14. MODELS OF FINANCIAL SYSTEM FRAGILITY[1]

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Abstract

This survey analyses two types of models: 1. Models based on assumptions of monetary and financial market equilibrium disturbance, in line with mainstream thinking according to which if there is a self-regulating market the units would have rational expectations, and the crisis would be a temporary phenomenon caused by exogenous shocks. Here are the main objectives and features characteristic of three generations of models; 2. Models based on financial instability hypothesis, taking into account the dynamics of financial market, as well as the role of uncertainty, interdependency and dynamic complexity. We present here Minsky's concept of financial instability and then analyse the content of some simplified models.

Keywords: instability, model generations, balance sheet, hedge units, speculative units, Ponzi units, cyclical fluctuations, complexity

JEL Classification: C61; C62; C83; D84; E12; E13; E32; F44

1. Introduction

The financial instability and the economic crisis facing most countries in the world have become the hottest issues of economic research, public debates, and economic and financial policies. The debates imply critical comments on economic research and policy for their inability to forecast and prevent such phenomena and processes.

That the present crisis took even the specialists in this field by surprise is explained by the existing gap between mainstream thinking (aiming to explain and model the origins, the nature, the effects and the dynamics of crises) and real economic processes or, in other words, by systematic inconsistency of mainstream theory and its formalized tools with very complex, dynamic and uncertain realities subject to acceleration and multiplication, delay, propagation and contagion (Crotty, 1986;

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Kregel, 2007; Sau, 2010; Wray, 2008, 2009). We should also consider that economic and social processes are surrounded by dialectical penumbra or that they include qualitative elements that cannot always be expressed numerically and used in formalized models (Georgescu-Roegen, 1971), or require special conditions and forms for being expressed, modelled and interpreted (Rosser, 2000, 2005).

Because of the high level of financialisation and complexity of developed national economies and world economy (Epstein, 2005; Palley, 2007), the economic cycles of the last decades are determined by monetary-financial flows or, in other words, the evolution of the economies from one stage of the economic cycle to another is determined by significant changes in the monetary and financial flows. While several decades ago the models of economic cycles considered almost exclusively the fluctuations of real economy variables as determinants generating and initiating economic crises, in the last decades most models are mainly based on fluctuations of nominal variables and their power of contagion (chain reaction) due to the high degree of financialisation.

In the economic literature we find a wide variety of models dealing with financial crises and the impact of these crises on the real economy. These models can be classified by several criteria: the mode of interpreting the functioning of economies and markets, the openness of markets, methodologies, etc. Among these criteria, that concerning the interpretation of the functioning of financial markets is the most important. In fact, it determines how correctly the economic and financial phenomena and processes are seen, analysed and treated in relation to reality. According to this criterion, the models of financial crises may be classified into two large categories[3]:

- *Models based on the assumption of disturbing the equilibrium of monetary and financial market,* in accordance with the mainstream thinking, implying that this market is self-adjustable, the agents might have reasonable expectations and the crisis is a temporary phenomenon caused by exogenous shocks, which are placed in the centre of the analysis of the financial cycle.
- *Models based on the assumption of financial instability,* which consider both the dynamics of financial markets as processes and institutions and the fundamental role of uncertainty, interdependence and dynamic complexity of financial processes in relation to those of real economy (Keynes, 2009; Minsky, 1986, 1992a, 1992b; Goodwin, 1949, 1951; Hicks, 1950, 1974; Sau, 2010; Vercelli, 2000; Sordi, Vercelli, 2006).

One should note that in the last half century (after the dissolution of the Breton Woods system) several crises and events related to financial markets have occurred in the

[3] *When referring to causes of financial instability and crisis, Lina Sau (2010) points out that there are two approaches in economic and financial sciences:*

a. The traditional one (represented by the Chicago School and the New Macroeconomics), based on the assumption that there are efficient markets; this mode places the shocks of exogenous factor in the centre of the analysis of the financial cycle and analyses;

b. That based on the assumption of financial instability proposed and developed by Minsky and his followers; this assumption takes into account the dynamic complexity of financial markets as well as the significance of uncertainty and organic interdependence, which, in turn, cause speculative "bubbles" and financial instability.

world (in various countries and areas). Quite often, the crises that took place in Asian countries (in the 1990s) and Mexico and, especially, the 2008-2010 world crisis, which practically affected all countries of the world, are compared with the 1929-1933 Great Depression because of their extent, profoundness and losses. But at a closer look we find out that each crisis has its own context at different levels (Eichengreen, 2000, p. 3). When referring to causes and forms of manifestation of the crises, as well as to the classification of crisis models by generation, Krugman points out that models reveal a quite discouraging fact, that is, each crisis wave seems to choose a new style of model, which clarifies the crisis in accordance with reality or facts (Krugman, 2001, p. 1).

Below, we present a synthesis of the most representative contributions to modelling the crises of the financial system in accordance with the two assumptions mentioned above. In Section 2 we deal briefly with the three generations of models (as classified by Krugman) built in relation to the distortion of the financial market equilibrium and point out the main characteristics and limits. In section 3 we present the Minskian model in the variant developed by Taylor-O'Connell and Foley, and Section 4 includes a post-Minskyan variant developed by Vercelli and his colleagues, placed in the context of financial markets defined as fundamentally uncertain and interdependent complex dynamic systems that cause financial instability directly or by propagation.

2. Models based on the assumption of distorting the financial market equilibrium

The history of models dealing with monetary and financial crises begins with "A Model of Balance of Payments Crises" built by Paul Krugman in 1979 and the model "Collapsing Exchange Rate Regimes: Some Linear Examples" built by Flood and Garber in 1984, which were followed by many others. The authors confine these models to the context of facts and events and, according to this, within the limits of knowledge and methodologies and establish the research objectives, analyse causes and find the best solutions. In over 30 years, an impressive number of models dealing with monetary and financial crises have been built.

Considering the need to synthesize fundamental ideas and to ensure their compliance with realities at each analysed stage, Krugman (1999, 2001, 2010) classifies[4] the models of currency and financial crises into three generations of successive interpretations concerning the evolution of facts and events, the causes, the extent and forms of manifestation, and effects of these crises. His approach is based on the following three observations:

a) The monetary crises in early 1990s, caused by disequilibrium in the payment and budget balances and by speculative attacks, could be resolved by devaluation, revaluation, changes in monetary mechanisms (fixed exchange rate, floating exchange rate, changes in the width of floating bands, etc.) and

[4] *The first specialists who introduced the terminology for the first generation and the second generation of models of monetary and financial crisis were Eichengreen, Rose and Wyplosz (1995).*

readjustment to the mechanisms, without significant effects on real economy indicators (unemployment, production diminution, etc.).

b) The severe crises of the 1990s took place in Asia and Russia in the context of high mobility of capital, when the main problem was the macroeconomic policy concerning the speculative attacks.
c) There is a significant inconsistency of the models with currency and financial crises in the second half of the last decade and in the present decade (2001-2010).

2.1. The first generation of models

This generation began with the model built by Krugman (1979, 1990) and developed and refined by Flood and Garber (1984), according to which the exogenous factor is the cause of the crisis. This factor is represented by speculative attacks on economies in distress due to fiscal deficits and the diminution of currency reserves below the critical level.

Krugman's model is based on the following assumptions:

a) Authorities keep a fixed exchange rate until monetary reserves are exhausted and at that moment they make the currency float,
b) The deficits in the government's budget determine speculative attacks on pegged currencies,
c) All budget deficits are financed by domestic loans. In this case, investors exchange only part of the growth of the domestic loan supply and the shadow exchange rate is depreciated gradually. When it equals the current exchange rate, investors attack the fixed rate and exhaust the remaining reserves (Eichengreen *et. al*., 1995, p. 11).

Krugman's model and Flood and Garber's model were developed and expanded to include deviations from the purchasing power parity, the capital control, the uncertainty about monetary and fiscal policies, the portfolio optimisation by investors. All these expansions are described by models illustrating various types of speculative attacks that cause currency and financial crises in many countries.

The literature dealing with first generation models discusses the role of some additional factors able to explain the crisis dynamics, such as current account deficit, deviations of real exchange rates, effects on the cost of public debt service when expected devaluation and foreign currency loan implications occur in order to protect stability (Allen *et al*., 2002).

2.2. The second generation of models

According to this generation, crises represent the consequences of the conflict between the fixed exchange rate at a certain level and government's (political forces') wish to follow a more expansionistic monetary policy in order to solve the problem of unemployment, of economic growth, etc., which implies a change in the monetary parity and interest rate. The change in parity and interest rate determines the speculators' action, which leads to monetary crises and a new exchange rate balance. The second generation includes models that describe the monetary crises in European countries pertaining to the European monetary mechanism, ERM, between 1992 and 1993, and the monetary crisis in Mexico between 1994 and 1995. The

attack on these countries' currencies made researchers study more and find adequate conclusions concerning these speculative attacks and the fragility of monetary systems (with fixed exchange rates) (Flood and Marion, 1996, 1998). Moreover, it made the researchers expand the study to the dynamic characterisation of the episodes of the crises (of the recent ones, as well), on one hand, and create systems of early warning about monetary crises, on the other hand.

Obstfeld (1994) opened the way to new approaches on the assumption that crises are a consequence of the conflict between the fixed exchange rate and the wish of the political authorities and economic agents to follow a more expansionistic monetary policy, on one hand, and to adapt themselves to the changes in the currency market and the real economy, on the other hand. For example, when financial investors expect that the government may not prefer to maintain the same parity for foreign currency exchange, they manipulate the interest rate in order to cause the exchange rate modification (Blancas, 2007). Thus, one recognizes that a crisis might be caused by a response of the endogenous policy, namely that provided by the authorities that decide the devaluation in accordance with the trade-off between benefits and costs of the transition from the fixed rate regime to the floating rate regime (Allen *et al*., 2002, p. 10).

Besides the fundamental weaknesses of the system consisting in currency overvaluation and current account deficit, panic self-creation and stirring-up add up. For example, in Mexico, the investors' panic played a major role in provoking the crisis, since for the short-term foreign currency debts reaching maturity, the foreign currency reserves were not sufficient to cover the debt service, which explained and fully justified the investors' panic that produced the contagious effect on the entire economy (Allen *et al*., 2002; Obstfeld 1994; Drazen-Masson, 1994; Cole and Kehoe, 1996).

Many second generation models include solutions with multiple equilibriums for the exchange rate (Blancas, 2007; Allen *et al*., 2002; Krugman, 2010). The possibility of multiple equilibriums could be reinterpreted in the context of dealing with the balance sheet as a product of the inconsistency of liquidities in the governmental sector and private sector. Explicitly, the reinterpretation of multiple equilibriums based on inconsistency of liquidities may lead to the debt revolving crisis or banking crisis (Allen *et al*., 2002). Essentially, the second generation models express the vulnerability of the balance sheets of the governmental and private sectors and the fragility of the fixed exchange rate regime.

Both generations of models express the vulnerable character of the fixed exchange rate regime in relation to speculative attacks and shortcomings caused by keeping fixed rates to hinder economic expansion by limiting demand and, consequently, GDP growth and unemployment diminution.

Many of the monetary crises in the two generations of models did not cause significant negative effects on real economy in the form of economic recession. In Krugman's opinion (2010, p. 6-7), the positive side of the crises described by these generations of models should be appreciated. The fact that the foreign currency system yielded to speculative attacks proved to be positive for employment and GDP growth. In

absence of mechanical constraints required by fixed exchange rates, governments gained more freedom to raise demand within the new foreign exchange regime[5].

2.3. The third generation of models

The analysis of the 1997-1998 crises in Asian countries and Latin American countries represent the start of the third generation models. It differs from the first two generations both in objectives and in issues discussed. On one hand, this class of models takes into account the crisis causes and factors caused by the reforms aimed to liberalize markets and open economies, accompanied by profound changes in financial, economic and institutional mechanisms. On the other hand, this class of models exceeds the domain of the foreign currency crises, explained mainly by the depreciation in the nominal exchange rate and speculative attacks. Depreciation seems to be a symptom rather than a fundamental aspect of this crisis, as Krugman (2001, p. 8) points out. Moreover, the third generation of models takes into account the speculative capital, the confidence factor, the financial fragility in accordance with Bernanke and Gertler (1989)[6], the financial crisis, when the price of assets is crucial, and many others.

By passing from the foreign currency-monetary crisis issues to the monetary-financial crisis issues, the study scope becomes broader, more complex and more diversified. This is reflected in the large number of models built, in the variety of aspects analysed and in approaches. Most models tried to reveal and explain vulnerabilities of the private corporation sector, associated with those of the banking sector and the capital market and the imminent start of the crises at the same time with giving up protectionistic public policies and subsidies, as well as with the liberalisation of current account and capital account.

There are several variants to interpret the main causes and forms of the third generation crises.

The first variant deals with moral hazard as a common source of overinvestment, excessive foreign loans and current account deficits, mostly caused by hidden subsidies, government guarantees for private loans, etc. The elimination of such

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[5] *Krugman's joke is true to some extent when he says that the British should cast a statue of the speculator Soros, because after the 1992 crises provoked by him the pound changed status and could contribute to unemployment diminution and economic growth (Krugman, 2010).*

[6] *Eager to advance in defining financial stability, Bernanke and Gertler say that this stability depends on the net value of the potential debtors. This proposition is based on the following view: in general, the smaller the contribution of a debtor from his own value to his project is, the more divergent his interests are from those of the lenders. When a debtor has better information on his project or a capacity to take unseen action that affects the income distribution within the project, a bigger inconsistency of interests increases agency costs associated with investments. Financial instability (fragility) may occur when entrepreneurs, assume low net value investment projects based on sources external to the company. For unpredictable reasons (especially during early stages of economic development, lasting recession, debt deflation, etc.), a substantial increase in agency costs may occur, thus leading to lower return on investments and economy, in general (Bernanke, Gertler, 1990).*

practices causes imbalances, difficulties and panic in the economy (McKinnon, Pill, 1998; Corsetti, Pesanti, Roubini, 1999; Krugman, 1998)[7].

The second variant deals with the confidence-based banking. Losing confidence turns usually into precipitated action taken by financial agents liquidating the investments (Chang, Velasco, 1998; Diamond, Dybving, 1983; Blancas, 2007). Following this kind of reasoning, some authors (Sachs, Tornell, Velasco, 1996; Radelet, Sachs, 1998) underline in their models that a crisis might be caused not by fundamental factors, but mostly by unexpected panic of foreign investors, reflected in capital outflow, no loans, cash-flow rush, etc. In the absence of panic, such crises would have no reason to take place.

The third variant, developed by Krugman, reveals the leading role of corporate balance sheet in determining their capacity to invest and the role of capital flows, which – by assuming that the real exchange rate is affected – could impact on the balance sheet (Krugman, 1999, p. 3; Blancas, 2007, p. 6). Depending on the capital flow direction and, implicitly, on exchange rate and on their impact, the balance sheets may or may not support investments and, consequently, may or may not fuel the financial crisis. By means of a simple, modified version of the of Mundell-Fleming model containing three equations (aggregate demand, currency demand, reference interest equation), which includes, as specific additional computation elements, the interest rate, net exports and real exchange rate, Krugman relates the importance of the balance sheet result and the exchange rate level (Krugman, 2001, p. 9-11). The idea to take into account the balance sheet as a fundamental analysis and computation element opened a new chapter in crisis modelling. This idea was adopted for almost all approaches, including the alternative ones (outside the neoclassical trend).

The fourth variant of model is based on the effects of the financial market liberalisation as a factor stirring up crises. Here also we find various approaches. For example, Dell'Arricia and Marquez (2004) demonstrate that financial liberalisation leads to less option and less protection of the banks, which causes a potential increase in the periods of boom and collapse of loans within the cycle, and Martin and Rey (2005) show that the interaction between capital market liberalisation and financial frictions in asset markets causes investment boom and then financial collapse.

Rancière, Tornell and Westermann (2003, 2006, 2008) use in their model the same assumption, but expand the approach in order to determine both theoretically and empirically the link between economic growth and financial liberalisation and the two

[7] *For example, Mc Kinnon and Pill (1998) point out that, when reform and stabilisation programmes are implemented, countries prefer excessive foreign loans, which finally prove to be sustainable. Using a variant of Fisher's framework model, the authors formulated a model in which the short-term deviations from sustainable conduct are caused by the failure of financial markets. Since markets fail in the conduct concerning effective information between depositors and creditors, excessively optimistic expectations may occur in relation to the successful reform between internal residents, international investors and political authorities. Initially, improved economic performance and foreign capital inflows justify this optimism. But later, binds occur in relation to sustainability conditions and the economy goes into recession, financial crisis and capital outflow.*

dual sides of the latter: a) the relaxation of the constraints on loans and capital movement, which leads to increasing investment and speeding up economic growth; b) the stimulation of the systemic risk, which causes financial fragility and increases the probability of financial crisis and economic recession. These sides occur and produce effects simultaneously. The contribution of each one to economic growth differs from one country to another and it depends on the institutions of each country, the structure and characteristics of these institutions, the structure of the economy by branches (the share of tradeable goods and non-tradeable goods), and the economic policy.

To measure and analyse the connection between the systemic risk and economic growth, Rancière, Tornell, Westermann (2008) use a new additional tool called the skewness index[8] of loan increase. They distinguish between the following two types of frequently used development models:

- The economic boom is interrupted by rare and steep explosions;
- Up-and-down movements are more frequent, but more symmetrical and free of explosions.

Against the idea that financial liberalisation would not favour economic growth because it increases economic fragility and prepares the way for financial crises with severe negative effects on real economy, the above authors proved through applications to a panel of 58 countries and over-forty-year time series that liberalisation causes a faster economic growth on long term by relaxing the loan market and increasing investment.

3. Models based on Minsky's financial instability hypothesis

The three generations of models based on the financial equilibrium concept are too limited to provide satisfactory explanations and viable solutions. The transition to a new category of models based on the instability hypothesis means the interpretation of phenomena and processes according to a new concept that considers the random behaviour of contemporary financial markets, their complexity and fragility, the strong financialization and globalisation of the contemporary economy and the opening of heterodox and proposed by Minsky, is based on Keynesian, Schumpeterian and Marxian conceptual and methodological elements, besides the neoclassical ones (critically approached), which are still valid.

Keynes's and Schumpeter's works and the critical comments made on Asian countries, the USA and European countries were important sources for Minsky and his followers for a new approach and interpretation of financial crises within economic

[8] *The skewness index measures the asymmentry of a distribution and is computed as follows:*

$$sk = \frac{1}{n}\sum_{i=1}^{n}\frac{(y_i - \bar{y})^3}{var^{3/2}}$$

where: $\bar{y}$ *is average size and var is the distribution vatriation.*

cycles. Minsky (1975, 1982, 1986, 1992a, 1992b) developed the financial instability hypothesis as an interpretation, as he said, of the substance of Keynes's General Theory and as an attempt to confirm the significant characteristic of modern capitalism.

The financial instability hypothesis, as a theoretical argument of crises, is based on the following important findings:

1. Modern capitalist economy is based: a) on investments in assets and capital (accumulation) that follow a real schedule; b) on a sophisticated and complex financial system that is linked to the investment process and the real economy process.
2. Capital assets, able to produce income/profit, determine the economic agents to provide at present several amounts (including money borrowed from banks) for investments in order to obtain future return. Therefore, the present demand for investment goods depends on the size and intensity of expectations for future incomes, which expectations change rapidly, that is they have a high elasticity level. But the supply of investment goods is inelastic on short term. It changes only on long term. The highly optimistic expectations for future profit in conditions of widening gap between supply and demand raise the price of investment assets. The considerable rise in asset price is stimulated by the financial agency of banks and other financial institutions through loans, derivates, and sub-primes, which threaten financial stability.
3. There is a general trend in the financial system to become increasingly indebted especially during periods of prosperity, which causes increasing vulnerability because of the debt deflation crisis in conditions of tolerance of both debtors and creditors for the high leverage of the public and the private sectors.
4. To present realistically different financial situations in which economic units (households, companies, governmental units, banking and non-banking institutions and, by extension, national economies) find themselves because of the contradiction between expectations and current realities, Minsky takes into account the way the funding sources, on one hand, and fund utilisation in terms of cash flows, on the other hand, are managed, in other words, in what proportion they are:

- Internal sources (profit) and external sources (loans), and
- Debt service payment (interest + debt rate) and the new investment:

Profit + loan = new investment + debt service.

To classify economic units, Minsky also considers the three types of cash flow:

- from income (return),
- balance sheet flow (existing and inherited obligations or debts),
- portfolio flow (resulted from transactions in which capital and financial assets change hands or the owner).

Cash flows from incomes are at the basis of balance sheet flows and portfolio flows.

Considering these important findings, Minsky classifies economic units (including national economies) into the following three categories:

- *hedge units* for which the cash flows from realized and expected incomes are enough to meet any time the main payment obligations (debts) and make investments;
- *speculative units,* when existing and inherited payment obligations (debts) are bigger than collections from realized and expected incomes, so that the only way to meet the payment obligations is debt rollover or even debt increase. To refund debts a good functioning of financial markets is required;
- *Ponzi units*[9] represent the situation when, in most of the future moments, the payment obligations of the units exceed incomes, and these units have to increase debts to be able to pay the debt service. The Ponzi units (but less the speculative one) resort also to portfolio transactions to meet their payment obligations, i.e., selling assets or debts. The success or the failure of these transactions depend on the economic cycle phase when the price of assets rises (the prosperity phase) or it decreases (the crisis phase when the assets bubble blows up)[10].

The degree of financial instability or exposure of the economic system to the financial crises is closely linked to the share of each of the units mentioned above. A high share of hedge units ensures the robustness of the economic system. But a high share of speculative units and, especially, Ponzi units – in conditions of changes in the financial market (increasing interest or decreasing price of assets) – endangers the financial stability of the entire economic system and may stir up a financial crisis and economic recession.

3.1. Developments of the instability hypothesis in the Taylor-O'Connell Model

Although familiar with mathematics[11], Minsky developed his theory mostly by descriptive means. The first step towards the mathematical formalisation of Minsky's theory, which characterizes the crisis in a macromodel for a closed economy, was made by Taylor and O'Connell (1985). Two general assumptions are considered in this model: a) the total nominal value in the system, macroeconomically determined, is dependent on confidence and the state (stage) of the economic cycle; b) there is high degree of asset substitution in household portfolios under certain circumstances.

According to the above-mentioned authors, the first assumption may be properly understood if one adopts the postulate that the selection of assets by companies and households is not coordinated and companies invest in the physical capital for which they obtain funds by issuing shares and bonds and borrowing from intermediaries.

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[9] *This category is associated with fraudulent financial practices and is named after a person who – in early 20th century – used a pyramid-type game scheme, according to which gains come from incomes collected from new-comers.*

[10] *The transaction frequency may also cause a price decrease or the bubble blowing-up.*

[11] *Minsky graduated from the Faculty of Mathematics and was granted the degree of doctor in economics at Harvard. Among all his works, mathematical formulations are found in the following books: John Maynard Keynes, Columbia University Press, New-York, 1975 and Stabilizing an Unstable Economy, McGraw Hill, New York, 2008.*

Households use financial intermediaries for cash deposits, share buying, etc., which means directing their savings to companies. The market value of shares may substantially deviate from the accounting value of the capital, which means decisions for the portfolio restructuring taken by the population and institutional investors to cause financial troubles to companies and expose them to disequilibriums that fuel crises.

The second assumption regards the companies' cash rush. When panic occurs, interest rates rise, investments decrease and rates of return diminish as well. Therefore, the companies' value of capital assets and net value are on the decline. Thus we come to the phase of a debt deflation. This process represents financial disintermediation and partial disappearance of the value of capital assets. Both sets form a system analogue to IS-LM.

The model analyses the dynamics of the relation between the net corporate value, on one hand, and the rate of return and the interest rate, on the other hand, during different phases of the economic cycle. The stage of early boom is characterized by increasing rate of return, diminishing interest rate and increasing net corporate value. It is the phase when companies reach the hedge position. To expand business, companies raise more and more loans owing to high rates of return and low interest rates.

The peak of the cycle is characterized by a high debt level (a high ratio of debt to net corporate value) while the net corporate value diminishes. It is the stage when companies reach the *speculative position*.

The collapse stage is characterized by steep decrease in profit and confidence, accumulation slow-down, sudden diminution in the market price of assets, which all cause further decline in profit and investment as well as increase the leverage up to *insolvency (Ponzi)*.

Taylor and O'Connell show that bankruptcy might replace the high level of asset substitution, which causes dynamic instability in the stage of monetary contraction. Returning to Minsky's ideas, the two authors underline the importance of financial intermediaries for speeding up both the boom and the crisis due to the expansion and contraction of assets and bonds as well as of the production sector.

3.2. Developments of the instability hypothesis in the Foley Model

An important step in the theoretical and empirical approach to financial instability was made by Foley (2003) by changing the Minskyan model of the crises formalized by Taylor and O'Connell. According to critical comments made by Foley, the Taylor-O'Connell model, preserving the closed economy hypothesis, had to keep the Kaleckian relation of equality between the asset increase rate (g) and the saving rate (s), from return (r), namely, $g = sr$. This relation implies a sub-unit saving coefficient, $s < 1$, and, at the same time, a Minskyan regime of hedge units in which the rate of return is higher than the asset increase rate, $r > g$, which is contradicted by reality.

The adoption of the open economy hypothesis for the inflows (imports) of capital from abroad allows that the asset increase rate (investment rate) exceed the rate of return, $g > r$, which implicitly means that Minsky's speculative regime is accepted as a real and natural fact.

Foley analyses in his model the financial fragility not only at the company level, but also at the national economy level, as national economies are considered the totality of companies or their aggregate mean. He uses, on one hand, Minskyan criteria to comply with the three financial situations of the companies and national economies (hedged, speculative and Ponzi) while passing through the stages of the economic cycle (revival, boom, collapse) by comparing some specific indicators expressed either in absolute figures or in relative figures computed in two ways: by average rates and by marginal rates.

Foley uses Krugman's cash flow balance sheet method (1979, 1999), according to which the total of funding sources should be equivalent to total utilisation of funds. The specific indicators, expressed in absolute figures, refer, on one hand, to the funding sources and represent the net operational returns, R, and net loans, D, and, on the other hand, they refer to fund utilisation and represent investments (accumulations), I, and debt service, V. The two categories of funds, expressed through the above indicators, have the form of the following equivalence relation:

$$R + D \equiv I + V.$$

The above-mentioned indicators are used to define the three Minskyan financial states in which companies and national economies might be within the economic cycle:

Hedged situations, characterized by net cash flows higher or at least equal to the amounts representing investments and debt service in conditions when the new debts are equal or, at most, equal to zero:

$$R \geq V + I \text{ and } D \leq 0;$$

Speculative situations, defined by the existence of net cash flows higher or at least equal to debt service but smaller than the sum of debt service and investments and also when the new debts are higher or, at least, equal to zero and bigger than investment:

$$R \geq V \text{ but } R < V + I, \text{ and } D \geq 0 \text{ but } D < \mathrm{I};$$

Ponzi situations, characterized by the existence of net cash flows smaller than debt service and new debts bigger than investments and the sum of payments and debt service:

$$R < V, \text{ so that } D > \mathrm{I}.$$

Foley takes from the Taylor-O'Connell model also the notion of net corporate and national economy value, considered as the difference between the asset value, A, and total loan value, B, that is:

$$W = A - B.$$

This net value could rise $(\dot{W})$ by investments $(\dot{A} = I)$ and diminish by new borrowings $(\dot{B} = D)$, namely*):

$$(\dot{W} = \dot{A} - \dot{B} = I - D).$$

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*) *The point above the variables represents the derivate in relation to time (e.g.,* $\dot{W} = dW / dt$ *).*

If the net corporate value is zero or lower than zero ($W \leq 0$) the company becomes insolvent and creditors cannot recover the loans granted even by selling assets. Theoretically, the situation can also be extended to the national economy.

The position of the companies and the national economy in accordance with the three financial states and the evolution of these states in time can also be determined by means of variables like those mentioned above but expressed as indexes or average rates of the change in assets, debts, financial results, etc. related to one asset unit, as follows:

- asset growth (accumulation) rate: $g = \dot{A} / A = I / A$;
- rate of return : $r = R / A$, or $r = \pi X / A$, where: π is the share of return and X is the production value;
- the interest rate, representing the ratio of debt service to debt stock, i=V/B;
- new loan rate, d=D/A.

The definition of the financial states and the evolution of these states by combining the above-mentioned average rates is achieved as follows:

- The economy (company) is considered *hedged* if r > g > i, or r > i > g. In this case, the debt service is paid from return, and the new investments are made from return and loans;
- The economy (company) is considered *speculative* if g > r > i. When the interest rate rises, the debt service can be paid as long as there is return from productive investments (Schroeder, 2002, p. 14);
- The economy (company) is considered *Ponzi* if i > r. In this case, the debt service is paid by means of new loans. In this state, the economy becomes very vulnerable to a financial crisis.

Declaring an economy (company) insolvent is fully dependent on creditors' confidence in the capacity of that economy (company) to recover and generate incomes. If creditors perceive this capacity as a diminishing one, then their confidence decreases, which causes, on one hand, more expensive credits and even the failure to contract new loans, and, on the other hand, chain bankruptcy of companies, which produces a dramatic impact on real economy and social life.

The risk of insolvency decreases or even disappears when the return increases or the rate of return is higher than the interest rate: r > i. In this case, the economy moves directly from the Ponzi state to the hedged state.

Shaikh (1996) and, later, Schroeder (2002) proposed the use of marginal rates either instead of average rates or as an alternative of comparison, considering that in an essentially uncertain world this form could be a better guide for what companies expect to gain from new investments. For example, if the marginal rate of return functions as a signal for directing capital flows, then why could this rate not implicitly influence also the capital accumulation?[12]

[12] *The proposals consists of the following simple computation formulas based on differences:*

After applications, Schroeder found that the marginal rate of return tended to be more volatile than the average rate since it reproduced cyclical changes on short term in the aggregate demand, which questioned the idea that marginal rates could actually be a guide for making investments (Schroeder, 2002; Blancas, 2007, p. 25).

4. Cyclical fluctuations and financial instability in a post-Minskyan dynamic and structural interpretation

Important steps in modelling a financial crisis in a Minskyan tradition have been made by Vercelli (1999, 2000, 2009a, 2009b), Sordi, Vercelli (2003, 2006, 2010), Dieci, Sordi, Vercelli (2005) and others. Vercelli and his collaborators reinterpret Minsky's financial instability hypothesis, moving from the description of so-called moments to the description of dynamic processes and considering as analysis instruments the balance of net financial flows and the liquidity and solvency coefficients (rates) at unit level and aggregate level. Also, they explain cyclical fluctuations, redefine the financial instability states and the expectation extrapolation, and reconsider the Minskyan classification of units and economies according to their financial state. Sordi, Dieci and Vercelli describe the complex dynamic behaviour[13] of units and economies and the conditions of discontinuities[14], bifurcations and the chaos state of the economies,

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- *the marginal rate of return computed by the ratio of return change between two periods to asset stock change over the same periods:*

$$r' = \Delta R / \Delta A = \Delta R / I_{t-1}, \text{ where:}$$

$$\Delta R = R_t - R_{t-1}; \Delta A = A_t - A_{t-1} = I_{t-1};$$

- *the marginal rate of accumulation determined by the ratio of investment amount change to the asset amount change:*

$$g' = \Delta I / \Delta A = \Delta I / I_{t-1}, \text{ where:}$$

$$\Delta I = I_t - I_{t-1}; \Delta A = A_t - A_{t-1} = I_{t-1};$$

- *the marginal interest rate determined by the ratio of debt service to the previous year's loan amount:*

$$i' = \Delta V / \Delta B = \Delta V / D_{t-1}, \text{ where:}$$

$$\Delta V = V_t - V_{t-1} \text{ şi } \Delta B = B_t - B_{t-1} = D_{t-1}.$$

[13] *According to Rosser (2005), broad tent complexity includes four sub-domains (sub-types), known as the 4 Cs: 1) cybernetics, developed by Norbert Wiener (1961) and applied to economic sciences by Lange (1967), Forrester (1977) and others; the theory of catastrophe developed by René Thom (1972) and applied to economic sciences first by Christopher Zeeman (1974), Hal Varian (1979), Kaldor (1940); the chaos theory developed by Ed. Lorenz (1963) and other mathematicians and physicists and applied to economic sciences first by Robert May (1976), David Rand (1978), Strotz, McAnulty, Naines (1953), Goodwin (1967); Albu (2006, 2010); Purica (2006); small tent complexity, focused on heterogenous models including interacting agents and using computer simulations, was applied to economic sciences first by Fölmer (1974).*

[14] *Discovered by Poincaré during his research on the qualitative theory of differential equations, bifurcation is the fundamental element for analysing discontinuities in non-linear dynamic*

using a simple aggregate model with equations containing differences, as well as an amended and generalized version of the discrete-time non-linear multiplying-accelerating model built by Goodwin (1949, 1951, 1988).

The above-mentioned authors based their approaches on the Keynesian idea that the explanation of fluctuations and instability should consider dynamic incongruities between certain current realities and long-term expectations for a low-level probability of investments, of their rate of return and of other factors and ingredients[15]. Moving from the real economy to the nominal economy[16] we may come to the same explanation of the cause of instability, i.e., that one represented by the interaction between the evolution of current cash flows and the evolution of anticipated (intertemporal) cash flows considered at the unit level and aggregate level. This idea could be functional only by introducing the following indicators:

a) *Current liquidity coefficient,* k_{it}, resulted from the ratio of cash outflows, e_{it}, and cash inflows, y_{it}, in a certain period, t.

$$k_{it} = \frac{e_{it}}{y_{it}}. \quad (1)$$

The lower than 1 the coefficient is, the higher (in excess) the liquidity level is.

b) *Expected solvency coefficient,* k_{it}^*, measures the ratio of cash outflows and inflows expected within a time horizon, n, to the current interest rate, r, and is computed by the following formula:

$$k_{it}^* = \frac{\sum_{s=0}^{n} E[e_{it+s}]/(1+r)^s}{\sum_{s=0}^{n} E[y_{it+s}]/(1+r)^s}. \quad (2)$$

The expected financial solvency (sustainability) of the system is ensured when $k_{it}^* \leq 1$.

These two coefficients, as main variables, can be combined to create new dynamic analytical tools to express financial fluctuation and instability, and Minsky's taxonomic map can be expanded and made operational.

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systems. It regards the bifurcation of equilibria of non-linear dynamic systems at critical values (inflexions), i.e., when discontinuities or transitions to new qualitative states take place. The chaos theory and the theory of catastrophe are two distinct sides of discontinuity. Chaotic dynamics defines the sensitivity of dependence on the initial conditions so that a small change in an intial condition (in a variable or a parameter) causes very big changes, even distruction, on the dynamic trajectory of the system (Rosser, 1998).

[15] *Keynes, 2009, pp. 211-2.*

[16] *To a certain point, the relations within the money economy represent the mirror of real economy relations. Beyond this point, the money economy influences the real economy decisively and mostly in one direction (Epstein, 2008).*

Both the current liquidity coefficient and the expected solvency coefficient expressed as a ratio of cash outflows to cash inflows were placed in mutual relations in a Cartesian diagram (Figure 1) with coordinates (k_{it}^*, k_{it}), in which the horizontal line, called the liquidity line, starts from k_{it}=1 upwards of downwards, and the vertical line, called the solvency barrier, starts from k^*=1 to the left or to the right. Measures 1 are limit values. Exceeding values 1 means lack of liquidity and lack of solvency, respectively. Going below these values means liquidity surplus and additional solvency, respectively.

The Cartesian space created by coefficients k_{it}^* and k_{it} and used for studying financial fluctuations allows selecting a safety limit defined by an additional vertical line, which – being placed to the left of the solvency barrier – shows the minimisation of bankruptcy risk. Beyond this, the unit cannot go since solvency comes into question. The safety limit is denoted by 1 - μ. Parameter μ represents the aversion to risk that may take on the values (0 < μ < 1).

The definition of the above coefficients and the relations between them allowed Vercelli to classify the financial states of companies into six positions: over-hedged, hedged, hyper-speculative, speculative, hyper-distressed, distressed and characterize their place and dynamics within financial fluctuations.

Figure 1

Classification of companies by financial state

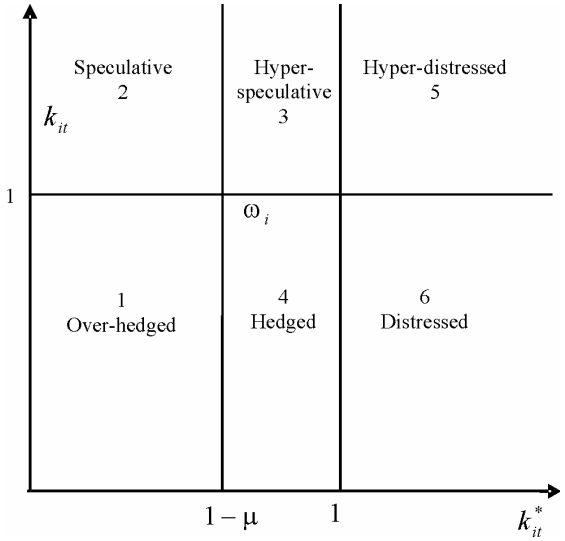

Figure 1 shows the map of the positions held by units classified according to their financial conditions and distributed according to the stages they go through within the economic cycle. The diagram also shows the liquidity line (k = 1), the insolvency barrier (k^* = 1) and the safety limit (1 - μ).

The dynamic study of financial conditions of a unit in the area defined by the two

coefficients (k_{it}^{*} , k_{it}) is based on the following assumptions:

a) Each unit prefers higher returns in unchanged conditions (*ceteris paribus*);
b) Financial returns are positively correlated in relation to the risk shown by the distance from the safety limit;
c) Economic units (including households) are characterized by the competitive behaviour and the "herd" behaviour caused by the market pressure and mass psychology, respectively.

Under these circumstances, a feedback occurs between the coefficients k_{it} and k_{it}^{*}, described by Vercelli by means of a model including Lotka-Volterra growth rates[17]:

$$\frac{k_{it+1}^{*} - k_{it}^{*}}{k_{it}^{*}} = \beta_i (k_{it} - 1) \tag{3}$$

$$\frac{k_{it+1} - k_{it}}{k_{it}} = -\alpha_i \left[k_{it}^{*} - (1 - \mu)\right] \tag{4}$$

where: $(k_{it+1} - k_{it}) / k_{it}$ represents the growth rate and $\alpha_i, \beta_i > 0$ represents the adaptation speed of unit i. Within this model describing the cyclical fluctuations of variables k_{it}^{*} and k_{it}, the equations have the logical basis presented below:

Equation (3) deals with relations between the extrapolated expected solvency value and current liquidity values, and it implies discussions and disputes against which Vercelli brought certain arguments that deserve consideration. When units see a realized current liquidity coefficient higher than 1 because of cash outflows in excess against inflows, they expect that this happen in the next periods as well. Even if the units are aware of the existence of financial cycles and anticipate a shift to financial inflows in excess over a longer period, their importance for making decisions is smaller because of the discount (capitalisation) of the values. Questioning the reasonable character of the expectation extrapolation, Vercelli considers that the extrapolated expectations proved unreasonable ex post only in proximity to the turning-point (crisis) of the cycles, since they are intrinsically unpredictable (Vercelli, 2009a, p. 12 and Sordi and Vercelli, 2009b);

Equation (4) shows that when the expected solvency coefficient has a value below the safety limit of a unit, the current liquidity coefficient tends to increase just as utility or return might do. On the contrary, as the safety threshold is crossed, the unit makes efforts to return to the safety area and tries to increase the liquidity level and diminish indebtness.

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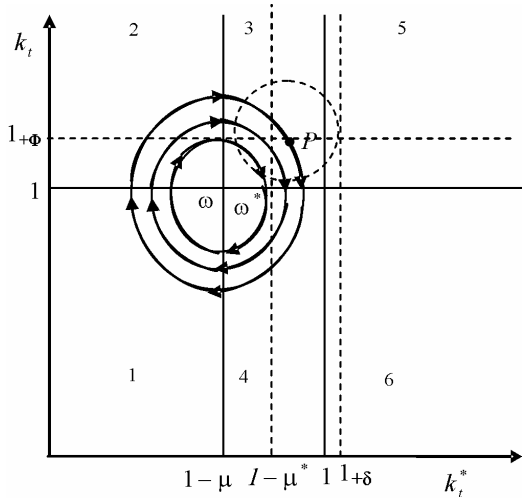
[17] *This type of model expresses the dynamic relation between plundering populations and plundered populations. The Lotka-Volterra model, known as "model of predator-prey interactions", consists of a pair of differential equations of first order, used to describe the dynamics of biological systems in which two species predator-prey) interact in nature. In economic sciences, this model, adopted accordingly, was used in 1967 by Richard Goodwin to describe economic fluctuations, by combining aspects of the Harrod-Domar growth model with the Phillips curve to generate endogenous cycles at the macroeconomic level. Moreover, the Lotka-Voltera model was extended by Steve Keen (1998) to the study of the debt–deflation process.*

The analysis of the stages in the diagram of the above-mentioned model concerning the dynamics of the financial state of the units as described by variables, (k_{it}^* , k_{it}), shows that this state fluctuates clockwise in an orbit around the centre, $\omega_i \equiv (1-\mu,1)$, located in the intersection point of the variables with values k_{it} = 1 and k_{it}^* = 1-μ (Figure 2). Centre ω represents an equilibrium state in the sense of the dynamic term (Vercelli, 2009a, p. 13).

There is an infinit number of possible orbits around centre ω , which depend on the initial conditions and various (external and internal) shocks. The shocks causing an increase in variables k_{it}^* and k_{it} change the representative points in external orbits that reach large areas beyond not only the safety limit, but also beyond the solvency barrier as well as beyond the liquidity line and this leads to the instability state of the system. Varicelli's model can explain this trend. For this purpose, we must consider the relation between mass (group) psychology and the formation of expectations in a highly financialized world (Epstein, 2008; Palley, 2008). According to this relation, the state of a long-lasting boom causes an increasing euphoria of exaggerated confidence in expectations and the weakening of the capability to perceive a risk, which materializes in the expansion of the sub-primes and the broad expansion of the derivates, which stimulates an exuberant growth of the loans for investment and consumption along with the relaxation of the guarantees for loans.

Figure 2

Financial fluctuations: Dynamic and structural instability



All means that the safety limit of the system traced in the diagram, (1 - μ), changes to the right, (1 - μ^*). Therefore, this change causes the extension of the stage, when the representative point (equilibrium point, P) moves upwards and to the right close to the insolvency barrier, and many more fragile units are pushed over this barrier on the way to bankruptcy (Figure 2).

When the number of such units is high and their size and impact on the economy are significant, the system undergoes changes, moving gradually to the instability state (departure from the dynamic equilibrium state) and, consequently, to chaos.

To make the above-mentioned model operational, Sordi and Vercelli considered the requirement that the feedback between the current liquidity coefficient, k_{it}, and the expected solvency coefficient, k_{it}^*, should be expressed in difference equations to characterize the unstable behaviour of the dynamic system.

These equations take the following form:

$$k_{it+1}^* = k_{it}^* + \beta(k_{it} - 1) \quad (5)$$

$$k_{it+1} = k_{it} - \alpha\left[k_{it}^* - (1-\mu)\right] \quad (6)$$

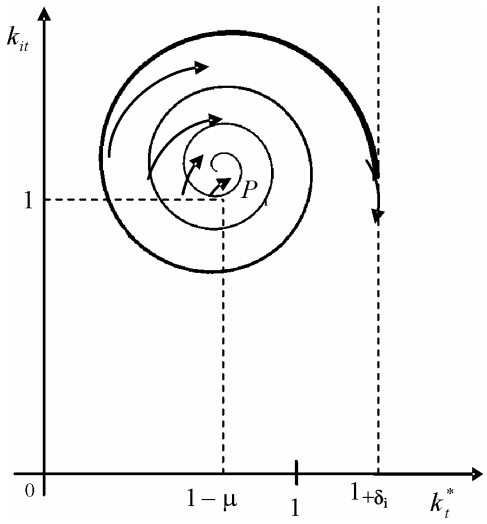
The same dynamic system can also take an aggregate form per representative units in which the current liquidity rates and the financial intertemporal solvency rates should represent average amounts.

By means of the graphic representation of the system of relations presented above (Figure 2) we can find that the system instability (where $k_{it}^* > 1$) is reached gradually, starting from the singular point, $P_i \equiv (1-\mu_i, 1)$ by the interaction of the current financial constraints and the intertemporal ones, unless certain barriers or ceilings are set.

For example, we may get an intertemporal financial coefficient lower or, at most, equal to $1+\delta_i$, set as a maximum limit (barrier) up to which a financial unit can be exposed, and this is generally accepted by creditors. The value $1+\delta_i = k_i^*$ redefines the financial instability of the unit with parameter δ_i in a certain area in relation to the financial position and the confidence in the unit or the financial system.

Figure 3

The diagram of the dynamic system stages



Dieci, Sordi and Vercelli extended the analysis of the financial system fragility to the entire economy using. To build the model, they assume that the system as a whole does not enter an area of intertemporal financial rates higher than unit[18]. This assumption determined the authors to reformulate equation (5), i.e., the right side should be below or equal to 1 to be valid. The discrete dynamic formalisation of the intertemporal financial rate may be rewritten as follows:

$$K^*_{t+1} = \begin{cases} K^*_t + \beta(K_t - 1) & \text{if } K^*_t + \beta(K_t - 1) \leq 1 \\ 1 & \text{under changed conditions} \end{cases}$$

or, synthetically:

$$K^*_{t+1} = min\{K^* + \beta(K_t - 1), 1\}$$

When it comes to the entire economy we should consider that the total cash outflow, E_t, is the sum regarding the endogenous private aggregate outflows, E_t^{pr}, and the public exogenous net aggregate outflows, E_t^{pu}, that is, $E_t = E_t^{pr} + E_t^{pu}$. In turn, the public net cash outflows represent the summing-up of public deficit, D_t, and the exchange of the currency in circulation, ΔM, i.e. $E^{pu} = D_t + \Delta M$, and the public deficit represents the difference between public expenditure, G_t, and revenue from taxes and other collections from the private sector, T_t, i.e., $D_t = G_t - T_t$. If the public net cash outflows are positive, $E_t^{pu} = D_t + \Delta M_t > 0$, this means an inflow in the private sector of additional amounts of cash flows equal to those going out from the public sector[19].

As for accounting, there is equality between aggregate cash outflows from buyers, E_t, and the aggregate cash inflows, Y_t, from sellers. Still, we should consider that there is a lag between cash inflows and outflows of the financial units: $E_t = Y_{t+1}$.

Considering the above description, the authors formulated the following non-linear dynamic system:

$$K^*_{t+1} = min\left[k^*_t + \beta\left(\frac{E_t - E_t^{pu}}{Y_t} - K^*_t\right), 1\right] \quad (7)$$

$$K_{t+1} = K_t - \alpha\left[K^*_t - (1-\mu)\right] \quad (8)$$

$$Y_{t+1} = E_t \quad (9)$$

$$E_{t+1} = \left\{K_t - \alpha\left[K^* - (1-\mu)\right]\right\}Y_t + E_t^{pu} \quad (10)$$

which remains valid if:

$$K_{t+1} = K_t - \alpha\left[K^*_t - (1-\mu)\right] \geq 0\,. \quad (11)$$

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[18] *It is important to note that this assumption is not valid at the unit level since units may become bankrupt and, consequently, reach or even go beyond the barrier* $1+\delta_i$.

[19] *The situation can be reversed, when the public net cash outflows are negative* $E_t^{pu} = D_t + \Delta M_t < 0$. *These two situations generate two categories of important political regimes concerning the dynamic behaviour of the macroeconomic system: inflation and deflation.*

The model includes the condition of non-negativity of the dynamic variables and, besides, K^* may be considered a measure of the fragility of the entire economy.

By numerical simulations, the authors show that the dynamic model presented could produce endogenous fluctuations in the current and intertemporal financial rates of a remarkable sensitivity. The trajectory and the quality of these fluctuations depend on the key parameters, α and β, and various possible cases of values may receive specific interpretations as follows[20]:

- When key parameters, α and β, take very low values, the system reaches a long-term stationary stable state.
- When parameter β is small and the response of parameter α is high enough (but in a normal state, $0<\alpha<1$), fluctuations occur along a continuously closed attracting curve that is touched by the system independently of the initial state.
- For very high values of parameters α and β there is a strange attractor when the system dynamics is chaotic. In this case, a ceiling of variable K_t^* changes the nature of financial fluctuations, from even to uneven.
- When parameter α is high and parameter β is conservative there is a special regime in which a stable stationary state coexists with a closed attracting curve. The ceiling of variable K_t^* seems responsible for the sudden appearance of an attractor and for the complicated structure of the attractor pools.

Such qualitative analyses based on numerical simulations are necessary to acquire profound knowledge of the evolution and behaviour directions of the variables and the parameters and orientate the anti-crisis decisions.

5. Conclusions

In this survey, we review the main results obtained in the field of modelling the fragility of the monetary and financial system from a conceptual and methodological perspective.

Since such a vast issue was dealt with in a limited space, many aspects and valuable models were left aside. The space did not allow us to make more comments on the works and ideas and of other important authors who made contributions to this field or even initiated profound research of high complexity and technicality such as: Fisher, (1933); Fölmer (1974); Goodwin (1988, 1990); Hicks (1950, 1974); Keen (2000); Kregel (2007); May (1976); Rosser (2005). In this respect, we give the following illustrative examples: the use of the multiplier and accelerator in defining and diminishing the fragility o the fiscal system, the widening of the domain of models

[20] *Parameter α measures the speed at which the current financial rate, K_t, responds to the deviation of the intertemporal financial rate, K_t^*, from the safety limit, 1 – μ. High values of parameter α means an overreaction of the financial units. Parameter β measures the intensity at which the current financial rate affects the future (expected) financial constraints represented by the intertemporal financial rate.*

regarding the explicit use of the theory of catastrophe and the chaos theory to interpret and describe financial instability, the connections between financial instability and the instability of the real economy, the construction and use of systems able to signal financial instability and the definition of the conditions for the transition from the chaos state to the normal state of the system during the cyclical financial fluctuations, the impact of the inflationary political regime and of the deflationary one on the qualitative characteristics of the dynamic behaviour of the macroeconomic system.

But by our presentation we tried to cover the most significant part of the research outcome in the field, starting with comments on the early generations of models and going on with more recent models that seemed adequate to explain the instability of the present financial system.

It is a known fact that Marx, Schumpeter, Keynes and Minsky are the economists who openly discussed the problem of the stability and instability of the economic and financial capitalist system. This caused a real gap among economists and publications as regards the approach to the matter: those who further trusted the traditional thought, called orthodox, and those who joined without reserve the new trend called the new economics. The fact that both groups – although they made important scientific contributions – ignore one another is quite harmful. Paying attention to the conceptual and methodological contribution of both groups, beyond any ideology, for explaining and interpreting financial instability means more opportunities to expand the knowledge horizon and more theoretical and practical approaches and solutions.

A heterodox approach is more and more requested (Colander, Holt, Rosser Jr., 2007; Voinea, 2009) since this means, on one side, considering the multitude of opinions, methodologies and solutions for covering the huge variety of aspects of the countries' economic and social reality, and, on the other hand, meeting the expectations of the society with regard to economic research, which has to increase its contribution to signalling and monitoring financial and economic instability and providing solutions for overcoming the crisis.

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