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The "Solvency Rule" of the Central Banker in a Monetary Scheme of Reproduction

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An alternative interpretation of monetary policy suggests that central bankers are not able to manage the business cycle and inflation. Rather, they set interest rates and other monetary policy variables in order to regulate the conditions of solvency in the economic system and the related tendency towards "centralization" of capital. This "solvency rule" of central banks is determined here within a two-sector monetary scheme of reproduction in which some restrictive assumptions contained in previous versions are removed. The main result of this scheme is that any sort of "neutrality" of monetary policy must be excluded, not only from the points of view of the scale of production or the distribution of income, but also from that of the solvency conditions and the related centralization of capital in each sector of the economic system.

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A THEORETICAL BACKGROUND FOR THE "SOLVENCY RULE"

According to the conventional interpretations of monetary policy inspired by the works of John B. Taylor, the central bank follows a "rule" of conduct aimed at stabilising the economy around the "natural" rate of unemployment – or a "natural" GDP growth rate - and an implicit or explicit target for the inflation rate (Taylor, 1993, 1999, 2000). The general theoretical framework for this rule can be found in the so-called New Consensus Macroeconomics (NCM) and its background 'Dynamic Stochastic General Equilibrium' (DSGE) representations (e.g. Clarida *et al.*, 1999; Woodford, 2003). This line of research rests on the conventional idea that monetary policy can

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lead to changes in the effective rate of interest around the "natural" interest rate and in this way is able to control inflation and fluctuations in unemployment around the natural equilibrium. This approach assumes that the natural equilibrium levels of the interest rate and other macroeconomic variables are determined ultimately by the so-called neoclassical "fundamentals" of endowments, preferences and technology, which are considered independent from monetary policy. Because of these characteristics, the NCM and standard DSGE models pretend to analyze in depth the effects of monetary policy over the business cycle and inflation while denying its impact on those natural equilibrium positions, both in their short-term and long-term versions.

As it is known, the conception of monetary policy suggested by the NMC and standard DSGE models has enjoyed considerable success. In particular, the works devoted to the verification of the validity of the Taylor rule have been very numerous (see, among many examples, Castelnuovo and Surico, 2003; Chinn, 2008). In the literature, however, it is also possible to find some objections to the stability and even the existence of the relationship between monetary policy and the fluctuations of unemployment and inflation which is implicit in the Taylor rule (Krisler and Lavoie, 2007). Moreover, the critique of the neoclassical theory of capital detects some inconsistencies in the so-called "fundamentals" (Pasinetti, 2000; Petri, 2004) on which the Taylor rule is based (Brancaccio, 2009). The same critique also suggests a different conception of the economic system under which, among other things, monetary policy can affect the "equilibrium" or "normal" level of the interest rate. In this alternative theoretical framework it is possible to assume that by setting interest rates, central bankers also determine the normal rate of profit and the related functional income distribution (on this point see, among others: Panico, 1985; Pivetti, 1985). Furthermore, by suggesting a further specification of the relation between interest rates and profits, it also becomes possible to argue that the effective monetary policy "rule" is not necessarily the one conventionally assumed. It is in fact possible to suggest that the central banker follows a "rule" which is aimed at defining the conditions of solvency in the economic system rather than pursuing the stabilisation of unemployment and an objective target for inflation. In this case, by setting the interest rate central bankers influence the structure of the economic system by regulating insolvencies and then liquidations and acquisitions, i.e. the rhythm of what Marx called the "centralization" of capital (Brancaccio and Fontana, 2013; on the Marxian concept of centralization of capital and the related empirical evidence, see: Brancaccio, Giammetti, Lopreite, Puliga, 2018).

The interpretation of the monetary policy that comes from this alternative "solvency rule" seems to find interesting applications in many current discussions, not least those relating to the relationship between monetary policy and the solvency conditions of the member states of the European Monetary Union (Brancaccio and Fontana, 2016). However, the idea that monetary policy affects the "equilibrium" or "normal" rate of interest and by this way can also affect the solvency conditions of an economic system, represents an unusual thesis. For this reason the representations of the "solvency rule" based only on macroeconomic models may be insufficient. A better support for this "rule" could then result from a more general theory of monetary and relative prices and income distribution. A landmark in this respect can be represented by a "monetary scheme of reproduction" (Brancaccio, 2008), which brings together some traditional features of the Post-Keynesian macroeconomic analysis with a theory of prices and distribution deriving from the so-called Surplus approach (Garegnani, 1990; Kurz and Salvadori, 1995) and Monetary Circuit approach (Graziani, 2003; on the ancestry of this line of research see Graziani, 1984).

It should be clarified that this scheme does not come from nothing (see: Lunghini and Bianchi, 2004; Halevi and Taouil, 1998; see also the collections of essays edited by Deleplace and Nell, 1996; Rochon and Rossi, 2003; Arena and Salvadori, 2004; and their introductions). In fact it is inspired by a line of research driven by the aim of establishing a consistent link within "heterodox" schools of thought between the theories of relative prices, distribution and accumulation and the theories of money. One of the main scopes of this line of thought is to examine the classic problem of reproduction of an economic system in terms not only physical but also monetary and financial. This purpose has been expressed in various circumstances but for a long time there have not been relevant advances in this sense (on this point, see the discussion contained in Kregel, 1983; see also Minsky, 1992, p. 368, and the debate with Garegnani in the same volume; more recently, however, there has been significant progress towards a constructive dialogue between the heterodox schools of thought, for example in order to delineate a shared link between the Surplus theory of value and distribution and the Post-Keynesian theory of money: see Aspromourgos, 2004; Lavoie, 2013). In this respect, as we shall see, the monetary scheme of reproduction gives a specific contribution by focusing on the deviations of utilization of productive capacity, prices and income distribution from their respective "normal" levels and analyzing the impact of these deviations on the monetary flows within and between social groups and the related solvency conditions in the economic system.

The first version of the monetary scheme of reproduction was based on some restrictive assumptions: the rate of interest on wages paid in advance was considered negligible and the rates of growth and profit in the various sectors were assumed to be uniform (Brancaccio, 2008). In this paper we intend to show that these restrictions can be removed from the original framework without altering the conclusions, which are indeed enriched with further significance. In particular, we shall see that in a context where profit rates are not necessarily uniform the monetary policy "rule" of the central banker can also have an impact on the solvency of the single sectors in the economic system.

A MONETARY SCHEME OF REPRODUCTION

We shall examine a capitalist system closed to trade with other countries. The actors involved in the analysis are workers, firms and their owners regarded as a whole, banks, the central bank and the possible addition of the public sector. As regards physical production, it is assumed that two goods are produced, corn and iron in this instance, by means of the goods themselves and labour. It is also assumed that there is only one technology, which is given, and that the means of production last for only one period. Both goods are regarded as "basic goods" in that each serves as input in the production of itself and the other. As regards circulation of money, it is assumed that at the beginning of each period firms require monetary loans from banks in order to finance the nominal wages paid to workers in advance and the purchase of means of production. The monetary loans and relative interests must be repaid at the end of the same period with respect of nominal wages and the end of the next period as regards the monetary value of means of production. The variables used in analysis are listed below.

- a_{jh} Technical coefficients of production: the quantity of good j needed to produce one unit of good h
- l_j Coefficients of labour: the quantity of labour needed to produce one unit of good j
- K_j Quantity of good j used as input in the entire economy at the beginning of every period
- X_j Quantity of good j produced at the end of every period
- p_j Monetary price of the production of good j calculated in terms of the "normal" rate of profit

q_j^α Quantity of good j consumed by agent α (for α=L by workers; for α=K by capitalists; for α=Z by the public sector or other centre of autonomous expenditure not generating productive capacity)
K Total monetary value of capital (i.e. of goods used as input)
W Monetary wage per unit of labour
r Normal rate of profit
i Interest rate
g_j Rate of accumulation of inputs needed to produce the output good of sector j
λ^α Proportion of goods consumed by agent α
γ_j Deviation of the rate of profit from its "normal" level r in sector j (if γ =1, the market rate of profit is equal to the "normal" rate)
δ_{jt} Deviation in period t of the monetary price of good j from the price corresponding to "normal" distribution (δ_{Jt}=1 means no deviation)
u_j Deviation in sector j of the degree of utilisation of productive capacity from its "normal" level (u_j=1 means no deviation)
s_k Propensity to save of capitalists ($0 < s_k < 1$)
Y Monetary value of total production gross of reinvestment
C Monetary expenditure on consumption
I Monetary expenditure on investment
Z Autonomous monetary expenditure generating no productive capacity (e.g. public spending)

The technical coefficient a_{jh} will serve here to indicate the quantity of the generic good j (input) needed to produce one unit of the generic good h (output). It should also be noted that in this system with just two sectors, the subscripts c and i will be adopted respectively for corn and iron. Every period corresponds to a period of production of the goods. The variables with no subscripts regard time t. The scheme consists of the following fifteen equations:

$$p_c = (1+r)l_c w + (1+r)^2 (p_c a_{cc} + p_i a_{ic}) \tag{1}$$

$$p_i = (1+r)l_i w + (1+r)^2 (p_c a_{ci} + p_i a_{ii}) \tag{2}$$

$$Y = \delta_{ct} p_c u_c X_c + \delta_{it} p_i u_i X_i \tag{3}$$

$$\begin{aligned} Y = {} & l_i u_i X_i w + \gamma_c r l_c u_c X_c w + \gamma_i r l_i u_i X_i w + \\ & + (1+\gamma_c r)^2 \left(\delta_{c(t-1)} p_c a_{cc} X_c + \delta_{i(t-1)} p_i a_{ic} X_c\right) + \\ & + (1+\gamma_i r)^2 \left(\delta_{c(t-1)} p_c a_{ci} X_i + \delta_{i(t-1)} p_i a_{ii} X_i\right) \end{aligned} \tag{4}$$

$$Y = C + I + Z \tag{5}$$

$$I = (1+g_c)(\delta_{ct} p_c a_{cc} X_c + \delta_{it} p_i a_{ic} X_c) +$$
$$+ (1+g_i)(\delta_{ct} p_c a_{ci} X_i + \delta_{it} p_i a_{ii} X_i) \tag{6}$$

$$C = (l_c u_c X_c + l_i u_i X_i)w + (1-s_k)[\gamma_c r(l_c u_c X_c)w + \gamma_i r(l_i u_i X_i)w] +$$
$$+ (1-s_k)[(1+\gamma_c r)^2 (\delta_{c(t-1)} p_c a_{cc} X_c + \delta_{i(t-1)} p_i a_{ic} X_c)] +$$
$$+ (1-s_k)[(1+\gamma_i r)^2 (\delta_{c(t-1)} p_c a_{ci} X_i + \delta_{i(t-1)} p_i a_{ii} X_i)] \tag{7}$$

$$(l_c u_c X_c + l_i u_i X_i)w = \delta_{ct} p_c q_c^{\ L} + \delta_{it} p_i q_i^{\ L} \tag{8}$$

$$(1-s_k)[\gamma_c r l_c u_c X_c w + (1+\gamma_c r)^2 (\delta_{c(t-1)} p_c a_{cc} X_c + \delta_{i(t-1)} p_i a_{ic} X_c)] +$$
$$+ (1-s_k)[\gamma_i r l_i u_i X_i w + (1+\gamma_i r)^2 (\delta_{c(t-1)} p_c a_{ci} X_i + \delta_{i(t-1)} p_i a_{ii} X_i)] =$$
$$= \delta_{ct} p_c q_c^{\ K} + \delta_{it} p_i q_i^{\ K} \tag{9}$$

$$Z = \delta_c p_c q_c^{\ Z} + \delta_i p_i q_i^{\ Z} \tag{10}$$

$$K_c = a_{cc} X_c + a_{ci} X_i \tag{11}$$

$$K_i = a_{ic} X_c + a_{ii} X_i \tag{12}$$

$$\lambda^Z = \frac{q_i^{\ Z}}{q_c^{\ Z}} \tag{13}$$

$$\lambda^L = \frac{q_i^{\ L}}{q_c^{\ L}} \tag{14}$$

$$\lambda^K = \frac{q_i^{\ K}}{q_c^{\ K}} \tag{15}$$

Equations (1) and (2) describe the system of prices. These are monetary prices determined as a function of the "normal" rate of profit and the monetary wage. These prices are strictly related to those reported in the common systems of prices of production typical of the Surplus approach. Compared to the usual formulations of production prices, the only substantial difference concerns the fact that here we assume two different durations of the production process, in the case of labour and in the case of other means of production. That is, while labour input at the beginning of each period contributes to the production of the output at the end of the same period, instead the inputs of the other means of production at the beginning of each period contribute to produce the output at the end of the subsequent period. This explains why the upside of the rate of profit calculated on the value of the means of production is squared. It is of course possible at any moment to transform the monetary prices represented in (1) and (2) in prices of production. Their presentation in nominal terms shall make it possible, however, to highlight the relationships between their possible deviations from what is described in the Surplus approach as the "normal" or "long-period" position of the economic system and the macroeconomic equilibrium conditions. Furthermore, with respect to the common prices of production, the monetary prices analysed in this scheme incorporate rates of profit which are calculated on the monetary value of wages paid at the beginning of the current period, and on the monetary value of means of production paid at the beginning of the previous period.[1] Equation (3) indicates the value of national production, (4) the distribution of national income between wages and profits, (5) the macroeconomic equilibrium, (6) the expenditure on investments and (7) the total expenditure on consumption. Equations (8), (9) and (10) describe the expenditure on consumption on the part of workers, capitalists and the public sector, and equations (13), (14) and (15) the proportions of the goods involved in the same. Only for the sake of simplicity, in equation (8) it is assumed that workers spend all their income for consumption. Finally, equations (11) and (12) give the quantities of corn and iron employed as productive inputs at the beginning of every period. For given levels of K_c and K_i available as inputs, the corresponding levels of X_c and X_i will indicate the production that can be obtained in conditions of "normal" utilisation of productive capacity.

The structure of the system is largely the same as in Brancaccio (2008). With respect to the original version, however, two major simplifying assumptions are removed here, the first being that there are no differences between sectors in rates of accumulation, in deviations from normal prices and capacity, and hence also in market rates of profit. These variables can instead differ here between one sector and the other. The sectors will therefore have different rates of accumulation g, different deviations δ from normal prices, different deviations u from normal utilisation, and different deviations γ from the normal rate of profit, all suitable specified by means of the respective subscripts. It should be clarified that the analysis of these deviations does not necessarily rule out the tendency towards uniformity of profit rates which is typical of the Surplus approach. Rather, this scheme can "photograph" the movements of the actual rates of profit around the single normal rate. It should also be noted that each of the rates of accumulation refers to the increase in the inputs required for the production of output in each sector.[2]

The second simplifying assumption eliminated here is that the rates of interest and profit are both negligible with respect to wages paid in advance. As a result of this elimination, the mechanism for the financing of productive activities, the formation of profits and the repayment of loans is altered as follows. First of all, it is confirmed the existence of two different intervals between loans and repayments, one for the wages paid in advance and the other for the funds needed to purchase means of production. The reason is that workers are paid at the beginning of every period and work and produce in that period; the means of production are also bought and paid for at the beginning of every period, but it is assumed that it takes exactly one period to produce them, which means that they can only be used in the following period. The length of the circuit of reimbursement is thus one period for wages and two for means of production. In other words, while a loan made at the beginning of a period will have to be repaid at the end of the same period in the case of wages paid in advance, it could be repaid at the end of the following period in the case of means of production. The rate of profit will therefore be calculated on wages or the value of means of production on the basis of different deadlines: a rate of profit on wages paid in advance that refers to a single period and a rate of profit on loans to purchase means of production that refers to two periods. This also holds of course for rates of interest.[3]

The last change with respect to the original scheme is that this version admits expenditure on consumer goods not only for workers but also for capitalists and the public sector. It is therefore necessary here to specify the distribution of the consumption of corn and iron of all three of the social parties considered.

A "SNAPSHOT" OF THE MONETARY CIRCUIT OF REPRODUCTION

The system described has 15 equations and 38 variables. On the assumption that the conditions of existence for an economically significant solution are in force, solving the system will involve setting 23 exogenous variables in order to obtain the remaining 15 endogenous ones. Let us examine some possible mathematical solutions for this system. As we shall see, they represent a sort of "snapshots" of the monetary circuit that try to capture some aspects of the so-called «actual» or «market» values in the sense of the long-period method on which the Surplus approach is based (Kurz and Salvadori, 1995, p. 20). Afterwards, we shall also analyse the "sequence" of the monetary circuit.

In attaining the solution of the system, as we shall see, an important role is played by the deviations u from the degree of "normal" utilisation of productive capacity and the deviations δ from monetary prices determined as a function of "normal" distribution. While the first kind of deviation has been widely addressed within the surplus approach (Garegnani, 1992; Kurz, 1994), the second one can be considered implicit in the monetary circuit (Graziani, 2003) and also in the theoretical schemes which link accumulation and distribution by assuming a normal utilisation of capacity on the basis of a Cambridge equation (Brancaccio, 2005). The choice between the one or the other option has usually been evaluated as a kind of theoretical crossroads between different ways of conceiving the macroeconomic adjustment. However, there is in principle no reason to consider these options as conflicting alternatives. In the present scheme, for this reason, both of them will be admitted. The solution of the system of equations can then be defined a snapshot because it captures "market values" which admit deviations from normal utilisation of capacity as in the "long-period" analysis, but can also differ from the "long-period" position because of deviations from monetary and relative prices corresponding to normal distribution.[4]

The determination put forward below rests on the following exogenous variables:[5]

$l_c, l_i, a_{cc}, a_{ci}, a_{ic}, a_{ii}, r, w, K_c, K_i, \delta_{i(t-1)}, \delta_{c(t-1)}, s_k, g_c, g_i, Z, \lambda^L, \lambda^K, \lambda^Z, \gamma_i, u_i, \delta_{ct}, \delta_{it}$

The remaining 15 variables will therefore be endogenous:

$p_c, p_i, X_c, X_i, \gamma_c, u_c, Y, C, I, q_c^{\,L}, q_i^{\,L}, q_c^{\,K}, q_i^{\,K}, q_c^{\,Z}, q_i^{\,Z}$

Alternatively, u_c could be regarded as an exogenous variable and δ_{ct} as endogenous. In order to solve the system, we shall assign r, w and technical coefficients l_j and a_{jh} so that equations (1) and (2) determine the prices p_j. Given the inputs K_j too, equations (11) and (12) determine the quantities X_j that can be produced in conditions of the normal utilisation of productive capacity. By replacing equations (4), (6) and (7) in (5) and equation (3) in (4), we obtain a system of two equations, (5') and (4') respectively, which make it possible to express the following two functions:

$\gamma_c\,(\delta_{ct}, \delta_{it}, \gamma_i, u_i; l_c, l_i, a_{cc}, a_{ci}, a_{ic}, a_{ii}, r, w, K_c, K_i, \delta_{i(t\text{-}1)}, \delta_{c(t\text{-}1)}, s_k, g_c, g_i, Z)$
$u_c(\delta_{ct}, \delta_{it}, \gamma_i, u_i; l_c, l_i, a_{cc}, a_{ci}, a_{ic}, a_{ii}, r, w, K_c, K_i, \delta_{i(t\text{-}1)}, \delta_{c(t\text{-}1)}, s_k, g_c, g_i, Z)$

The algebraic expressions of these two functions can be obtained by means of the solution procedure mentioned above, which is not discussed in full so as to avoid weighing down our exposition unduly. These functions make it possible to establish the macroeconomic equilibrium values both of the deviation γ_c of the market rate of profit in the corn sector with respect to the normal rate of profit, and of the deviation u_c from the normal productive capacity in the corn sector. Alternatively, if δ_{ct} is taken as an endogenous variable, (5') and (4') will be represented by the functions:

$$\gamma_c\,(\delta_{it}, \gamma_i, u_c, u_i;\ldots)$$
$$\delta_{ct}(\delta_{it}, \gamma_i, u_c, u_i;\ldots)$$

which can be interpreted in the same way as the previous ones with the sole difference that the deviation u_c from the normal level of productive capacity in the corn sector is taken as exogenous in this case while the deviation δ_{ct} from the normal price p_c is determined endogenously.

If the mathematical conditions of existence are met, the above procedure is the one required in order to obtain a solution for the system. It may now prove useful, however, to focus attention on the link existing between the scheme examined here and the original analysis in Brancaccio (2008). This can be done by working back gradually from the former to the latter and reintroducing the eliminated simplifying assumptions one at a time. Among other things, this will make easier to elucidate the equations of the system and offer an opportunity to note some previously hidden characteristics of the theory. Let us begin by reintroducing the assumption that the rates of interest and profit calculated on the wages paid in advance are negligible. The system takes the following form:

$$\begin{aligned}1+\gamma_c r = {} & \frac{1}{s_k\left(\delta_{i(t-1)}p_i a_{ic}X_c + \delta_{c(t-1)}p_c a_{cc}X_c\right)} \\ & \Big[\; Z - s_k(1+\gamma_i r)\left(\delta_{i(t-1)}p_i a_{ii}X_i + \delta_{i(t-1)}p_c a_{ci}X_i\right) + \\ & + (1+g_c)\left(\delta_{ct}p_c a_{cc}X_c + \delta_{it}p_i a_{ic}X_c\right) + \\ & + (1+g_i)\left(\delta_{it}p_i a_{ii}X_i + \delta_{ct}p_c a_{ci}X_i\right)\;\Big]\end{aligned} \qquad (5')$$

$$\begin{aligned}\delta_{ct}p_c u_c X_c + \delta_{it}p_i u_i X_i = {} & (l_c u_c X_c + l_i u_i X_i)w \;+ \\ & + \;(1+\gamma_c r)^2\left(\delta_{c(t-1)}p_c a_{cc}X_c + \delta_{i(t-1)}p_i a_{ic}X_c\right) + \\ & + \;(1+\gamma_i r)^2\left(\delta_{i(t-1)}p_c a_{ci}X_i + \delta_{i(t-1)}p_i a_{ii}X_i\right)\end{aligned} \qquad (4')$$

As stated above, given δ_{ct}, equation (5') makes it possible to determine γ_c. Once the values of δ_{ct} and γ_c are known, equation (4') therefore enables us to determine u_c. In more general terms, it can be said that equation (4') identifies all the combinations of u_c and δ_{ct} that are compatible with the macroeconomic equilibrium. It should be borne in mind, however, that it would also have been possible to assign a value to u_c and then use the system of (4') and (5') in order to obtain γ_c and δ_{ct}.

The values assumed by the variables δ_{jt} and u_j will depend on entrepreneurial decisions with respect to the various possible ways of bringing the value of production into line with monetary expenditure. Entrepreneurs can decide to deviate from normal prices, by modifying the δ_{jt}, or from normal utilisation of productive capacity by means of the u_j. It is of course legitimate to assume that they will act on both fronts in reality, identifying the combinations of variations in price and quantities considered most appropriate case by case. Therefore, we shall refrain from formulating any specific hypotheses as to entrepreneurial decisions on prices and quantities here, thus leaving the field open to changes in one or the other or both.

We now find ourselves with an intermediate solution midway between the present version of the scheme and the original one (Brancaccio, 2008), having reintroduced the simplifying assumption of negligible rates of interest and profit on wages but maintained the possibility of different rates of growth and profit in each sector. This hybrid case makes it possible to discern an important property of the production system, namely the interdependence of sectors, which remained hidden in various respects in the original version of the scheme. It should be noted in this connection that the decisions taken in one sector of production with regard to prices, quantities and rate of profit can have a crucial effect on the possible combinations of prices, quantity and profits in the other. One of the two sectors could even act as a driving force for the production system as a whole, forcing the other to adapt and keep in step. In formal terms, the predominant position of one sector with respect to the other could be represented through the appropriate selection of exogenous and endogenous variables but it is not a simple mathematical choice: it reflects a structural feature of the economy described by this scheme, which reveals a causal dependence of the dynamics of one sector from dynamics of the other one (on this point see Lunghini and Bianchi, 2004).

We can now complete the description of the procedure for the identification of a solution. Having obtained *Y* from equation (3) and *C* from (7), we can calculate *I* from (6). From equations (8), (9) and (10) together with (13), (14) and (15), it will then be possible to obtain the physical quantities of corn and iron consumed respectively by workers, capitalists and the public sector. Moreover, in this specific case in which one of the deviations from normal prices is endogenous, it can be ascertained at the strictly formal level that the consumption of workers, and hence also the real wages, constitute a residue determined at the end of the analysis. While the possibility of a change in normal real wages is not ruled out, in mathematical terms it will always take place through a change in the exogenous normal rate of profit, perhaps prompted by the constant pressure of monetary wage claims (if the contractual strength of workers changes) or coefficients of labour. The juxtaposition of equations (4') and (5') will now enable us to obtain the following equation, which describes the macroeconomic equilibrium:

$$Z + (1+g_c)(\delta_{ct} p_c a_{cc} X_c + \delta_{it} p_i a_{ic} X_c) + (1+g_i)(\delta_{it} p_i a_{ii} X_i + \delta_{ct} p_c a_{ci} X_i) =$$

$$= s_k \left[\delta_{ct} p_c u_c X_c + \delta_{it} p_i u_i X_i - (l_c u_c X_c + l_i u_i X_i) w\right] \qquad (6')$$

Let us now reintroduce the other simplifying assumption of the original scheme, namely that the various γ_j, δ_{jt}, $\delta_{j(t-1)}$, u_j and g_j are the same in the two sectors. In this case, equation (5') is greatly simplified and can be written as follows:

$$1+\gamma r = \frac{1}{s_k}\frac{\delta_t}{\delta_{t-1}}\left(\frac{Z}{\delta_t K} + 1 + g\right) \qquad (5'')$$

in which, by definition:

$$K = p_c a_{cc} X_c + p_c a_{ci} X_i + p_i a_{ic} X_c + p_i a_{ii} X_i = p_c K_c + p_i K_i$$

If it is also assumed that the propensity to save of capitalists is equal to 1, that $\delta_{jt} = \delta_{j(t-1)}$, and that the autonomous component of expenditure is zero, we obtain:

$$1+\gamma r = g \qquad (5''')$$

Under these simplifying assumptions, macroeconomic equilibrium corresponds simply to equality between the market rate of profit and the rate of accumulation.

THE "SEQUENCE" OF THE MONETARY CIRCUIT: LOANS AND REPAYMENTS

The mathematical solution described above is no more than a "snapshot" which captures the departures of the monetary circuit of reproduction from the "long-period" position. We shall now attempt to outline the "sequence" of the monetary circuit referred to the continuous reproduction of loans and repayments. First of all we shall focus on the start of the monetary circuit, which involves the loans made to firms by banks, and an initial definition of the macroeconomic equilibrium. Afterwards we shall examine the phase of the final repayment of these loans and especially the ability or otherwise of each sector to conclude the circuit of financing. It should be borne in mind that in describing the sequence of the monetary circuit, we shall again eliminate the simplifying assumptions contained in Brancaccio (2008) and return to a scheme which envisages both differing rates of profit and accumulation in the different sectors and non-negligible rates of profit and interest on the wages paid in advance.

We shall maintain the assumption that the normal rate of profit and monetary wages are exogenous variables. It is also assumed initially that firms utilise their productive capacity at the normal level: $u_c = u_i = 1$. If the techniques a_{jh} are known and the quantities of initial inputs available K_j are given, the quantities X_j to be produced are therefore also known as well as the distribution of the inputs between the productive sectors. Let us assume that the prices also correspond originally to their "normal" level: $\delta_{jt} = \delta_{j(t-1)} = 1$. The sequence starts with the loan applications submitted by firms to banks. One category of loan will serve to cover the wages that firms will have to pay their workers in order to produce the quantities X_j. This will be equal to:

$$\left(l_c X_c + l_i X_i\right)w$$

A loan equal to:

$$(1+g_c)(p_c a_{cc} X_c + p_i a_{ic} X_c) + (1+g_i)(p_c a_{ci} X_i + p_i a_{ii} X_i)$$

will also be requested for the purchase of means of production as replenishment and investment. Let us now go on to analyse the macroeconomic equilibrium. If we assume for simplicity that the autonomous component of aggregate demand Z is zero, the replacement of (3), (6) and (7) in (5) will give the following condition of macroeconomic equilibrium:[6]

$$\begin{aligned}\delta_{ct} p_c u_c X_c + \delta_{it} p_i u_i X_i = &\left(l_c u_c X_c + l_i u_i X_i\right) w + \left(1 - s_k\right) \left[\gamma_c r l_c u_c X_c w + \right. \\ &+ \left(1 + \gamma_c r\right)^2 \left(\delta_{c(t-1)} p_c a_{cc} X_c + \delta_{i(t-1)} p_i a_{ic} X_c\right) + \gamma_i r l_i u_i X_i w + \\ &\left. + \left(1 + \gamma_i r\right)^2 \left(\delta_{c(t-1)} p_c a_{ci} X_i + \delta_{i(t-1)} p_i a_{ii} X_i\right) \right] + \\ &+ \left(1 + g_c\right)\left(\delta_{ct} p_c a_{cc} X_c + \delta_{it} p_i a_{ic} X_c\right) + \\ &+ \left(1 + g_i\right)\left(\delta_{it} p_c a_{ci} X_i + \delta_{it} p_i a_{ii} X_i\right)\end{aligned} \tag{7'}$$

As the assumption of cross-sector uniformity in the rates of growth and profit has been abandoned, the macroeconomic equilibrium described above is in no way tantamount to sectoral equilibrium. The individual sectors can in fact be in a state of imbalance while maintaining the equilibrium indicated by (7'). It is therefore necessary to solve the problems of indetermination caused by an exclusively aggregate approach. To this end, and so as not to make the algebraic exposition unduly cumbersome, we shall reintroduce some simplifying assumptions, namely that capitalists save all of their income (s_k = 1) and that the autonomous component of demand generating no productive capacity is zero ($Z = 0$). These assumptions obviously modify equations (5) and (7). At the same time, they make equations (9), (10), (13) and (15) meaningless, as there is no longer any problem regarding the consumption of capitalists or the public sector. The condition of macroeconomic equilibrium thus becomes:

$$\begin{aligned}\delta_{ct} p_c u_c X_c + \delta_{it} p_i u_i X_i = &\left(l_c u_c X_c + l_i u_i X_i\right) w + \\ &+ \left(1 + g_c\right)\left(\delta_{ct} p_c a_{cc} X_c + \delta_{it} p_i a_{ic} X_c\right) + \\ &+ \left(1 + g_i\right)\left(\delta_{it} p_c a_{ci} X_i + \delta_{it} p_i a_{ii} X_i\right)\end{aligned} \tag{16}$$

The total value of production must be equal to the overall value of monetary expenditure, which corresponds to the total wage bill plus the demand for investments. As regards the sectoral equilibria of expenditure and income, their elucidation is not required for the purposes of our argument. Our objective now is to ascertain whether the firms are in a position to repay their loans, which can be done quite simply by comparing income and reimbursements regardless of the level and the distribution of the expenditure that generated them. The sectoral equilibria between expenditure and income can be elucidated here purely as an example. To this end, however, it will be necessary to introduce some simplifying assumptions with respect to the distribution of the workers' expenditure between corn and iron. If we assume for example that $\lambda_L = 0$, i.e. that workers spend all of their wages on corn, the sectoral equilibria of expenditure and production can be described by the following equations:

$$(1+\gamma_c r)\ l_c u_c X_c w + (1+\gamma_c r)^2 \left(\delta_{c(t-1)} p_c a_{cc} X_c + \delta_{i(t-1)} p_i a_{ic} X_c\right) =$$

$$= l_c u_c X_c w + l_i u_i X_i w + (1+g_c)(\delta_{ct} p_c a_{cc} X_c) + (1+g_i)(\delta_{ct} p_c a_{ci} X_i) \quad (17)$$

for the corn sector and:

$$(1+\gamma_i r)\ l_i u_i X_i w + (1+\gamma_i r)^2 \left(\delta_{c(t-1)} p_c a_{ci} X_i + \delta_{i(t-1)} p_i a_{ii} X_i\right) =$$

$$= (1+g_i)(\delta_{it} p_i a_{ii} X_i) + (1+g_c)(\delta_{it} p_i a_{ic} X_c) \quad (18)$$

for iron. The assumption as regards the sectoral distribution of workers' expenditure is of course arbitrary and can be replaced by any other. As pointed out, however, if our purpose is to ascertain the loan repayment capacity of each sector, then it is sufficient to compare reimbursements and income with no need whatsoever to consider expenditure and how it is divided between the goods produced. We shall therefore ignore demand and focus attention on the problem of the repayment of loans. In equations (17) and (18) total profit is calculated on the capital borrowed in the previous period and hence in terms of the deviation δ_j for that period. Now, out of the income obtained through the sale of their production, the firms will have to make the following repayments to the banks, the first term regarding the payment of wages and the second expenditure on investments:

$$(1+i)\ (l_c u_c X_c + l_i u_i X_i)\ w +$$

$$+ (1+i)^2 \left[\ \left(\delta_{c(t-1)} p_c a_{cc} X_c + \delta_{i(t-1)} p_i a_{ic} X_c\right) + \left(\delta_{c(t-1)} p_c a_{ci} X_i + \delta_{i(t-1)} p_i a_{ii} X_i\right)\ \right]$$

where i is the yearly rate of interests on bank loans. Only for the sake of simplicity we assume here that the interest rate is determined directly by the central bank. In other words, we assume that there is no difference between the interest rate that banks charge on loans and the rate of interest at which the central bank provides liquidity to banks. The reimbursements due respectively from the industries of corn and iron will be:

$$(1+i)\ l_c u_c X_c w\ +\ (1+i)^2 \left(\delta_{c(t-1)} p_c a_{cc} X_c + \delta_{i(t-1)} p_i a_{ic} X_c\right)$$

and:

$$(1+i)\ l_i u_i X_i w\ +\ (1+i)^2 \left(\delta_{c(t-1)} p_c a_{ci} X_i + \delta_{i(t-1)} p_i a_{ii} X_i\right)$$

As regards due dates, it should be remembered that there is an interval between the reimbursement of loans for the payment of wages and the reimbursement of loans for the purchase of means of production. It is in fact assumed that while the loans for wages contracted at the beginning of the period must be repaid at the end of the same, those for investments contracted at the beginning of a period can be repaid later, at the end not of the current period but the next, and that they will entail payment of a compound interest rate *i* set exogenously through negotiation between firms and banks. It should be noted in this connection that, net of the interest paid, the second term in the above expressions corresponds precisely to the investment of the previous period. In overall terms:

$$\left(\delta_{c(t-1)}p_c a_{cc}X_c + \delta_{i(t-1)}p_i a_{ic}X_c\right)+\left(\delta_{c(t-1)}p_c a_{ci}X_i + \delta_{i(t-1)}p_i a_{ii}X_i\right) =$$

$$= \left(1+g_c\right)\left(\delta_{c(t-1)}p_c a_{cc}X_{c(t-1)} + \delta_{i(t-1)}p_i a_{ic}X_{c(t-1)}\right) +$$

$$+ \left(1+g_i\right)\left(\delta_{c(t-1)}p_c a_{ci}X_{i(t-1)} + \delta_{i(t-1)}p_i a_{ii}X_{i(t-1)}\right) = I_{t-1}$$

Broken down to the sectoral level, this gives the following respectively for the industries producing corn and iron:

$$\left(\delta_{c(t-1)}p_c a_{cc}X_c + \delta_{i(t-1)}p_i a_{ic}X_c\right) =$$

$$= \left(1+g_c\right)\left(\delta_{c(t-1)}p_c a_{cc}X_{c(t-1)} + \delta_{i(t-1)}p_i a_{ic}X_{c(t-1)}\right) = I_{c,(t-1)}$$

and:

$$\left(\delta_{c(t-1)}p_c a_{ci}X_i + \delta_{i(t-1)}p_i a_{ii}X_i\right) =$$

$$= \left(1+g_i\right)\left(\delta_{c(t-1)}p_c a_{ci}X_{i(t-1)} + \delta_{i(t-1)}p_i a_{ii}X_{i(t-1)}\right) = I_{i,(t-1)}$$

It should be pointed out that the only assumption essential to the results of the scheme is that for at least one type of loan, its reimbursement takes place with a delay of one period. This delay repayment of loans allows firms to use current revenues to pay interests on loans contracted in the past. This makes it possible to avoid a problem that has given rise to a long dispute in debate on the circuit, namely the fact that in a system where loans are to be made and repaid in the same period, it would be impossible to pay the interest owed to the banks in money. Moreover, the same assumption lends plausibility to the existence of a multiplier of autonomous expenditure within the monetary circuit (see Brancaccio, 2005, 2008 for further discussion). All the other assumptions serve exclusively to simplify the algebra.

"SOLVENCY RULE" AND SECTORS IN A MONETARY SCHEME OF REPRODUCTION

When the time comes to repay their loans with the associated interest, the firms will be left with non-negative net profits only if their income from sales is no lower than the reimbursements due. Only in this case can the firms be regarded as solvent. At the aggregate level, the following condition must be met:

$$\begin{aligned}&(1+\gamma_c r)\ l_c u_c X_c w\ +\ (1+\gamma_c r)^2\left(\delta_{c(t-1)} p_c a_{cc} X_c + \delta_{i(t-1)} p_i a_{ic} X_c\right) +\\ &+\ (1+\gamma_i r)\ l_i u_i X_i w\ +\ (1+\gamma_i r)^2\left(\delta_{c(t-1)} p_c a_{ci} X_i + \delta_{i(t-1)} p_i a_{ii} X_i\right) \geq\\ &\geq\ (1+i)\ (l_c u_c X_c + l_i u_i X_i)\ w\ +\ (1+i)^2\ \left[\ \left(\delta_{c(t-1)} p_c a_{cc} X_c + \delta_{i(t-1)} p_i a_{ic} X_c\right) +\right.\\ &\quad \left. +\left(\delta_{c(t-1)} p_c a_{ci} X_i + \delta_{i(t-1)} p_i a_{ii} X_i\right)\ \right]\end{aligned}$$

This could be solved by replacing $\gamma_c r$ and $\gamma_i r$ with an average rate of profit. In order to ascertain the solvency of each individual industry, it will instead be necessary to focus on the difference between income and reimbursements in each sector. We will have therefore the following respectively for the industries producing corn and iron:

$$\begin{aligned}&(1+\gamma_c r)\ l_c u_c X_c w\ +\ (1+\gamma_c r)^2\left(\delta_{c(t-1)} p_c a_{cc} X_c + \delta_{i(t-1)} p_i a_{ic} X_c\right) \geq\\ &\geq (1+i)\ l_c u_c X_c w\ +\ (1+i)^2\left(\delta_{c(t-1)} p_c a_{cc} X_c + \delta_{i(t-1)} p_i a_{ic} X_c\right)\end{aligned}$$

and:

$$\begin{aligned}&(1+\gamma_i r)\ l_i u_i X_i w\ +\ (1+\gamma_i r)^2\left(\delta_{c(t-1)} p_c a_{ci} X_i + \delta_{i(t-1)} p_i a_{ii} X_i\right) \geq\\ &\geq (1+i)\ l_i u_i X_i w\ +\ (1+i)^2\left(\delta_{c(t-1)} p_c a_{ci} X_i + \delta_{i(t-1)} p_i a_{ii} X_i\right)\end{aligned}$$

If now we posit:

$$x = \gamma_i r$$

$$L_j = l_j u_j X_j w$$

$$K_j = \left(\delta_{j(t-1)} p_j a_{jj} X_j + \delta_{h(t-1)} p_h a_{hj} X_j\right)$$

it can be ascertained that the equation

$$(1+x)L_j +\ (1+x)^2 K_j =\ (1+i)L_j +\ (1+i)^2 K_j$$

with x unknown, admits two roots:

$$x_1 = -\frac{L_j + (1+i)K_j}{K_j}, \quad x_2 = i$$

If we discard the negative solutions for $\gamma_j r$, the two previous inequalities can only be satisfied if:

$$\gamma_c r \ \geq \ i \tag{19}$$

$$\gamma_i r \ \geq \ i \tag{20}$$

As can be seen from (5') or from (5''), for any given level of the deviation of the rate of profit in the iron sector, the deviation of the rate of profit in the corn sector depends on the rates of accumulation and the dynamics of prices. Then we can write: $\gamma_c = \gamma_c(g_c, g_i, \delta_{ct}, \delta_{c(t-1)}, \delta_{it}, \delta_{i(t-1)})$. If we now assume that the central bank's objective is to set a rate of interest consistent with the financial solvency of both sectors, then we can group (19) and (20) in the following condition:

$$i \leq min[r\gamma_i ; r\gamma_c(g_c, g_i, \delta_{ct}, \delta_{c(t-1)}, \delta_{it}, \delta_{i(t-1)})] \tag{21}$$

Condition (21) represents the "solvency rule" of the central banker which is derived from the monetary scheme of reproduction. This version of the rule differs from that contained in Brancaccio and Fontana (2013) in two respects. On the one hand, for the sake of simplicity this rule describes only "covered" financial positions in Minsky's sense which entail the complete repayment of loans at the end of each period, while the previous version took also into account the existence of "speculative" and "ultra-speculative" positions. On the other hand, this version does not come from a simple macroeconomic model but arises from a two-sector scheme of reproduction. The advantage of the rule expressed by (21) is that it clarifies that if the rates of profit between sectors differ from each other, the rule of the central banker should be tuned to the solvency conditions of the industry less profitable and the related processes of liquidation, acquisition and centralization of capital within that specific sector.

CONCLUSIONS

The solvency rule described here reveals some superficial similarities with the conventional Taylor rule. Suffice it to say that both rules determine the interest rate as a function of the same variables, such as inflation rates, or variables closely linked, as the rates of accumulation and growth rates of GDP, or variables conceptually substitutes, as the "normal" rate of profit and the "natural" rate of interest. However, the analogy between the two rules is only formal. In reality, they represent two alternative conceptions of monetary policy. Taylor sees his rule as indicating the intention of the central banker to calibrate interest rates in relation to the objective of ensuring the stability of inflation around the target rate, and the convergence of income towards its natural level determined on the basis of the neoclassical "fundamentals". The alternative approach suggests that the central banker has the very different task of adjusting interest rates and other monetary policy variables in order to set the solvency conditions in the economic system. The representation of this alternative view in the context of a two-sectors monetary scheme of reproduction allows to highlights a further implication of this alternative view: the solvency conditions set by the central banker can also have different effects on the different sectors in the economy considered. In this sense, the interest rate which derives from the "solvency rule" (21) is a sort of benchmark: depending on whether the actual monetary policy of the central banker is more or less restrictive with respect to that interest rate, the number of insolvent companies and entire industries may be higher or lower, and the related rhythm of liquidations, mergers, acquisitions and the related Marxian tendency towards "centralization" of capital will not necessarily be the same in the two sectors. The result is that any sort of "neutrality" of monetary policy must be excluded, not only from the points of view of the scale of production or the distribution of income, but also from that of the centralization of the capital in the economic system and in each of its sectors.

Footnotes

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[1]As we shall see, in this scheme monetary wages are paid at the beginning of each period while the basket of goods that make up the wage is bought at the end of the same period. For a different and more common setting, which also assumes that real wages are paid post-factum but does not consider advances of monetary wages, see Kurz and Salvadori (1995, p. 45). In any case, both the Surplus approach and the Monetary Circuit analysis can admit several hypotheses as regards the moment in which monetary and real wages are paid and spent. The important thing is to define precisely the monetary and physical concepts of "capital advanced" at the beginning of the production period and calculate the rates of interest and profit on it in a consistent way.

[2]This means, for example, that g_c refers to the corn sector in the sense that it corresponds to the rate of accumulation of the inputs of iron and corn required to produce the output of corn.

[3]In principle, these changes mean that we should admit as many rates of profit and interest as there are periods considered. It can, however, be assumed as an initial approximation that the rates of interest and profit are established within a span of two periods. As can be seen from the equations of the system, this makes it possible to distinguish the amounts of the rates of profit and interest for one period from those for two periods simply by squaring the latter. It should be pointed out that this assumption is in no way indispensable to attainment of the basic results of this scheme. It simply enables us to avoid uselessly overburdening the system with variables.

[4]On these concepts of "market" and "long-period" positions see Kurz and Salvadori (1995) and Petri (2004). Given that the "long period" position admits deviations from the normal utilization of productive capacity, it is important to distinguish it from the concept of stationary growth. On the differences between these definitions and the marginalist concepts of "secular", "long period" and "short period" (temporary and intertemporal) equilibrium, see also Brancaccio (2010).

[5]As we shall see, taking the inputs K_j as exogenous variables does not mean joining the logic of the marginalist concept of "scarcity" because the prices corresponding to normal distribution remain determined so as to ensure the conditions of reproducibility of the system, and with no reference to the equilibrium between endowments of given resources and their respective demands which is typical of the marginalist theories (see also Brancaccio, 2008, 2010).

[6]Despite the more general assumptions on which equation (7') is based, it can still be traced back to (6') by considering the fact that in (7') the value in square brackets is equal to the value of total production minus wages and that Z is equal to zero in (7').

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