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THE THEORY OF THE MONETARY CIRCUIT

The present paper reviews the pre-history, the process of formation and the possible directions of future development of the theory of monetary circuit. The author reveals the main theoretical constructions of Graziany and the other leading representatives of the circuitist school. The principles of derivation of transaction and balance sheet matrices reflecting the main ideas of the theory are discussed. The dynamic variants of the theory as well as the connection between the circuitist approach and the input-output model are subject to examination. The paper studies the possibility the circuitist approach to be further broadened on the basis of the mathematical graphs theory. The author emphasizes that the theory of monetary circuit denies the neoclassical dichotomy and rejects the postulate of the neutrality of money. The opportunity is also offered to upgrade the monetary circuit theory by using the mathematical graph theory. The paper includes also a critical evaluation of the presented theory.

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Brief history of circulation approach to money

The theory of the circulation of money (The Theory of Monetary Circuit) is formulated as a distinct theoretical approach dedicated to explain the nature of money and its economic functions within the post-Keynesian doctrine at the end of the 20th and the early 21st century. The interest in the currency circulation, however, is much older. The latter has always been one of the focuses, attracting the attention of economists, dealing with the issues of money.

In the 17th century, Sir William Petty, one of the associates of Oliver Cromwell, was probably the first, at the time of the birth of the classical political economy, who put at the center of his research the functions of money and its velocity of circulation (Petty, 1997 [1899] p.112-113). He even makes the important conclusion that economic growth presupposes acceleration of the velocity of circulation of money.

Nearly a century later, the physiocrats renewed the interest in money as a means of exchange and circulation. According to François Quesnay (Quesnay, 1991) the circulation of money is necessary for the generation of the income of individual social groups, the landlord class being the one that advances farmers. Under Quesnay approach the circulation of money is a mandatory component of the production cycle, guaranteeing the inter-sector exchange.

Adam Smith continues the tradition of physiocrats in the sense that he understands the essential role of the currency circulation for income formation and marketing the products of individual manufacturers. Later, another representative of classical political economy, David Ricardo applies the labor theory of value for commodity money, but adds elements of the quantity theory of money, close to the

views of David Hume. Unlike Ricardo, Karl Marx (Marx, 1979) unshakably adheres to the labor theory of value. He believes that the circulation of currency is determined by the circulation of goods, but the banking and credit system have a strong feedback effect on the real economy, especially in periods of financial and economic crises.

For its part, the neoclassical school as a whole is characterized by an emphasis on partial equilibrium analysis, especially as it concerns Alfred Marshall, or attempts to formulate general equilibrium models, in which the currency has no significant role. In model of Leon Walras and later in Arrow and Debreu, money is simply a "veil" and unit of account, the exchange takes place at equilibrium prices, without the mediation of money and credit. The economic analysis is characterized by the so-called “classical dichotomy”, i.e. it is inspired by the idea that the real and monetary processes can be considered separately. The great exception among neo-classics is Jevons (Jevons, 1875), who focuses his attention on the role of money as an intermediary of exchange, eliminating the need for double coincidence of wants. The conjectures of Jevons however did not find any further development within the neoclassical school.

The revival of the quantity theory of money is associated with two opposing trends. On the one hand a quantitative theory is marked by its adherence to the classical dichotomy. On the other hand, authors such as Knut Wicksell and Irving Fisher attach great importance to the currency and its velocity of circulation. In particular, Wicksell (1978) noted that the velocity of money is an important independent factor regulating the prices of goods. Fisher, in addition to his famous equation of exchange, combining the velocity, quantity and price level of goods and services, pays particular attention to the dynamics of the velocity of money over the business cycle (Fisher, 1933). M. Friedman and A. Schwartz (1982) considered that the velocity of money is an important parameter, reflecting the demand for money.

The main feature of the Keynesian revolution in the field of monetary circulation is the rejection of the neoclassical dichotomy (Keynes, 1936). This means that the processes of determination of relative prices and price level and of generating demand and supply in general, are taking place simultaneously and cannot be separated from the circulation of currency. In particular, this implies that the short-run Phillips curve is not vertical as if we assume the validity of the neoclassical dichotomy. On the other hand, the Keynesian approach to money and monetary circulation, due to its complexity, is characterized by multiplicity of interpretations. Here we can cite the IS/LM model of sir John Hicks, the Baumol model, the model of overlapping generations of Paul Samuelson, the portfolio model of James Tobin and others.

The theory of the circulation of money (monetary circuit theory) can also be attributed to Keynesian family of theories and more specifically to the post-Keynesian approach, distinguished by its stricter adherence to the initial conceptual connotation of Keynesian thought.

The origin and the fundamentals of the theory of monetary circuit

The theory of the circulation of money is a concretization of the Keynesian idea of the existence of a circulating flow of goods and services in the economy, flow mediated by counter-movement of money in their capacity of means of circulation.[1] Typical features of the earliest studies in the theory of monetary circulation are: emphasize on the function of money as means of circulation; introduction of creation and destruction of money as an endogenous processes driven by the needs of the real economy; ability of the banks to create money.

Another feature of the theory of monetary circulation is the rejection of marginalist approach to the distribution of national income, typical for the neoclassical school. The circulation of money approach has its predecessors in Sweden, Germany, France, Canada, Italy and Great Britain (Graziani, 2003).

What distinguishes the circuitists (i.e. the adherents of the theory of the currency or money circuit) from the traditional Keynesians is that at the center of their analysis is placed the function of money as a means of circulation, as opposed to the function of store of value or wealth, which is usually associated with the Keynesian approach (Graziani, 2003). Moreover, in terms of money supply, circuitists focus less on central bank policy, in favor of the relationship between firms and banks.

For example, obtaining a bank loan by a company in order to pay the salaries of its employees is creating money. This money creation may coincide with the transfer of funds to the accounts of employees in the bank, thus bank creating both assets (loan to the firm) and liabilities (deposits of the employees). The repayment of the loan is treated as destruction of the originally issued money. The circuitists focus precisely on the circulation of money, i.e. on their operation as means of circulation, throughout which money is transferred from the balance sheet of one economic agent to the balance sheet of another, while intermediating the movement of goods and services in the economy.

Another feature of the circuitist approach is the specific transition from micro to macro level. If within the neoclassical paradigm shift is related to the aggregation of individual supply and demand, for circuitists the macro level is defined as formation of a socio-economic groups, who have different relationships with the banking sector (Arena and Salvadori, 2003). The entrepreneurs dispose of capital and can borrow from the banks. Conversely, the employees are paid in cash and have no access to financial resources. The chain of monetary transactions commencing with bank lending to entrepreneurs in order to finance wage bill coincides with the production cycle of the economy. In theory, this method of money creation coincided with the so called “financial motive” for accumulation of money, introduced by Keynes.

[1] Some of the adherents of the circuitist school differentiate themselves from both Keynesians and neoclassicals.

The theory of monetary circulation is closely related to the so-called coherent approach to the problem of stocks and flows in the economy (stock-flow coherent approach). Distinctive for this approach is the construction of two types of matrices (Lavoi, 2001). These are the matrix of the most important balances or stocks in the economy and the matrix of transactions, representing the flows in the economic system.

Table

Transaction Matrix

	Households	Firms		Banks		∑
		Current	Capital	Current	Capital	
Consuption = C = sales = S	$-C$	$+S$				0
Stocks		$+\Delta I$	$-\Delta I$			0
Wages	$+W_B$	$-W_B$				0
Interest payments of the firms		$-rL_{-1}$	$+rL_{-1}$			0
Firms profits	$+F$	$-F$				0
Banks profits	$+F_b$			$-F_b$		
Change of inventories:						
Money	$-\Delta M$				$+\Delta M$	0
Loans			$+\Delta L$		$-\Delta L$	0
∑	0	0	0	0	0	

The Table gives a summary of cash receipts and payments in a simple closed economy (Godley, 2003). The plus sign means an influx of cash and the mark minus indicates outflow of resources. The aggregation of rows and columns always gives zero. Household's consumption is indicated by C, companies sales by S, stocks by I, wage by W, interest rate by r, loans by L, profits by F and money by M. The transaction table can be extended to include capital markets, public sector and the balance of payments (Godley and Lavoie, 2007).

As it can be seen from the Table, the household's consumption is financed by the revenues from wages, profits of corporations and banks, as well as via the change of monetary reserves. Firms' expenditure consists of payments of wages, profits and interest rates. The former are covered by the sales and the change of inventories. The accumulation capital by the corporations is financed with bank loans. The banking sector creates both "internal" money and lends funds to firms. Bank profits are generated from the interest payments.

The endogeneity of money is one of the characteristics of the circuitist models. Basically they split the money in circulation into external (external to the private sector), created by the central bank or government and internal, issued by the private banking sector. The latter is endogenous, i.e. is determined by the requirements of the economic exchange.

Dynamic approach to the monetary circulation

The so described basic principles of classical circuitist analysis are based on models with discrete time. Representative feature of these models is the strict separation between flows and stocks. Another key concern is the consideration of credit as a kind of "anti money." In other words, the repayment of loans supplied in the typical case by banks to the capitalists leads to the destruction of money, i.e. the deposits of companies. Under these restrictions, it is difficult to analyze the dynamics of production and the process of simultaneous accumulation of both credit and money.

Therefore, some authors replace the discrete by continuous analysis (Keen, 2009). In this situation, the dynamics of the main parameters of the economy are described by a system of differential equations. Stocks are determined by the initial conditions of the system expansion. In this model, the repayment of the loans does not lead to reduced credit but to an increase in reserves and the liquidity of the banking system, respectively. Conversely, the expansion of credit is at the expense of increased reserves. An increase of credit through the capitalization of loan repayments is also assumed. Similarly, the accumulation of interest on deposits does not automatically lead to payments from firms to banks, but can represent capitalization of interest. This approach assigns an important role to the variations of the velocity of money.

The dynamic interpretation of monetary circulation solves some important problems of economic theory and practice. First of all, it explains relatively easier, compared to discrete analysis, the monetization of corporate sector profits and wages. The dynamic modeling approach allows the explanation of the contraction of credit in times of economic turbulence such as the current global economic crisis and the "Great Depression" in the 30's of the last century. This contraction (credit crunch) is a consequence of the change of the parameters of the behavior of the banking sector. The circuitist dynamic model predicts higher prices in times of crisis and further deterioration of the economic situation in the event of reduction in real wages.

Open question in both dynamic and static circuitist models of currency circulation remains the policy of the central bank. The reason is that according to circuitists money is endogenous, i.e. created by the private banking sector to solve the economic problems of the decentralized exchange. The economic exchange is not a barter, as in neoclassical models, but a trilateral act, involving the buyer, the seller and the intermediary, represented by the bank. It is not clear how in this model should be integrated the paper money issued by the central bank.

One of the options is to consider the issue of money by the central bank as an endogenous act, related to the government debt financing, which also can be viewed as an endogenous variable, reflecting the activities of the state as an important economic agent. In this context the central bank money assumes also credit feature.

Model including the central bank and the fiscal sector is constructed by Zezza and Santos (Zezza and Santos, 2012). Computer simulations based on the extended circuitist model (the central bank influences the economy via interest rate policy and minimum reserves requirements while the government operates through fiscal deficit and taxes) allow for the verification of the basic postulates of the post Keynesian doctrine. In particular, simulations confirm the paradox of saving-augmented share of consumption leads to increased demand, investment and growth. The policy of moderate fiscal deficits has a positive impact on the economy by accelerating growth and reducing the budget deficit as a share of GDP in prospect. The central bank autonomous policy produces relatively little effect compared to the fiscal one and, in addition, at times monetary policy stimulus can cause contradictory results.

The application of the tools of the input-output analysis

The natural extension of the circuitist approach is the use of theoretical tools of the input-output analysis. This means that the supply of goods between different sectors of the economy should be expressed in monetary terms, as each physical delivery from one sector to another sector of the economic system should be counterbalanced by movement of cash in the opposite direction. Moreover, from the point of view of the real sector two equations should be introduced, equation, reflecting the role of prices and equations involving quantities of goods exchanged.

These equations can be specified as follows (Febrero, 2008):

(1) $$\boldsymbol{p}'\boldsymbol{A}(1+r) = \boldsymbol{p}'\boldsymbol{B}$$

(2) $$\boldsymbol{A}\boldsymbol{q}(1+g) = \boldsymbol{B}\boldsymbol{q}$$

Equation (1) reflects the price system, where $\boldsymbol{p}'$ is the vector order of price, $\boldsymbol{A}$ and $\boldsymbol{B}$ are matrices corresponding input and output production (input and output matrices), and $\boldsymbol{r}$ is a scalar reflecting a profit. Equation (2) is a quantitative system in which $\boldsymbol{q}$ is a column vector of goods and $\boldsymbol{g}$ is the growth rate. Both equations are systems of eigenvectors and eigenvalues (eigensystems) with one degree of freedom.

The price vector is a left eigenvector associated with the maximum eigenvalue of the matrix $\boldsymbol{AB^{-1}}$, while $\boldsymbol{q}$ is a right eigenvector of the matrix $\boldsymbol{B^{-1}A}$. Equations (1) and (2) are based on the input-output model of John von Neumann and assume equality of the profit rate and the rate of growth. The latter values are inversely proportional to the maximum matrix $\boldsymbol{AB^{-1}}$ eigenvalue. The model also implies equality between the rate of profit, growth rate and interest rate.

The relationships between different sectors and segments of the economy can be modeled on the basis of the pattern of the equations (1) and (2). In, particular, if a sector has a positive balance of payments with other sectors, his debt to the banking system decreases, while the indebtedness of the rest of the economy to the banking system grows.

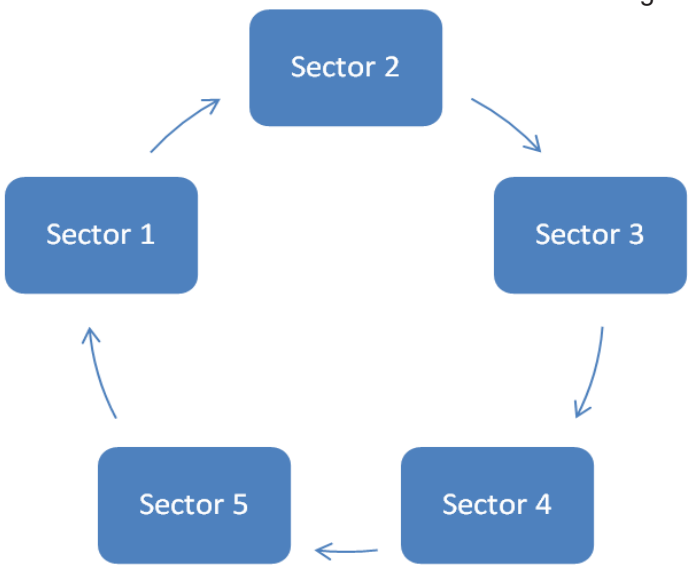
In this model, the fabricated output is exchanged against cash after being available, but before being used for consumption or as inputs to the other production sectors. Money is created and destroyed within the sphere of circulation in a closed circuit within the respective interrelated sectors without the need for taking into account the relations with other areas of circulation and external sectors.

The pattern of input-output monetary balance analysis allows for finding solution to a number of problems. Banks can finance long-term financial needs of the economy, supplying intermediation services between borrowers and the owners of deposits. In case of sustainable long-term growth, steady increase of credit and money is feasible, especially if the interest rate is lower than the profit rate. The model gives a good explanation of the mechanism of creation and insertion of value added in the economic system.

Guidelines for developing circuitist approach using graph theory and probability theory

In principle the theory of monetary circuit has not found yet the best mathematical expression of its ideas. Possible direction of development is the use of graph theory. The latter is a mathematical theory that analyzes special objects called graphs. They consist of vertices or nodes connected by edges. The graphs can be simple and directed or digraphs. In the latter case the vertices are connected by arrows. The Figure shows a directed graph forming a closed loop.

Figure



In the Figure the vertices represent the respective sectors of the economy while the edges visualize cash flows between the sectors. The existence of monetary flows forming a closed circle or cycle is a necessary precondition for the proper functioning of a monetary economy.

We can imagine any economic system as a complex graph, where each vertex represents a particular sector, product, market, or economic agent involved in the production and exchange. Edges between the nodes reflect the ties among economic entities. From a monetary point of view, these links are payments for goods, services or financial instruments. Since the economy is an interconnected system, any economic agent or market should in some way be connected to each other agent as a constituent receiving payments for the supplied goods and services and as a participant, paying for the obtained inputs.

In the graph theory, we have two basic approaches to the analysis of the connectivity of the system's elements. These are the cycles of Euler and Hamilton. In the case of Euler cycles we assume the existence of such a path within the graph that we can visit all *edges* without repetition. In the Hamilton cycles the objective is to visit all the *vertices* without recurrence. Figure № 1 is a clear example where both Euler and Hamilton cycles are realized. This figure is similar to the traditional Keynesian visualization of the circular flow of goods, services and payments in a closed economy.

From the point of view of monetary circulation the Hamiltonian cycles are of particular interest for us, as they guarantee the possibility of forming a closed circulation systems containing all economic agents and markets. One of the paradoxes of the graph theory is that the composition of Hamiltonian cycles is significantly more complicated than the construction of Euler ones.

In particular, there is no general mathematical formalism for finding Hamilton cycles, the problem being NP-complete, what means that we need enormous computing time for calculating the possibilities for constructing Hamiltonian cycles with growing number of vertices (markets) and edges (cash payments between agents). For example, if a computer is able to calculate 10 000 cycles per second, it will take about 18 seconds to calculate the cycles between 10 vertices (economic agents), 50 days for 15 vertices, two years for 16, and 193,000 years for twenty vertices.[2]

The Euler cycles may be associated with the neoclassical theory, postulating interdependence between all markets (for example in terms of the so-called gross substitutability), but with no monetary circuits. Without circulating currency the exchange is possible either on the basis of bilateral matching of wants in the case of decentralized exchange or via simultaneous centralized exchange at equilibrium prices between all participants in the economic process. Both options are practically not viable. The monetary circulation removes restrictions on the exchange, but creates problems with the complexity of financial and monetary arrangements, mediating exchange relations.

[2] www.csd.uoc.gr/~hy583/papers/ch14.pdf

The practical impossibility of artificial construction of complex Hamiltonian cycles drives the mathematical theory into another direction- linking graph theory with probability theory. This particularity of the graph theory is especially suitable for application in the field of finance and money, since the latter are necessarily related to concepts such as risk and uncertainty. Instead of explicitly construct Hamilton cycles we may simply postulate the existence of such objects (Hamilton random graphs) with a certain probability (Erdos and Renyi, 1960).

Studies show that closed Hamiltonian cycles are highly sensitive to the structure of relationships between elements. Under certain parameters of the system closed loops may exist with a probability close to unity (Brunet, 2005), while under other values of the parameters the system breaks down into subgroups, distinguished by the presence of sources and sinks.

These features of the theory of random directed graphs allow for the modeling of processes such as phase transitions of the economic system from one mode to another. In particular, it we can model the transition from a command (which does not necessarily require the presence of closed loops) to a market economy or the shift from the phase of boom (expansion cycles) to bust (disruption of monetary circuits). Consequently, the crisis divides the economy into sectors accumulating financial assets (sources of funds) and sectors with increasing liabilities. At the beginning of the current financial crisis sources were the financial institutions investing in mortgage backed bonds and sinks represented liabilities related to the accumulation of real estate.

Conducting monetary and fiscal policy (refinancing and recapitalization of commercial banks with the help the Treasury) is nothing but creation of new relationships in the payments chain in order to replace the broken links that led to a breakdown of the system's connectivity and to formation of sink-source dependencies, to close the monetary circulation and to create new Hamiltonian cycles with high probability.

Overall, the use of graph theory allows for the creation of adequate micro foundations of the circuitist analysis and for relating the processes at macro level to the connectivity between participants in the money intermediated exchange.

Conclusions

The theory of the money circuit fills a significant gap in our knowledge about the role of money and credit. Unlike the neoclassical and monetarist models, where we have external money issued by the central bank, the circuitist approach relies on endogenous money, created by banks in the process of financing investment and production. The circuitist theory takes into account the different economic positions of the distinct social groups and their interdependence in the process of production and marketing of the value added.

The theory of the circulation of money waives the marginalism, though some variants of the circuitists' models allow for neoclassical type of pricing- the Keynesian models usually include cost based rigid mark-up pricing while in the

neoclassical and monetarist schemes the impact of demand and liquidity is more explicit. Strength of the circuitist model is the possibility of dynamic interpretation and the successful application of the input-output analysis.

The theory of monetary circulation is not without weaknesses. The partition of the economic agents into three groups-employees, entrepreneurs and banks is too schematic. The idea of creation and destruction of money needs clarification. The assumption, that only capitalists have access to bank lending is not realistic-one of the origins of the current financial crisis is exactly the excessive supply of mortgage and consumption loans.

The circuitist method of aggregation of the economy may also be subject to critical analysis. The definition of the banking and corporate sector as aggregated systems creates problems in terms of circulation of money. Payments between companies are not carried through aggregated banking sector, but involve separate banks. Moreover these payments generate additional payments between banks. In its turn, the interbank payments are mediated by the central bank. All this modifies the mechanisms of monetary circulation and reduces the importance of circuitist dichotomy of creation and destruction of money.

Nevertheless, the circuitist approach to the circulation money has significant advantages over the neoclassical one reducing the function of money to the unit of account and store of value. Circuitists demonstrate that the real and the monetary processes should be analyzed simultaneously and their separation into independent areas is methodologically incorrect.

In the same time, as shown in the last section of this paper, further improvements of circuitist approach with the application of the mathematical graph's theory. The latter provides new prospects for monetary circulation modeling. Graph theory presents a clear distinction between micro and macro level of the monetary analysis, allows for adequate consideration of the probabilistic nature of the processes in the monetary and financial sphere and permits the description of the complex economic systems transitions from one qualitative state to another.

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