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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.

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' 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 (BLI's)" 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 in Taiwan is shown in Table 1. The outcomes of National Well-being Indicators were first launched in August 2013 and their effect on how people feel has not reported which intrigues us studying on this topic.

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 complied 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.

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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:

$$X^{(0)} = \left\{ x^{(0)}(1), x^{(0)}(2), ..., x^{(0)}(k), .., x^{(0)}(m) \right\} \qquad (1)$$

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

$$X^{(1)} = \left\{ x^{(1)}(1), x^{(1)}(2), ..., x^{(1)}(k), ..., x^{(1)}(m) \right\} \qquad (2)$$

where

$$x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i), \ k = 1, 2, ..., m. \qquad (3)$$

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.

$$\frac{d \hat{X}^{(1)}}{dt} + a \hat{X}^{(1)} = b \qquad (4)$$

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

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

$$\frac{d \hat{X}^{(1)}}{dt} = \lim_{\Delta t \to 0} \frac{\hat{X}^{(1)}(t + \Delta t) - \hat{X}^{(1)}(t)}{\Delta t} \qquad (5)$$

If the sampling time interval is unit, then let $\Delta \to$

$$\frac{d \hat{X}^{(1)}}{dt} \cong x^{(1)}(k+1) - x^{(1)}(k) = x^{(0)}(k+1), \ k=1,2,3, \quad (6)$$

and $\hat{X}^{(1)}(t)$ is defined as

$$\hat{X}^{(1)}(t) \cong P x^{(1)}(k) + (1-P) x^{(1)}(k+1) = z^{(1)}(k+1, \ k=1,2,3, \quad (7)$$

where $z^{(1)}$ is termed background value, P is traditionally set to 0.5. The source model then can be obtained as

$$x^{(0)}(k) + a z^{(1)}(k) = b, \ k=2,3,4, \qquad (8)$$

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

$$\begin{bmatrix} a \\ b \end{bmatrix} = (B^T B)^{-1} B^T Y_N, \qquad (9)$$

where B and Y_N are defined as follows

$$B = \begin{bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \vdots & \vdots \\ -z^{(1)}(m) & 1 \end{bmatrix}, \ Y_N = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(m) \end{bmatrix}, \qquad (10)$$

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

$$a = \frac{\sum_{k=2}^{m}\left[z^{(1)}(k)\right]\sum_{k=2}^{m}x^{(0)}(k) - (m-1)\sum_{k=2}^{m}x^{(0)}(k)z^{(1)}(k)}{(m-1)\sum_{k=2}^{m}\left[z^{(1)}(k)\right]^2 - \left(\sum_{k=2}^{m}z^{(1)}(k)\right)^2} \qquad (11)$$

$$b = \frac{\sum_{k=2}^{m}x^{(0)}(k)\sum_{k=2}^{m}\left[z^{(1)}(k)\right]^2 - \sum_{k=2}^{m}x^{(0)}(k)z^{(1)}(k)\sum_{k=2}^{m}z^{(1)}(k)}{(m-1)\sum_{k=2}^{m}\left[z^{(1)}(k)\right]^2 - \left(\sum_{k=2}^{m}z^{(1)}(k)\right)^2} \qquad (12)$$

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

$$\hat{X}^{(1)}(k+1) = \left(x^{(0)}(1) - \frac{b}{a} \right) e^{-ak} + \frac{b}{a}, \ k=1,2,3,......, \qquad (13)$$

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

$$\hat{x}^{(0)}(k+1) = (1 - e^{-a})(x^{(0)}(1) - \frac{b}{a})e^{-ak}, \ k=1,2,3,...... \qquad (14)$$

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

$$\text{RPE} = \varepsilon(k) = \frac{x^{(0)}(k) - \hat{x}^{(0)}(k)}{x^{(0)}(k)} \times 100\%, \ k=2,3,4,...,m, \qquad (15)$$

where $x(k)$ 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

$$\text{ARPE} = \varepsilon(avg) = \frac{1}{m-1}\sum_{k=2}^{m}|\varepsilon(k)|, \ k=2,3,4,...,m. \qquad (16)$$

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 developing trend. The results could provide the government direction of proposing policies.

Consumption expenditure per capita

Consumption expenditure per capita is defined as household consumption expenditure divided by number of family member. 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 data from year 2010 to 2014, the figure gradually increases from NT 216,090 to 239,736 which show the positive economic development. The forecast value from year 2015 to 2018, it also shows positive direction. The modelling error is only 0.32% and highest point residual

Topics	International Indicators	Domestic Indicators
Housing conditions	Rooms per person	Average dwelling space per person
	Housing expenditure	Ratio of house price to income
	Dwelling without basic facilities	Ratio of rent to income
		Satisfaction with present dwelling
		Satisfaction with dwelling surrounding environment quality
Income and Wealth	Household net adjusted disposable income(PPP)	Annual change rate of median disposable income per capita
	Household financial wealth(PPP)	Consumption expenditure per capita
		Ratio of income share of highest 20% to that of lowest 20%
		Subjective evaluation of material wellbeing
		Ratio of relative poverty
Jobs and Earnings	Employment rate	Ratio of part-time, temporary or dispatched workers
	Long-term unemployment rate	Unemployment rate of age 15 to 24
	Personal earnings(PPP)	Satisfaction with Jobs
	Job security	Real earning
Social connections	Quality of support network	Frequency of socializing with friends
		Frequency of socializing with relatives
		Time spent volunteering
		Trust in others
		Satisfaction with family relationship
Education and skills	Educational attainment	Lifelong learning
	Years in education	
	Students' skills in maths, reading and science	
Environmental quality	Air pollution	Average green spaces per person in the urban area
	Water quality	Participation in political activities
Civic engagement and governance	Voter turnout	Confidence in national government
	Consultation on rule-making	Confidence in judicial system and courts
		Confidence in media
		Satisfaction with democratic life
		Satisfaction with the freedom of speech
Health status	Life expectancy	Self-reported limitations in daily activities
	Self-reported health	Caregiver's burden
		Healthy life expectancy
		Percentage of rejection cases in food inspection and test
		Foodborne Illness
Subjective well-being	Life satisfaction(Cantril Ladder)	Life satisfaction
		Characteristics contribute to Taiwan's well-being
Personal security	Homicide rate	Victim of domestic violence
	Assault rate	Occurrence of residential burglary
	Mortality from accidents	
	Feeling of security	
Work and life balance	Employees working very long hours	Commuting time
	Time devoted to leisure and personal care	Satisfaction with allocation of time

Note: 1The international indicators are based completely on OECD Your Better Life Index.
2 No total score will be added up for the domestic indicators.
Source: http://happyindex.dgbas.gov.tw/e_index.htm?y=201506

Table 1: The national well-being indicators in Taiwan.

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

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				
Forecast value	NT dollar	216,090	220627	226,688	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	44,446	45,494				
Forecast value	NT dollar	44,989	45,092	45,059	45,027	44,995	44,962	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

Table 2: Actual and forecast value of three economic related indicators.

people is based on what they actual face. The real earning decline 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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