For office use only	Team Control Number	For office use only
T1 ________________	84018	F1 ________________
T2 ________________		F2 ________________
T3 ________________	Problem Chosen	F3 ________________
T4 ________________	C	F4 ________________

2018

MCM/ICM

Summary Sheet

We Will Get O Prize(Not U Prize)

Summary

hello world

Keywords:
hello; world

Contents

1 Overview

1.1 Background

The rapid development of modern social economy benefits from the development of energy production. The issue of energy usage and production has always been the focus of world economic development.

In the 21st century, with the economic development and improvement, the energy shortage and the increasing contradiction between supply and demand. Meanwhile, the production and use of fossil energy sources have had a huge negative impact on the environment. Therefore, developing clean and renewable energy is imperative.

The differences between states such as geography, industry, population, climate lead to the contradiction of energy supply. Interstate cooperation and joint management and development of clean and renewable energy are regarded as the best solution to these problems. Nowadays four state governors –California, Arizona, New Mexico and Texas –wish to form a realistic new energy compact. Texas leads the country in total (non-hydro) installed renewable energy capacity, almost all of which comes from the state’s 9,410 MW of wind capacity. California is the leader in solar energy installed capacity, both for photovoltaic technology (738 MW) and concentrating solar power (364 MW).

1.2 Restatement of the Problem

We are required to provide an overview of energy profile for each of the four states and model how these profiles have evolved from 1960 to 2009. In addition, it is necessary to make our results understandable through discussion, including similarities and differences between 4 states. Then we need to establish a criteria model and choose the "best" profile use of cleaner, renewable energy usage targets. Finally, we need to give our suggestions about exact action to achieve the goal we set based on what we predict.

In order to identify In order to determine whether it is clean and renewable energy, for which we check the information and classification of various types of energy.

cleaner, renewable energy (defination from SEDS and):

- Conventional hydroelectric power
- Solar thermal direct use energy and photovoltaic electricity net generation
- Electricity produced by wind
- Wood and wood-derived fuels, biomass waste
- Fuel ethanol minus denaturant

2 Notations and Assumptions

2.1 Notations

2.2 Assumptions and Justifications

We make the following basic assumptions in order to simplify the problem. Each of our assumptions is justified and is consistent with the basic fact.

1. **Ignore the external costs caused by power generation other than coal:**

   In 2005, the mean external damage of coal in the United States due to coal combustion was 3.2 cents/kWh, The external cost of natural gas power generation is 0.16 cents/kwh, which is actually almost entirely caused by coal-fired power. Also life-cycle CO2 emissions from nuclear, wind, biomass, and solar appear so small as to be negligible compared with those from fossil fuels.(information comes from the report "Hidden cost of energy unpriced consequences of energy production and use")

2. **The conversion between generation and consumption is 100%, and the consumption is used to represent the amount of power generation to evaluate.**

Symbol	Meaning
n	the number of samples
p	the number of original indicators
k	the number of principal component
X	$\{x_{ij}\}$ original data matrix (i = 1, 2,⋯, n ; j = 1,2,⋯,p)
Z	$\{z_{ij}\}$ standardization matrix with z-scores (i = 1, 2,⋯, n ; j = 1,2,⋯,p)
U	$\{u_{ij}\}$ partial covariance matrix (i = 1, 2,⋯, n ; j = 1,2,⋯,p)
C	$\{c_{ij}\}$ covariance matrix (j = 1,2,⋯,p)
R	$\{r_{ij}\}$ correlation matrix (j = 1,2,⋯,p)
F	$\{f_{ij}\}$ The eigenvectors matrix of Z (j = 1,2,⋯,p)
Y	$\{y_{ij}\}$ principal component matrix (i = 1, 2,⋯, n ; j = 1,2,⋯,k)
V	$\{v_{ij}\}$ decision matrix (i = 1, 2,⋯, n ; j = 1,2,⋯,k)
A^+ / A^-	positive / negative ideal profile
S_i^+ / S_i^-	positive / negative ideal profile
λ_j	the eigenvalues of Z (j=1,2,⋯,p)
y_i	principal component
C_i	the final performance score in TOPSIS method
kmo	the value of KMO test
p	autoregressive terms
d	differential times
q	average moving term
y_t	the original data sequence
$y_t^{'}$	smooth data sequence
$\hat{\rho}_k$	the auto-correlation function
$\hat{\varphi_{kk}}$	partial auto-correlation function

Table 1: Abbreviation and Description

3 Statement of Our Model

3.1 Model Overview

Firstly, considering energy production and consumption, environmental impact, technology, economy, we extract 12 variables from 605 variables to get general energy profile of each state.

In order to show the evolution of energy production, we construct a comprehensive evaluation index system for the level of cleaner, renewable energy development. We use the **Principal Component Analysis** method to carry out the correlation cluster analysis of the index. To make the similarities and differences between 4 states understandable, we use **TOPSIS** method to show our results.At the same time, we can get the extracted principal componment choosing the "best" profile from comprehensive evaluation results ranking.

After determining the “best” profile, we use **ARIMA** method to predict the energy profile of each state, especially as we evaluate the cleaner, renewable energy development in the future.

3.2 Model Theory

3.2.1 Principal Component Analysis Theory

The purpose of PCA is to use the idea of dimensionality reduction to convert multipleindicators into a few composite indicators. When using statistical methods to study multivariable problems, too many variables will increase the computational complexity and increase the complexity of analyzing the problems. We hope that in the process of quantitative analysis, fewer comprehensive variables are involved to make the results more Intuitive.

The method can be summarized as follows :

1. **Organize the data set and normalization** Supposing that there are n samples, and each sample has P indicators, the original variable data X are arranged as a set of n data vectors with each representing a single grouped

observation of the p variables, which as shown in formula(1)

$$X = \begin{vmatrix} x_1^T \\ x_2^T \\ \cdots \\ x_n^T \end{vmatrix} = \begin{vmatrix} x_{11} & x_{12} & \cdots & x_{1p} \\ x_{21} & x_{22} & \cdots & x_{2p} \\ \cdots & \cdots & \cdots & \cdots \\ x_{n1} & x_{n2} & \cdots & x_{np} \end{vmatrix}$$

We choose zero-mean normalization to standardize the original data matrix.The standard score of a raw score xij is shown as formula(2)

$$z_{ij} = \frac{x_{ij} - \mu_j}{\sigma_j}$$

where: μ_j is the mean of the row j .

σ_j is the standard deviation of the row j.

Then we get the standardization matrix Z as shown in formula(3).

$$Z = \begin{vmatrix} z_{11} & z_{12} & \cdots & z_{1p} \\ z_{21} & z_{22} & \cdots & z_{2p} \\ \cdots & \cdots & \cdots & \cdots \\ z_{n1} & z_{n2} & \cdots & z_{np} \end{vmatrix}$$

2. **Determine the correlation between the indicators** Correlation test is a statistical test of how the variables are related and how relevant they are. Thus, it' s also the basis of principal component analysis. The Kaiser-MeyerOlkin (KMO) test method is used in this model. Correlation coefficient is a statistical indicator of the close relationship between the response variables, whose range of values between 1 to -1.

   The formula(4) for KMO test is :

$$kmo_j = \frac{\sum_{i \neq j} r_{ij}^2}{\sum_{i \neq j} r_{ij}^2 + \sum_{i \neq j} u_{ij}^2}$$

   where :

   //R = [r_{ij}] is the correlation matrix.

U = $[u_{ij}]$ is the partial covariance matrix.

And for reference, Kaiser put the following values on the results :

value range	result
0.00 to 0.49	unacceptable
0.60 to 0.69	miserable
0.70 to 0.79	mediocre
0.80 to 0.89	meritorious
0.90 to 1.00	marvelous

Table 2: KMO reference table

3.2.2 Autoregressive Integrated Moving Average Model

The basic idea of this ARIMA model is to assume that the time series under study is a non-stationary time series generated by a random process. The non-stationary time series is treated several times to make it a stationary time series. Then the time series observations Value to establish the autoregressive moving average model of the stochastic process, using the optimal model established to predict.ARIMA model has 3 parameters. It is usually recorded as ARIMA(p,d,q). ARIMA is one of ARMA's expansion. ARMA's general expression is as followed:

$$y_t = \varphi_1 y_{t-1} + \varphi_2 y_{t-2} + ...\varphi_p y_{t-p} + u_t$$

Predictive model establishment process:

1. Obtain and pretreate the data:

   Do run-length test to determine whether the sequence is a smooth sequence. if it is a non-stationary sequence, using the difference method to make it smooth: y'_{t-i} = y_t - y_{t-1}, The sequence is preprocessed. After each difference, the data is run-tested until the difference data can pass the stationarity test and recorded as d-difference to obtain a new stationary sequence: y'_1, y'_2, y'_3.

2. ARMA model recognition:

   Model recognition was performed by calculating the(ACF)$\hat{\rho_k}$and pre-processed (PACF)$\hat{\varphi_{kk}}$ of the preconditioned sequence y'_t.

$$\hat{\rho_k} = \frac{\sum_{t=1}^{N-k} y_{t+k}^{'} y_t^{'}}{N}$$

$$\hat{\varphi}_{11} = \hat{\rho}_1$$
$$\hat{\varphi}_{k+1,k-1} = (\hat{\rho}_{k+1} - \sum_{j=1}^{k} \hat{\rho}_{k+1-j}\hat{\varphi}_{kj})(1 - \sum_{j=1}^{k} \hat{\rho}_j \hat{\varphi}_{kj})^{-1}$$
$$\hat{\varphi}_{k+1,j} = \hat{\varphi}_{jk} - \hat{\varphi}_{k+1,k+1}\hat{\varphi}_{k,k+1-j}, j = 1, 2, ..., k$$

3. Parameter Estimation and Model Ordering. ARIMA model parameter identification using Marquardt nonlinear least squares method.

4. Model test: First, we must test whether the model can satisfy the stability and reversibility. If the model is chosen properly, the residual sequence should be a white noise sequence.We can get a reliability prediction model.

$$y_t^{'} = \hat{\varphi}_1 y_{t-1}^{'} + \hat{\varphi}_2 y_{t-2}^{'} + ...\hat{\varphi}_p y_{t-p}^{'} + u_t$$

4 Model Implementation and Results

4.1 Definition

4.2 Other Assumptions

-
-
-
-

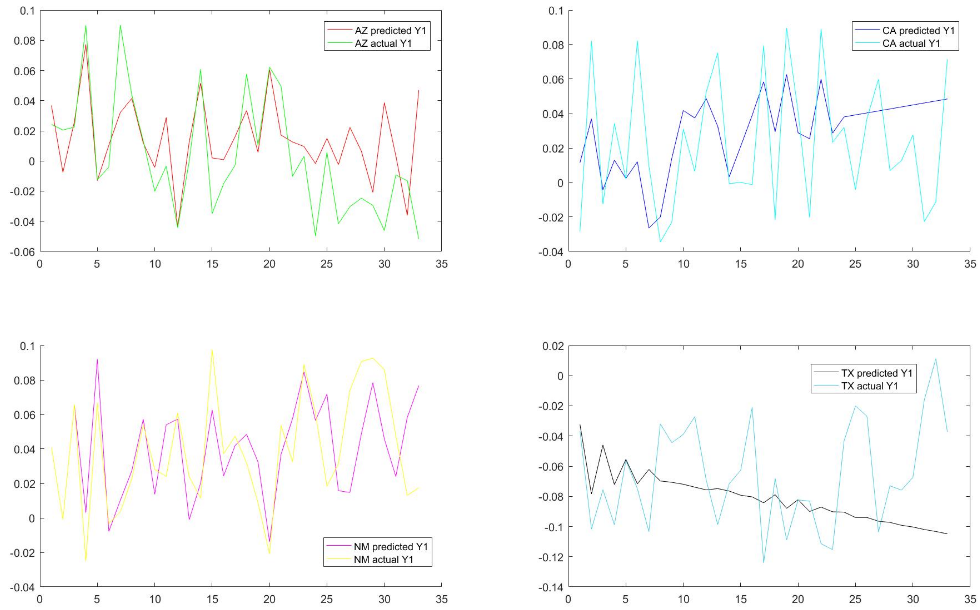

Figure 1: estimate

5 Our suggestions to the governor

Figure 1.

$$a^2 \tag{1}$$

$$\begin{pmatrix} *20ca_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix} = \frac{Opposite}{Hypotenuse} \cos^{-1}\theta \arcsin\theta$$

$$p_j = \begin{cases} 0, & \text{if } j \text{ is odd} \\ r!\,(-1)^{j/2}, & \text{if } j \text{ is even} \end{cases}$$

$$\arcsin\theta = \oiiint_{\varphi} \lim_{x\to\infty} \frac{n!}{r!\,(n-r)!} \tag{1}$$

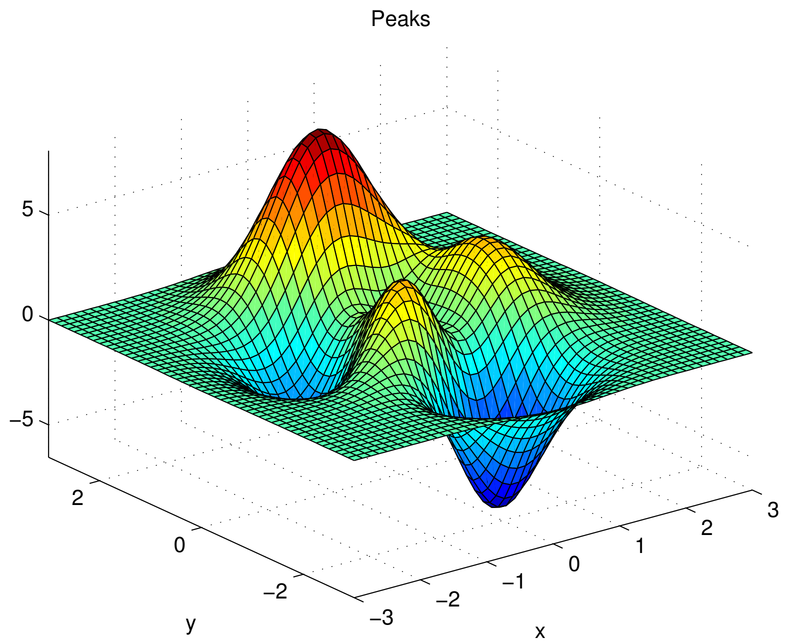

Figure 2: Figure example 1

Figure 3: Figure example 2

Figure 4: Figure example 3

6 Model analysis

6.1 Sensitivity Analysis

6.2 Strength and weakness

A_{ij} and A_{ij} 不一样

(123) and $\Phi 123 \Psi$ and （123）不一样

CTEX中最繁琐的是表格输入,不过数学建模竞赛中，一般要求输入三线表，这样统一格式的情况下，对于输入表格就简单一点了。

双斜杠是强制换行，在矩阵，表格，大括号的公式常用。
关于表格的合并，见下一部分。给出的例子。

Year	theta	S_1^-	S_2^-	S_3^-	S_4^+	S_5^+	S_6^+
2016	1	0	0	0.0001	0	0	0
2017	0.9997	0.0555	0	0.2889	0.1844	0.463	0
2018	0.9994	0	0	0.0012	0.3269	0.7154	0
2019	0.9993	0	0	0	0.4325	1.0473	0
2020	0.9991	0	0	0	0.5046	1.2022	0
2021	0.999	0	0	0	0.5466	1.2827	0
2022	0.9989	0.0017	0	0.3159	0.562	1.2995	0
2023	0.9989	0	0	0.0109	0.5533	1.2616	0
2024	0.9989	0	0	0	0.5232	1.1769	0
2025	0.9989	0	0	0.1009	0.4738	1.0521	0
2026	0.9991	0	0	0	0.4071	0.8929	0
2027	0.9992	0.0004	0	0.1195	0.3248	0.7042	0
2028	0.9994	0.0164	0	0.046	0.2287	0.4902	0
2029	0.9997	0	0	0.0609	0.12	0.2545	0
2030	1	0	0	0	0	0	0

7 Conclusions

年份	指标	
2017	0.9997	0.0555
2018	0.9994	0
2019	0.9993	0

Let's to see Table 3.

<table>
<tr><td colspan="2" rowspan="2">合并</td><td>测试</td></tr>
<tr><td>0.9997</td></tr>
<tr><td>2019</td><td>0.9993</td><td>0</td></tr>
</table>

年份	指标	
2017	0.9997	0.0555
2018	0.9994	0
2019	0.9993	0

Table 3: NAME

年份	指标		
合并	2017	0.9997	0.0555
	2018	0.9994	0
	2019	0.9993	0

- **Applies widely**
  This system can be used for many types of airplanes, and it also solves the interference during the procedure of the boarding airplane,as described above we can get to the optimization boarding time.We also know that all the service is automate.

- **Improve the quality of the airport service**
  Balancing the cost of the cost and the benefit, it will bring in more convenient for airport and passengers.It also saves many human resources for the airline.

-

References

[1] D. E. KNUTH The TEXbook the American Mathematical Society and Addison-Wesley Publishing Company , 1984-1986.

[2] Lamport, Leslie, LATEX: “ A Document Preparation System ”, Addison-Wesley Publishing Company, 1986.

[3] http://www.latexstudio.net/

[4] http://www.chinatex.org/

Appendices

Appendix A First appendix

Here are simulation programmes we used in our model as follow.

Input matlab source:

```
function [t,seat,aisle]=OI6Sim(n,target,seated)
pab=rand(1,n);
for i=1:n
    if pab(i)<0.4
        aisleTime(i)=0;
    else
         aisleTime(i)=trirnd(3.2,7.1,38.7);
    end
end
```

Appendix B Second appendix

some more text **Input C++ source:**

```
//===========================================================================
// Name        : Sudoku.cpp
// Author      : wzlf11
// Version     : a.0
// Copyright   : Your copyright notice
// Description : Sudoku in C++.
//===========================================================================

#include <iostream>
#include <cstdlib>
#include <ctime>

using namespace std;

int table[9][9];
```

```
int main() {

    for(int i = 0; i < 9; i++){
        table[0][i] = i + 1;
    }

    srand((unsigned int)time(NULL));

    shuffle((int *)&table[0], 9);

    while(!put_line(1))
    {
        shuffle((int *)&table[0], 9);
    }

    for(int x = 0; x < 9; x++){
        for(int y = 0; y < 9; y++){
            cout << table[x][y] << " ";
        }

        cout << endl;
    }

    return 0;
}
```