



Usefulness of Artificial Neural Networks for Predicting Financial and Economic Crisis

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ABSTRACT

The objective of the present study is to explore the issue of the forecasting of economic crisis using the neural network. The subject is of great importance in the economy, more so as that most countries affected by crisis, declared at the end of 2010, the economic growth but the crisis paralyzed the financial world over the past three years. Neural network techniques have been frequently applied in order to predict problems like economic forecasting. The results show that creating a model using the neural networks might be a powerful tool and could be applied to prevent economic crises.

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1. Introduction

Forecasting activity always accompanied human beings as a natural expression of their behavior. All the major economic crises had negative impact not only on the countries where it happened but also on the international capital markets. The present time, characterized by an accelerated development of economic and social life, requires research in economic activity forecasting.

The aim of this paper is to present the importance and the goals of forecasting and the usefulness of artificial neural networks that reduce the uncertainty and provide benchmarks for monitoring actual and future performance in economic domain. Statistics and econometrics are sciences "tools" that help economists to observe and understand the economic reality in its complexity. These two fields allow economists to make informed decisions and to forecast economic activity at both the microeconomic and macroeconomic levels. Using statistical data, econometric and informatics techniques, these models are applied to predict the likelihood of economic and financial crises, using for this purpose a few number of indicators related to internal and external factors, as well as social and financial conditions.

Generally, there is a temporal difference between an event and signals that predict and lead towards that event. This is a fundamental reason why forecasts and planning are two activities that are studying. Crises can be defined as situations characterized by a pronounced instability which are accompanied by volatility and increased uncertainty. Crises, of whatever form is, are characterized by a constant state of anxiety and uncertainty about the future, fear or panic. The financial crisis looks to be mostly behind us, and the economy seems to have stabilized and is beginning to grow again. The main causes of this situation are financial crises which have become more frequent and more global before period. The global recovery has been stronger than expected, mainly because the level of confidence has gone up among consumers and businesses as well as on financial markets. Activity in emerging and developing economies makes the financial conditions to remain as difficult as it was before the crisis. Macroeconomic forecasts predict the course of the aggregate economy concentrating on some variables such as interest rates, the rate of inflation, and the rate of unemployment. The recent economic crisis revived the interest in developing different models able to signal their occurrence in due time. The global economic crisis has affected all the investments and tends to impose more risks to all sectors worldwide. Informational and technological discovery and development of economic and financial instruments do not have enough contribution in order to forecast the actual economic and financial crisis. The capacity to predict some economic events is essential to be timely accurate and complete for the best decisions to be adopted on political, economic and financial levels. Decision makers are unable to achieve good governance and risk managers may navigate into nothingness, unable to bring emerging trends and signals of danger.

Each crisis highlights the weaknesses of the economic system and recent financial crisis is not deviation from the rule. Propagation velocity shows how important it is to have the indicators for the employment of measures looking and analyzing cross-border ties. If risk analysis has been solved by the complexity of new financial instruments, the crisis needs come up with track business activities and balance sheet unrecorded activities, activities often designed precisely to escape any control. There are many economic indicators and reports which can be used to evaluate an economic crisis, but it is important to understand and analyze a

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large number of them, and how their evolution (alone or in combinations) affects a nation's economy. Based on recent studies, this paper will try to emphasize the importance of creating models to predict futures economic and financial crises. Neural networks are flexible functional forms that allow approximating any continuous, hence also nonlinear function. Therefore, they can be expected to provide effective nonlinear models for financial time series and thus to allow for a better prediction.

2. Neural network models in economic areas

It is known that an increasing number of researchers from various fields of science are concerned with neural networks, in an attempt to simulate and model the human brain structure and functions. Called connectionist architectures, parallel distributed processing, artificial neural networks are information processing paradigms inspired by the parallel structure of the human brain, densely connected, and processing the information. A neural network is a system able to learn, modeled after the human nervous system. After lots of practice, a neural network can recognize patterns without human intervention.

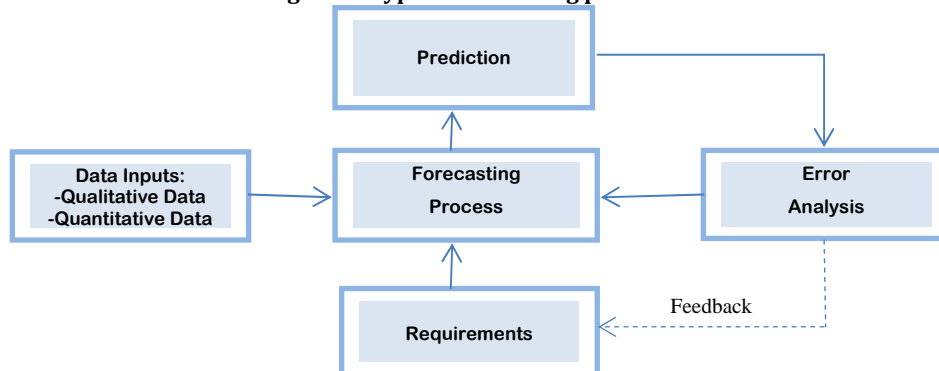
Neural Networks is an adaptive nonlinear parallel distributed system used for function approximation, time series prediction, classification, etc. One of the strengths of the neural network model may be characterized by its ability to capture underlying patterns of non-linear trends. [Zhang, 2005]

Fashioned after the human brain and nervous system [Thawornwong and Enke, 2004; Qi, 1999], a neural network has the ability to process complex data similar to stock market data by utilizing its parallelism and harnessing the power of its processing elements to process data. [Zhang et al, 1997] Artificial neural networks are universal approximations and in theory can approximate any function arbitrarily closely. However, the mapping function represented by a network is not perfect due to the local minimal problem, suboptimal network architecture and the finite sample data in neural network training. Therefore, it is clear that neural networks actually provide estimates of the posterior probabilities. [Cybenko, G., 1989]

The macroeconomic indicators are useful in prediction, however they do not provide the underlying reasons for a financial crisis, and those reasons can be endless. Crises usually come with the convergence of multiple external and internal factors, which overwhelm the economy. Some causes tend to lead to crisis more than others, but most crises have several market failure causes in common. In preparing a financial response plan, an understanding of the various causes is crucial to that effort. [Allen; Gale, 1999]

One of the major causes of many crises for developed countries in the last several decades has been the lack of regulation or financial liberalization. That came as a result of lax government regulations of banking and financial institutions as well as other regulatory tools. Many countries had been following the "Washington Consensus", which promotes liberal financial regulation to create easy credit and money across all countries to develop their economies. Up until recently, this policy seemed to work, however recent events have shown that liberalization can go too far. The problem is that it takes years to see the effects of deregulation, so no warning or downside was visible to other countries including our own. In the case of the Nordic and Japanese crises, these governments cite several instances of liberalization leading to asset bubbles and financial crisis [Aldean, C., 2009] which range from a few weeks up to many years. Economic forecasts are widely used in business and government to help formulate policy and strategy. Can be said that the economic forecasting is the process of estimating future events, and it is fundamental to all aspects of financial and economic processes based on quantitative analysis, qualitative analysis or a combination of both. In Figure 1 can be observed the typical forecasting process scheme. Given a time-based series of input data, qualitative or quantitative data, a neural network will predict future values. The accuracy of this forecasting process will be dependent upon many factors, such as the quantity and relevancy of the input data. The goals of forecasting are to reduce uncertainly and to provide benchmarks for monitoring actual and future performance; the resultant forecasts are evaluated by comparing predictions with actual results.

Figure 1. Typical forecasting process



Source: adapted by [Cangiano M., 2010]

This assessment is accomplished by examining the error terms. An error term is the difference between the prediction and the actual outcome. Based on an error assessment, the forecasting process is continually updated through the adjustment of model inputs. The artificial intelligence techniques and emerging

information technologies are being used to improve the accuracy of forecasts and thus making a positive contribution to enhance the bottom line. Over the time, predictive models to analyze economic crisis have raised two major problems: accuracy of prediction as a result of statistical data analysis and the explanatory power of economic models.

Neural networks can be defined as collections of mathematical models that emulate some of the properties observed in biological nervous systems and are designed by analogy with biological adaptive learning. They are particularly useful for solving problems that cannot be expressed as a series of steps, such as series prediction and data mining. The neural networks are the best option when there is a lot of data, information and empirical knowledge, and algorithms cannot be fast enough and correct for their processing. In terms of statistical methods, the simple functions can be used based on historical economic values, statistical public data available that can be used as a very good first approximation for the prediction very complex process in economics area.

3. The importance of designing the neural network models for forecasting economic events

The impacts of the financial crises that touch the entire world economy have been a massive burden to the public budgets in nearly all countries of the world. In addition to tax revenue shortfalls and higher costs for social benefits, governments have been massively burdened by bank rescue measures and economic stimulus packages. The governments try to bolster savings in periods of growth in order to mitigate the risk of boom and to generate savings for future economic downturns and redouble efforts to coordinate economic strategy internationally, to engage the developing world in this process and to ensure that recovery strategies are environmentally sustainable.

Some of the afflicted economies of euro zone countries had problems, since 2008, with excessive wages and prices that far exceed the competitive level, the exports are held down by worldwide high prices, and high incomes generate a volume of imports that is not sustainable. All the anti-crisis politics assumed by some governs mints world wide are launched to construct strategies for keeping workers gainfully employed, and also to ensure that they are trained for new jobs and are maintained above the poverty line so as not to permanently undermine their employment prospects. But, most important it is to analyze that the underlying conditions that caused the ongoing food crisis have not significantly changed and that policies are needed to ensure that food is available to the hundreds of millions living on the edge of starvation. [Cangiano M., 2010]

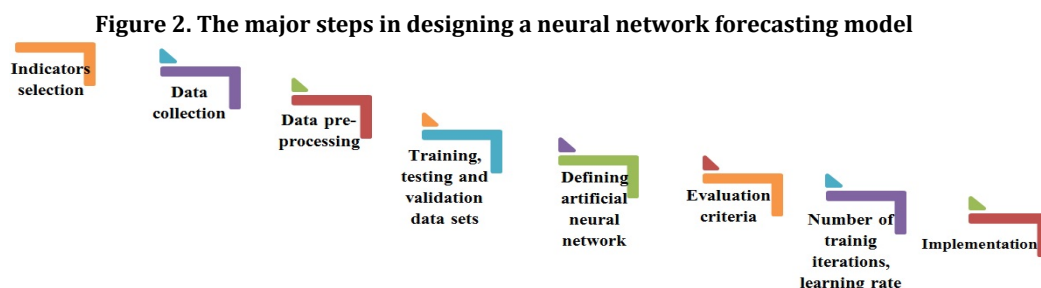
In the last ten years, many empirical studies have sought to develop models able to emit timely signals of the occurrence of an economic and financial crisis. One of this was the result obtained by Manasse et al., who find that logit model predicts 74 percent of all crises entries while sending few (6 percent) false alarms, and the recursive tree 89 percent while sending more false alarms. [Manasse,P., 2003]

In a survey of the literature, Hill et al. report mixed evidence as to forecasting results of Neural Networks, although they performed “as well as (and occasionally better than)” the statistical method. [Hill, T., 1994]

Using statistical data and econometric techniques, these models are applied to predict the likelihood of economic and financial crises, using for this purpose a large number of indicators related to internal and external factors, as well as social and political conditions. According to the type of approach adopted, models can be classified between parametric and non-parametric. [Abiad, A., 2003; Berg, A., 2004; Ciarlone, A., 2004]

Economic theory has developed three generation of models explaining financial crises: first and second generation models focus on currency crises and public imbalances, while third generation models include a wider variety of crises and are better suitable at explaining episodes occurred in the late '90s which were caused, principally, by private imbalances. Financial and economic crises that occurred in emerging countries in 2008 have revived theoretical and empirical interest in understanding their causes and consequences, as well as in developing statistical and econometric models able to signal their occurrence in due time manner.

In the last decade, many empirical studies have concentrated their attention on developing models able to timely signal the occurrence of a financial crisis, the so-called early warning system. A method of designing an artificial neural network forecasting model into major steps is detailed in Figure 2:

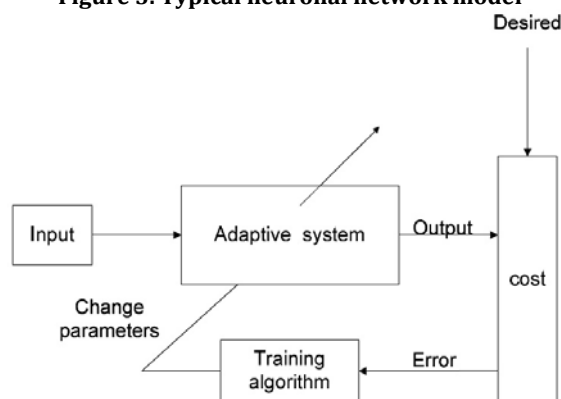


Source: adapted by [Deboeck, G., Cader, M., 1994]

According to Figure 2, the first step in designing a neural network model is the indicators selection, which is an important and critical problem because it is difficult to know which input indicators are most important in the economic area. Here comes the economic (microeconomic or macroeconomic) theory and rules that can manage to help choosing the parameters that can be used in order to design the optimal forecasting model. The second step, data collection, consists in the necessity to evaluate the availability, accuracy and the cost of process data collection. All the indicators and data collection should be checked for errors, logical consistency and actuality of update. All these factors have a major importance in training and evaluating the

process of network performance. The network designer must decide on the input type, size, and complexity of the network. It must be decided what setup values to assign the system to initially start the network training process including the percentage of the total dataset to set aside for training and testing. The diagram in Figure 3 below is a simple design of a neural network model. Neural network is sometimes called soft computing. [Bodis, 2004]

Figure 3. Typical neuronal network model



Source: adapted by [Bodis, 2004]

The role of the third step, data pre-processing, is to correct data inconsistencies, selecting the relevant information from the input and output data indicators, the representation of the data is critical in correctitude of model. In practice, the data preparing process, which consists in operations such as data normalization, involves much trial and many errors. A good method to select appropriate data is to test various combinations; groups of indicators could be pretested several times in different combinations differing by two or three variables. This procedure recognizes the likelihood that some indicators may be excellent predictors only when they are combined with other indicators.

In the fourth step, training, testing and validation data sets are one of the most important processes. The training data set is used by the artificial neural network to learn the patterns present in the data. The testing data set is used to evaluate the ability of a supposedly training network, in function of the type of network and the learning algorithm that was chosen. The validation data set should observe and examine the consistency or variation of the results and the performance of the network.

The fifth step, defining the artificial neural network, consists in a variety of ways to design this. The combination of the number of input neurons, the type of interconnections and the number of layers, make from the neural network a powerful instrument in forecasting. The artificial neural network is a multivariate artificial intelligence technology that provides successful results in cases where sophisticated interference exists between the variants and there is not only one solution set. As a result of these properties, artificial neural nets seem to be a suitable method to be used in economic failure fields.

The sixth step, evaluation criteria, supposed that the researcher observe and examine the most important errors offered by the software witch trained and tested the network. These errors may not be the final evaluation criteria, but they are among the most important in this case. In function of these errors would be set the performance of the network.

The role of the seventh step, the number of trainings and iterations, the neural network relives if the type of neural network and the algorithm which was chosen, offers the optimal results according to the objective.

The eighth step, implementation, supposes that the results that were obtained be acceptable, the model is robust with respect to retraining frequency. The neural networks are mathematical constructs that emulate the processes that people use to recognize patterns, learn tasks, and solve problems. Neural networks are usually characterized in terms of the number and types of connections between individual processing elements, called neurons, and the learning rules used when data is presented to the network. Every neuron has a transfer function, typically non-linear, that generates a single output value from all the input values that are applied to the neuron. Every connection has a weight that is applied to the input value associated with the connection.

A special feature of neural networks that distinguishes them from traditional methods is their ability to classify data which are not linearly separable. The most common neural network model used in economic forecasting is the multilayer perceptron and back propagation.

The multilayer perceptron represents a type of neural network which known as a supervised network because it requires a desired output in order to learn. The goal of this type of network is to create a model that correctly maps the input to the output using historical data so that the model can then be used to produce the output when the desired output is unknown.

Multilayer perceptron, with direct activation, consists in one or more layers between input nodes and output nodes, which have more hidden levels. The algorithm consists of two essential steps: first step is to browse the network directly from input to output; the network output values are enabled and activated; the second step is going through a reverse network output to input; the results are compared to the expected outputs and the estimated value of the error.

A multilayer perceptron is a back propagation artificial neural network model that maps sets of input data onto a set of appropriate output. A multilayer perceptron consists of multiple layers of nodes in a directed graph, with each layer fully connected to the next one. Except for the input nodes, each node is a neuron (or a processing element) with a nonlinear activation function. MLP utilizes a supervised learning technique called back propagation for training the network. The multilayer perceptron is a modification of the standard linear perceptron, which can distinguish data that are not linearly separable.

The MLP model is schematically represented in Figure 4; the data are fed into the input layer and get multiplied by interconnection weights as they are passed from the input layer to the first hidden layer. Within the first hidden layer, they get summed then processed by a nonlinear function (usually the hyperbolic tangent).

Figure 4 depicts a generic fully-connected multilayer feed-forward neural network (or a multilayer perceptron), trained by the back-propagation algorithm. The operation of an MLP is determined by the following four factors:

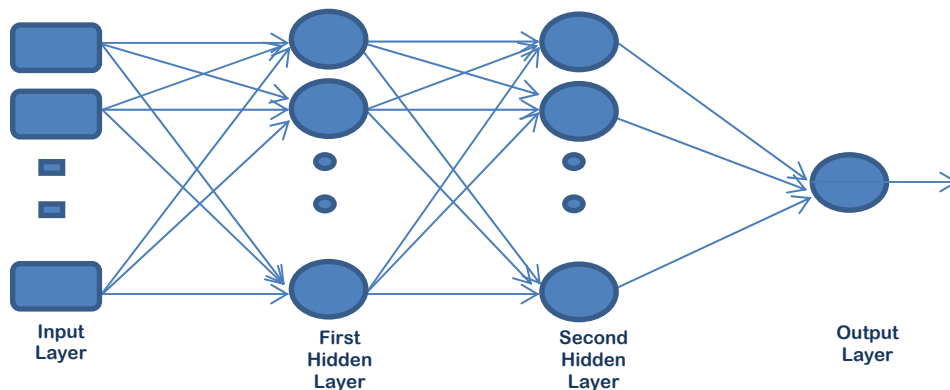
- the architecture or topology of layers, neurodes and their interconnections;
- the learning law;
- the activation or transfer function and
- the training parameters.

As the processed data leaves the first hidden layer, again it gets multiplied by interconnection weights, then summed and processed by the second hidden layer. Finally the data are multiplied by interconnection weights then processed one last time within the output layer to produce the neural network output. The choice of output neurode depends on the nature of the research study. A single output neurode indicates a dichotomous and categorical output that can be expressed in binary terms: 1 and 0.

The architecture of an MLP specifies the number of layers, the number of neurodes each layer contains and how the neurodes are interconnected. The design of an MLP architecture is “more of an art than a science”, in the sense that optimal design is based more on heuristics or experience rather than on proven methods. [Zhang, 1998; Haykin, 1999]

The multi-layer perceptron and many other neural networks learn using an algorithm called backpropagation. With backpropagation, the input data is repeatedly presented to the neural network. With each presentation, the output of the neural network is compared to the desired output and an error is computed.

Figure 4. Graphical representation of multi-layer perceptron (MLP)



Source: adapted by [Abolhassani, H., 2006]

This error is then fed back (backpropagated) to the neural network and used to adjust the weights such that the error decreases with each iteration and the neural model gets closer and closer to producing the desired output. Each problem is unique, and so are the solutions. Sometimes adding additional nodes or layers will stabilize a system. There are no hard rules, but there is one thing for certain; whether a neural network is computed by a computer, implemented in hardware, or propagated by hand, neural networks do not cogitate.

They are simply powerful computational tools and their sophisticated mathematical computation positions them to be used to solve a broad range of problems. The MLP depicted in Figure 1 is fed-forward, because none of the weights cycles back to an input unit or to an output unit of a previous layer. In addition, the MLP is fully connected, because each neurode provides input to every neurode in the next forward layer.

Most neural network designed to solve the problem of forecasting for economic area are using a multilayer network trained with backpropagation algorithm. The use of this type of neural networks is common because the processes are easy to understand, and the results are easy to interpret.

The neural network learning model is demonstrated by the exclusive-or data. The exclusive-or data are repeatedly presented to the neural network, and with each presentation, the error between the network output and the desired output is computed and fed back to the neural network. The neural network uses this error to adjust its weights such that the error will be decreased. Finally, this sequence of events is usually repeated until an acceptable error has been reached or until the network no longer appears to be learning.

The power of neural networks comes from their ability to learn from experience (that is, from historical data collected in some problem domain). Neural networks are increasingly being used in real-world business and economic applications and, in some cases, such as fraud detection, they have already become the method of choice.

Their use for risk assessment is also growing and they have been employed to visualize complex databases for marketing segmentation. This boom in applications covers a wide range of business interests—from finance management, through forecasting, to production. Applications of artificial neural networks received a great attention in recent years in many fields because of their enormous storage capacity and capabilities of learning and prediction.

4. Conclusions

In conclusion, the crisis should be used as an opportunity: structural reforms to enhance growth in general and fiscal frameworks in particular. In this context the neural networks' tolerance makes them an excellent choice for solving real economic world problems. But, as with any solution, there are costs which depend on the domain and obtaining sufficient and suitable training data, and this can be challenging. In the economic area, the neural network models exploit patterns found in historical and transactional data to identify risks and opportunities. Models capture relations among many factors to allow assessment of potential risk associated with a particular set of conditions, guiding decision making, which is important for government decisions. Predictive neural network model is used in science, financial services, insurance, telecommunications, retail, travel, business and other fields.

Everyone needs to know the forecast of the future: bankers need to predict customer's credit worthiness, marketing analysts want to predict future sales and economists want to predict economic cycles. Neural networks are very effective when lots of examples must be analyzed, or when a structure in these data must be analyzed but a single algorithmic solution is impossible to formulate. When these conditions are present, neural networks are used as computational tools for examining data and developing models that help to identify interesting patterns or structures in data. The data used to develop these models are known as training data. The present paper has conducted to some conclusions which show that the neural networks have been shown to be a promising tool for forecasting financial time series. Several design factors significantly impact the accuracy of neural network forecasts. These factors include selection of input variables, architecture of the network, and quantity of training data. Neural systems are one of the best options when are used large amounts of data, information and empirical knowledge, and algorithms for processing cannot be achieved sufficiently fast and accurate. In addition to high reliability, neural systems provide a good functionality at lower price maintenance. Another consequence of this study about predicting financial crisis with artificial neural network model is that creating a model using the neural networks could be applied to prevent the economic crises and could effectively capture the economic variables associated with the currency crises, and might be a powerful tool to provide macroeconomic time series data. The main advantage of artificial neural networks is their flexibility to distortions in the input data and their ability to learn, offering ideal solutions for a variety of problems of classification, signal recognition, forecasting and modeling systems where processes shows higher complexity. In the future work are many things worth to be tried. For example, to exam if the artificial neural networks forecasting is able to use the pre, during and post crises data to evaluate, investigate and predict new economic crises.

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