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European Economies' Stability Faced With Potential Outburst of Sovereign Debt Crisis. An Empirical Study Using Neural Network

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ABSTRACT

Instilment, on a European level, of a state incompatible with the state of stability on a macroeconomic level and in the financial-banking system lead to continuous growth of vulnerability of European economies, situated at the verge of an outburst of sovereign debt crises.

In this context, the current paper's main objective is to produce a study regarding the vulnerability of European economies faced with potential outburst of sovereign debt crisis, which implies quantitative analysis of the impact of sovereign debt on the sensitivity of the European Union's economies. The paper also entails the following specific objectives: completing an introduction in the current European economic context, conceptualization of the notion of "sovereign debt crisis", presenting the methodology and obtained empirical results, as well as exposition of the conclusions.

Indexing terms/Keywords

Economic vulnerability; sovereign debt crisis; artificial neural networks.

Academic Discipline And Sub-Disciplines

Macroeconomics, Finance, Artificial Neural Network, Mathematical Modeling

SUBJECT CLASSIFICATION

Social science, Computer Science

TYPE (METHOD/APPROACH)

Quantitative Study

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INTRODUCTION

The current macroeconomic trajectory, dominated by risk and incertitude, is faced with growing vulnerabilities on the background of effects caused by the global economic crisis and its components: monetary crisis, financial crisis, sovereign debt crisis, etc.

By referring to existent causality between constituting elements of behaviors afferent to strong economies, dependent on imports and exports, we may say that the continual frailty of commercial relations in countries characterized by import/export lead to a drop of credibility in financial-economic credibility. The exchange rate, element which characterizes economic-commercial relations between countries, generated more and more unpredictable behavior, due to the impact of socio-economic factors (such as: transitional factors, stock factors, political factors, sustainability factors, juridical factors, etc.) on micro and macroeconomic endeavors on the international scene.

The sensitive component of an economic crisis, the sovereign debt crisis, is a phenomenon induced by considerable growth in the degree un macroeconomic unsustainability, in countries heavily reliant on international economic relations.

Currently, in the European Union, we may speak of an increase in economic-commercial instability between member states, as international rapports tend to constantly alter.

A concrete example in this sense is the case of Greece. If, in the year 2010, Greece was in a sovereign debt crisis, followed by difficult years for the Greek economy[1], it is now on the verge of a "divorce" with the International Monetary fund, according to America's Wall Street Journal.

Another representative case is given by Hungary's situation, which fully reimbursed a loan taken from the IMF in 2009[2], thus increasing its immunity in front of the rest of the European countries.

In countries such as: Portugal, Spain and Italy the increase of instability in the banking system is felt, the latter being in danger of losing 250 billion euros, according to Agerpres (information was furnished on the 10th of October, 2013).

On the other hand, financial instability is also felt in other countries, such as the US, Pakistan, etc. The US is undergoing a budgetary crisis, which is hampering increase of the debt ceiling.

In this context, countries that were unable or late in reimbursing loans, according to rules imposed when the loan was granted, or countries that plan to take loans from the IMF have a high probability of entering a sovereign debt crisis.

According to Stancu, Constantin, Voinescu (2012), the European Union is still at the top of areas most affected by the recent financial crisis, as in its case:

- Regulating governmental spending is difficult;
- Monetary mass emission is difficult;
- Implicating monetary funds, which leads to larger external debts.

The current paper concluded a study regarding the vulnerability of European economies faced with a potential outburst of sovereign debt crisis.

SOVEREIGN DEBT CRISIS

A sovereign debt crisis can be induced, at any time, by problems existing in the European Union, particularly, the Eurozone.

The concept of "sovereign debt crisis" signifies the situation in which a country is characterized by lack of liquidity or insolvency. To be more precise, the sovereign debt crisis[3] in a country is activated only when a country can no longer honor set date liabilities, which establish themselves as sovereign debt. Sovereign debt is the kind of loan taken out by a country to balance macroeconomic behavior.

It is worth mentioning that the illusion "salvation through the Euro"[4] in national markets lead to creating circumstances favorable for the outburst of sovereign debt crisis. Dinu Boboc, in the article *Europa, din nou în fibrilaţii: Criza datoriilor suverane, gata să revină*[5] [n.a: "Europe requires defibrillation once more: the sovereign debt crisis, ready to return"],

[1] In the year 2011 the IMF gave Greece, forced to adopt and apply austerity measures, a 110 bn. Euro loan.

[2] International Monetary Fund

[3] In other words, a country finds itself in the sovereign debt crisis if:

- there are consistent arreas regarding debt pays or external interest obligations of commercial creditors (banks or stockholders) that surpass 5% of total remaining debts;
- there is a rescheduling or debt restructuring agreement with commercial creditors which is found in the GDF (Global Development Finance).

Source: Stancu, S., Constantin, A.M. et al. (2013)[a]

[4] Which generated increased budgetary deficits.

[5] Published on site manager.ro on the 3rd of July

claims that Portuguese government problems and the delicate state of Greece are considerable signs that Europe might be forced to face the sovereign debt crisis once again.

STUDY REGARDING THE VULNERABILITY OF EUROPEAN ECONOMIES FACED WITH A POSSIBLE OUTBURST OF SOVEREIGN DEBT CRISIS

The study regarding vulnerability of European economies faced with a possible outburst of sovereign debt crisis implies quantitative analysis of the impact of sovereign debt on economic sensitivity of countries part of the European Union.

With its help, a series of conclusions are drawn that are meant to give a broad image of the correlation between European economies' instability and the probability of outburst of sovereign debt crisis.

Methodology

By using techniques from the field of artificial intelligence, neural networks and modeling techniques of chronological series, complex processing was underwent and a series of models that highlight existing relations between component variables of economic vulnerability and variables that directly affect economic vulnerability in the European Union.

Economic vulnerability can be aggregated in the capital-freeze index, according to the same-titled article, „The capital-freeze index" published by economist.com on the 19th of September 2013[6].

The capital-freeze index is a result of aggregating multiple macroeconomic components: current account balance, volume of credit contracted by these countries (belonging to the EU), the volume of external payments that these countries must periodically make to cover borrowed sums.

The study entails modeling the causal relations in: government debt, budgetary deficits, European Central Bank interest rates, current account balance, volume of credit contracted by European countries, volume of external payments EU countries must periodically make, capital flux and economic vulnerability. On the other hand, the current study also entails modeling chronological series afferent to the components of vulnerability.

Based on recent trimestral data[7] (concerning last year and the current) for the considered variables, the neural network[8] generated econometric-mathematical models that reveal the causality of vulnerability in rapport with variables responsible for modifying the degree of the latter.

The neural network used consists of: four entry neurons, each neuron receiving its aggregated, corresponding, set of data regarding the analyzed variables in rapport with economic vulnerability of European countries; twenty five hidden neurons and one exit neuron, corresponding to the variable that defines economic vulnerability.

Responsible with implementing and training the neural network, but also with the time series, was the GMDH Shell software, version 3.0.5.

Empiric results

Data processing generated models regarding causal relations between: government debt, budgetary deficits, European Central Bank interest rates, current account balance, volume of credit contracted by European countries, volume of external payments EU countries must periodically make, capital flux and economic vulnerability. Thus, we get:

Model 1 (without taking into account sovereign debt):

$$y = -4.14352 \cdot 10^{-9} + 5.9864 \cdot 10^{-12} CR + 2.4081 \cdot 10^{-14} CR \cdot DI + 0000719331 \cdot N_{12} \cdot CR + 0.494382 \cdot N_{16}. \quad (1)$$

where:

CR is the volume of credits contracted by EU countries;

DI is the volume of direct investments in EU countries;

N_{12} is the equation afferent to neuron 12;

N_{16} is the equation afferent to neuron 16.

The equation of neuron 12 is:

[6] See: http://www.economist.com/blogs/graphicdetail/2013/09/daily-chart-3

[7] Taken from the official EUROSTAT website. Interest rate values are expressed percentually, and other variables are expressed in billions of Euros.

[8] For more details on neural networks, structure of neural networks, training algorithms, etc., please see: Stancu, S. (2012) *Calcul Neuronal. Teorie şi aplicaţii economice*, Editura ASE, Bucureşti.

$$N_{12} = 0.1968 - 5.255 \cdot 10^{-5} \cdot DI \cdot PI + 0{,}0401018 \cdot DI \cdot IR + 0.000112 \cdot DI \cdot BP - 4.53536 \cdot 10^{-5} \cdot DI^2$$
$$- 0{,}00147935PI - 0{,}0074335 \cdot PI \cdot IR + 2.58529 \cdot 10^{-5} \cdot PI \cdot BP + 4.94605 \cdot IR^2 - 0.001961 \cdot BP - \quad (1.1)$$
$$- 4.54539 \cdot 10^{-5} \cdot BP^2$$

and the equation of neuron 16 is:

$$N_{16} = 12.9601 - 5.859 \cdot CA + 1.16411 \cdot CA \cdot DB - 1.29604 \cdot CA \cdot DF - 2.999 \cdot 10^{-11} \cdot DB \cdot DF + 1.5529 \cdot 10^{-11} \cdot DF^2 \quad (1.2)$$

where:

CA is the capital account of EU countries;

DB is the external payment balance of EU countries;

PI is the total value of investment portfolios in EU countries;

DF is budgetary deficit in EU countries;

IR is the ECB's interest rate.

Relation (1) shows the relation between degree of economic vulnerability and simultaneous increase/decrease, singular or coupled, of macroeconomic variables.

Based on relations (1), (1.1) and (1.2) we may see that interest rate evolution influences increase in vulnerability the most, if sovereign debt is not taken into account.

Model 2 (sovereign debt is taken into account):

$$y = 1.489 \cdot 10^{16} + 0.083N_{11} + 0.07519N_{11} \cdot N_{15} + 0.08526 \cdot N_{11} \cdot N_4 + 0.0776 \cdot N_{11}^2 + 0.06947 \cdot N_{15} +$$
$$+ 0{,}06889 \cdot N_{15} \cdot N_{16} + 0.06195 \cdot N_{15} \cdot N_4 + 0.08475 \cdot N_{15}^2 + 0.08099 \cdot N_{16} + 0.07658 \cdot N_{16} \cdot N_4 + \quad (2)$$
$$+ 0.08863 \cdot N_{16}^2 + 0.07658 \cdot N_4 + 0.070707 \cdot N_4^2$$

where:

N_i is the equation of neuron i.

Observations:

1) All considered variables are found in equations afferent to neurons from relation (2);
2) The afferent variable of sovereign debt is found in the equations afferent to neurons: 16, 22, 23, 28.

Due to the inclusion of sovereign debt, the relations between other macroeconomic variables in rapport with the latter become far more complex and more sensitive, in the sense that sovereign debt affects in a considerable amount evolving connections between the considered macroeconomic parameters. This is due to the phenomenon of macroeconomic induction: the probability of entering a sovereign debt crisis is governed by politics and strategies adopted on a macroeconomic level to cover budgetary deficits and to maintain economic parameters at a given state and, implicitly, through feedback, the increased probability of entering a sovereign debt crisis will generate increased sensitivity in economies more or less affected by the recent economic crisis.

Through econometric-neuronal modeling of components of economic vulnerability in rapport with sovereign debt, the volume of credits contracted by the EU with the rest of the world is most affected by a possible outburst of sovereign debt crisis. The generated equation is:

$$CR = -106433 + N_3 \quad (3)$$

where:

N_i is the equation afferent to neuron i;

The equation of neuron 3 is:

$$N_3 = -106433 + 0.197268DT - 2.5439 \cdot 10^{-8} DT^2 \quad (3')$$

where:

CR is the volume of credit contracted by the EU from the rest of the world;

DT is the level of sovereign debt in the EU.

Based on relations (3) and (3'), we may say that an infinitesimal increase of sovereign debt would considerably decrease the volume of credits contracted by the EU with the rest of the world, by 106433 bn. euro, which would lead to an increase in the degree of vulnerability.

Modeling time series implies studying the sensitivity of current and future values in rapport with recent past values, thus demonstrating that there is at least one autoregressive component in the chronological series analyzed.

Parameters directed by autoregressive components are those that sensitize the trajectory of influenced variables through the probability of dependency on recent historic values. In our case, the total value of investment portfolios, direct net investments and sovereign debt are the parameters that contain autoregressive components.

Their equations are:

For sovereign debt:

$$DT_t = 385629 + 0.3233DT_{t-1} + 0.341282DT_{t-2} \quad (4)$$

where:

DT is the volume of sovereign debt in EU countries, at time t.

For direct investments:

$$DI_t = -9.05262 + 0.26573DI_{t-1} - 0.7238DI_{t-2} \quad (5)$$

where:

DI_t is the volume of direct net investments at time t.

For total value of investment portfolios:

$$PI_t = 48.9876 - 0.3025PI_{t-1} + 0.32903PI_{t-2} \quad (6)$$

where:

PI is the total value of investment portfolios in EU countries, at time t.

Based on relations (4)-(6) we may deduce that recent history has a considerable impact on parameters that heavily influence vulnerability, and, as such, on increased instability in the European financial system.

CONCLUSIONS

Economic vulnerability is a complex phenomenon that implies analyzing causal relations that lead to increased risk and uncertainty on the economic-financial market, as they are affected by the ever more sensitive trajectory of international economic relations.

The European economy has proven, through the completed study, to be sitting on "*a large scaffolding of improbability*" (P. Teilhard de Chardin), so that the probability of entering a new sovereign debt crisis is ever greater.

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