Neural Networks as tools for increasing the forecast and control of complex economic systems

Massimo Salzano

Dipartimento di Scienze Economiche, Università di Salerno†
Salerno, Italy
salzamas@netlab.it

Abstract: ***The idea that NN can be usefully used for a better understanding of economic complex mechanisms is present in the literature. Our interest is to show that this is correct if we use the larger possible amounts of information that data conveys. At this end we will start with the consideration expressed by Mandelbrot that a traditional model could explain the economic behaviour 95% of time, but that in terms of amount the remaining 5% means quite the complete set of phenomena that we want to understand. We need complex models for dealing with this part. For their characteristic of being general approximators NNs seem one of most interesting instrument. This is true both for macroeconomic and for financial data.Often, the economic system is so complex that, to grasp the meaning of the information conveyed by the data, even a general approximator like NN is not enough. Larger information could be obtained using 2 or more instruments in cascade or in parallel. We will concentrate on this topic. We will try to illustrate how the combination of tools is possible. Applications will refer to Italian macroeconomic and financial data.***

1. The Modellisation of Complex Economic Behaviour

The idea that NN can be usefully used for a better understanding of economic complex mechanisms is present in the literature. Often, the economic system is so complex that, to grasp the meaning of the information conveyed by the data, even a general approximator like NN is not enough. In fact, to reach a good result it seems necessary to use a sort of pre-analysis of the data, so to recuperate the larger part of the amounts of information that data conveys.

Mandelbrot show that a traditional model could explain the economic behaviour 95% of time, but that in terms of amount the remaining 5% means quite the complete set of phenomena that we want to understand. Two specific situations will be considered in which such a phenomenon will occur: when for the system under consideration there exists a fractal attractor and when there is a “threshold” effect in its behaviour. In both cases, the traditional model is able to explain the

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main behaviour of the system but it fails to explain a part of it. Of course, those cases are not exhaustive but must be considered only as examples of complexity. Both cases are very often present in economic data. As we will see both need some sort of pre-processing. In two preceding works concerning the use of NN's in the economic sector we have already demonstrated: a) the existence of permanence on some macro-economic data[1]; b) the effect of using a pre-analysis for a better description of an macro-economic phenomena[2]. In what follows we will make reference to these works.

2. The modelisation of permanence on some macro-economic data: The existence of permanence in the increment of Italian pro-capita income

In Fig. 1 the Increment of Italian pro-capita Income (Istat 1861-1940) is plotted. It seems to be casual.

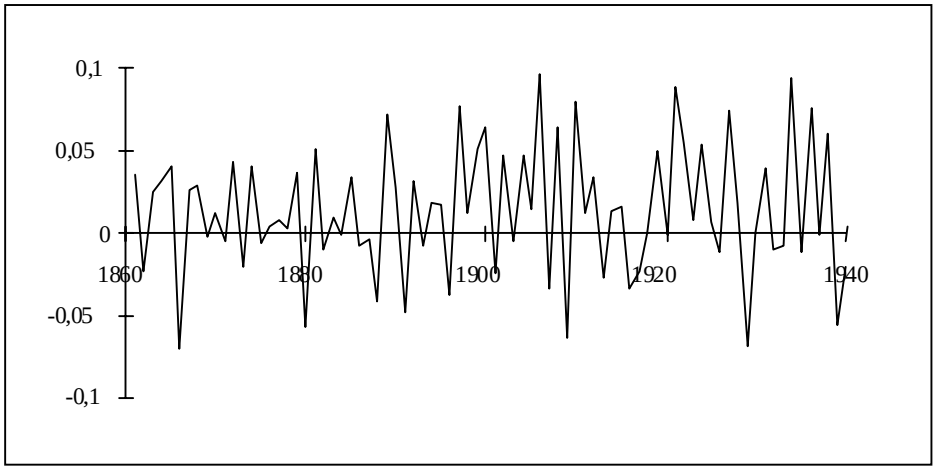


Fig. 1 Increment of Italian pro-capite Income (Istat 1861-1940)

[1] M. Salzano, La struttura frattale di alcuni indicatori economici italiani, Ischia, AMASES.

[2] M. R. Alfano and Salzano M. (1998): The Effect of Public Sector on the Financial Sector: A NN Approach in a View of Complexity. Wirn 98 Springer Verlag

Vice versa, the valuation of Hurst's exponent highlights the existence of a permanence in the data. For evaluating the H exponent we calculated the R/S index considering the original observations in one single group of 90 observations, in two groups of 45 observations … in 18 groups of 5 not overlapping elements. The resulting values (log(N) e di log(R/S)) are reported in Tab. 1.

The Hurst's exponent was than calculated using a linear regression between log(R/S) and log(N) for the various N (90, 45, …5). This is the method suggested by Mandelbrot

N	90	45	22	11	5
log(N)	1,954243	1,653213	1,342423	1,041393	0,69897000
log(R/S)	1,047284	0,879234	0,310132	-0,11954	-0,71025431
H	0,670448				

Tab. 1- R/S analysis and Hurst Exponent

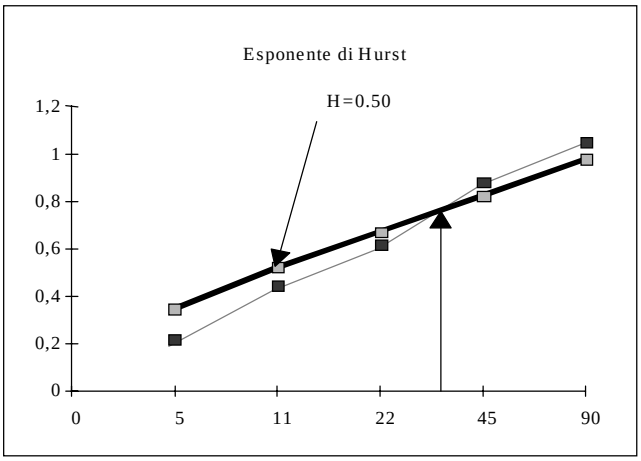


Fig. 2 - R/S Analysis of the Italian pro-capite Income

In Fig. 2 the bold line show the value of log(R/S) for the casual case (H=0.50).

The obtained result (H=0,670448) means that there is permanence in the data. This means that around the 0,27 % ($C=2^{\wedge(2H-1)}-1$) of its modification could be explained by past periods movements[3].

Mandelbrot (1972) has demonstrated that the inverse of H is the fractal dimension, this dimension for our data is 1/0,670448 o 1,49154.

So the data of Italian national income have a fractal structure. They are characterised by non periodic cycles. So they must be analysed by a non linear system. The correlation derived from the Hurst's exponent is a measure of the expectation generated by the past events.

Starting from the existence of permanence in the increment of Italian National Income (1861-1950), we tried to apply a NN to see which part of it could be explained only on the base of past values. For this scope, we used a GRN (general regression net) from NeuroShell. The result is summarised in the fig. 2a where we can see the forecasting possibility of this approach. A larger part of the increments (30 %) where explained on this base only. This seems in strong contrast with the usual model that is based only on "fundamental" analysis[4]. It seems necessary to make full use of such an explanation. Generally, parametric models are not able to capture these non linear relations. Consequently, non parametric model must be considered. The NN's appear to be one of the more easily implemented of such class of models. However, they need same pre-processing for starting from the correct hypothesis that the system is complex. In fact, if the system is not complex they could consider noises as information.

3. The integration of technical and fundamental analysis

One of main difficulties of integrating fundamental analysis in the macroeconomic forecasting seems constituted by the fact that very often the meaningful variable present a " threshold " effect that is difficult to capture using one of the usual approaches. It seems that a pre-analysis could help for this end.

[3] The long term memory disappear after 30 years as it could be seen in the figure.

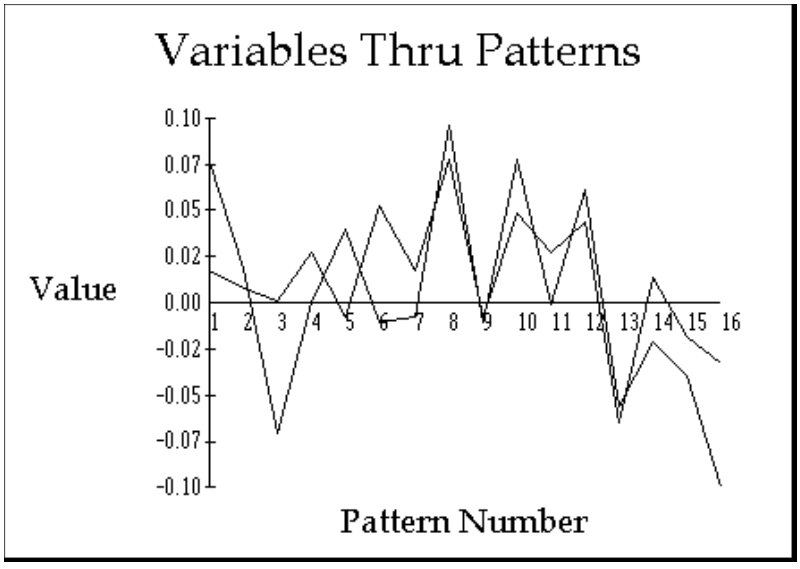
[4] Here we intend for "fundamental" analysis those based on other economic explicative variable different from the past values of the same variable we are considering.

The effect of using a pre-analysis for a better description of a macro-economic phenomena

In a preceding work we have already demonstrated the existence of a strong sensibility of financial date to fiscal events[5], but also that it is subject to a "threshold" effect.

The considered period was from 1/1/1991 to 31/12/1996. For the Italian financial market the official data about Comit30 was used. For the fiscal sector data about IRPEF, IRPEG and IVA from the "Ministero delle Finanze" were considered.

The fiscal timetable was used for estimating the amount of fiscal burden that the economic system had supported on any given day of the period.



R^2=0.47; 16 observations of forecasting

[5] M. R. Alfano and Salzano M. (1998): The Effect of Public Sector on the Financial Sector: A NN Approach in a View of Complexity, Wirn 98, Springer Verlag.

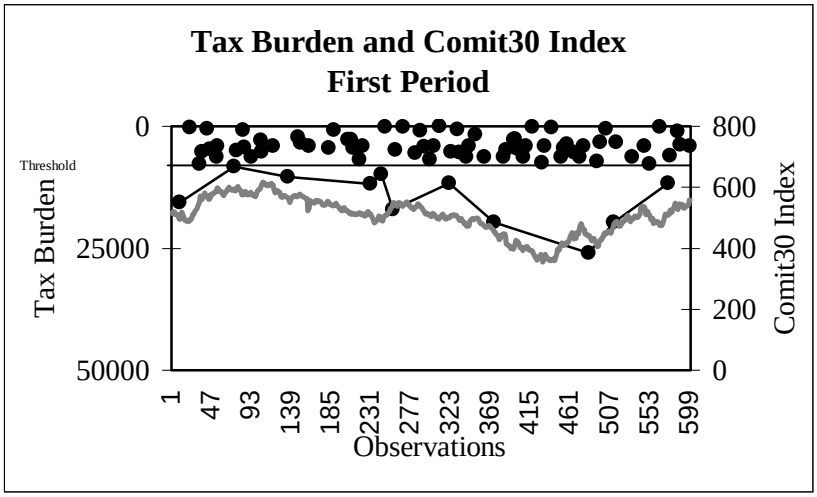


Fig. 3

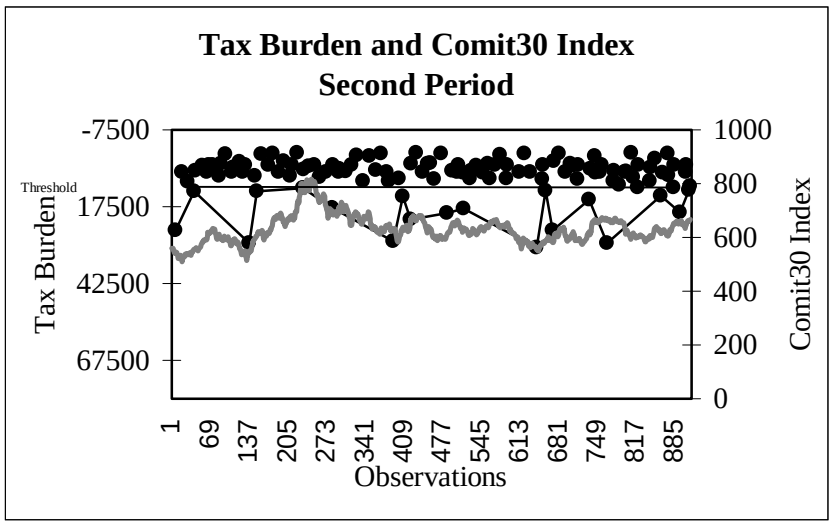


Fig. 4

Figures 3 and 4 show the existence of a strong link between the index of the financial market and the tax receipt with the evidence of a threshold value under which the tax burden does not influence financial behaviour. Due to the existence of this threshold, the fiscal phenomena had to be considered complex (in the graphs

only the threshold values of tax burden and corresponding financial values are represented).

The level of this threshold was flexible during the period. Overall, it amounted to 7800 mld for the first period ending on May 19th 93and 11400 mld for the second.

A NN (Levernberg-Marquardt) with 4 hidden neurons, one feedback and a penalty of 0.01 was used. (NNDT114)

The financial application

Italian data by Comit30 Index was used. The considered period was from 1993 to 31/08/1994; (only working days). Initially, the possibility of forecasting differences relative to the previous day's trading was evaluated with and without the tax burden. The difference in the results was very interesting (see Fig. 5 and 6)[6].

The results seem very interesting, In fact, the increase in the accuracy of forecasting of financial market obtained from the use of fiscal data was very important.

Than, it seems worthwhile to use a pre-analysis of the data. For this end, a NN could be used for which the inputs are the values obtained applying different thresholds. Such a NN was build for this work obtaining results only slightly different from those obtained by direct data observation.

Therefore, when there is a well-based hypothesis that it exists a threshold effect it seems possible to use a cascaded NN's system in which the first level made a pre-analysis of the data and the second the forecasting.

4. Conclusion

It seems important to use a mixture of technical and fundamental analysis and some pre-processing for capturing the modification and the effect of the public sector activities on macroeconomic variables. We tried to show this methodology

[6] In the Figures 5 and 6 are depicted the results of NN to explain our financial monthly data: i) only with the level of Comit30 index (one observation lag); and ii) with both the level of Comit30 (same lag) and tax payments. In fact, the rms was 0.1139 and the training showed a 1-observation lag. Both the levels of Comit30 (same lag) and tax payments gave good results The rms was 0.0712. This was the direct consequence of using tax burden.

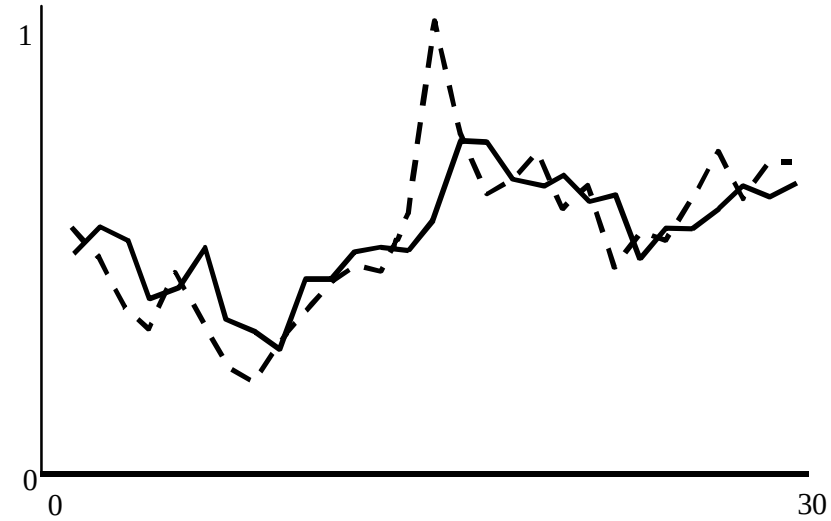


Fig. 5 - NN's training Comit30

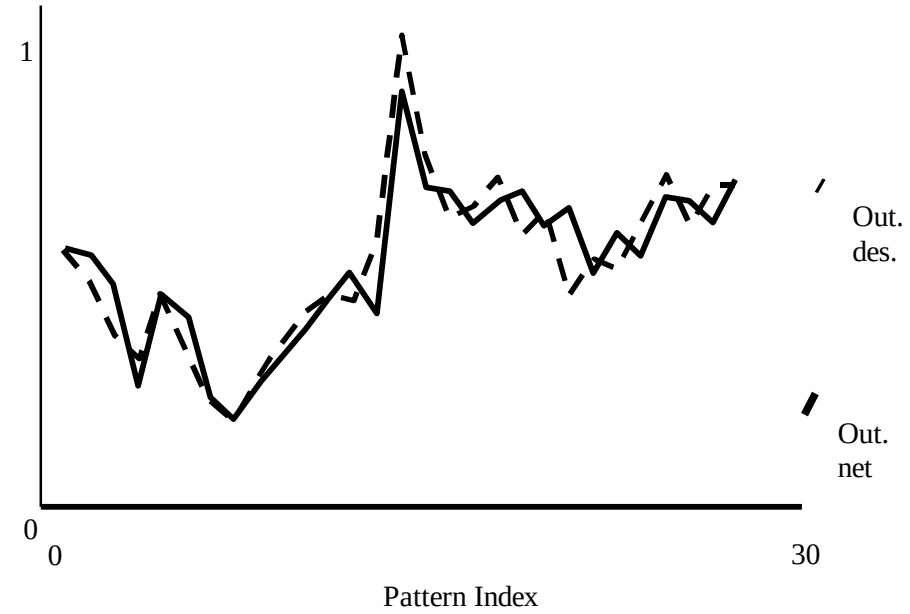


Fig. 6 - NN's training - Comit30 and tax burden

for two simple cases. The pre-processing seems to strongly increment the goodness of fit for Macroeconomic sector; hence, it improves the economic forecast. This seems a good way of capturing the main part of information conveyed by the data, and then it means an increase in the efficiency of economic control.

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