Using Artificial Neural Networks and Monte Carlo Simulation in Terms of Uncertainty for Prediction of Budget Deficit in Iran
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Abstract
In this paper using neural network models and Monte Carlo simulation to estimate and forecasted the Iran budget deficit. First stipulated fundamental variables and model, studied stationary of the variables and were unstable some variables. Most variables were stationary including structural breaks and the computed Zivot - Anders and Gregory - Hansen tests. Then there was a little chaotic time series in the review chaos by Lyapunov exponents. More using the neural network model to examine and forecasted budget deficit. In the end, forecasted optimal budget deficit with using Monte Carlo simulation in the presence of uncertainty caused by government policies. Expected results of Monte Carlo prediction show what should it be and neural network prediction show what it is.

Keywords: Budget Deficit, Artificial Neural Networks, Monte Carlo Simulation, Lyapunov Exponents, Zivot - Anders and Gregory – Hansen Test.

1. Introduction
Look at the situation in the Iranian government's revenues and payments, the official statistics released by the central bank, suggests a growing state budget deficit in recent years. Therefore it is very important. Forecasting budget deficit will be useful in future policy. Neural networks are efficient and useful for predicting the budget deficit because they have small prediction error.

The questions posed in this paper are what will the future destiny with this trend has been Iran budget deficit? How much should be budget deficit balanced despite sporadic policies in Iran and in the presence of uncertainty caused by government policies? To answer these questions in this study, we tried to use neural network models to forecasted Iran's budget deficit.

First presented the budget deficit theory then specify the model and identified variables. Then check the variables stationary with different tests, after examining the chaos in time series and field provided to estimate and forecasted budget deficit model. More by using artificial neural network model will be forecast Iran’s budget deficit. In the end, optimal budget deficit was forecasted by using Monte Carlo simulations in the presence of uncertainty caused by government policies. Expected results of Monte Carlo forecasting show what should it be and neural network prediction show what it is.

Much research has been done in Iran’s budget deficit. But any research hasn’t independent predict and no one used neural network models and Monte Carlo simulation to it. Here only a brief refers to some performed research in Iran. Hadian (1991) says budget deficit is increased government payments at him received that often financed by borrowing and he said therefore the conditions, government net borrowing estimate budget deficit. Ahrabi (1996) introduced government budget deficit Feedback as one of the most important economic factors that plays role significant to goals such as growth and development, economic stability and other tasks. Maroof Khani (1998) in him Research estimates the effect of government budget deficits on some economic variables, after estimating the long-run relationship and examined dynamics of model in the short term. Musavi Kasmaai (1999) investigated budget deficit relationship with the vector auto regressive pattern. Results show budget deficit policy in short-term could provide grounds for increased production and may lead to increased economic growth. Zavareiyan study (2003) show a Collective relationship between budget deficit and macroeconomic variables in the long term. Shaghaghi shahri (2004) have shown there is a long-run equilibrium relationship between real budget deficits and government’s macro-financial variables. Borumand Jezi and Kahram (2005) in him Research examine the relationship between budget deficits, exchange rate and oil revenues. Mehrara and Moradi (2008) found a significant positive relationship between the government budget deficit and economic variables including current. Farah Bakhsh and Farzin Vash (2009) in their study used panel data and reviewed the budget deficit and its relationship with economic growth.

2. Literature Review
As we know, based on theory, government budget deficits in public sector may be caused by many different reasons. Sometimes the governments works actively in the economy for its economic tasks; and increase their investment spending resort to budget deficit policy for relief from the recession, until economy can lead to a balanced state. Economists such as Keynes support a policy of government, to bring economy towards full employment. According to balance condition, in a three-part economics, we will review the status of the state budget:

\[ T - G = I - S \]
This situation government forced Increase their spending for implementing an active fiscal policy which leads to deficit in the government budget (Jafari Samimi, 2008, 24). Sometimes, occur budget deficit without government plays an active role in the economy or selects the active fiscal policy. It’s deficit that represents weak and passive government role in economy generally different with deficit of government’s active fiscal policies. In this case budget deficit will be established due to a reduction in national income level and thus reduce savings level in the economy. Government faces with budget deficit when government payments exceed revenues (Jafari Samimi, 2008, 24).

Iranian government faced with budget deficit problem for several years. Budget deficit in Iran created to difference between government revenues and payments (Pajuyan, 2008, 250):

\[
\text{Budget deficit} = \text{government payments} - \text{government revenues}
\]

3. Model Specified

In this study, budget deficit model in Iran expressed as follows:

\[
LBD = \alpha_0 + \alpha_1 LEX + \alpha_2 LTR + \alpha_3 LOR + \alpha_4 LGDP + \alpha_5 LNX + \alpha_6 LINF + \alpha_7 LGINV + \alpha_8 D_V
\]

Where BD Budget Deficit, EX Government Expenditures, TR Tax Revenues, OR Oil Revenues, GDP Gross Domestic Product, NX Net Exports, INF Inflation, GINV Government Investment and DV Dummy Variable, its value for years before the revolution is zero, and for years after revolution is one.

4. Stationary of Variables

The following results about stationary of variables obtained with Dickey Fuller test:

- Variables LBD, LOR, LGDP and LINF are stationary of one degree, I (1).
- Variables LEX, LTR, LNX and LGINV are stationary of zero degree I (0).

Peron (1989) said in the absence expected structural breaks, is necessary special care when using the unit root test, because Dickey Fuller test oblique for not rejected unit root shown in diagram below. Gregory - Hansen test determined most important of structural break in Iran’s economy as follows. There is a structural break type of full break in 1981 year considering trend of time series:

**Figure 1:** Gregory - Hansen test: Determining the time of structural break in Iran’s economy

As can be seen structural break in the Iran’s economy happened in 1981 year, simultaneously with start of the war. Here Gregory - Hansen Test done in Full Break, that break occurred in intercept and in trend also. Now if we use the collective tests to determine the long-term relationship between the model variables, must apply endogenous Structural breaks in model that our results do not with bias (Noferesti, 1999, 52). The final output of this test, Minimum T-Statistic absolute value statistic equal to -6.510 that is higher of critical value statistic at 5% level (-6.41); So null hypothesis was rejected based on lack of long-term relationship and accepted against hypothesis. Thus, there is a long-term equilibrium relationship between budget deficits, government revenues and payments despite the endogenous structural break.

Zivot and Anders designed a test that using it can be achieved the most important of structural break in any of the variables. Zivot - Anders test shows stationary of variables in the presence of endogenous structural break also (Pahlavani, 2009, 854). In the following reported results of this test which obtained using RATS software.
Table 1: Results of Zivot - Anders test: Break to intercept and trend

<table>
<thead>
<tr>
<th>Variables</th>
<th>Symbol</th>
<th>Break time</th>
<th>Optimal lag</th>
<th>$t_b$</th>
<th>Stationary</th>
<th>Break reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Budget deficit</td>
<td>BD</td>
<td>1981</td>
<td>1</td>
<td>-5.32</td>
<td>Stationary</td>
<td>Began of the war</td>
</tr>
<tr>
<td>Government expenditure</td>
<td>EX</td>
<td>1981</td>
<td>1</td>
<td>-6.22</td>
<td>Stationary</td>
<td>Began of the war</td>
</tr>
<tr>
<td>Tax revenues</td>
<td>TR</td>
<td>1978</td>
<td>1</td>
<td>-2.32</td>
<td>Non-stationary</td>
<td>Islamic Revolution</td>
</tr>
<tr>
<td>Oil revenues</td>
<td>OR</td>
<td>1981</td>
<td>2</td>
<td>-5.11</td>
<td>Stationary</td>
<td>Began of the war</td>
</tr>
<tr>
<td>GDP</td>
<td>GDP</td>
<td>1978</td>
<td>2</td>
<td>-5.16</td>
<td>Stationary</td>
<td>Islamic Revolution</td>
</tr>
<tr>
<td>Net export</td>
<td>NE</td>
<td>1978</td>
<td>0</td>
<td>-6.72</td>
<td>Stationary</td>
<td>Islamic Revolution</td>
</tr>
<tr>
<td>Inflation</td>
<td>INF</td>
<td>1989</td>
<td>2</td>
<td>-3.33</td>
<td>Non-stationary</td>
<td>End of the war</td>
</tr>
<tr>
<td>Government investment</td>
<td>GINV</td>
<td>1989</td>
<td>1</td>
<td>-6.43</td>
<td>Stationary</td>
<td>End of the war</td>
</tr>
</tbody>
</table>

Reference: Research Finding

As can be seen most variables are stationary in the presence of structural breaks; these results attest to the importance of structural breaks in econometric calculations.

5. Investigation of chaos in Iran’s budget deficit time series

It is necessary done chaos tests to investigate the possibility of predicting budget deficit; this study used Lyapunov exponents. System has ability to predict the short term with using nonlinear modeling in the confirmed existence of chaos (Fallahi, 2005, 149). Here Lyapunov exponents check with substitution procedure. The results of estimating Lyapunov exponents for budget deficit time series during the period 1971-2008, represents estimated quantities stable cointegration for N period. As a result can be used a greater extent past information to predict from. It should be noted if there is chaos in the system, is not possible long-term forecast. Only can done necessary forecast for short-term. The following table reported Lyapunov test results for budget deficit time series that was done by the Mat lab software during the period 1971-2008.

Table 2: Results of Lyapunov test for budget deficit time series 1971-2008

<table>
<thead>
<tr>
<th>Dimension</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original</td>
<td>0.033</td>
<td>0.021</td>
<td>0.0052</td>
<td>0.003</td>
</tr>
<tr>
<td>Disorganization</td>
<td>0.05</td>
<td>0.041</td>
<td>0.010</td>
<td>0.007</td>
</tr>
</tbody>
</table>

Reference: Research Finding

To ensure of Lyapunov exponents calculation used Disorganization test. As can be seen in the above table Lyapunov exponent value for disorganization Time series is most of the original Time series, that Indicating being certain and non-random concerned Time series.

6. Estimation of artificial neural network model and budget deficit long-term prediction

To predict more than one period, used of predicted rather than actual quantities. First, predicted government revenues for this purpose. In this mode neural network structure is first order recurrent type and there 3 neurons in hidden layer. Sigmoid tangent hidden layer stimulus function, linear output layer stimulus function and learning network based on error propagation law. Forecast results for a next period with using this network shown in below diagram.

Figure 2: Forecast of government revenues and forecast error curve in a next period

Reference: Research Finding
Then by using weights and biases obtained at this stage, forecast the long term; that outputs of each period used as the next period inputs. So Predicted government revenues for the last 5 years (2009-2014), that can be seen results in the below diagram.

**Figure 3:** Forecasting government revenues for 5 next period and Prediction error curve

![Image](image-url)

Reference: Research Finding

However, using government revenues prediction values to predict budget deficits. Artificial neural network prediction results reported in following table.

**Table 3:** Actual and predicted values of the budget deficit using artificial neural networks 2004-2014 (Billion riyals)

<table>
<thead>
<tr>
<th>Value year</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
<td>49229.1</td>
<td>60853.4</td>
<td>147431.1</td>
<td>105554.9</td>
<td>181810.5</td>
<td>-*</td>
</tr>
<tr>
<td>Prediction</td>
<td>48999</td>
<td>61080.5</td>
<td>147741.3</td>
<td>105505.4</td>
<td>181823.9</td>
<td>23110.2</td>
</tr>
<tr>
<td>Prediction error</td>
<td>0.46</td>
<td>0.37</td>
<td>0.34</td>
<td>0.046</td>
<td>0.007</td>
<td>0.07**</td>
</tr>
<tr>
<td>Value year</td>
<td>2010</td>
<td>2011</td>
<td>2012</td>
<td>2013</td>
<td>2014</td>
<td></td>
</tr>
<tr>
<td>Actual</td>
<td>-*</td>
<td>-*</td>
<td>-*</td>
<td>-*</td>
<td>-*</td>
<td></td>
</tr>
<tr>
<td>Prediction</td>
<td>249931.9</td>
<td>310749.5</td>
<td>331123.6</td>
<td>377816.3</td>
<td>442762.4</td>
<td></td>
</tr>
<tr>
<td>Prediction error</td>
<td>0.03**</td>
<td>0.01**</td>
<td>0.00**</td>
<td>0.01**</td>
<td>0.04**</td>
<td></td>
</tr>
</tbody>
</table>

* Accurate and reliable statistics not existing for these years.
** This error is estimated of probable error that increases in terms of over time.

**Figure 4:** Forecasting budget deficit for 11 next periods and Prediction error curve

![Image](image-url)

Reference: Research Finding

### 7. Monte Carlo simulation with uncertainty in government behavior

One of the best methods of risk analysis is Monte Carlo simulation. Monte Carlo analysis is a method initially developed in the 1940s that uses statistical sampling techniques to obtain a probabilistic approximation to the solution of a mathematical equation or model. Another potential use of Monte Carlo analysis is for examining the sensitivity of a model to changes in specific parameters about which there is a high degree of uncertainty. As
such, it is a tool that can be used for conducting probabilistic risk assessments (Hayse, 2000). In order to simulate, we used Crystal Ball software that is the product of Decisioneering Company. The purpose is to calculate the uncertainty of government behavior for bilateral effect of the budget deficit and government policy. Indeed, dramatic changes have been created in risk management in recent years. This evolution has started by creating a new index called the Value at Risk (VaR).

Now we are to calculate VaR through Monte Carlo simulation technique, in order to determine the optimal budget deficit. Hence as the sample assume there is a desire by government to budget deficit, and further assume there are four states in budget deficit impressibility of government policies.

Table 4: Distribution fitted by the budget deficit impressibility of government policies

<table>
<thead>
<tr>
<th>State</th>
<th>Impressibility fitted distribution</th>
<th>Graphical form</th>
</tr>
</thead>
<tbody>
<tr>
<td>State one</td>
<td>Normal</td>
<td></td>
</tr>
<tr>
<td>State tow</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td>State tree</td>
<td>Log-Normal</td>
<td></td>
</tr>
<tr>
<td>State four</td>
<td>Gamma</td>
<td></td>
</tr>
</tbody>
</table>

After definition of assumptions, simulation will be performed by Crystal Ball software and what can be reported from the software application is plenty of charts (Rezaie, 2007). At 95% confidence level, an example of frequency charts is as follows:

Figure 5: an example of frequency charts acquired by the software to calculate VaR at 95% confidence level

The graph is in fact the estimated distribution and simulation of the budget deficit lost with 10 000 replication. Evidently, at 95% confidence level, the maximum likelihood of the budget deficit is acquired up to 50% of the budget total; That suggests high relatively sensitivity the desire to budget deficit to implement different policies, and There are a lot of uncertainty in budget deficit at implementation of diversification government policies. Now use this software to determine government value at risk in above four states. The following figure Reported prediction of government budget value at risk in a given distribution, which is result of computer simulation:
As shown in the above chart, with counting beta distribution for government function budget, value at risk is similar to case used real data; this suggests that appropriate statistical distribution for government behavior is beta distribution and can be using this distribution to future prediction. Now according to the above, can be used optimal utility function. At this stage we have two different goals for governments; first goal based on utility maximization theory, is maximization of social utility:

\[
\max U = E(\varepsilon_i) x_1 + \cdots + E(\varepsilon_n) x_n \\
\sum_{i=1}^{n} \varepsilon_i x_i^2 + 2 \sum_{i=1}^{n} \sum_{j=1}^{n} \varepsilon_i \varepsilon_j x_i x_j + \var\leq \beta, x_i \geq 0
\]

The second goal is minimizing the variance of social utility:

\[
\min Z = \sigma^2 \\
E(\varepsilon_i) = \sum_{i=1}^{n} \varepsilon_i x_i \beta E(\varepsilon_i) \\
\sum_{i=1}^{n} x_i = 1, x_i \geq 0
\]

E (\varepsilon_i) is represents the average of impressibility budget deficit on government policy, \( x_i \) is budget deficit riyal levels and \( \beta \) is the total of government budget. We can now combine the above two models, and calculate the optimal amount of budget deficit that including uncertainty in tax policy.

\[
\max U = E(\varepsilon_i) x_1 + \cdots + E(\varepsilon_n) x_n \\
\min Z = \sigma^2 \\
\text{s.t.} \quad \sum_{i=1}^{n} \varepsilon_i x_i^2 + 2 \sum_{i=1}^{n} \sum_{j=1}^{n} \varepsilon_i \varepsilon_j x_i x_j + \var\leq \beta \\
E(\varepsilon_i) = \sum_{i=1}^{n} \varepsilon_i x_i \beta E(\varepsilon_i) \\
\sum_{i=1}^{n} x_i = 1 \\
x_i \geq 0
\]

The placement corresponding figures, can be solved the problem with Lingo software. The following graph shows percent of optimal budget deficit in the years studied and considering the uncertainty in government policies effectiveness:

**Figure 7:** Optimal percent of budget deficit in uncertainty conditions, 2011-2014

<table>
<thead>
<tr>
<th>Year</th>
<th>Neural Network</th>
<th>Monte Carlo</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>450640</td>
<td>200540</td>
</tr>
<tr>
<td>2012</td>
<td>510111</td>
<td>251132</td>
</tr>
<tr>
<td>2013</td>
<td>559711</td>
<td>281823</td>
</tr>
<tr>
<td>2014</td>
<td>632140</td>
<td>300000</td>
</tr>
</tbody>
</table>
As can be seen, prediction of Monte Carlo simulation reported lower quantities in comparison with other predictions. The reason is that Monte Carlo simulations calculated optimal values of budget deficit including 50% uncertainty in government policies; but the pattern of neural network using real statistics and the process of information to predict possible values to become reality in the next years. As described in the artificial neural network, Prediction of this pattern has been less prediction error and is closer to reality. So results of Monte Carlo prediction show what should it be and neural network prediction show what it is. Thus difference between these two will show budget deficit gap in the years ahead.

8. Conclusion

Throughout this paper used neural network model and Monte Carlo simulation to predict budget deficit. Hence to detect chaos in time series and determine how predictions used Lyapunov test, that the chaos in time series was low. At the end of this paper, using Monte Carlo simulation in the presence of uncertainty caused by government policies to predict optimal budget deficit. It is noteworthy Monte Carlo prediction show what should it be and neural network prediction show what it is. Monte Carlo simulation results show lower values that Suggests is being optimized this prediction. According to the obtained results, appropriate statistical distribution for budget deficit in Iran is the beta distribution. As a result, policymakers for their programs can be used this distribution. Total, Increase the budget deficit is worrisome in Iran and should be thought to this situation.
References


