A CYBERNETICS APPROACH TO THE SOVEREIGN DEBT CRISIS

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The purpose of this paper is to approach the sovereign debt crisis from a cybernetics perspective, as a system that includes several interrelated subsystems. We emphasize the dynamic nature and sustainability of the sovereign debt system. The paper also discusses the transition from a sovereign debt dynamic system to a sovereign debt crisis dynamic system, transition included in the feedback control loop of the dynamic system of national economy.

Key words: *sovereign debt crisis, cybernetics approach, dynamic system, national economy, feedback.*

JEL Classification: C22, H63, P4.

1. INTRODUCTION

The systemic approach to the national economy through the dynamics, feedback and self-regulation of internal mechanisms is determined by the multidimensional complexity of the micro, meso and macroeconomic systems, which are adjusted through macroeconomic policies.

Starting from the widening strategy of covering budget expenditures by making loans, sovereign debt is one of the tools which irreversibly influence the internal and external behavioral trajectories of the economic system, thus causing the economic system's response to internal and external changes.

The cybernetics of sovereign debt crisis requires a comprehensive approach, which should be framed into the macroeconomic system. The system corresponding to sovereign debt is composed of complex elements. These elements are interdependent (e.g. debtor-creditor relations, the amount borrowed, contractual terms, balance of payments etc.) and work together to achieve the desired objective (namely, covering the budget deficit).

2. THE DYNAMIC SYSTEM OF NATIONAL ECONOMY

The National Economy System (NES) is defined by the characteristics of a Complex Adaptive System (CAS). The study of processes within the national economy system is carried through aggregated indicators that comprise "flows and levels of connections and interdependencies" between the subsystems of the national economic system [1] (Scarlat & Chiriță, 2012).

3. THE DYNAMIC SYSTEM OF BUDGET DEFICIT FINANCING

Sovereign debt - a regulating instrument in the feedback mechanisms

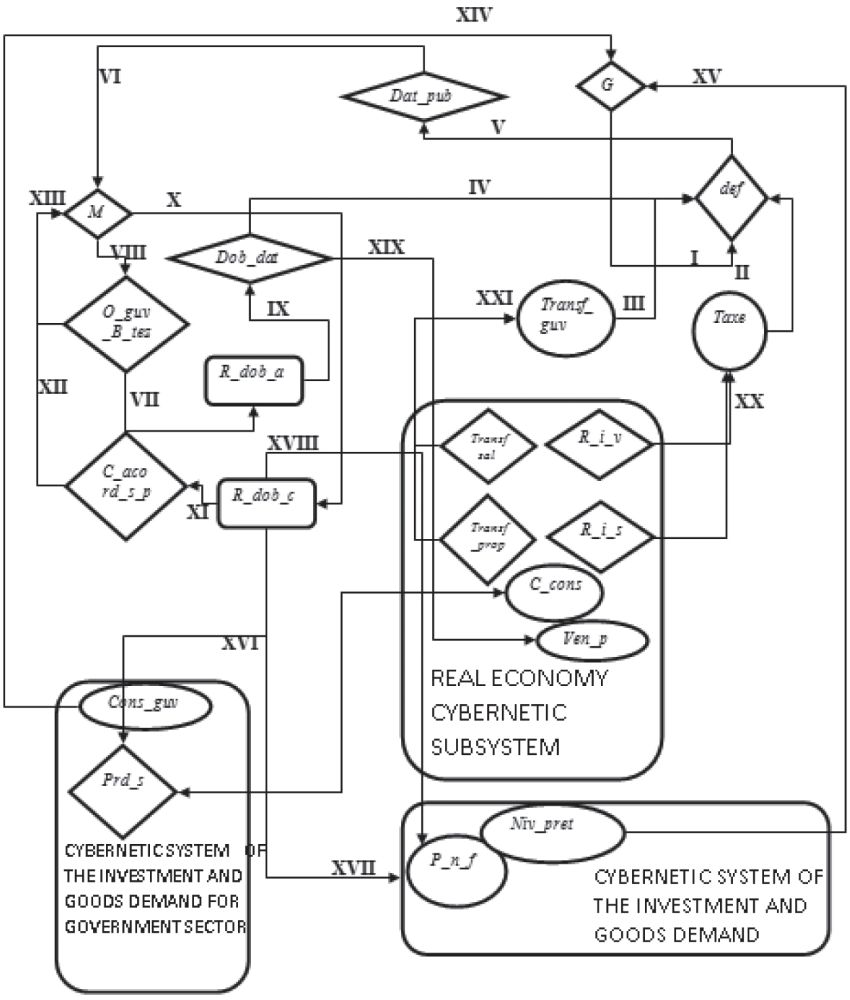

Fig. no. 1. The processes of budget deficit financing

for financing the budget deficit - requires a brief presentation of the budget deficit, according to [2] Scarlat (2005). The relationship defining the budget deficit is:

$$Def_t = Bud\_rev_t - Bud\_exp_t \quad (1)$$

where:

Def_t - The budget deficit at time t;

Bud_rev_t - Budget revenue at time t;

Bud_exp_t - Budgetary expenditure at time t;

The constituents of the process of budget deficit financing (**Figure 1**) are:

M – money supply;

O_guv_B_tez – is the value of government bonds and treasury bills;

C_acord_s_p – are the loans to the private sector;

Dob_dat – is the interest paid on public debt;

R_dob_a – is the interest rate on government assets level;

R_dob_c – is the interest rate on loans to the private sector;
Cons_guv – is the government consumption;
Prd_s – is the production volume stored;
P_n_f – is the net profit in the companies / businesses;
Niv_pret − the level of prices;
Ven_p − is the income from property;
C_cons − is the demand at consumers level;
Transf_prop − represents the money transfers directed to owners;
Transf_sal – represents the money transfers directed to employees;
R_i_s – represent the property tax rate;
R_i_v − represents the income tax rates;
Transf_guv – represens the government transfers;
Taxe − represents volume of the taxes and the duties;
def – is the value budget deficit;
Dat_pub – is the volume of public debt;
G – is the the volume of government spending.

Starting from the systemic approach of sovereign debt, it results that the Real Economy Cybernetic Subsystem is influenced through government transfers, taxes and duties. Moreover, a positive budget deficit will induce the rise of public debt, while a negative budget deficit will induce a decrease in public debt.

If the debt can be fully exchanged in coins, the volume of available money supply would exceed the values of CTD (current transactions demand), SMD (speculative money demand) and SD (security demand). At the same time, governmental strategies are oriented to achieving loans - whose aggregate value would amount to the total value of government bonds and treasury bills – relationship included in relationship (VIII). The interest rate for government assets (*R_dob_a*) is what determines the amount of interest paid on debt related (*Dob_dat*), conditioning shown through relationship (V). There also is an inverse relationship between the volume of money supply (*M*) and the

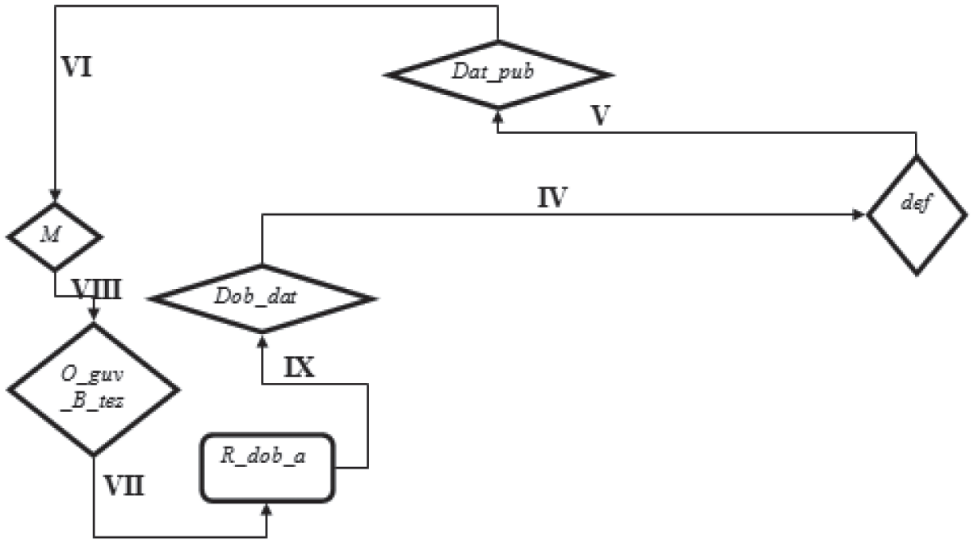

Fig. no. 2. The basic feedback loop formed at the level of the budget deficit financing system

value of government bonds and treasury bills (*O_guv_B_tez*), as emphasized by (XIII). On the other hand, *O_guv_B_tez* influences the value of the interest rate on government assets (*R_dob_a*). The volume of money supply (*M*) is strongly influenced by the level of loans granted to the private sector (*C_acord_s_p*), as evidenced in relationship (XII). Relationships (X) and (XI) highlight the inverse proportionality between the money supply (*M*) and the interest rate on loans to the private sector (*R_dob_c*) and respectively, the direct proportionality between *M* and the level of loans granted to the private sector (*C_acord_s_p*), An increase in the interest rate on loans to the private sector will lead to a diminishing consumption value. According to relationship (XVII), a significant interest rate on loans to the private *sector* (*R_dob_c*) will lead to a decrease in the net profit of companies (*P_n_f*).

The Monetary Economy Sistem (MES) affects the path of the Real Economy System (RES). But RES also has a major impact on MES, a phenomenon highlighted by relationships (XIV) and (XV), through government consumption (*Cons_guv*) and prices level (*Pr_lev*).

The basic feedback loop formed at the level of the budget deficit financing system is presented in figure 2. Therefore, the feedback loop presents in its structure reverse connections between its constituent elements. A growing trend in the annual budget deficit (*Def*) leads to an increased public debt (*Dat_pub*) and also to an increased risk of rising government debt. An increase in the volume of public debt leads to the need for a greater money supply and also to an increased volume of government bonds and treasury bills transactions (*O_guv_B_tez*), increasing the value of stock assets. Reducing the value of the interest rate on government assets (*R_dob_a*) - which is induced by the increased value of stock-type assets - determines a diminished value of the interest paid on public debt (*Dob_dat*). Subsequently, the feedback process reaches the starting point and ends with a diminished budget deficit. A negative status of the feedback loop designates the interrelation between money supply (*M*) and public debt (*Dat_pub*), in order to optimize the covering of budget deficit.

4. THE DYNAMIC SYSTEM OF SOVEREIGN DEBT AND ITS SUSTAINABILITY

According to Albu [3] (2008), the equation of budget constraints is considered the starting point for studying the dynamics and sustainability of sovereign debt and looks as follows:

$$\Delta dat = (\rho_t + r_t) dat_{t-1} + def_t + fin_t \qquad (2)$$

where:

$\Delta dat = dat_t - dat_{t-1}$ – the difference between government debt at time *t*, Dat_t, and government debt at time *t*-1, Dat_{t-1}.

r_t – the average nominal interest rate on public sector debt, at time *t*;

ρ_t – the coefficient of the revaluation effect of public sector debt at time *t*;

def_t – the primary deficit at time *t*, expressed as a percentage of GDP;

fin_t – the direct budgetary funding from the Central Bank at time *t*.

Optimizing the budget constraint equation implied dividing relationship (2) to the nominal rate of GDP, yielding to:

$$\Delta dat = def_t - fin_t + \frac{dat_{t-1}(\rho_t + r_t}{1+n_t} \quad (3)$$

where:

n_t – is the nominal growth rate of GDP in period *t* to *t*-1.

The nominal GDP growth rate will be regarded as the sum between the changes produced in the GDP deflator (*defl*) and the real GDP growth rate [4] (Albu, 2008). Equation (3) becomes:

$$\Delta dat = def_t - fin_t + \frac{dat_{t-1}(\omega_t - g)}{1+n_t} \quad (4)$$

where:

g_t – the real growth rate of GDP in period *t* to *t*-1.

w_t – the average real effective interest rate on public sector debt.

The iterative resolution of relationship (4) determines the dynamics of debt accumulation. We therefore have:

$$dat_{T=} dat_0 \lambda_T \sum_{j=1}^{T-1} (def_j - fin_j)\, \lambda_{T-j}$$

where: $\lambda = \frac{1+w+defl}{1+defl+g}$;

$defl$ – the GDP deflator.

A positive real growth rate of GDP induces a decreasing debt ratio in GDP.

Sustainability requires complying with the system limitations, which implies maintaining its continuous functionality to acceptable levels. Controlling the impact of economic activities upon the micro and macroeconomic policies in order to optimize the structuring and implementation of adequate policies is a good example in this direction.

According to Albu [4] (2008), the function expressing the sustainability of the sovereign debt dynamic system is:

S=((def-fin)/dat)+((w-g)/1+g+defl) (5)

where: *def* – is the he primary deficit as a percentage of GDP;

fin – direct budgetary funding from the Central Bank, relative to GDP; *w* – is the effective average interest rate on real public sector debt; *g* – is the real rate of GDP growth in the current time against reference period *defl* – is the GDP deflator; *dat* – is the government debt.

The first order condition of the sustainability function implies that relation (6) will converge to zero in dynamics or towards an infinitesimal constant amount. The switching from dynamic system of sovereign debt to the dynamic system of sovereign debt crisis is comprised in the control of the feedback loop, represented in **Figure 2** by the governmental risk of not being able to honor its term obligations towards foreign creditors, banks, etc. When this risk intensifies, the connections at the NES level change and, for a quick adjustment, NES will suffer major shocks, reflected in the harsh austerity policies adopted at the level of banking, government spending etc.

REFERENCES

[1] Scarlat, E., Chiriță, N. (2011-2012). *The cybernetics of national economy, Chapter 1: Structure and properties of the national economy as a Complex Adaptive System* (academic course), Faculty of Cybernetics, Statistics and Informatics, University of Economic Studies, Bucharest.

[2] Scarlat, E. (2005). *Cibernetica sistemelor macroeconomice reale, Capitolul 5. Structura şi funcţionarea Sistemului Cibernetic al Economiei* Reale,

ISBN: 978-973-709-183-3, p. 163, Editura Economică, available at: http://www.biblioteca-digitala.ase.ro/biblioteca/pagina2.asp?id=cap7, last accessed: 24.07.2014

[3] Albu, L.L. (2008). *A simulation model of public debt sustainability*, MPRA Paper No. 11713, University Library of Munich, Germany.

[4] Contessi, S. (2012). *An application of conventional sovereign debt sustainability analysis to the current debt crises*, Federal Reserve Bank of St. Louis Review, 94(May/June 2012).

[5] Constantin, A.M., Cristea, A. (2015). *Analysis of the macroeconomic causal relationships which can determine a country to enter a sovereign debt crisis*, 14th International Conference on Informatics in Economy, IE 2015, Proceeding of IE2015, ISSN: 2284-7482, pp.428-431, ISI Proceedings.

[6] Molănescu, G., Aceleanu, M.I. (2011). *Consecinţele deficitului bugetar în România în contextul crizei actuale. Implicaţii asupra pieţei muncii*, Economie teoretică şi aplicată, vol. XVIII, no. 2(555), pp. 58-74, available at: http://store.ectap.ro/articole/556_ro.pdf, accessed 22.07.2014.

[7] Online cybernetics course, available at: http://cyberproiect.3x.ro/, last accessed 25.07.2014

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