maturity. This is the Ricardo-Barro equivalence. On both graphs we circle the consolidated sector of customers and bankers. In the right graph, the Ricardo-Barro equivalence reduces the total financial wealth. Actually, in this point of view, no matter the debt of the state, the financial wealth can only remain constant.

them all. The main conventional tools are the control of short term interest rates, and the reserves requirements.

- Conventional monetary policy is about controlling the short term interest rates. We have already seen in § III.C that in its simplest implementation, the central bank performs outright purchases of short term Treasury bonds so as to control the interest rates on the short term public debt. Nobody is forced to sell, but in practice, if the central banks buys at a higher price than the face value of the bond, it would always be able to convince a bank to sell its bond. By doing this, it controls indirectly the interbank rate, which is anyway constrained to be larger than the rate paid on deposits, if any, and smaller than the discount window rate. Indeed, when a Treasury bond is bought by the central bank, the commercial bank which has sold the bond is left with central bank money which bears no interest. It can earn the interest rate on deposits, but might also try to earn more by lending to other banks this excess of central bank money. Other banks might be interested only if these interbank loans are made at a rate lower than the discount rate, since this is the rate at which they can always borrow. So the central bank needs only to fine tune the rate between the rate on deposits and the discount rate, to reach its target on interbank rates. Let us stress again that in the Eurozone, the ECB does not control the interest rate on Treasury bonds but only the interbank rate through repurchase agreements. It thus implements a weaker monetary policy, and states are treated as customers, that is they are treated as huge but independent companies.

  We must insist that controlling the interbank rate is not sufficient to control the rate at which customers borrow. Indeed, when commercial banks lend, they need to apply at least the interbank rate as it is the rate at which they need to borrow when the loan is used to pay outside of the commercial bank, or when a part of the amount loaned is transformed into cash, that is into central bank money. But they also need to apply a markup rate to this basic interbank rate at which they borrow for several reasons. First, the borrowers might default and the bank needs to make sure that it generates enough profits from non defaulting loans to compensate for the defaulting ones[8]. Second the commercial banks need to make a profit to cover their running costs as they need to pay at least the salaries of their employees. Finally, since they have borrowed on a short term basis, but they lend on a longer term basis, they need to have a security margin in case the central bank increases the interbank rate. For all these reasons, the effective rate at which the economy is functioning, is different from the basic interbank rate chosen by the central bank. If the central bank wants to foster credit with low interest rates, it is as important to set a low interbank rate as to communicate about the fact that this interest rate shall remain low, so as to decrease as much as possible the markup rate. Finally, we must stress that the interest rate is not the only criteria to ask for a credit, as decisions are made on much more fundamental economic grounds. Even if the markup rate remains constant, the interest rate set by the central bank is only an indirect tool to control credit and thus the total money.

- The second most common monetary tool is made of the reserve requirements for commercial banks. In the theory of the money multiplier, the central money held by banks should be a fraction of its liabilities toward its customers, and this fraction should be set by the monetary authorities. It is then assumed that by controlling the amount of central bank money held by the banks, and by fixing the ratio, the central bank could control the total credit, and thus the total money. But this tool cannot be efficient, because the amount of central

[8] When the loan is an investment loan, such as when customers buy houses, the investment in real assets is also used as a guarantee. If the borrower fails to repay the loan, the property of the real asset, e.g. the house, is transfered to the bank.

bank money held by banks is not exogenously set. Indeed what is counted as a reserve for a commercial bank is not its net central money, but its central money. So if the bank does not have enough central money reserves, for instance because it has granted too many loans, it can borrow the reserves needed at most at the discount rate, and more probably at the interbank rate. When the bank does so, at the same time it receives central bank money and increases its reserves to comply with its legal obligation, but it owes it as well at a later date, and this does not count negatively in the reserves. We see that the difference between net central bank money and central bank money is very important. The central bank can control its net liabilities toward the banks, e.g. by performing outright purchases of Treasury bonds, but it cannot control its liabilities, as these are endogenously determined by the needs of the commercial banks. In practice, banks lend whenever they think it is profitable for them, and if they fail to meet their reserve requirements at the end of the day, they just borrow (directly to the central bank at most at the discount rate or to other banks) what is needed. In a few developed countries (Canada, Australia, UK, Sweden, Norway) there are no more fractional reserves and nothing special happens. As long as the required reserves are not net reserves, they are entirely useless. Furthermore, even if the fractional reserve system was applied to net central money held by banks, this would only set an upper limit to credit, but it could not increase automatically the amount of credit if it is below the cap.

In fact the net assets of the banks, that is their net worth which includes the capital which has been given in by the stockholder, is instead extremely important. These are true reserves which are going to be used whenever a bank suffers losses. It is thus no wonder that after the 2008 financial crisis, the rules for the fractional reserves have not been modified, whereas the capital requirements have been radically increased in the third Basel Accord.

G. Unconventional Monetary Policy

Unconventional monetary policy does not really differ from the conventional one in its nature, but it differs in scale and maturity. In conventional monetary policy, the central bank controls only the short term interest rates. In unconventional monetary policies, the central bank starts to control also the long term interest rates. As for the short term interest rates, there are two rates that need to be controlled. The rates on bonds, and the interbank rates. So the unconventional monetary policies consists in huge amount of loans to bank with long maturities [like in the Long-Term Refinancing Operations (LTRO)], and huge outright purchases of long term Treasury bonds (see Fig. 20 for illustrations).

- For huge amounts of loans, there is absolutely no change to the net worth of banks, because as we should remind, for any amount of central money created in a loan, there is a corresponding debt which is also created. So the net effect is rather insignificant. It is only used to ensure that the banks which have suffered heavy losses can meet their reserve requirement without having to borrow at the discount rate which is noticeably too high. And also by making these loans long term (a few years) rather than short term (a few days or weeks), it is symbolically a guarantee that interest rates will remain low, and it is hoped that it will contribute to reduce the markup rate for the loans granted by commercial banks. This tool was mainly used by the ECB at the onset of the Eurozone debt crisis, as it could not perform outright purchases of Treasury bonds. The hope was that with this excess of central bank money, the commercial banks would lend to Eurozone Treasuries with more favorable conditions.

- Quantitative easing (QE) is a massive outright purchase of assets, among which long term Treasury bonds. If the bonds which are bought by the central bank to the commercial banks are corporate bonds, it removes the risk by transferring it to the central bank. The commercial bank gets rid of a non-liquid and risky asset which bears interest, for an absolutely non-risky asset which bears no interest, that is central bank money. If the bonds are long term Treasury bonds, then it is part of the interest rate management of the public debt. By its scale, this outright purchase of Treasury bonds ensures that the central bank would need to give a good price for the banks to accept getting rid of otherwise non risky assets. The difference between the face value of a Treasury bond, and the price paid by the central bank goes directly in the bankers net worth. Now the only difference is the scale. If this is made on massive heaps of Treasury bonds, the increase of the bankers net worth might be sizable. It is equivalent to spend directly into the net worth of bankers. It is a form a public spending, but instead of spending for the benefit of all, the central bank creates IOUs for the sole benefit of bankers. The longer the central bank waits to buy bonds, and the best profit the bankers make. This is what has happened inside the EU in 2015. A major part of long term Treasury bonds, on which the bankers have asked already large interest rates for inexisting risks, will be bought by the ECB, ensuring an easy profit for bankers.

  To conclude, the outright purchase of Treasury bonds in a QE has only a very small effect as it replaces debts of one kind (Treasury bonds) by debts of another kind (central money). Its main effect is

to lower the rates on long term bonds. But Treasuries do not need to issue long term bonds, as they can always decide to issue only short term bonds, for which the rate is automatically controlled through the conventional monetary policy. The excess of central bank money generated by the QE in the balance sheets of commercial banks has no reason to expand the credits made to the private sector, and this is another way to understand that the theory of the money multiplier is flawed. This is why nothing happens in the real economy. However in the process, there is a sizable money creation in the bankers net worth. The hope is then that bankers will spend this amount of money and foster the growth of the GDP.

In a further step, they might think that they have too much central money and not enough corporate bonds compared to their habits. If this is the case, they will trade in buying corporate bonds, that is they will exchange central money and corporate bonds in opposite directions, up to the point where higher prices for corporate bonds will satisfy their portfolio allocation. If this is the case, the QE is just creating a bubble on financial markets by increasing the price of corporate bonds.

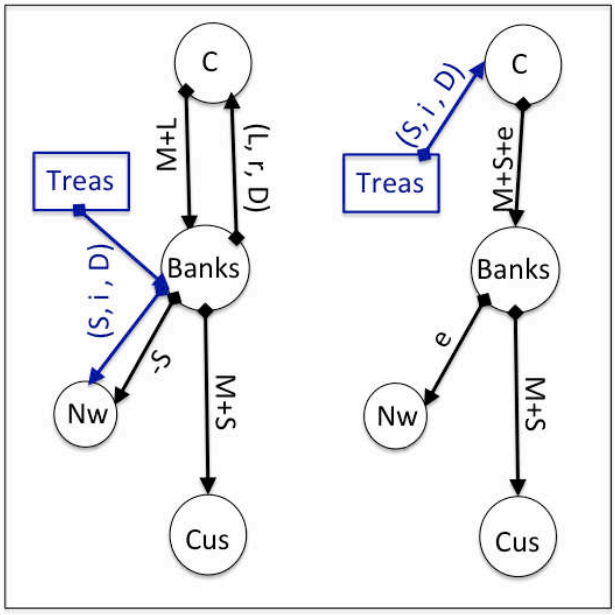

FIG. 20 Left: a LTRO increased the deposits of the commercial banks at the central bank, but it also increases their debts. The net worth of the banker is unchanged. Right: In an outright purchase of bonds (e.g. a QE), the central bank had to pay an extra amount to the bankers so as to convince them to sell. Even if tiny, this amounts to money creation which might be spent if bankers decide to spend it. Or it can be kept in the commercial bank sector and lead to higher prices for all other financial assets like corporate bonds. This depends on portfolio preferences of the commercial banks.

IV. INTERNATIONAL MONETARY SYSTEM

So far, we have idealized as much as possible the monetary system for the sake of simplicity and clarity. There is nothing which prevents in exposing the same situation using graphs in many more details. But for the purpose of answering simple and fundamental questions such as *what is money and when is money created?*, *what is the effect of public debt?*, *is a QE equivalent to money printing?*, there is no need for many details, and on the contrary consolidated graphs are a major tool. As we have emphasized, the main advantage of a representation using graphs is that it helps understanding the various positions about the interpretation of the monetary system. *Can we consolidate the Treasury and the central bank? Is there a Riccardo-Barro equivalence for new public debt emission?* As we have already answered, the different possible answers to these questions are just about interpretation of graphs, that is about words that we can drape around possible situations.

However, there is so far a major simplification which we cannot overlook anymore. There are inevitably several sovereign states, each with its own currency, that is its own central bank and its own Treasury, using its own unit of account. A complete model of our monetary system must thus be a model of several monetary systems, together with their interactions. It is now time to consider the possibility of foreign currencies interacting with a national currency. There are several presentations which could be made to present the various possible international arrangements. For simplicity, we choose a rather historical presentation, in which we first focus on fixed exchange rates system which were more common in the past, and present only thereafter floating exchange rates which are now the international standard. We finally discuss the notion of debt in international monetary systems. In order to emphasize that we have now several states, we will talk about citizens rather than bank customers throughout.

A. Fixed exchange rate system

Whenever a national citizen, is paid by a foreign citizen in a foreign currency, he might prefer an asset denominated in his national currency rather than an asset in a foreign denominated unit of account. As usual, there is no universal law behind this, and all possible choices are in principle possible. He might find it perfectly fine and preferable to hold foreign currencies. However, we must remind that taxpayers need to pay their taxes in the national currency, so in principle this should trigger at least a small preference for the national currency depending on the state of the commercial balance[9].

[9] If the amount of foreign currencies paid to national citizens is the reflection of a current account surplus, there is no special need

In the case where the citizen indeed wants to get rid of a foreign asset, he will ask his bank to exchange it for a national asset. In a fixed rate exchange system, the amount which should be traded is obvious. The commercial bank will take the foreign currency for itself (for its net worth), and will create a deposit denominated in the national unit of account, that is it will create a deposit for the citizen who got rid of foreign currencies. The process might then be repeated between the commercial bank and the central bank. The commercial bank might prefer to hold a liability of its national central bank than a liability of a foreign central bank. In that case, the central bank will take the foreign central bank money as an asset and will increase the national central bank money deposit of the commercial bank. These steps are illustrated in Fig. 21.

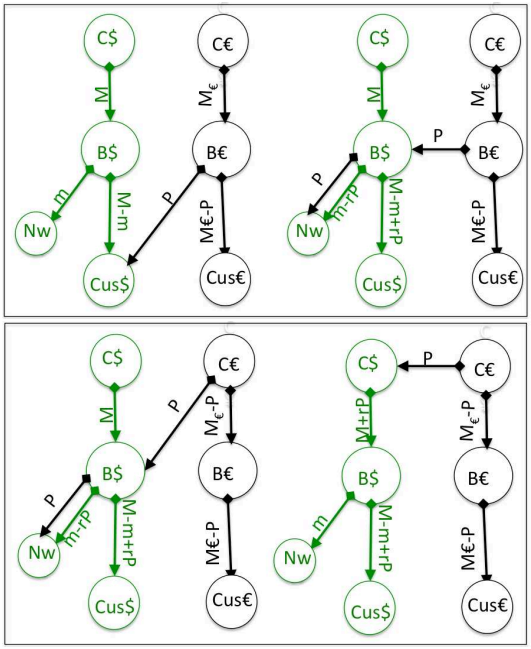

FIG. 21 Top left: a national citizen is paid with foreign currency. Top right: he asks to its commercial bank to transform this foreign asset into a national currency asset. Bottom. left: the national central bank prefers to hold the foreign central bank IOUs than foreign commercial bank IOUs. Bottom right: the national bank asks its central bank to convert its asset denominated in a foreign currency to an asset in the national currency.

As a final result, it is the national central bank which directly possesses the liability of the foreign central bank, that is which has a deposit at the foreign central bank. The resulting situation is extremely similar to what would have happened if the national citizen had been paid in gold in a regime of convertibility, and if at every stage the gold had been passed to the higher level (from the citizen to its commercial bank and then to the central bank). The resulting situation is indeed that the total net money of the national sector has been increased by rP, where P is the initial foreign payment, and r is the rate of conversion to the national unit of account. It is because of this analogy that commodities and foreign currencies held by central bank are treated essentially on the same footing. In a regime of fixed exchange rate, foreign currencies are treated like gold in a regime of convertibility. If payments are made in gold or in foreign currencies, they can be passed over to the central bank which creates the corresponding net money. Conversely when gold or foreign currencies are asked, the central banks reverts the situation and detaches the asset from its balance sheet, but in the process it also reduces its liabilities in central bank money, effectively reducing the net national money.

In a regime of convertibility between money and gold, we have already seen that the system cannot hold since all the liabilities of the commercial banks are guaranteed to be converted into gold, and whenever there has been debt issuing, this is more than the total amount of central bank money reflected into the deposits of the commercial banks at the central bank. To illustrate it simply, it is sufficient to borrow money at any given commercial bank, and then ask the corresponding deposit to be converted to gold. At some point this cannot be done because gold is only the reflection of the net money of the monetary system and not the total money, part of it was created as a counterpart of debts. Given the analogy between gold and foreign currencies in a fixed exchanged rate system, the same argument applies to foreign currencies. It is always possible to break down the fixed exchange rate by asking the conversion of national currency into foreign currency, and given that there is more money than net money, there is always a way to reach the point at which the central bank reserves are depleted.

Even though what we state here is obvious, we should remember that after having believed the world could work with both gold convertibility and a lending banking sector, it was then widely believed (e.g. in the 80s and 90s) that fixed exchange rates (a currency peg) for developing countries would be the right system. It is not the purpose of this paper to try to understand why this happened to be the case, even though a simple thought experiment is enough to understand it can obviously not work. As an example, the currency pegs lead to the Asian crisis in 1997.

In fact any national central bank can compute two limiting exchange rates.

- An *incoming* exchange rate. If the total assets in foreign central money is M_{F}, and the total amount of national central money created in counterpart was M_{N}, then we can define an entering rate as

$$r_{\mathrm{i}} \equiv \frac{M_{\mathrm{N}}}{M_{\mathrm{F}}} \ . \tag{3}$$

For instance if the eurodollars are the euro created

for national currencies in order to pay national taxes.

by the ECB when accepting Fed central money, the ratio of the eurodollars created to the dollar received is the entering exchange rate between euros and dollars.

- An *outgoing* exchange rate. It is the ratio between the total money $M_{\rm tot}$ (and not just the net money $M_{\rm net}$) to the foreign currencies held

$$r_{\rm o} \equiv \frac{M_{\rm tot}}{M_{\rm F}} \quad \Rightarrow \quad r_{\rm o} \equiv r_{\rm i} \frac{M_{\rm tot}}{M_{\rm N}} \quad . \tag{4}$$

  This exchange rate is the only one which the central bank is sure to be able to guarantee, since by construction there will always be enough reserves.

By construction, we also realize that $r_{\rm o} > r_{\rm i}$. A central bank trying to defend a constant exchange rate will always try to defend the incoming rate, whereas it can only defend the outgoing exchange rate which is much larger[10]. In other words, a central bank can never defend a fixed exchange rate. As long as it has a banking sector, the project of defending an exchange rate is born dead. This does not mean that central banks should not accept foreign currencies, in time of current account surplus, but just that they do not guarantee the backward conversion of national currency into foreign currency at the prevailing incoming exchange rate.

The only possibility for the system to hold would be if the national central bank had the right to borrow foreign central money to the foreign central bank. But if this right was granted, then the situation would be rather similar to the case of commercial banks having the right to borrow from a central bank, and this would ensure that all liabilities can be cleared at par, that is with a fixed exchange rate. This was exactly the European situation between 1999 and 2002, when all eurozone currencies had a fixed exchanged rate with the euro foreign currency, and all national central banks were granted the right to borrow from the ECB as much as they needed. Eventually, as planned earlier in the Maastricht treaty, all national currencies were abandoned and the system was further integrated into a single currency, as this was just a technical intermediary situation. But in general a foreign central bank has no particular interest in granting the right to borrow from the national central bank.

We realize again that granting the right to go in debt is the key of financial power. At every vertex of the tree structure, granting the right to go in debt to vertices which are lower is a form of power on them. The household is afraid that its commercial banker might not grant a loan, and needs to accept the conditions set by the banker, the commercial bank is told at the higher level at which rate, under which conditions, for which maturity, it can borrow central bank money. And if the national central bank now wants to borrow a foreign currency, it will have to accept the conditions of the foreign central bank.

If an economy starts to fix its currency at parity with a foreign currency, its central bank somehow inserts itself in the tree structure of the foreign country, and instead of being at the apex of the system, it is now situated below the foreign central bank and needs to ask for the permission to go into debt. Even though this type of power of the foreign central bank onto the national central bank is formally similar to the power a commercial has on its customers, it is also extremely different. A central bank possesses a form of power on the national financial system as it sets the condition of debts in commercial banks and thus below for national customers/citizens. At least in principle, it is acting for the interest of the national economy as it is a creature of the state. Instead, when a foreign central bank grants the right to a national bank to borrow foreign central bank money, it has absolutely no reason to act in the interest of the national citizens.

If a weak economy wants to fix its currency to a strong economy, and does not have a full constitutional right to borrow in this external currency, as is always the case, there are essentially two possible situations. Either the country ensures that it will never need foreign currencies to defend the exchange rate. In order to achieve this it would need a strong commercial surplus, and even this might not be enough to make sure that the currency cannot be hedged given the internal inconsistency of the system. Or it needs to borrow the foreign currency, e.g. because of a current account deficit, and needs to comply with the politics imposed by the foreign country. The alternative is thus either to work for free (this is the essence of a permanent commercial surplus for which the dominant foreign countries pays simply by public deficits) or to be told how to work and what to sell (structural reforms imposed by creditors). In both situations, the strong foreign country has the means to ensure that the situation is profitable. Either it can live at a higher standard than it could, or it decides what it wants to buy and at which price under the programs of *structural reforms*.

But this era of fixed exchange rate is now over as the pegs to the US dollar have damaged too heavily developing economies. Let us thus examine the case in which exchange rates are floating as they are not guaranteed by central banks.

B. Floating exchange rates

Under a regime of floating exchange rate, the process of passing foreign currencies can still be performed rather easily, because whenever foreign currencies are accepted by national citizens, it has to be done with a given exchange rate (the one prevailing on the markets at that time) which can be used to decide which amount of national central bank money should be created in exchange

[10] In the way we defined the exchange rate, a higher exchange rate means a weaker national currency.

of the foreign currency. The only thing which must not be guaranteed is the backward conversion. Once a citizen and then its bank has asked to convert a foreign currency into their national currency, the central bank does not provide a way to revert this. Or at least does not guarantee that it will accept doing it in any case.

As a consequence, if national citizens now want to pay foreign citizens, they will have to use their national currency and make sure that it gets accepted by foreign citizens, who will in turn pass it on to the central bank as they might prefer holding liabilities denominated in the foreign currency (which for them is a national currency). If this is the case, we reach a situation where a central bank A has liabilities toward a central bank B, and conversely the central bank B has liabilities toward the central bank A. This situation is depicted in Fig. 22. It is possible to cancel these mutual relationships, only if the two central banks can agree on an exchange rate.

As a side comment, note that in practice central banks will not keep their assets denominated in a foreign central bank money very long. Indeed, these bear no interest and it is thus preferable to exchange them for foreign Treasury bonds which bear interest. Both foreign central bank money and foreign Treasury bonds are gathered under the term *foreign reserves* in annual reports of central banks. In that sense one would say that countries with recurrent current account surpluses finance the public deficits of foreign countries. This highlights that if economists still argue about the possibility of consolidating the Treasury with the central bank, central bankers, who peer into foreign systems only from far, always consider that there are two types of foreign assets, those who bear no interest (central bank money) and those who bear interest (Treasury bonds), but they equally deserve the name of *foreign reserves*. It does not matter for them who is at the origin of the asset, as long as the assets are reliable (the foreign country could e.g. decide sanctions and unilaterally cancel these assets), they are equally good, with those bearing interests being even better to be used as *reserves*. In fact, as long as the foreign central bank has a target on interest rates, it will always be willing to buy its own national Treasury bonds, to avoid an increase in interest rates, ensuring a type of convertibility from bonds to central bank money.

More realistically, there are several foreign currencies as there are several foreign sovereign states, and the central banks hold assets denominated in many other central banks unit of account, not just one. We thus have a situation rather similar to a decentralized system of banks, where each central banks is at the top of a tree structure, but the central banks interact through one-to-one asset/liability relations. The only but substantial difference that all these assets/liabilities relations between central banks are denominated in different units of account. We are back to a monetary system which is not optimally organized as the network of central banks has many loops.

The system can even be more complex if the liabilities

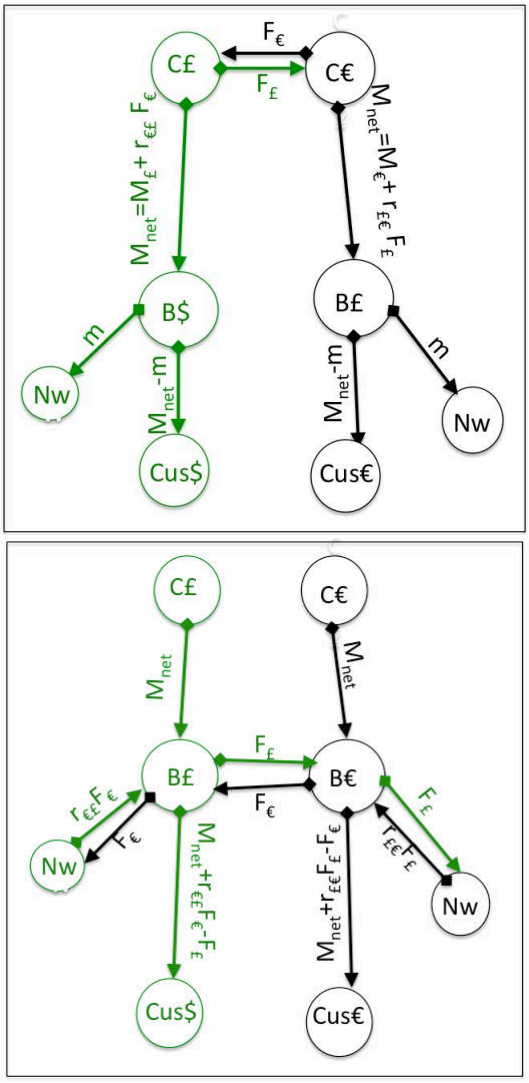

FIG. 22 Top: the central bank has taken foreign assets and converted them onto national liabilities. Bottom: commercial banks have kept foreign assets and have created national currency liabilities.

held by commercial banks in foreign currencies are not passed to their central bank. Indeed, a commercial bank can decide to keep assets denominated in other units of account, originated from foreign commercial banks. In that case, we can see that the national money creation induced by the income of foreign currency is originated in the net worth of commercial banks and not by their central bank. This situation is also depicted in Fig. 22. As the number of commercial banks is much larger than central banks, all these mutual relations can reach a level of high complexity, as each bank of each country needs to have asset/liability relations with all other banks from the world. The typical number of currencies is 100, when the typical number of banks within a currency area is $10-100$, so this means that this system implies 10^6-10^8 bilateral relations.

Every time the system is too complex, it will self organize into a tree structure which is more efficient. This is essentially done in two manners.

- First, small commercial banks will interact only with one major commercial bank of a given currency area. This means that in a given currency area, there are major commercial banks, who organize small foreign commercial banks into a tree structure below them, so that we have effectively a system with four levels (central banks, major commercial banks, smaller commercial banks, and customers/citizens), and with a reduced number of loops.
- Second, international trade will be made in only a small number of strong currencies. In practice, this means that commercial banks will only accept assets denominated in foreign currencies, if this foreign currency corresponds to a strong enough economic area. This led the current international system to be based on the dollar, the euro, the yen and the pound.

We already see the problem that weak economies will encounter. It is not easy either for a weak economy to work under a floating exchange rate, since it might be hard to get its national currency accepted. Indeed, everyone can create money, but the most difficult is to get it accepted. Conversely, the US are extremely good in making sure that their currency gets accepted. The capability of a given country to pay in its own currency is a direct reflection of its international power. As a consequence, any country which runs a commercial surplus has no interest in accepting payments in foreign currencies. To put it in simple words, the US are able to pay in dollars either because other countries are naive enough to accept it, or because the US have enough power on them to impose it.

All central banks but the Fed do maintain reserves in foreign currencies, mostly in yens, euros, dollars and pounds. Indeed, the US have insignificant foreign reserves compared to their economic size (Fed, 2012), mainly in the form of SDR, and they are the only ones able to do so. They are indeed completely sure, in the current context, that they can impose a payment in their own currency. And in that sense, it can be said that they completely dominate the international monetary system, as they locate their central bank at the apex, writing IOUs denominated in dollars to exporting countries from which they import, rather than borrowing from them in the foreign currency.

As a political comment, one should note that there is absolutely nothing fundamental in it. From a neochartalist perspective, one would observe that there is no international tax denominated in dollars so the power of imposing the dollar as the ultimate currency is not enforced by the ability to tax, but is rather a soft power of cultural domination inherited from past history. Indeed current leaders in the world were trained and raised before the end of Bretton-Woods agreements where only the US dollar was convertible in gold, and they are thus inevitably biased in thinking that there is a fundamental reason for the US dollar to be the dominant currency. However nothing prevents this to be reverted at any time. To make it simple, the Chinese government might decide not to accept anymore Fed or US Treasury IOUs in payment of the US/China commercial deficit, but rather ask that the payment be made through loans denominated in yuans. Should several major developing and exporting countries ask this at the same time, then there would be a currency crisis hitting the US, as the terms of international trade would be strongly shifted.

In practice, even if it is true that there is no international tax denominated in dollars which would be *sufficient* to enforce the domination of the dollar in the international monetary system, it should be noted that commodities, and most importantly oil, are traded and paid for in dollars. This fact, which again is only based on habits and history but on nothing fundamental, acts effectively as if there was an international tax in dollar on all net importing countries, and even if this tax is not benefiting the US Treasury but rather the exporting countries, it seems that it is enough to maintain this system in which the dollar dominates. Given that the US are net importers of commodities (oil is also imported in the US as shale oil is not enough for US consumption), there is no reason why this should remain the case in the future. At some point exporting countries of key commodities might ask to be paid either in their own currency, which in practice means that they would control the terms of the debt contracted by importers, or at least in other currencies than the dollar. It is of course impossible to predict when this situation will end, since it will always be possible that exporting countries prefer to be paid in dollars, even though they do not have to, and even though by doing this they do not act in their best interest as it ensures they remain dominated by the US.

C. International loans and the IMF

We have seen that the key to international financial power is to control the right of others to borrow in one's currency. Even though the US have an effective supremacy, they would certainly lose it immediately if they were imposing strong conditions to borrowers. Indeed, there are several major currencies which could then step in and grant the right to borrow under milder conditions. And as they are major currencies they would be as good to finance commercial deficits of importing countries. To make it simple, if a developing country cannot borrow in dollar to pay for its oil imports, it could do so in euros or pounds, and it would probably be accepted by oil exporters. Indeed it is not because oil prices are set in dollars that they are always paid for in dollars.

It is thus essential for creditors who want to use their

power of granting loans to control the economies of borrowers to act collectively, so as to avoid unnecessary competition. If the US dollar cannot maintain itself at the apex of the system, it must at least share this better position with a few other strong currencies. The International Monetary Fund (IMF) is currently implementing that logic at the international level. On the good side, it creates an international system of debts and loans as we shall explain. But on the bad side for the borrowers, when times are difficult, it is also the only way to access international loans. Since the shares of votes inside the IMF reflect the economic power of each member country, the IMF is a tool used by a pool of strong economies to impose their conditions on individual weak economies in crisis. It is thus no surprise that the IMF is one of the most controversial institutions. As already emphasized, those who get to grant the loans in a monetary system have the financial power on those to whom they grant the loans, and the IMF is the incarnation of that power.

The structure of the international arrangement with the IMF are however formally slightly complex. It is not a structure which sits undoubtedly at the top of a monetary tree, as the ECB sat at the top of the newly created eurozone in 1999. It would be more exact to say that the IMF mimics the apex of an international monetary system as it funnels the loans and debts through it.

In a first stage, member countries joining the IMF have to pay their quota share to the IMF, in dominant reserve currencies (that is yens, euros, pounds and dollars) or gold partly (25%), and the rest in their own currency[11]. If we think of the Treasury and central bank of each individual currency area as being consolidated, it does not really matter if the Treasury emits bonds bought by the central bank so as to be able to pay the part of the quota share in national currency, or if it is the central bank which just adds a new liability to its balance sheet out of thin air. The latter possibility is the most sensible implementation [and also the most common choice made by governments (IMF, 2014)], because after quota share payment, the central bank will receive an asset from the IMF, denominated in Special Drawing Rights (SDR). The SDR are equivalent to a weighted sum of the four major currencies (yen, pound, dollar and euro). At first it would seem that the IMF has the power of creating net money in these dominant currencies, as a central bank would do by accepting foreign currencies and transforming them into national central bank money. Indeed a country which has a weak currency would pay its quota share in its internationally unused currency and get in return SDR which seem to be equivalent to assets in these four dominant currencies.

But in order to make sure that this is not the case, the IMF makes sure that the SDR are not claims on the assets of the IMF. So the SDR are valued as a weighted sum of the dominant currencies, but *they are not IOUs* in this basket of currencies. So in the first stage, member countries contribute for 75% which costs them nothing and which is created out of thin air, and in return they get liabilities which are worth nothing. There is thus a need for a mechanism to ensure that, even though the SDR are not claims on the assets (the reserves) of the IMF, they can be exchanged for the dominant currencies. If countries which need dominant currencies to finance a current account deficit, or for reserve management purposes (in order to try to defend a currency peg), cannot find countries willing to buy the SDR in exchange of dominant currencies, the IMF can designate countries which would have to accept the bilateral trade. The difficulty in creating a currency is to get it accepted, and it is by this mechanism, that the IMF is eventually sure that the SDR will be accepted. In practice the IMF never had to use this power because the account held in SDR at the IMF bears interest, and the interest is the exact reflection of short term interests rates of the corresponding basket of dominant currencies. So the system has been made such that possessing a SDR or the corresponding currencies generates the same profits.

To be more precise, it is only the difference between the quota share of SDR and the actual amount of SDR held which generates interests. It is not entirely exact to state this since interests are in fact paid on that part of the 25% which was not paid in gold but in dominant currencies, and this is likely to be because the IMF can exchange them with interest-bearing Treasury bonds of the corresponding dominant countries. The idea is that 75% of the quota share was paid in national currency created out of thin air by the corresponding central bank. Then in the remaining 25% of the quota share (the so-called *Reserve Tranche*), the part which was paid in gold was not generating interests and it should remain so after being paid to the IMF. But the part of the reserve tranche which was paid in dominant currencies was most likely held in Treasury bonds of the corresponding dominant countries, and was bearing interests. In order to make sure that countries are willing to become and remain members of the IMF, the IMF pays interests on this part of the quota share to maintain the profits of central banks. Ignoring this technical detail, one could summarize the system by saying that if a country exactly keeps unchanged its amount of SDR which corresponds to its quota share payment, it does not receive any interest. But if after some bilateral trades it has more SDR, it should receive interests, and if it has less then it should pay interests, in both cases in SDR. So the IMF is inspecting the accounts of member countries in SDR, and deducts interests from countries having less SDR than the quota share and pays interests to countries having an excess of SDR. It acts in that sense as a perfect bank

[11] To be more precise, at its creation, these 25% had to be paid in gold. As the quota shares were increased subsequently, they had to be paid in one of the dominant currencies. The IMF pays no interest on the gold part nor on the 75% contributed in national currency. But it does pay interests on the non-gold part of the 25% of the quota share (IMF, 2014)

which takes no intermediate profit to feed a net worth, since the interest paid on short positions is the same as the interest paid on long positions.

The SDR are a simple way for countries to gain a right to be in debt, and are in that sense *drawing rights*. Indeed, even if the SDR they hold are not a claim on the IMF reserves, they are guaranteed to be able to exchange them for dominant currencies, and then will have to pay interests on their IMF account as it will have less SDR than its initial quota share. But as we have seen many times now, the financial power lies in the right to grant loans. Since this system essentially grants the right for member countries to borrow dominant currencies, this has been intentionally limited. The quota shares are actually rather small, and in case a country would need to defend an exchange rate or would need to finance a temporary current account deficit this would very rapidly be insufficient. If the scale at which the member countries could go in debt in SDR was much larger, one could say that this system achieves a first step toward the unification of the international system. Actually it was designed right before the end of the Bretton-Woods system in 1969, when all currencies were traded in fixed exchange rate. After the end of the international fixed exchange rate, there was no more need, or no more will, for further international integration and this might explain why the system remained downscaled for a very long time. However, after the international crisis of 2008, the quota shares have been increased by at least one order of magnitude, as the need for further international integration was felt again.

But the first goal of the IMF was to grant loans, that is to be at the apex of the international system. Since no country wants the IMF to be a bank with a sovereign power, it acts more like a financial institution than like a bank. That is, at first it does not create the deposits corresponding to the loans out of thin air, as a normal central bank would do at its discount window for its national commercial banks, but really loans the funds which were received in the quota share payments. In case of crisis in a weak economy, that is if an economy has a strong need of foreign dominant currencies, e.g. to deal with a temporary commercial deficit, or to (try to) defend a fixed exchange rate, the IMF would loan the funds received and impose its conditions, which are the usual structural reforms of the *Washington Consensus*. This is how the power of granting loans is exerted on weak economies. Any loan of the IMF comes with conditions, that the economy in crisis has no choice but to accept.

But since the quota shares have been made intentionally small, the lending capabilities of the IMF are limited in case of huge global crisis. These are the two sides of the same coin. Furthermore, an economy in crisis wants to borrow strong currencies, and not all sorts of currencies which have been given to the IMF in the quota share payments. So the IMF sometimes needs to borrow directly from the central banks of the dominant currencies the funds that it will then lend to the countries in crisis.

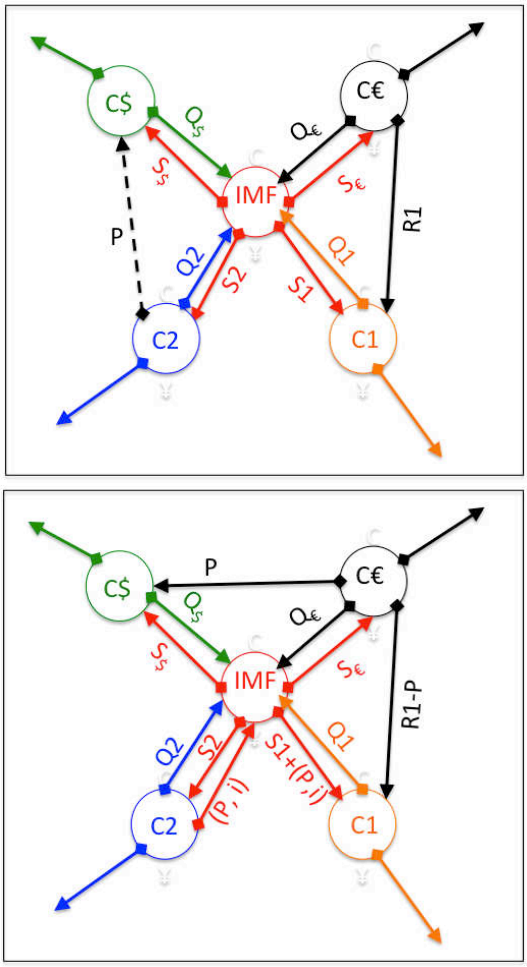

FIG. 23 Top: The IMF has allocated the SDR according to the quota shares, in exchange of foreign reserves (it is oversimplified here as each central bank has paid its share only with its national currency). In dashed line there is a pending payment due to e.g. a commercial deficit from country 2. Bottom: In order to settle the payment, the country 2 agrees to sell some SDR (for simplicity we assume all currencies are exactly at par at that moment) in exchange of foreign reserves (in the example it is in exchange of euros). With these euros the country 2 is able to settle the payment. As a result country 2 now owes the amount borrowed in SDR plus interests, and the country 1 now owns more SDR and will receive interests on it.

This is made possible by the *Arrangements to Borrow* which are formally equivalent to a temporary increase of the quota share for the countries involved in the arrangement. By doing so, the IMF acts only as an intermediary for credit condition negotiations between the various dominant countries which are lending to the countries in crisis. The IMF starts as a financial institution which lends the deposits of its contributors, but if necessary it is just acting for the dominant central banks.

In Fig. 24 we depict the situation in which a country borrows the currency of a dominant country to then pay a third party, possibly because of a current account deficit.

We considered the case were the IMF has enough of this dominant currency from the quota share payments. The graph is more complicated than expected because the IMF does not want to think itself as a financial institution which lends. So it rather builds the transaction as a repurchase agreement. The country in crisis formally purchases with its own currency (which it can create out of thin air in unlimited amounts) the dominant currency that it needs, and the IMF is committed to return it once the loan is repaid. As stated in the IMF annual report (IMF, 2014), *"although the purchase-repurchase mechanism is not technically or legally a loan, it is the functional equivalent of a loan"*. For simplicity, we have considered that the country which lends the dominant currency is also the country of this dominant currency, but it can also happen that one dominant currency is lent by another country if the latter has strong foreign reserves. This leads to a more complicated situation which could also be explained visually by its graph structure.

By analyzing the structure of the loans made by the IMF, we realize that the amounts lent come from the usual creation of central bank money by the dominant central banks against a debt with interest. The only difference being that the debt is to be repaid through the IMF, meaning that the conditions are set by the IMF. The IMF is only there to funnel the loan through a single institution, to strengthen the creditors with respect to the debtor. That way, it makes sure that the loans made in the various dominant currencies are made under the same conditions, so that the economy in crisis is left with absolutely no alternative, no negotiating power to put the dominant central banks in competitions for the funds they loan. This way of hammering weak economies is so efficient that the IMF always gets repaid. Indeed, whenever a loan is made, there is a risk that it will not be repaid. By acting together through the IMF, the creditors make sure that there is no possibility for the weak country to default. On the contrary, through the so-called structural adjustments, the creditors make sure they can be repaid by the sales of real assets, such as major public companies, since they stand strong together to impose it.

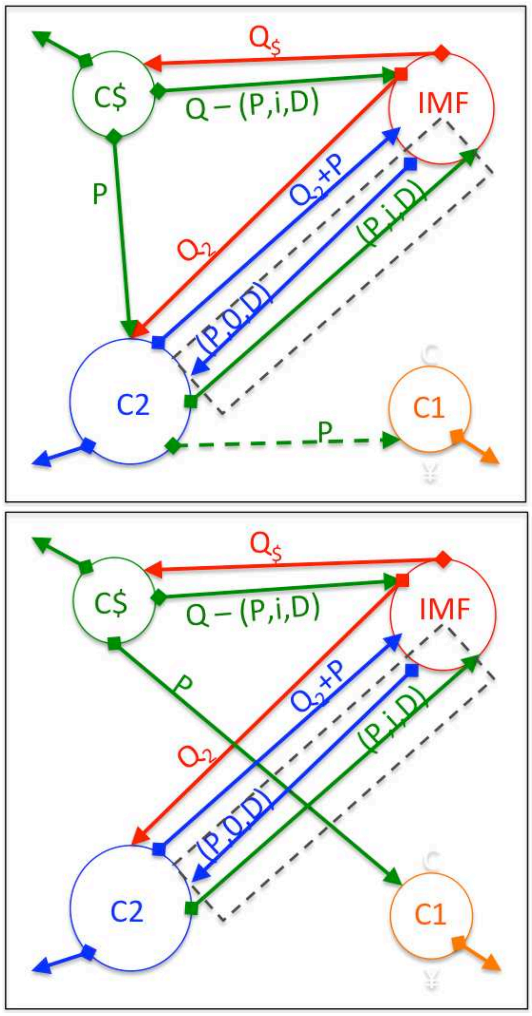

FIG. 24 Top: at first the IMF lends to the country in need the dominant currency that it has received from the quota share payments. The country in need receives thus a liability from the central bank of this dominant currency but it then owes the same amount with an interest rate to the IMF. Since the IMF does not want to formally lend, it prefers to think that it sells the dominant currency to the country in need with a repurchase agreement. The country in need creates out of thin air more of its currency that it gives to the IMF, and the IMF is committed to return it at a later time and without interest when the initial loan is repaid. The black dotted line highlights the repurchase agreement which has been agreed upon. Bottom: the country can pay the third party and is left with a debt toward the IMF.

V. OPEN DISCUSSIONS

We are still very far from having given a comprehensive description of the current monetary system. However we have presented the key features, the salient points, which are required to understand in deeper details any particular part of the system. Any refinement is just a zoom in greater details into the general graph of asset/liability relations. There are however a few points that are worth being mentioned, even though we necessarily have to remain superficial.

A. Central banks accounting

We have described a bank as being a net worth resulting essentially from the difference between assets and liabilities. The customers can also in a sense be considered as banks since they also have assets and liabilities, from which one can define a net worth. However adding this detail in the graph is not really useful and adds unnecessary complexity which would hamper the clarity of graphical representations. For this reason, we have de-

liberately treated the customer, that is the leaves of the tree structure, differently from a commercial bank.

One might ask a similar question about the other part of a given currency tree-structure. That is we might wonder if the central bank itself could not be described as a standard bank, with a given net worth. Of course again, the answer is that it is possible, but again, as for customers, this would add unnecessary complexity. Central banks can be formally treated as usual commercial banks, but they will still remain special as they are by construction the issuers of the fundamental IOUs of a monetary system, which are the central bank money liabilities they issue. Technically they can always add a new liability which has no asset counterpart, if they feel it is necessary, e.g. if they give central bank money to the Treasury instead of lending. That would increase the total net money, as it amounts to central money printing. One can argue (see § III.A.1) that if we consider a consolidated state, with Treasury and central bank taken together, then even if the Treasury issues a bond for the central bank money it receives and then spends, from the outside, it will be equivalent as a shift in the total net money, that is it is equivalent to net money creation. Many have thought that if we allow for these possibilities, pure direct money creation or indirect money creation by direct financing of the Treasury, this would undermine the confidence in the monetary system as it would possibly foster inflation in the long run. The neo-chartalists would argue that the confidence would be restored as long as the sovereign states tax enough money so as to drain out the inflation driving excess of net money. Pure money creation can always be reverted by taxes, but in the process it leads to internal redistribution among citizens, so eventually the debate is a political debate about inequalities.

It is a fact that these fears have currently won the debate, especially in times in which governments have campaigned about tax reductions. This led to decide in nearly all developed countries, that:

- the Treasury should never sell its bonds directly to the central bank;
- the central bank should never create new liabilities without corresponding assets.

As we already emphasized in § III.A.1, the Treasury now needs to sell its bonds to the commercial banks, and the central bank buys them after, in order to control the interest rates, leaving a small profit to the benefit of commercial bankers. As for the second point, the central banks now need to define a net worth which should grow only from the interests earned. All operations of central bank creation must have a counterpart in the form of a debt recognition, e.g. a Treasury bond, to maintain instantly the net worth to its value. To be short, central banks should only act as commercial banks. The interests earned are then spent back into the tree system, either when the central bank pays its employees with it, or when it transfers any remaining excess to the Treasury[12]. If this was not the case, the net worth of the central bank would increase and the total net money in the rest of the system would decrease, with the risk that it could possibly lead to deflation and then to recession.

But what happens to the foreign reserves and the commodities (gold) held by the central bank? Any change in the exchange rate or any change in the price of gold, which is a form of exchange rate, would affect the net worth of the central bank. After a revaluation of foreign assets and gold prices, it would thus be fair that the central bank transfers a corresponding amount of central bank money to the Treasury, so as to maintain a constant net worth. Indeed one could invoke that because the central bank is the bank of the state, it should act in the interest of everybody and thus share its benefits. Once the Treasury spends, it would effectively increase the net money held by the customers of the national monetary system. And in the opposite case, when the prices of foreign currency and gold fall, the Treasury would need to tax heavily so as to maintain the net worth of the central bank.

The problem of course lies in the fact that we asked for the net worth to be maintained constant, as we assumed that the net worth of the central bank should belong to everybody and should thus be shared. This is because we have assumed that the central bank was a normal bank whose natural shareholders, that is those who have a right and a duty on the net worth, are the citizens taken collectively. In order to circumvent this issue, it is customary for central bank accounting to split the net worth in two parts. The first part of the net worth is increased by the interest received (and decreased by the interests paid on reserves if it happens to be the case), and the second part of the net worth varies only according to the variations of foreign exchange rates and gold prices. This second net worth is called *Revaluation Account*. It is then only the first part of the net worth which is passed on to the Treasury. This situation is illustrated in Fig. 25. To summarize, today the central banks think themselves as commercial banks, and communicate in their reports about how well they managed to increase their net worth, but in order to do so, they need to ignore the major source of net worth variation. Following that logic, the given amount at which the net worth should remain is equal to the capital of the central bank, since the central bank wants to consider itself as a company with an initial capital input brought by stockholders. The capital of the ECB, that is the first part

[12] The fact that all profits generated by the interests earned are transfered to the Treasury is another way to realize that the central bank is not independent and can meaningfully be consolidated with the Treasury. Indeed, the base interest rate that the central bank charges on the loans made to commercial banks, as it is passed on to the Treasury, can be viewed as a form of tax levied on the borrowers of these commercial banks.

of the net worth, is held by the National Central Banks (NCB) of the Europan Union (ECB, 2014).

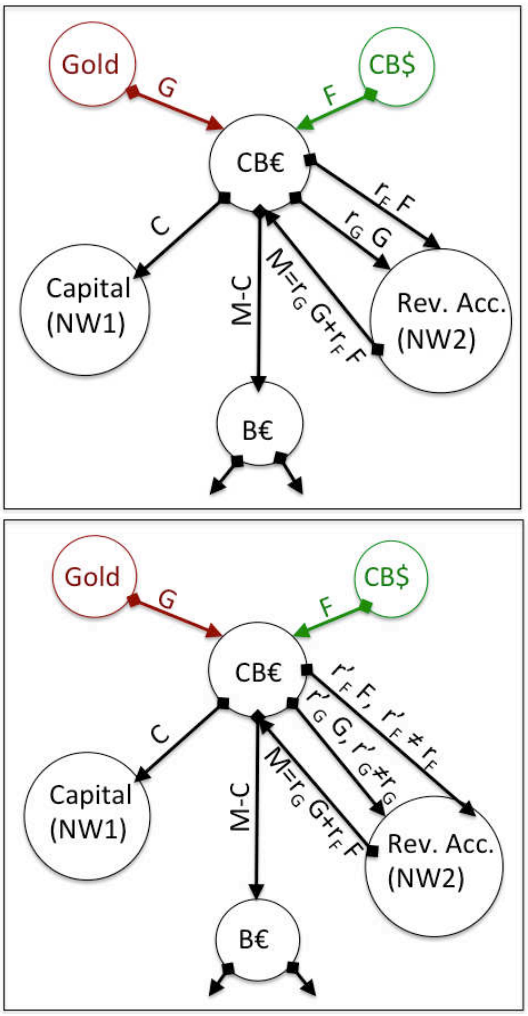

FIG. 25 Top: When the commodity G or the foreign currency F enter for the first time the balance sheet of the central bank with a given price r_G and exchange rate r_F, a corresponding amount central bank money is created $M = r_G G + r_F F$, and this is encapsulated in the revaluation account which starts initially by being neutral. Bottom: when the price of the commodity and the exchange rate of the foreign currency have evolved to different values r'_G and r'_F, this affects conventionally only the value of the revaluation account, which becomes $(r'_G - r_G)G + (r'_F - r_F)F$, and not the value of the capital which remains constant (C). Only the interests earned out of the loans made to the commercial banks (which reduce the net financial wealth of the private sector, $M-C$ in this simple description) might be transfered to increase the capital, but they are instead given directly to the Treasury, who spends them back when needed into the private sector.

B. State consolidation: artefact or reality?

The debate about state consolidation is probably the most controversial debate, and also the most simple one in terms of the underlying monetary graphs. First, one should remind that we should always distinguish between what has been, what happens to be now, and what should or might be. The idea that central banks should be independent has recently prevailed, reverting the history of their creations. The idea that state intervention should be restrained and that everything should be done to avoid government interference in the private sector has gained support over the past decades. Deciding that central banks should be free is actually only a small step in that direction, as one could instead decide much more radically to switch back to gold convertibility in a network of competing commercial banks as in § II.B. But this would lead us to the debate about what *should or should not be* or *could or could not be*. Here we just want to discuss what *has been* and what *is currently* happening in the monetary systems.

If we examine the past situation, that is before most central banks were proclaimed to be independent, then for sure the Treasury and the central bank could be consolidated together as the Treasury could borrow directly from the central bank. However, now that central banks have been proclaimed to be independent, and have been asked to defend the interest of savers (by defending a low inflation rate, and thus the value of financial assets), this can be questioned. Since the 2008 global financial crisis (GFC), the central bankers were forced to react to the rapidly rising deficits. In some countries, like in the UK and in the US, the central bank has acted effectively in the interest of the Treasury, as it bought huge amounts of Treasury bonds of all maturities to keep the interest rates under control. As argued in § III.A.1, apart from the small profits given to bankers, this is equivalent to a Treasury being financed directly by the central bank. So the GFC has revealed that the central banks of these countries communicate about independence to satisfy their state allergic opinion, but still act as a creature of state in the interest of the Treasury, that is in the general interest. As long as the bankers get their profit margin in the intermediation they provide in financing the public debt, there is certainly no lobby standing against this system. In countries like the UK or the US, what we can state for sure is that the current situation is a fake independence of their central bank. For these countries there is thus no logical impending of a state consolidation and the monetary system is effectively the one of a *sovereign state currency*. Those who reject state consolidation in the case of countries like the UK or the US, given the behavior of their central banks, essentially confuse what they *would like to be*, and what *happens to be*.

C. The European Monetary Union

The ECB intentionally rejects the possibility of controlling interest rates on Treasury bonds by buying automatically Treasury bonds on the secondary market.

Even the Outright Monetary Transactions (OMT) program, which was opposed by Germany but nonetheless created after the Eurozone debt crisis sparked, was never deployed since it was associated with too stringent conditions. We comment briefly on this situation in this section, even though it deserves more attention since it is a crucial problem for the European Union, probably the most important one as it undermines its foundations. More details about the flaws of the European Monetary Union can be found in e.g. Bell (2001).

When a central bank fails to buy its own Treasury bonds to keep their interest rate under control, then the consolidation of the Treasury with the central bank hides some salient features of the system. This is exactly what happens in the monetary union. By construction the ECB cannot identify its Treasury bonds as there are several distinct independent Treasuries. The ECB cannot serve the interest of the European countries, and instead serves indirectly only the interest of Germany. Indeed, since only the interest rates of German Treasury bonds remain low, this is as if the ECB was only managing the interest rates on the German bonds, and not on the other bonds. The spread of interest rates between the various Treasury bonds and the German Treasury bonds becomes then a measure of the disintegration of the European Union. Effectively, peripheric countries are borrowing in a foreign currency as their National Central Banks (NCB) cannot control the interest rate of their public debt. They thus face the same problems as weak countries whose Treasuries need to borrow in foreign currencies and need to accept whichever conditions of the creditors. In that specific case, one could say that the ECB is effectively independent by being legally impotent. This puts strong pressures on countries running a public deficit, as the conditions are now set by commercial bankers in their own interest, instead of being set by central bankers in the interest of the whole monetary system. The country with the smallest deficit, Germany, is thus in position to impose its views on how other countries in the Eurozone should organize their economy, effectively leading to a Germany run EU. The last Greek episode after the general elections of January 2015 is just another episode of creditors setting stringent conditions to debtors in an international competition. If the ECB was acting as a normal central bank in a sovereign state, it would buy as many Greek bonds as necessary to maintain a low interest rate, and Greek Treasury bonds would be effectively part of the net total money as they will remain forever (see § III.E). One of the first things asked by the Greek minister of finance was thus to exchange the Greek bonds held by creditors with permanent debt bearing a very low interest rate. He only wanted to remind the creditors that public debts are meant to stay, not to be reimbursed, as they are financial wealth to the private sector.

This critical international tension inside the Eurozone will only end when there is a sovereign state running a sovereign currency. If the Eurozone monetary system evolves drastically, it can enforce the enforce the normal behaviour of the ECB, allowing for instance for the issuing of European bonds whose interest rates are controlled by the ECB. But this would mean that there is further European integration as some financial solidarity would need to be agreed upon. However, if the eurosceptic parties win too many national elections, the previous situation where Europe is made of several countries, each with its own sovereign currency, can be restored. This would imply a strong devaluation of the new currencies of the weak countries.

D. Monetary aggregates

Usually the amount of money in a given monetary system is estimated through monetary aggregates. They all correspond to using a subregion of the monetary system for consolidation purposes. The total net asset consolidated for that particular region is a particular aggregate.

1. M_0 and M_B

The simplest monetary aggregate is M_0 and is composed of the assets directly held by the customers at the central bank, in the form of coins and paper money (C in Fig. 26). Whenever a customer deposits money at its commercial bank, this amount is reduced, and conversely it is increased when deposits at commercial banks are withdrawn in cash. If for simplification we assume that some customers have everything in cash and other have everything in commercial banks, the corresponding region is just made of those customers carrying only cash.

If we then include all net deposits held by commercial banks at the central banks (including the reserves they have at the central bank but subtracting their debt toward the central bank), we just need to extend the closed region to include the commercial banks with their underlying tree-structure of assets and liabilities made of deposits and loans. This defines the monetary basis M_B. We have made sure to exclude everything which is related to the public debt issuing, and we have thus made sure the contour of the closed region does not select this part of the commercial banks net worth. This ensures that the entering lines of the contour are only made of bank deposit at the central bank plus customer account possessed in the form of coin and paper money. We already see that since we have split the net worth of bankers in two parts, excluding only Treasury bonds, but including other assets, this definition of the monetary basis will always vary whenever the central bank does its job of interest rate setting through the purchase and sells of Treasury bonds. Indeed, when the central bank buys bonds held by the bankers, and if it is able to do so at the prevailing market price, it does not modify the net worth of bankers, but the part of the net worth which has to be included in the contour has to be modified. Put in other

words, the aggregate M_B counts only assets which enter through central bank IOUs, but not the asset which have entered from Treasury IOUs. Finally note that our definition for M_B takes into account only the net deposits of the commercial banks at the central bank, and not just the deposits. This is different from the usual definitions of the monetary basis. With our definition, any central money borrowed at the discount window does not affect the monetary basis M_B, whereas it would affect the usual definitions of the monetary basis.

2. $M_{\rm net}$ and $M_{\rm CB}$

This arbitrariness leads to consolidate the full aggregate of customers and bankers $M_{\rm net}$. This aggregate now counts the Treasury debts as well, as it includes all types of assets entering the bankers net worth. Whenever the central bank engages in open market operations, buying or selling bonds, this monetary aggregate does not change. It corresponds to the net financial assets held by the whole economic system and this is what we have called the *net money*. An operation of quantitative easing, which is just a massive outright purchase, changes M_B but not $M_{\rm net}$. But the whole system perceives only its net position. This is why a quantitative easing has no effect except a psychological one if widely advertised, and a small effect on the profits made by bankers when selling their Treasury bonds above market prices to the central bank. This is where a clear understanding of the aggregate under scrutiny, that is of the consolidation which is considered, is crucial for the debate. If we use the ambiguous word *money* for different aggregates, we would unavoidably disagree on the effect of open market operations. Those looking at M_B would certainly agree that it increases the money supply, whereas those looking at $M_{\rm net}$ would find no variation in their definition of the money supply. Again the use of graphs in representing what is considered considerably clarifies the debate.

However, it should be noted that $M_{\rm net}$ is not conserved whenever the Treasury spends by increasing its debt. We can thus define a central bank aggregate $M_{\rm CB}$ which encompasses everything but the central bank, and this one will remain constant, whatever the public debt. This aggregate is the reflection of all gold and foreign reserves of the central bank (plus the foreign money possessed directly by national citizens).

3. M_i

Further complication can also be introduced if we now decide to exclude the liabilities of customers, but to include only some assets, in an attempt to extend M_B. This leads to the various definitions $M_1, M_2, \ldots$, that we gather collectively as M_i. The more assets of customers are excluded (with all liabilities excluded in all cases), the larger the aggregate M_i is. We thus have a hierarchy $M_1 < M_2 < \ldots$. Any loan issued by a bank would surely affect some of the M_i as it would increase the assets held by customers. Depending on the nature of the asset, it would count in some M_i and not in others. These definitions of the aggregates are a way to estimate the amount of lending made by commercial banks. More precisely the ratio between M_i and $M_{\rm net}$ can be used the estimate the amount of credit in the origin of money.

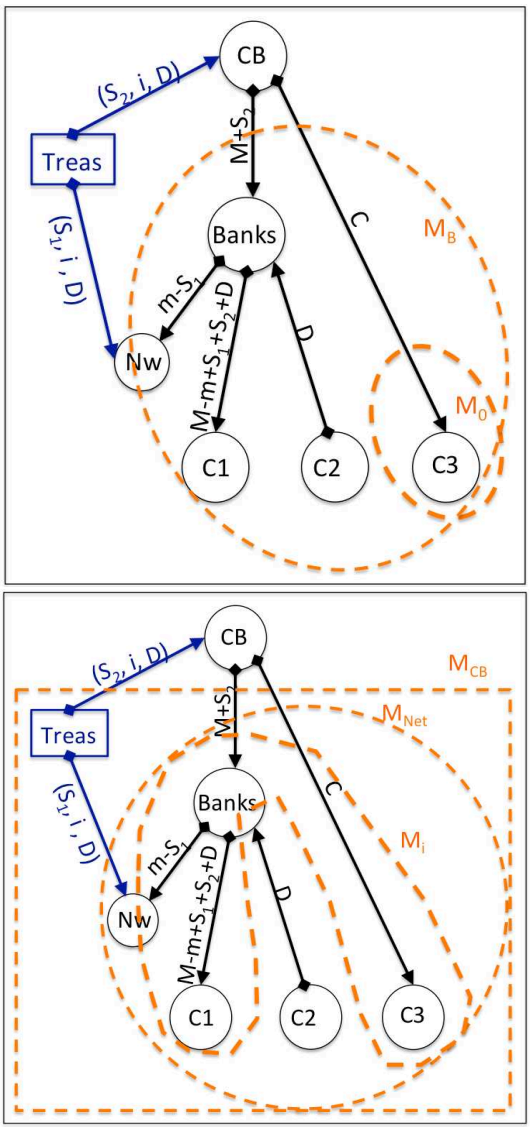

FIG. 26 Top: Schematic representation of M_0 and M_B. Bottom: $M_{\rm net}$, M_i and $M_{\rm CB}$.

4. Aggregates in the economic debate

In the quantity theory of money, the variations of monetary aggregates are assumed to be related to long term inflation as they are assumed to affect the aggregate demand. But the aggregate which should be used for such a theory is ill-defined. Should we consider only the net

money M_{net} or a type of customers total assets as M_i? The answer strongly depends on the behaviour of customers and is certainly not unique. In time of optimism, they might look only at their assets, and the amount of outstanding credit is a driver of inflation. But they could equivalently behave more pessimistically by also looking at their liabilities, effectively taking decisions according to M_{net}. Again, forecasting the behaviour of economic agents from aggregated indicators cannot work since there is no universal law for the behaviour of people. Some people at some given time in some given cultural situation might react differently from other people of a different epoch, at a different place with a different culture. Today, central banks have stopped monitoring the various aggregates, since they finally understood that, *i)* they do not control the M_i and *ii)* even if they did they could not know how this can be used to control the aggregate demand. They do not even control M_{net}, which depends also on public deficits. So they focus on interest rates which they enforce through open market operations. This discussion is continued briefly below in § V.F.

E. Sectoral financial balances

1. General construction

As we have just emphasized, defining aggregates on some closed regions of a monetary system allows to discuss the situation of stocks at a given time. It also allows, by looking at the variation of the stock, to examine the flows for these regions. One would for instance rather look at the variations of M_{net}, than M_{net} itself.

This idea of dividing the monetary system into major consolidated areas so as to examine their flow relations led to the so-called sectoral financial balances (SFB), which were popularized as a tool of macroeconomic analysis by Wynne Godley (Godley, 1999, 2000; Godley & Lavoie, 2007). The usual SFB analysis consists in dividing the monetary system into three global regions, which form a partition of the total system (that is such that their union covers the whole system). The first sector is the Treasury consolidated with its central bank, the second sector is the total foreign sector, and the third sector is the domestic sector. See Fig. 27 for an illustration.

The main interest in performing a partition is that it enforces the global conservation of flows. Said differently, the variations of the aggregate should compensate since the total sum of the aggregate should remain constant. In details, these aggregates evolve as follows.

- The government aggregate variation is noted $T-G$, and its stands for the difference between what it has taxed and what it has spent. The difference being necessarily in form of increased public debt if it is negative. From this aggregate perspective, any tax T has reduced the liabilities of the central bank toward the commercial banks, as it led to credit the Treasury account at the central bank. Any spending G reverts this process. Spending by public deficit affects the aggregate, in two possible ways. Either it increases the liabilities of the central bank toward the commercial banks if the central bank holds the new Treasury bonds, or it affects the bank net worth if the Treasury bonds are bought by the commercial banks.

- The total foreign sector variation comes from the current account position of the domestic sector. If the national system runs a current account surplus, it drains IOUs from outside. From a graph perspective, this means that the number of IOUs from outside toward either the national central bank, the commercial bank, or simply directly the national citizens if they hold foreign paper money, increases. So the evolution of the foreign aggregate is $-NX$, where NX stands for the current account balance of the national monetary system (net exports).

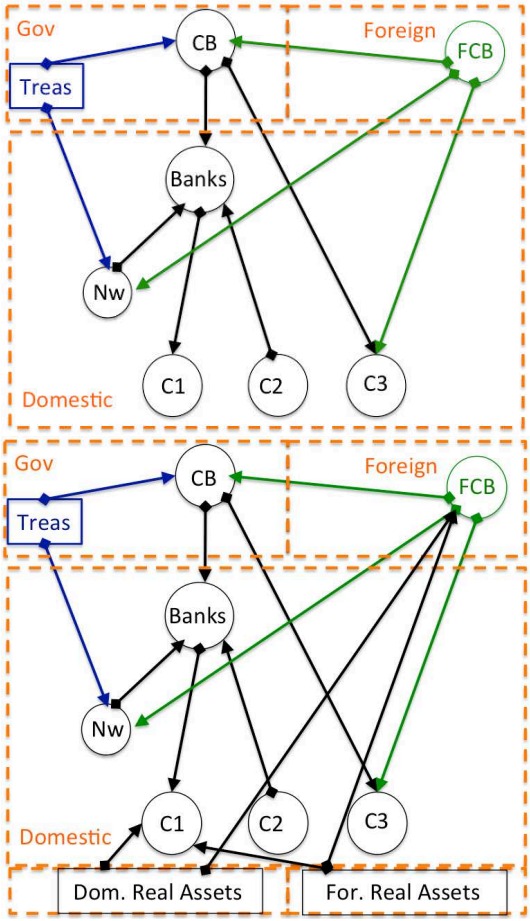

FIG. 27 Top: typical representation of the three main sectors. Consolidated government, Foreign sector and domestic sector. Bottom: we have added the real assets which do not sum up to zero and are not conserved, since they are nobody's liability. Foreign assets cam be possessed by the domestic or the foreign sector, just like domestic real assets.

- Finally the domestic sector aggregate is noted $S-I$, where S stands for the variation of the total of assets and I is the variation of the total of its liabilities. $S-I$ is simply the net variation of the domestic aggregate in terms of financial assets.

By construction the sum of the aggregates variations should vanish and we thus find the usual accounting identity

$$(T-G)+(S-I)-NX=0 \quad \Rightarrow \quad S-I=NX+(G-T)\,. \tag{5}$$

2. Current account balances

Note that a further simplified version of the sectoral balances is used in national and international accounting. Indeed, if instead of making a distinction between the consolidated state sector and the domestic private sector, we consolidate these together, then we have only two aggregates. One is the total domestic sector (state and private), and the other one is the total foreign sector (all states and private foreign sector lumped together). The variations of one of these two aggregates is then just the current account balances in the national accounting. Since they are necessarily opposite, we do not need to specify which aggregate we consider, as it amounts only to a sign convention. It is however standard to call the variation of the financial wealth of the foreign sector as the financial balance, and the variation of the financial wealth of the total domestic sector as the current account balance. The current account balance consists in looking at the assets of the domestic sector which are in the form of IOUs from the foreign sector, whereas the financial balance consists in looking at the assets of the foreign sector which are in the form of IOUs of the domestic sector, also called foreign investments. An exportation induces a positive current account balance, but a negative financial balance as it reduces the foreign investments.

3. SFB analysis

The main conclusion from this analysis is that the domestic sector can only save *financial assets* if the government runs a deficit or if the current account is in surplus.

The main shortfall of such analysis is that it ignores the variation of the real assets, as it focuses only on financial assets. That is it considers only the variation of assets which are claims on a debt. It is true that all financial liability/asset relations should balance, as any outgoing relation (a liability) has its ingoing counterpart somewhere (the asset). But the picture would be more complete if the evolution of real assets was also examined at the same time. The amount of real assets can evolve as companies are created or invest in production goods, new houses are built, new discoveries are valued as assets through patents etc... And the owners of the real assets might evolve as the exchange of real assets can be the counterpart of the exchange of financial assets, when these real assets are purchased. If we model simply the assets by two categories, one being the national real assets, and the other one the foreign real assets, the SFB analysis can be extended and this is depicted in Fig. 27.

The SFB analysis does not lead to too much controversy per se, as it is an accounting identity. It is rather how it is then used to predict the behavior of economic agents and thus to predict the evolutions of an economy that the SFB analysis leads to tough debates between the various theories of economy (see for instance Fiebiger (2013) for a critic of this type). Can we guess the decisions on spending, that is roughly speaking the aggregate demand, just by examining $S-I$? What about real assets? And again, what about the fact that there cannot be any universal law, as we already reminded in § V.D about monetary aggregates, given that what happens here, now, with these agents, might be different there, later, with other agents. One should not however be too pessimistic about economics and throw away all econometric analysis based on aggregated indicators. We should always remember that they are here to help describing a given situation, and not to forecast the future.

For instance, one cannot say that if $S-I$ decreases then the private sector will underspend. One can only say that if $S-I$ decreases, and if the private sector *has preferences, and maintains them*, for a given amount of net financial saving, then it will underspend since everybody will try, and necessarily fail, to maintain its net financial saving. The difference between the two propositions is that we assumed that some behavior of agents (the amount of net financial saving desired) is conserved. Taking decisions on aggregated indicators is thus a bet on the evolution or the constancy of behaviors with respect to these arbitrary indicators. Those who wanted to reduce the public deficits while still in the midst of the global financial crisis, have bet that the private sector is happy to reduce its net financial wealth (for instance assuming they would prefer to increase the wealth located in real assets). It is for instance the bet which has been done in Europe. After years of stagnation and at the brink of deflation, it is now obvious that it was as good as betting on a lame horse.

F. Exogenous vs Endogenous money

The deep nature of money is a hot topic of the economical debate. First there is no unique answer as it depends on the monetary system considered. We remind that we should distinguish between what is possible and what is actually realized.

1. The current system: endogenous money

Today, every central bank has its own definition of the various monetary aggregates. But apart for the net money M_{net}, the central banks have no control on aggregates (e.g. the M_i), as they depend on the lending effectively supplied by commercial banks, and this is why they have stopped monitoring these indicators. In fact, since reserves requirements can always be made at the discount window, the commercial banks first lend and then borrow what they need to comply with regulations. This fact is usually phrased by saying that *money is endogenous*. By money, we mean something related to the total financial assets (without their associated liabilities) of the private sector, somehow related to one of the M_i. Note that when a commercial bank borrows money to the central bank, it counts as reserves the central money received, but does not subtract the corresponding debt. So the required reserves themselves are endogenous and can always be met. The banks only lend if they think they will make a profit in their net worth, which essentially means that they will lend if they think that they will be repaid. It is thus strongly dependent on the true economic situation. What is conserved, at least if there is no current account deficit or surplus, is the central bank money M_{CB} as it is a pure reflection of gold reserves and foreign reserves. In that case one could say that the aggregate M_{CB} *is exogenous*. If we ignore the foreign sector, this statement is plain as it is just the statement that the gold held by the central bank is conserved.

It is intriguing to see that the endogenous theory is often ignored and most books prefer to present the exogenous system where the central bank supposedly controls the commercial banks reserves and indirectly sets an upper limit to credit money due to reserve requirements (see Boermans & Moore (2009) for a discussion).

2. Other possible monetary systems

If instead the reserves required were net reserves, that is if only the monetary basis M_B was used in the definition of reserves, then the central bank would have more control. Indeed the outstanding credits would necessarily be capped by a multiplicative factor of this net central bank money, due to reserve requirements. And the initial logic of lending would be restored, in the sense that the banks would need to have reserves first, and only lend afterwards with a multiplicative factor set by the regulation. Indeed even if they borrow from the discount window, that would not affect M_B since they build at the same time a liability and an asset toward the central bank. But one must bear in mind that whenever the central bank engages in open market operations, it would buy Treasury bonds from the commercial banks and increase accordingly M_B, so the central bank would have to reject this possibility (see Fig. 26 to visualize it). More control on the total money comes with less control on interests.

One can push this logic and try to imagine other systems to circumvent this. Maybe instead of using M_{B} for the definition of reserve, we should perhaps use M_{net}. Then the central bank would still be able to control the interest rate as the open market operations do not affect M_{net}. But this is already much more complicated, because the reserve requirement for each bank now depends indirectly on the Treasury. A bank could meet its reserve requirements one day, but if the Treasury increases its debt, then it might not meet its requirement anymore. So it would imply to control very strictly the public deficit. The central bank would control both the total credit money and the interest rate, but the Treasury would have its hands tied as it would not be able to spend more than what it taxes, and that would be the end of politics.

3. Horizontalism and Verticalism

The graph representation also helps to visualize the statement that a monetary system has both a vertical and an horizontal component (Moore, 1988). Indeed, having identified the root of the tree as the central bank, we might say this is the ground floor of the system. On the first floor we would then find the nodes which are below the central bank, and that would include the commercial banks and the Treasury[13], although by consolidation one might prefer to integrate the Treasury to the root of the tree. Below the commercial banks we typically find the customers and the net worth of banks. So the vertical structure appears very visually in the tree structure. Each node is promising at the level below the IOUs that it has received from the level above. The horizontal structure in the system is revealed by the polarization in assets and liabilities below a given node. It lies in the amount of credit that a given node has granted below it, and is thus endogenous. It is often referred to as the *circuitist* description of money. The vertical structure is imposed by the top of the tree, that is the consolidated government since the liabilities of the tree root are equal to the net assets of the leaves, as each node should be neutral. The horizontal and vertical structure of the monetary system is illustrated in Fig. 28. This structure is also often referred to as a pyramidal structure in economic literature, rather than a tree structure.

Conclusion

We have first presented natural tools to describe and discuss the theories of money. Indeed as formulated

[13] In the EMU, there is an additional level due to the National Central Banks.

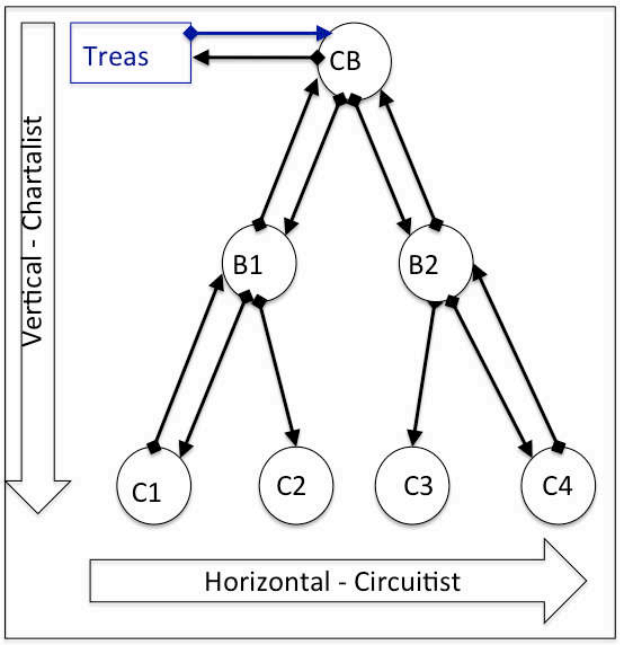

FIG. 28 Schematic representation of the underlying nature of money. It originates from a consolidated sector which controls by spending and taxing the vertical inflow. As for the horizontal component, it is originated by credit creation, and is endogenously determined by the economic conditions. Each node (the commercial banks) has debt/liability relations toward the level above and the level below.

by Minsky (1992, p12): *"A capitalist economy can be described by a set of interrelated balance sheets and income statements"*, and we argued that graphs for financial stocks are the easiest way to achieve this idea. By drawing together the balance sheets in a graph rather than explicitly writing one after another the balance sheets of each institution [e.g. in the figures of McLeay *et al.* (2014) or in the balance sheets explanations of Keen (2014)], we found that a given financial arrangement can be described more easily, and this simplifies the argumentation about the monetary systems.

For pedagogical reasons we have overlooked some building blocks which were not essential for understanding the general method. Even if we alluded to it, we have not insisted on the description of real assets as we intentionally restricted our description to the financial part made of asset/liability relations. We also ignored the representation of private companies, but they can easily be incorporated as a set of financial assets, real assets and liabilities, which induce a net worth possessed by the owners. Even for banks which are a type of company, we have not shown the relation between the net worth and the owners of the net worth (the stockholders) so as to alleviate the graphs. Instead we have deliberately focused on controversial topics about money. Indeed we developed in details how these tools can be used to analyze the structure of the state, with its central bank and its Treasury, and understand the true nature of money. We argued that in sovereign states running sovereign currencies, the Treasury and the central bank can be meaningfully consolidated, as we showed how their actions are coordinated thanks to the monetary policy. We explained that the state only controls the net money through public deficits, that is it sets the boundary conditions for the financial structure of the private sector, but it does not control the amount of credit which is endogenously determined.

The financial relations between all actors of a monetary system are complex and simple at the same time. They are simple because double-entry bookkeeping is understood at all levels of the system, given that it is extremely simple, and it is responsible for the conservation laws in the financial system. At every vertex of the graph, that is for every institution, the local laws of financial accounting necessarily hold, and they enforce the neutrality of the vertices in the graph structure. In a physical system with a high number of particles, there are complex structures which emerge from the simple local laws, and they are quite often very difficult to understand. Quite similarly, complex financial structures emerge out of the simple local laws of accounting, due to a high number of financial interactions. As a result, if the graph description is well understood, the different schools of economic thought should agree on the graph representation of any monetary structure, as they should agree on the local accounting at each vertex. Indeed, each given financial situation can be summarized by drawing the corresponding graph. But it will then appear that the disagreements always lie in the interpretation, that is on the words they want to drape around a given graph. This would be related to the various possible consolidations which can be made in a monetary structure, when trying to grasp the complex structures emerging out of these simple local laws.

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