Forecasting National Well-being Indicators of Taiwan

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Abstract

Newly proposed National Well-being Indicators from Taiwan government is investigated in research. These indicators are categorized into two categories and 11 topics based on the OECD’s Your Better Life Index. Three indicators which are consumption expenditure per capita, unemployment rate of age 15 to 24 and real earning are analyzed by grey forecasting model because of complete information provided. The result showed that consumption expenditure will increase, unemployment rate will keep at above 13% and real earning will decrease constantly in the future four year. The government should propose policies to prevent economic downturn in advance.

Keywords: Grey model (1,1); National well-being indicators; Unemployment; Consumption expenditure

Introduction

The responsibility of a government is to bring economic prosperity and well-beings for his people. Traditionally, government will announce statistical figures to show the status of economic situation and the level of people’s living standard, for example, gross domestic product (GDP), consumer’s price index (CPI), and so on. Unfortunately, people do not feel directly from these figures because these are macro-economic figures. People feel directly from his everyday lives, for example the food price, house price, rent, salary, employment and social security. It happens all the time that people are angry and complaint about government incapability when positive economic figures announced. The gap between government administration and people awareness is always an issue to solve. Therefore, concerns have emerged to develop new indicators which are beyond GDP and more inclusive of environmental and social aspects of progress. In order to comply with international trend, the Directorate-General of Budget, Accounting and Statistics (DGBAS) has been working on developing better measurements of well-being and progress. The National Well-being Indicators (NWI) in Taiwan were derived from the OECD “Your Better Life Index’s (YBLI)” There are 11 topics categorized into material living conditions which includes housing, income, jobs and quality of life matters which includes community, education, environment, civic engagement, health, life satisfaction, safety and work-life balance. For purposes of comparison, the international indicators and domestic indicators coexist in the NWI. The National Well-being Indicators of Taiwan to show the future changing trend.

In this research, the future changing trend of NWI is of concern. The grey forecasting theory [1] is one of the suitable tools to achieve the goal as limited data provided. Grey theory has been developing for more than 30 years and has progressed greatly recently because of many contributors working on this subject. Huang et al. [2] used the Artificial Fish Swarm Algorithm to dynamically adjust the parameters of the Gray Model Neural Network to enhance the precision of the stock forecast model as a whole. The result showed that the forecast capability of each stage after the optimization process is better than that of its previous stage, and the mixed stock forecast model (GP-AFSA+GMNN-AFSA) in stage 4 greatly enhanced the precision of the forecast. Hsin and Chen [3] combined game theory with NGBM to the forecasting of Taiwan’s GDP. The results show that five elements in raw data sequence are optimal topological length for constructing NNGBM in the case of Taiwan’s GDP forecasting. Topics about energy related economic indicators are one of the most concern. Kankal et al. [4] modeled the energy consumption in Turkey in order to forecast future projections based on socio-economic and demographic variables (gross domestic product-GDP, population, import and export amounts, and employment) using artificial neural network (ANN) and regression analyses. Finally, it was concluded that all the scenarios that were analyzed gave lower estimates of the energy consumption than the MENR projections and these scenarios also showed that the future energy consumption of Turkey would vary between 117.0 and 175.4. Xie [5] applied an optimized single-variable discrete grey forecasting model [OSDGM (1,1)] to measure the instigation effects of the energy-saving policy and forecast whether the planned reduction rate of energy consumption per unit GDP in the implementation stage could be accomplished or not. The results illustrate that China’s government has made major progress on energy saving even though the task is tough in the long run. Aydin [6] modeled Turkey’s primary energy consumption by regression analysis (RA) based on population (CP) and gross domestic product (GDP). The derived model is validated by various statistical approaches. The results show that the proposed model can be affectively used for forecasting of Turkey’s PEC. The scenarios also show that the future energy consumption of Turkey would vary between 174.65 and 203.13. Various researchers also worked on these topics [7-13].

Grey theory has been successfully applied to forecast various economic indicators. In this research, the newly compiled National Well-being Indicators in Taiwan since 2013 is of research interest. The characteristics of less data needed for grey theory is adopted to forecast the NWI of Taiwan to show the future changing trend.
Mathematical Methodology of Nonlinear Grey Bernoulli Model

The first order linear differential equation is the theoretical basis of grey forecasting model. The solution curve could fit the collected data by means of least square method. The characteristics of exponential function could provide more flexibility of fitting than linear regression model.

Traditional grey model GM (1,1)

This section provides the derivation of traditional grey forecasting in detail [14].

Step 1: Assume that the original series of data with m entries is:

\[ X^{(0)} = \{ x^{(0)}(1), x^{(0)}(2), ..., x^{(0)}(k), ..., x^{(0)}(m) \} \]  

(1)

where raw matrix \( X^{(0)} \) stands for the non-negative original historical time series data.

Step 2: Construct \( X^{(1)} \) by one time accumulated generating operation (1-AGO), which is

\[ X^{(1)} = \{ x^{(1)}(1), x^{(1)}(2), ..., x^{(1)}(k), ..., x^{(1)}(m) \} \]  

(2)

where

\[ x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i), \quad k = 1, 2, ..., m. \]  

(3)

Step 3: The result of 1-AGO is monotonic increase sequence which is similar to the solution curve of first order linear ordinary differential equation. Therefore, the solution curve of following differential equation represents the approximation of 1-AGO data.

\[ \frac{d X}{dt} + a X = b \]  

(4)

where \( a \) represents Grey forecast value. The \( a \) and \( b \) are model parameters and \( a \) could not equal to zero [14]. \( X^{(1)}(0) = x^{(0)}(1) \) is the corresponding initial condition.

Step 4: The model parameters \( a \) and \( b \) can be determined by discrete form of Eq. (4)

\[ \frac{d X}{dt} = \lim_{\Delta t \to 0} \frac{X^{(1)}(t + \Delta t) - X^{(1)}(t)}{\Delta t} \]  

(5)

If the sampling time interval is unit, then let \( \Delta t \to \) 

\[ \frac{d X}{dt} = x^{(1)}(k + 1) - x^{(1)}(k) = x^{(0)}(k + 1), \quad k=1,2,3. \]  

(6)

And \( x^{(i)}(t) \) is defined as

\[ X^{(i)}(t) = P x^{(i)}(k) + (1 - P) x^{(i)}(k + 1) = z^{(i)}(k + 1), \quad k=1,2,3. \]  

(7)

where \( z^{(i)}(k) \) is termed background value, \( P \) is traditionally set to 0.5. The source model then can be obtained as

\[ x^{(0)}(k) + az^{(1)}(k) = b, \quad k=2,3,4, \]  

(8)

From Eq. (8), by least square method, the model parameters \( a \) and \( b \) are

\[ \begin{bmatrix} a \\ b \end{bmatrix} = (B^T B)^{-1} B^T Y, \]  

(9)

where \( B \) and \( Y \) are defined as follows

\[ B = \begin{bmatrix} \bar{z}^{(0)}(2) & 1 \\ \bar{z}^{(0)}(3) & 1 \\ \vdots & \vdots \\ \bar{z}^{(0)}(m) & 1 \end{bmatrix}, \quad Y = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(m) \end{bmatrix} \]  

(10)

or, \( a \) and \( b \) can be expressed in the following form

\[ a = \frac{\sum_{k=2}^{m} \bar{z}^{(0)}(k) \sum_{k=2}^{m} x^{(0)}(k) - (m-1) \sum_{k=2}^{m} x^{(0)}(k) \bar{z}^{(0)}(k)}{(m-1) \sum_{k=2}^{m} \bar{z}^{(0)}(k)^2 - \sum_{k=2}^{m} x^{(0)}(k) \bar{z}^{(0)}(k)}, \]  

\[ b = \frac{\sum_{k=2}^{m} x^{(0)}(k) \sum_{k=2}^{m} \bar{z}^{(0)}(k) - \sum_{k=2}^{m} x^{(0)}(k) \bar{z}^{(0)}(k) \sum_{k=2}^{m} x^{(0)}(k) \bar{z}^{(0)}(k)}{(m-1) \sum_{k=2}^{m} \bar{z}^{(0)}(k)^2 - \sum_{k=2}^{m} x^{(0)}(k) \bar{z}^{(0)}(k)}. \]  

(11)

Step 5: Solve the Eq. (4) together with initial condition, and the particular solution is

\[ x^{(1)}(k + 1) = x^{(0)}(1) - \frac{b}{a} e^{-ak} + \frac{b}{a}, \quad k=1,2,3, \ldots \]  

(12)

Hence, the desired forecasting output at \( k \) step can be estimated by inverse accumulated generating operation (IAGO) which is defined as

\[ x^{(0)}(k + 1) = (1 - e^{-ak})(x^{(0)}(1)) - \frac{b}{a} e^{-ak}, \quad k=1,2,3, \ldots \]  

(13)

Error analysis

Error analysis is needed for examining the precision of forecasted results. Relative percentage error (RPE) compares the real and forecast values to evaluate the precision at specific time \( k \). RPE is defined as

\[ RPE = \frac{\varepsilon(k) - x^{(0)}(k)}{x^{(0)}(k)} \times 100\%, \quad k=2,3,4, \ldots, m, \]  

(15)

where \( X^{(0)}(k) \) is the actual value and \( \hat{X}^{(0)}(k) \) is the forecasted value by Eq. (14). The total model precision can be defined by average relative percentage error (ARPE) as follows

\[ ARPE = \varepsilon(\text{avg}) = \frac{1}{m-1} \sum_{k=2}^{m} |\varepsilon(k)|, \quad k=2,3,4, \ldots, m. \]  

(16)

Forecasting National Well-being Indicators by GM (1,1)

Among the 11 topics shown in Table 1, there are three indicators which are direct economic related and provided with complete five years information. These indicators are consumption expenditure per capita, unemployment rate of age 15 to 24 and real earning. Following, these three indicators are analyzed by GM(1,1) to show the future four years information. These indicators are consumption expenditure per capita, unemployment rate of age 15 to 24 and real earning. The forecast value from year 2015 to 2018, it also shows positive direction. The modelling error is only 0.32% and highest point residual
error is 0.62%. This shows high reliability of forecasting result. From the figure, it is believed the economic situation is still on track to the bright side. The forecasting is shown in Table 2.

Unemployment rate of age 15 to 24

Unemployment rate of age 15 to 24 is defined as total number of unemployment versus total number of labors in the age range. This indicator is also objective because it is calculated from collected statistical data and is negative because it is better to have lower figure. During the past five years, the unemployment rate of age 15 to 24 is kept on the high proportion rate from 12.59% to 13.09%. The reason might be the people in this age range are still in the school from junior high to university. The rate is forecast to be still high value because of this same reason. And this figure will be worse because of low birth rate in Taiwan. In the future four years, this indicator always is kept above 13%. The modelling error is only 1.51% and highest point residual error is 2.95%. The forecast result is shown in Table 2.

Real earning

Real earning is defined as average salary minus commodity price fluctuation. This indicator is objective because it is calculated from collected statistical data and is positive because it is better to have higher figure. From the past five years, the real earning is kept almost unchanged and even having trend of decline. In the future four years, the forecast real earning is decreasing year by year. This might be economic downturn or soaring commodity price. The direct feeling of
Table 2: Actual and forecast value of three economic related indicators.

| Indicators                      | units   | 2010     | 2011     | 2012     | 2013     | 2014     | 2015     | 2016     | 2017     | 2018     |
|--------------------------------|---------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Consumption expenditure per capita | NT dollar | 216,090  | 221,584  | 225,292  | 232,998  | 239,736  | 245,892  | 252,648  | 259,590  | 266,723  |
| Forecast value                  | NT dollar | 216,090  | 220,627  | 226,888  | 232,917  | 239,317  | 245,892  | 252,648  | 259,590  | 266,723  |
| RPE (%)                         | %        | 0        | 0.43     | -0.62    | 0.03     | 0.17     |          |          |          |          |
| ARPE (%)                        | %        |          |          |          |          |          | 0.32     |          |          |          |
| Unemployment rate of age 15 to 24 | %       | 13.09    | 12.47    | 12.66    | 13.17    | 12.63    |          |          |          |          |
| Forecast value                  | %        | 13.09    | 12.59    | 12.68    | 12.78    | 12.88    | 12.98    | 13.08    | 13.18    | 13.28    |
| RPE (%)                         | %        | 0        | -0.93    | -0.18    | 2.95     | -1.97    |          |          |          |          |
| ARPE (%)                        | %        |          |          |          |          |          | 1.51     |          |          |          |
| Real earning                    | NT dollar | 44,989   | 45,508   | 44,726   | 44,464   | 45,494   |          |          |          |          |
| Forecast value                  | NT dollar | 44,989   | 45,092   | 45,059   | 45,027   | 44,965   | 44,930   | 44,898   | 44,865   |          |
| RPE (%)                         | %        | 0        | 0.91     | -0.75    | -1.31    | 1.10     |          |          |          |          |
| ARPE (%)                        | %        |          |          |          |          |          | 1.02     |          |          |          |

Source: http://happyindex.dgbas.gov.tw/e_index.htm?y=201506

people is based on what they actual face. The real earning decrease will of course cause complaint from people. The government should make effort to urge boss to raise up salary in order to subside people’s anger. The modelling error is only 1.02% and highest point residual error is 1.31%. The forecast result is shown in Table 2.

**Conclusion**

The current official statistical figures are far reaching the heart of people. The positive economic performance could not win applause from people. In order to close to people real life, Taiwan government proposed National Well-being Indicators to actually reflect people’s life based on the everyday life statistics. There are two categories and 11 indicators. In this research, three indicators are forecast by grey forecasting model to show their future changing trend. The result showed that forecasting precision is very high. The consumption expenditure per capita will be kept increasing owing to high commodity price, Unemployment rate of age 15 to 24 will also be kept at high value because of 12 year compulsory education and low birth rate, real earning will be lowering which might be the sign of recession in economic. These results could provide the government to propose new policy in advance to prevent future deteriorating economic situation.

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**References**

1. Deng JL (1982) Control problems of grey systems. Systems and Control Letters 1: 288-294.
2. Huang CJ, Chen PW, Pan WT (2012) Using multi-stage data mining technique to build forecast model for Taiwan stocks. Neural Computing and Applications 21: 2057-2063.
3. Hsin PH, Chen CI (2015) Application of game theory on parameter optimization of the novel two-stage Nash nonlinear grey Bernoulli model. Communications in Nonlinear Science and Numerical Simulation 27: 168-174.
4. Kankal M (2011) Modeling and forecasting of Turkey’s energy consumption using socio-economic and demographic variables. Applied Energy 88: 1927-1939.
5. Xie NM, Pearman AD (2014) Forecasting energy consumption in China following instigation of an energy-saving policy. Natural Hazards 74: 639-659.
6. Aydin G (2014) Modeling of energy consumption based on economic and demographic factors: The case of Turkey with projections. Renewable and Sustainable Energy Reviews 35: 382-389.
7. Wang JZ (2011) Coal production forecast and low carbon policies in China. Energy Policy 39: 5970-5979.
8. Pao HT, Fu HC, Tseng CL (2012) Forecasting CO2 emissions, energy consumption and economic growth in China using an improved grey model. Energy 40: 400-409.
9. Zhao Z (2012) Using a Grey model optimized by Differential Evolution algorithm to forecast the per capita annual net income of rural households in China. Omega-International Journal of Management Science 40: 525-532.
10. Lee YS, Tong L (2012) The use of genetic programming for the construction of a financial management model in an enterprise. Applied Intelligence 36: 271-279.
11. Pan WT (2012) The use of genetic programming for the construction of a financial management model in an enterprise. Applied Energy 94: 251-256.
12. Yu SW, Zhu KJ (2012) A hybrid procedure for energy demand forecasting in China. Energy 37: 396-404.
13. Wang MW (2014) A Novel Clustering Model Based on Set Pair Analysis for the Energy Consumption Forecast in China. Mathematical Problems in Engineering.
14. Chen CI, Huang SJ (2013) The necessary and sufficient condition for GM (1,1) grey prediction model. Applied Mathematics and Computation 219: 6152-6162.