Team Control Number

For office use only
T1 ________________
T2 ________________
T3 ________________
T4 ________________

33124

For office use only
F1 ________________
F2 ________________
F3 ________________
F4 ________________

Problem Chosen

D

2015 Mathematical Contest in Modeling (MCM) Summary Sheet

Summary

In order to estimate the sustainability and create a more sustainable future, we develop three models and conclude an optimized and effective plan for **Mozambique**.

In first model, we take into account a variety of metrics of sustainability and divide them into **seven** categories. By using **nine-demarcation matrix method**, we qualify the **pairwise comparison matrix** reasonably. Then we apply **min-max method** to normalize and integrate data from different dimensions into unified unit and determine the **weight allocation** to different metrics. The result estimated by our model gives an accurate ranking of sustainability.

In our second model, we develop a **four-layer refined model** to diminish the influence of subjectivity and obtain precise sustainability measure (SM) value based on model 1. We employ **linear equalization** to eliminate the discrepancy caused by on-uniform distribution, which can bias overall result. To predict sustainability, we incorporate time dimension and use **model dynamization** to create our predicted model. Using **Grey Predicted Model**, we verify that the result of model 2 is consistent with result of model 1. Then we employ **sensitivity analysis** and **Robustness Analysis** to precisely estimate the impact of each index on the SM value. Finally, we present a report to conclude our 20-year plan and determine the most optimized and efficient strategies and policies after predicting the influence and changes after 20 years.

In the third model, considering the weighs of different indexes vary tremendously among different countries due to the disparity of their present situation. We design two weight models, which are referred to as the dynamic weight distribution equilibrium model and dynamic weight distribution model based on elliptical curve by applying **statistical analysis**, **fuzzy analysis** and **data fitting**. These two models can change weights distribution dynamically to adapt to specific situation. Considering the horizontal and vertical comparison of weight, we introduce **relative weights** and **satisfaction** to get a more reasonable weight measure.

We fully consider the cost-efficiency, feasibility, and correctness of our model throughout the modeling process. When we develop our plan, we pay more attention to **quantitative analysis** rather than only qualitative analysis.

Contents

1. Introduction 3
1.1 Restatement of the Problem 3
1.2 Task Overview 3
2. Assumptions 3
3. Nomenclatures 3
4. Model I 4
4.1 Introduction 4
4.2 Additional assumption 6
4.3 Evaluation System 6
4.3.1 Nondimensionalization process 6
4.3.2 Analytic Hierarchy Process 7
4.4 Solutions to Model I 8
4.5 Strengths and Weaknesses 8
4.5.1 Strengths 8
4.5.2 Weaknesses 9
5 Model II 9
5.1 Additional assumptions 9
5.2 Overview of detailed indexes 9
5.3 Strengths and Weaknesses 13
5.3.1 Strengths 13
5.3.2 Weaknesses 13
5.4 Sensitivity analysis 13
5.4.1 Calculation Methodology 13
5.4.2 Example 14
6 Our 20-year plan 14
6.1 Introduction 14
6.2 Programs and policies 15
6.2.1 Agriculture and food security 15
6.2.2 Energy 16
6.2.3 Land and Ocean 16

6.2.4 **Water resources** 16
6.2.5 **Industry and mineral resources** 16
6.2.6 **Education** 17
6.2.7 **Health** 17
6.3 **ICM's aid program** 17
6.4 **Future predictions** 19
7 **Model III** 19
7.1 **Dynamic weight distribution equilibrium model** 19
7.2 **Dynamic weight-distribution matching model** 20
8 **References** 20
9 **Appendix** 21

Our Common Future

1. Introduction

1.1 Restatement of the Problem

Sustainable development has played a significant role on the world's policy agenda. With the growth of population coupled with increasing consumption, the tension on the Earth's finite resources has never been so imperative. Countless governments and organizations have dedicated themselves to sustainable development by aggregating environmental well-being, economic development, and social coherence.

1.2 Task Overview

With the purpose of addressing above problem, which is also the ultimate goal of ICM, we conclude 3 tasks to tackle in this paper:

- Task 1: We develop an evaluation model of sustainability measure (SM) to distinguish which countries are more sustainable and clearly define when and to what extent a country is sustainable.
- Task 2: We design another model to predict the future and purpose an effective 20-year plan for Mozambique.
- Task 3: We determine the efficiency of each policy and program.

2. Assumptions

- We neglect the cross-impact among these indexes.
- We only take the current value of indexes and ignore the influence caused by their tendencies.
- We assume that our evaluation of weights of indexes in criteria layer and target layer is reasonable, and our pairwise comparison matrix is available.

3. Nomenclatures

S_i	Evaluation object
x_j	Evaluation index
n	The number of evaluation objects
m	The number of evaluation indexes

x'	Final evaluation index vector
M_j	Maximum of x_{ij}
m_j	Minimum of x_{ij}
A	Pairwise comparison matrix
λ	The largest eigenvalue
w	Weight vector
CI	Consistency index
RI	Random consistency index
CR	Consistency ratio
G	Evaluation score of AHP
S_{ij}	The j^{th} index of evaluation object S_i
P_{ij}	The average weight of S_{ij} relative to S_i
X_{ij}	The value of S_{ij}
F_{ij}	The evaluation function of X_{ij}
n_i	The number of sub-indexes of S_{ij}

4. Model I

4.1 Introduction

In order to qualify for SM and make it comparable, we construct this sustainability performance measurement framework to quantify the sustainability of different countries.

We consult a number of papers and related books to measure the sustainability indicators. Although there are numerous international efforts on measuring sustainability, few of them have an appropriate approach taking into consideration environmental, economic and social aspects. According to Dalal-Clayton and Sadler, the metrics used for SM involve the environmental, social, and economic domains, both individually and in various combinations, and include indicators, benchmarks, audits, indexes, and accounting, as well as assessments, appraisals, and other reporting systems. So we divide these indexes into seven categories.

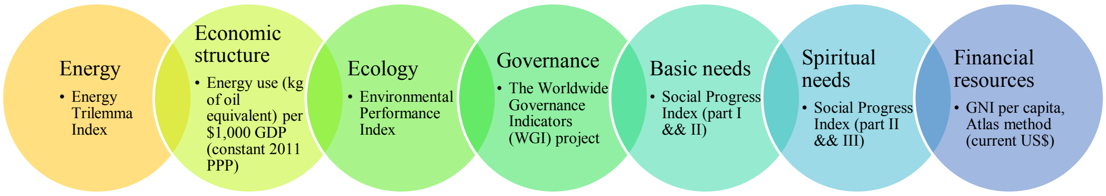


Figure 1 Discription of indexes

Table 1 Discription of indexes

Categories name	**Index used to measure corresponding category**
Energy	Energy Sustainability Index (ESI): It ranks countries in terms of their likely ability to provide sustainable energy policies through the 3 dimensions of the energy trilemma: energy security, energy equity, environmental sustainability.
Ecology	Environmental Performance Index (EPI): It ranks how well countries perform on high-priority environmental issues in two broad policy areas: protection of human health from environmental harm and protection of ecosystems.
Governance	Worldwide Governance Indicators (WGI): WGI is a research dataset summarizing the views on the quality of governance provided by a large number of enterprise, citizen and expert survey respondents in industrial and developing countries.
Basic needs	Social Progress Index (SPI): SPI offers a rich framework for measuring the multiple dimensions of social progress, benchmarking success, and catalyzing greater human wellbeing. In this category we choose its basic human needs and a part of foundations of wellbeing (health and wellness) indicators as a reference.
Spiritual needs	Social Progress Index (SPI): In this category, we choose its opportunity and a part of foundations of wellbeing (basic knowledge, information and communication).
Financial resources	GNI per capita, Atlas method (current US$): GNI per capita (formerly GNP per capita) is the gross national income, converted to U.S. dollars using the World Bank Atlas method, divided by the midyear population.
Economic structure	Energy use (kg of oil equivalent) per $1,000 GDP (constant 2011 PPP): It is the kilogram of oil equivalent of energy use per constant PPP GDP.

4.2 Additional assumption

- We neglect other indicators that cannot make a significant impact on the sustainability.
- We assume that countries do not have preference on these categories.
- Time is not included in this model, in other words this model only estimates the sustainability of current states rather than forecasts the further SM.

4.3 Evaluation System

We define n as the number of evaluation countries, and S_1, S_2… S_n (n>1) are the evaluation countries. m is the number of evaluation indexes, and x_1, x_2,…, x_m are the evaluation indexes. In this system, m = 7. So the evaluation index vector is

$$\mathbf{x} = [\, x_1, x_2, \dots, x_m] \; (m = 7)$$

Table 2 details of X

$\boldsymbol{x_1}$ -- ESI	$\boldsymbol{x_2}$ -- EPI	$\boldsymbol{x_3}$ -- WGI	$\boldsymbol{x_4}$ – SPI (part)
$\boldsymbol{x_5}$ – SPI (part)	x_6 -- GNI	x_7 -- Energy use per $1,000 GDP	

4.3.1 Nondimensionalization process

The indicators are expressed in different units, have different ranges and distribution patterns, and thus we employ a method to nondimensionalize the different indicators. More concretely, we convert the indicators to a common scale so that we can compare them horizontally.

The direction of the indicators' effect was also taken into account at this stage. For indicators where higher raw values are desirable, the formula was:

$$\frac{\mathrm{x_i} - \min(\mathrm{x})}{\max(\mathrm{x}) - \min(\mathrm{x})} \times 10$$

For indicators where lower raw values are desirable, the formula was:

$$\frac{\max(\mathrm{x}) - \mathrm{x_i}}{\max(\mathrm{x}) - \min(\mathrm{x})} \times 10$$

Then, we obtain the final evaluation index vector:

$$x' = [x_1{}', x_2{}', \dots, x_m{}']$$

Where $M_i = \max\limits_{1 \le j \le n} \{ x_{ij} \}, m_i = \min\limits_{1 \le j \le n} \{ x_{ij} \} \; (n = 7)$.

4.3.2 Analytic Hierarchy Process

We employ AHP to combine qualitative and quantitative analysis on the normalized data from nondimensionalization process. Figure 2 shows the hierarchical structure of AHP.

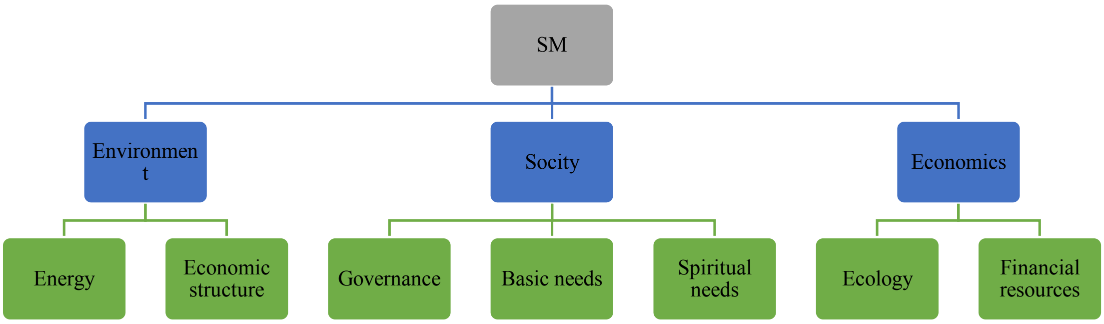


Figure 2 hierarchical structure of AHP

By comparing each pair of indexes $x_j{}'$, the weights of indexes in the criteria level can be determined. We construct the pairwise comparison matrix A as below:

$$A = \begin{bmatrix} 1 & 3 & 2 & \frac{1}{3} & 5 & 4 & 3 \\ \frac{1}{3} & 1 & \frac{1}{2} & \frac{1}{4} & 3 & 3 & 1 \\ \frac{1}{2} & 2 & 1 & \frac{1}{4} & 4 & 3 & 3 \\ 3 & 4 & 4 & 1 & 7 & 6 & 5 \\ \frac{1}{5} & \frac{1}{3} & \frac{1}{4} & \frac{1}{7} & 1 & \frac{1}{3} & \frac{1}{3} \\ \frac{1}{4} & \frac{1}{3} & \frac{1}{3} & \frac{1}{6} & 3 & 1 & \frac{1}{2} \\ \frac{1}{3} & 1 & \frac{1}{3} & \frac{1}{5} & 3 & 2 & 1 \end{bmatrix}$$

The greatest eigenvalue of A is: λ= 0.05175 and the weight vector is:

$$\mathbf{w} = [\,\mathbf{0.1781},\ \mathbf{0.0594},\ \mathbf{0.0890},\ \mathbf{0.5342},\ \mathbf{0.0356},\ \mathbf{0.0445},\ \mathbf{0.0594}]^T$$

Then, we examine the consistency of A. By the definition of consistency, we obtain the consistency index as follow:

$$CI = \frac{\lambda - n}{n - 1} = 5.175 \times 10^{-2}$$

After that, we can calculate the consistency ratio:

$$CR = \frac{CI}{RI} = \ 0.039 < 0.1 \ \ (\text{RI=1.32 when n=7})$$

This result demonstrates that the inconsistent degree of A is acceptable, and the weight of goal for criteria is vector **w**. Therefore the evaluation score of AHP G can be measured as:

$$\mathbf{G} = \frac{\mathbf{1}}{\boldsymbol{n}} \cdot \mathbf{x}' \cdot \mathbf{w}$$

Then, we can draw the conclusion: the higher ranking S_i when the greater G_i.

4.4 Solutions to Model I

So far we can obtain the sustainability ranking by the SM's value. We list top ten countries in Table 2, in Appendix illustrates is the ranking of countries all over the world (if the data got).

Table 3 the top ten countries

Switzerland
Norway
Sweden
Denmark
Austria
Finland
Canada
Netherlands
Australia
Germany

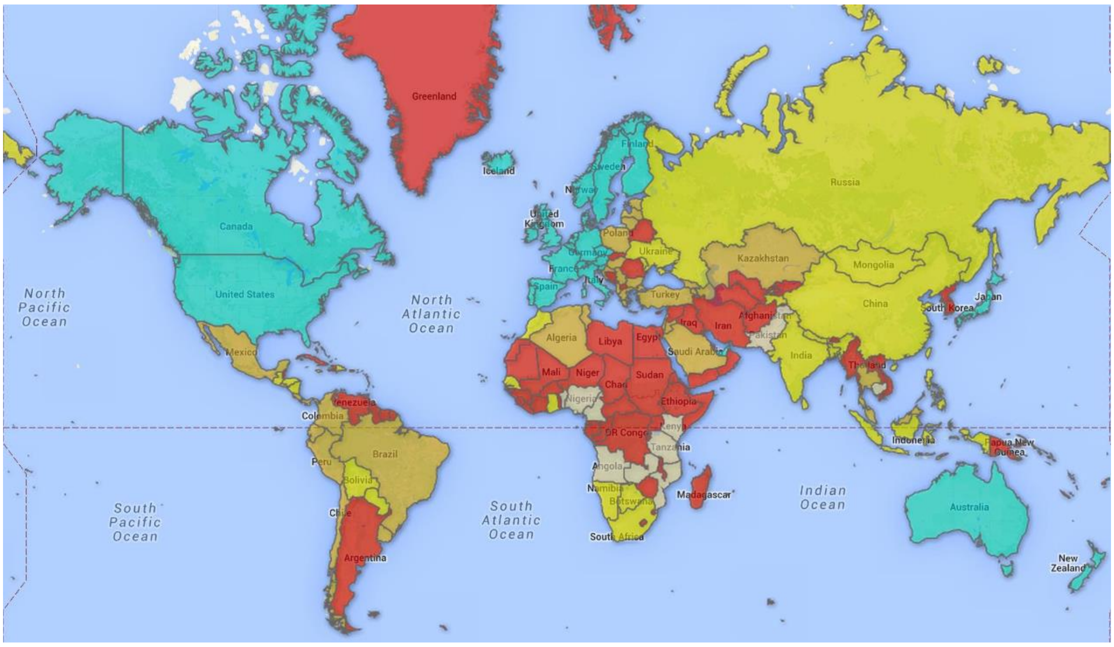


Figure 3 the SM value distribution（The darker the more developed and red ones for missing data）

4.5 Strengths and Weaknesses

4.5.1 Strengths

- Model 1 is brief and clear. The indicators it needs are accessible and the quantitative characterization of the problem is accurate. More importantly, its result is acceptable and meaningful.

- Model 1 is flexible and, therefore, can be used to solve other types of issues
- The major advantages associated with indices are because of its multi- dimensionality, use of normalization and aggregation based on scientific rules and robust statistical methods.

4.5.2 Weaknesses

- The indicators we choose are subject to subjectivity even though we choose indicator as objective as possible.

5 Model II

Model 1 is brief and effective to assess sustainability. However, its indicators, to some extent, are coarse and with bias, which could extremely distort the SM value. More importantly, it can only provide the SM value for the current state. To consider the influence of time and address weakness, we design another model to estimate the time dimension.

We optimize Model 1 in three aspects:

- To eliminate the discrepancy caused by on-uniform distribution, similarly histogram equalization, we define linear equalization: make the scores of raw data uniformly distribute in (0, 10).
- To diminish the influence of subjectivity and precise SM value, we choose 20 representative and detailed indicators from seven categories.
- We consider time as another dimension and forecast the SM in the future.

5.1 Additional assumptions

- We assume that the indexes below each indicator category are equally weighted.
- We suppose that each country equally weights our 27 indexes.
- We assume that each index will develop in the current pace in the future.

5.2 Overview of detailed indexes

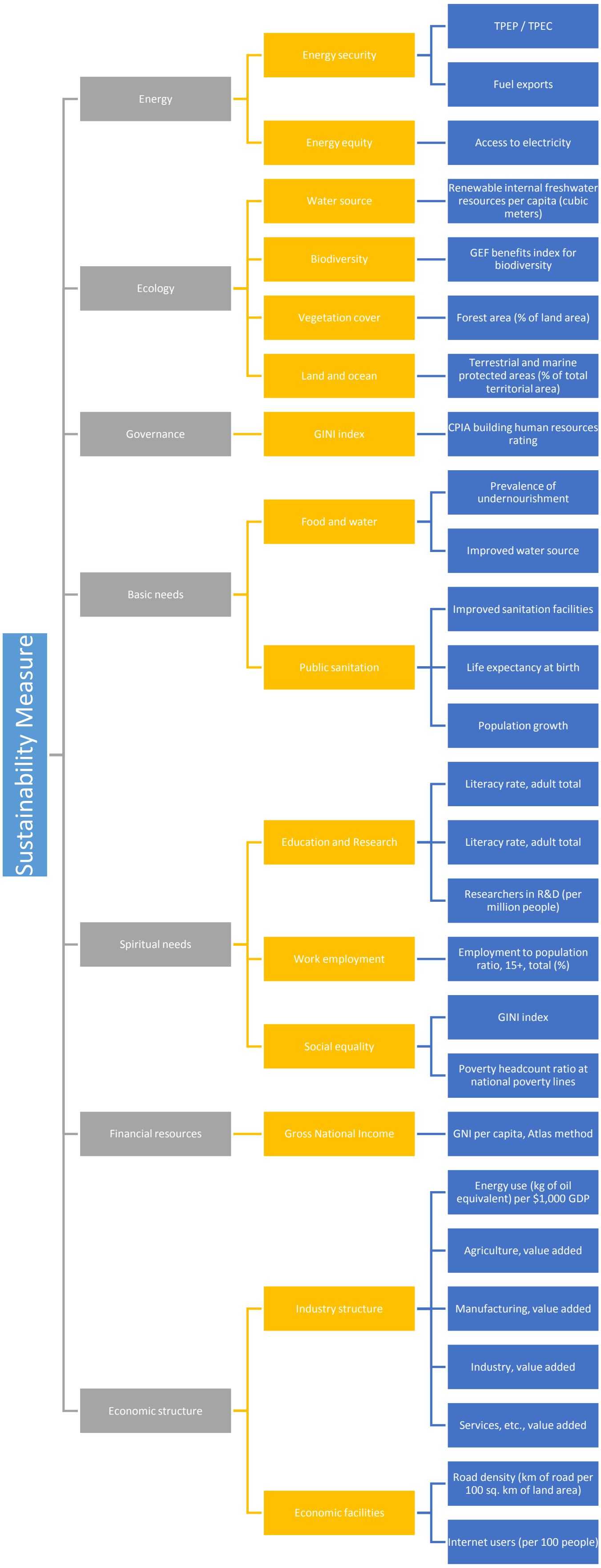


Figure 4 The structure of indexes

The description of each index is as follow:

Table 4 The description of each index

No.	Index name	Tendency function	Scoring function
1	TPEP / TPEC (net energy importer)	$X_{11} = p_1 \times t^3 + p_2 \times t^2 + p_3 \times t + p_4$	$F_{11}(X_{11}) = p_1 \times X_{11} + p_2$
2	Fuel exports (% of merchandise exports)	$X_{12} = p_1 \times t^3 + p_2 \times t^2 + p_3 \times t + p_4$	$F_{12}(X_{12}) = \frac{p_1}{X_{12} + q_1}$
3	Access to electricity (% of population)	$X_{13} = p_1 \times t^2 + p_2 \times t + p_3$	$F_{13}(X_{13}) = p_1 \times {X_{13}}^3 + p_2 \times {X_{13}}^2 + p_3 \times X_{13} + p_4$
4	CPIA building human resources rating	$X_{21} = p_1 \times t^2 + p_2 \times t + p_3$	$F_{21}(X_{21}) = p_1 \times {X_{21}}^3 + p_2 \times {X_{21}}^2 + p_3 \times X_{21} + p_4$
5	Prevalence of undernourishment (% of population)	$X_{31} = p_1 \times t^3 + p_2 \times t^2 + p_3 \times t + p_4$	$F_{31}(X_{31}) = \frac{p_1 \times X_{31} + p_2}{X_{31} + q_1}$
6	Improved water source (% of population with access)	$X_{32} = p_1 \times t + p_2$	$F_{32}(X_{32}) = p_1 \times {X_{32}}^2 + p_2 \times X_{32} + p_3$
7	Improved sanitation facilities (% of population with access)	$X_{33} = p_1 \times t + p_2$	$F_{33}(X_{33}) = p_1 \times X_{33} + p_2$
8	Life expectancy at birth, total (years)	$X_{34} = p_1 \times t + p_2$	$F_{34}(X_{34}) = p_1 \times {X_{34}}^2 + p_2 \times X_{34} + p_3$
9	Population growth (annual %)	$X_{35} = p_1 \times t + p_2$	$F_{35}(X_{35}) = p_1 \times {X_{35}}^2 + p_2 \times X_{35} + p_3$
10	Literacy rate, adult total (% of people ages 15 and above)	$X_{41} = p_1 \times t + p_2$	$F_{41}(X_{41}) = p_1 \times {X_{41}}^3 + p_2 \times {X_{41}}^2 + p_3 \times X_{41} + p_4$
11	School enrollment, primary (% net)	$X_{42} = p_1 \times t^3 + p_2 \times t^2 + p_3 \times t + p_4$	$F_{42}(X_{42}) = a \times {X_{42}}^b$

12	Researchers in R&D (per million people)	$X_{43} = p_1 \times t^2 + p_2 \times t + p_3$	$F_{43}(X_{43}) = p_1 \times {X_{43}}^2 + p_2 \times X_{43} + p_3$
13	Employment to population ratio, 15+, total (%) (modeled ILO estimate)	$X_{44} = p_1 \times t^2 + p_2 \times t + p_3$	$F_{44}(X_{44}) = p_1 \times {X_{44}}^3 + p_2 \times {X_{44}}^2 + p_3 \times X_{44} + p_4$
14	GINI index (World Bank estimate)	$X_{45} = p_1 \times t^2 + p_2 \times t + p_3$	$F_{45}(X_{45}) = p_1 \times {X_{45}}^2 + p_2 \times X_{45} + p_3$
15	Poverty headcount ratio at national poverty lines (% of population)	$X_{46} = p_1 \times t^2 + p_2 \times t + p_3$	$F_{46}(X_{46}) = \frac{p_1 \times X_{46} + p_2}{X_{46} + q_1}$
16	GNI per capita, Atlas method (current US$)	$X_{51} = p_1 \times t^2 + p_2 \times t + p_3$	$F_{51}(X_{51}) = \frac{p_1 \times X_{51} + p_2}{X_{51} + q_1}$
17	Energy use (kg of oil equivalent) per $1,000 GDP (constant 2011 PPP)	$X_{61} = p_1 \times t + p_2$	$F_{61}(X_{61}) = \frac{p_1 \times X_{61} + p_2}{{X_{61}}^2 + q_1 \times X_{61} + q_2}$
18	Agriculture, value added (% of GDP)	$X_{62} = p_1 \times t^3 + p_2 \times t^2 + p_3 \times t + p_4$	$F_{62}(X_{62}) = \frac{p_1 \times X_{62} + p_2}{X_{62} + q_1}$
19	Manufacturing, value added (% of GDP)	$X_{63} = p_1 \times t^3 + p_2 \times t^2 + p_3 \times t + p_4$	$F_{63}(X_{63}) = p_1 \times {X_{63}}^3 + p_2 \times {X_{63}}^2 + p_3 \times X_{63} + p_4$
20	Industry, value added (% of GDP)	$X_{64} = p_1 \times t^3 + p_2 \times t^2 + p_3 \times t + p_4$	$F_{64}(X_{64}) = \frac{p_1 \times X_{64} + p_2}{{X_{64}}^2 + q_1 \times X_{64} + q_2}$
21	Services, etc., value added (% of GDP)	$X_{65} = p_1 \times t^3 + p_2 \times t^2 + p_3 \times t + p_4$	$F_{65}(X_{65}) = p_1 \times {X_{65}}^3 + p_2 \times {X_{65}}^2 + p_3 \times X_{65} + p_4$
22	Road density (km of road per 100 sq. km of land area)	$X_{66} = p_1 \times t + p_2$	$F_{66}(X_{66}) = \frac{p_1 \times X_{66} + p_2}{X_{66} + q_1}$
23	Internet users (per 100 people)	$X_{67} = p_1 \times t^2 + p_2 \times t + p_3$	$F_{67}(X_{67}) = p_1 \times X_{67} + p_2$

24	Renewable internal freshwater resources per capita (cubic meters)	$X_{71} = p_1 \times t + p_2$	$F_{71}(X_{71}) = \frac{p_1 \times X_{71} + p_2}{X_{71} + q_1}$
25	GEF benefits index for biodiversity (0 = no biodiversity potential to 100 = maximum)	$X_{72} = p_1 \times t + p_2$	$F_{72}(X_{72}) = \frac{p_1 \times X_{72} + p_2}{X_{72} + q_1}$
26	Forest area (% of land area)	$X_{73} = p_1 \times t + p_2$	$F_{73}(X_{73}) = p_1 \times {X_{73}}^2 + p_2 \times X_{73} + p_3$
27	Terrestrial and marine protected areas (% of total territorial area)	$X_{74} = p_1 \times t^2 + p_2 \times t + p_3$	$F_{74}(X_{74}) = p_1 \times {X_{74}}^2 + p_2 \times X_{74} + p_3$

Therefore, the criteria for rating model2:

$$G = \sum_{i=1}^{m} \sum_{j=1}^{n_i} P_{ij} \cdot w_i \cdot F_{ij}(X_{ij})$$

And we get the SM value of our selected country, **Mozambique**, is **2.4088**.

In model 2, according to the current SM value and prior trend, the SM value of **Mozambique** after 20 years can be predicted as **2.8321**.

5.3 Strengths and Weaknesses

5.3.1 Strengths

- This model can predict the future precisely by incorporating the time dimension.
- By reinforced concrete on selecting indexes, the result becomes more reasonable.
- By employing sensitivity analysis, we clearly show the impact of each criteria on SM value.

5.3.2 Weaknesses

- Due to some tremendous fluctuations, the result of fitting is not perfect.
- Duo to loss of some key data, we cannot accomplish the fitting progress.

5.4 Sensitivity analysis

5.4.1 Calculation Methodology

Here, we determine the sensitivity of G. We define the sensitivity of G with respect to x_{ij} is:

$$S(G, X_{ij}) = \frac{\triangle G/G}{\triangle X_{ij}/X_{ij}} \approx \frac{dG}{dX_{ij}} \cdot \frac{X_{ij}}{G}$$

$$dG = \sum_{i=1}^{m} \sum_{j=1}^{n_i} P_{ij} \cdot w_i \cdot d(F_{ij}(X_{ij}))$$

As can be seen from above, when there is a slight change of weights, the result do not change. But with a relatively greater change, weights have an effect on the result.

5.4.2 Example

We give two examples for the two highest sensitivity.

For the x_{31}:

$$S(G, X_{31}) = P_{31} \cdot W_3 \cdot \left(3 \cdot P_1 \cdot {X_{31}}^2 + 2 \cdot P_2 \cdot X_{31} + P_3\right) \cdot \frac{X_{31}}{G} = 0.8798518037$$

For the x_{11}:

$$S(G, X_{11}) = \frac{dG}{dX_{11}} \cdot \frac{X_{11}}{G} = P_{11} \cdot W_1 \cdot P_1 \cdot \frac{X_{11}}{G} = 0.2241031273$$

6 Our 20-year plan

6.1 Introduction

Mozambique, officially the Republic of Mozambique lies on the eastern coast of southern Africa, between the mouth of the Rovuma River in the north and the Republic of South Africa in the south. It is kept separate from Madagascar by the Mozambique Channel to the east. The capital and largest city is Maputo. It is bathed by the Indian Ocean along a coastline that is about 2,700km long. It owns a surface area of 799,380 km and a population of about 22 million. It is split into 11 provinces subdivided into 128 districts. Mozambique is under a tropical climate with two seasons (rainy and dry) and its network of water resources covers more than 65 rivers. The country is equipped with rich and extensive natural resources such as forestry and marine resources, and an excellent rail and port location in the geo-strategic space of southern Africa. The country's economy is primarily based largely on agriculture, which is growing. Its industry, mainly food and beverages, chemical manufacturing, tourism and petroleum production, is growing. South Africa is Mozambique's main trading partner and source of foreign direct investment.

However, Mozambique's health, transportation and other infrastructure is not perfect. Low domestic government efficiency, the armed conflict in the domestic market, the spread of diseases such as diarrhea and AIDS leads to the absence in the global industrial chain. Half people of Mozambique are still in poverty. The average life expectancy is only 50 years old and 10% of the population is infected with HIV. Thus, for Mozambique, direct financial aids and food supports cannot meet the need for the development of Mozambique or improve the economic foundation for long-term sustainable development in Mozambique. We believe, based on the reality, aid to Mozambique should still stay in infrastructure construction, crop cultivation, basic health care and basic education. Furthermore, aids should be a long-term and steady process rather than "Destructive Enthusiasm".

According to the sensitivity analysis of our model 2, to meet the elementary needs for sustainable development of the country plays a crucial effect. Therefore, we believe that the main objective of Mozambique， in the next 20 years, remains:

1. To meet people's basic needs preferentially: the construction of basic agriculture, health, sanitation and water conservancy
2. To develop their own advantageous fields, to create a foundational market environment and join in the global coommercial chain in minerals, fisheries and tourism fields.
3. To improve government efficiency and strengthen basic education.

Based on the situation of Mozambique and our statistical data for the reality of the world, through quantitative analysis, we estimate "return on investment", namely: the impact caused by investment in all areas on sustainable development (SM). Then we develop a 20-year national development plan for Mozambique including the policies of development for key areas. At the same time, we also conclude a detailed 20-year financed plan for the ICM. We prove our model is correct by the estimation of future.

6.2 Programs and policies

6.2.1 Agriculture and food security

In Mozambique, agriculture is the main source of sustenance and income. About 80% of the Mozambican population works in agriculture, which contributes about 25% of the national GDP.

Agricultural development trend is good. The government should increase investment in agriculture to strengthen the agricultural infrastructure and improve the level of modernization.

- Constructing water conservancy infrastructure and irrigation facilities to reduce the impact of natural disasters

- To improve the level of agricultural modernization

6.2.2 Energy

The power rate (percentage of population) in 2010 was 15%. Currently, about 81% of the Mozambican population depends on energy from biomass. So it should strengthen its infrastructure construction of power facilities and improve network coverage to make full use of hydropower resources.

- Constructing basic power facilities (utilizing the existing hydropower station)

6.2.3 Land and Ocean

Nearly 20 years, forest cover rate declined from 55% Mo to 49%. Thus, Mozambique should reduce the destruction of trees and make full use of the geographic advantage to build an efficient port and develop the national railway transportation; Utilizing marine resources, processing fish before the sale, rather than a direct sale at low-level price. In Mozambique tourists can enjoy sun and beach tourism, ecotourism, cultural tourism, adventure tourism, and game watching and thematic tourism. So tourism is another crucial chance.

- The rational use of marine resources, the establishment of fisheries processing plants rather than directly selling fish
- The construction of an efficient port, the development of national railway
- The development of tourism industry, the development of the coastline

6.2.4 Water resources

For Mozambique, the target laid down for expanding access to clean drinking water is to reach 70% of the basis of the population by 2015. Providing reliable drinking water is the base of sustainable development.

- Improving infrastructure and water conservancy facilities and increasing the proportion of improved water

6.2.5 Industry and mineral resources

Industrial production has undergone a noteworthy growth (3.5% between 2005 and 2008), particularly the food and drink industry, furniture and other manufacturing industries, engineering, and the manufacture of electrical machinery and equipment. Mozambique should take the initiative to join the international market and accelerate domestic economic development.

- By utilizing fisheries and mineral resources, integrating into the international market and participate in the global industrial chain
- Introducing high technologies to developing mineral resources reasonably

6.2.6 Education

Mozambique has a foundation of primary education, thus it should continue to increase the proportion of the population of basic education and develop education to higher level. The conditions and quality of education, the expansion of secondary education, and a reduction in the drop-out rates (particularly for girls) remain the great challenges for the sector.

- Continue to increase the proportion of the population with basic education and construct a higher level of education

6.2.7 Health

Mozambique basic sanitation is still poor and its life expectancy at birth is only 50 years old, 10% of the population is infected with HIV. So Mozambique should construct basic medical facilities and health facilities, especially for pregnant women and newborn.

- Constructing basic health care, facilities for sanitation and covering more people
- Organizing educational campaigns for diseases such as AIDS and dysentery

6.3 ICM's aid program

According to the world historical data, we calculated the "return on investment", namely: the impact on SM caused by investments from all areas for Mozambique.

According to the sensitive indicators in model 2, we conclude the best financial investment program for ICM by performing linear optimization and using Lingo. This program has the greatest effect on the SM value of Mozambique.

We fit the data of the Mozambique aid cases, per capita GDP, education spending per capita, the world average level of health development and other data in recent years.

```
1.6*x1+4*x2+13*x3+7*x4+40*x5+5*x6<=100;
x1+2*x2>=25;
x2>=6;
x3>=0.5;
x4>=1.3;
x5+x6>=1;
x6>=0.7;
```

Figure 5 Lingo Data 1

```
Objective value:                          1.727814
Infeasibilities:                          0.000000
Total solver iterations:                         2

Model Class:                                    LP

Total variables:                  6
Nonlinear variables:              0
Integer variables:                0

Total constraints:                8
Nonlinear constraints:            0

Total nonzeros:                  20
Nonlinear nonzeros:               0

                           Variable           Value        Reduced Cost
                                 X1        28.06250            0.000000
                                 X2        6.000000            0.000000
                                 X3       0.5000000            0.000000
                                 X4        1.300000            0.000000
                                 X5       0.3000000            0.000000
                                 X6       0.7000000            0.000000
```

Figure 6 Lingo Data 2

Finally, we obtain the aid program:

1. Economic Assistance

In the next 20 years, investing **$ 1 billion** annual economic aid, which will be invested in food and water, public sanitation, energy security, energy equality，CPIA and economic infrastructure and the ratio of each aspect is **35:25:6:6:2:6.**

The absolute improvement of SM value is **0.246201** whereas the relative improvement is **0.14249277.**

2. Other aid

- Continuing to help Mozambique build large-scale infrastructure, such as: highways, dams, long-distance transmission lines, etc.
- Providing basic medical drugs and help training more doctors.
- Providing food support and help Mozambique increase food production by employing modern technologies.
- Making full use of existing forests, fisheries resources without damage to the environment.
- Encouraging more volunteers to support Mozambique and increase the communication between Mozambique and other people all over the world.

6.4 Future predictions

With our development plan, we can ensure that the effect of our plan on sustainable development of Mozambique is greatest. In model 2, according to the current SM value and prior trend, the SM value after 20 years can be predicted as **2.8321**. Through our plan, this value will grow to **4.1366** which will grow **1.3045** units about **46.06%** growth.

7 Model III

7.1 Dynamic weight distribution equilibrium model

In the previous analysis, we neglect the preferences different countries have among each indicator and consider this problem with average weights. This is unreasonable. Thus we purpose the dynamic weight distribution equilibrium model based on multidimensional indexes to enable countries develop the backward areas of industry without underestimating the advantages areas and conclude personalized programs.

Assuming that there are n indexes (the rays in Figure 4), we employ the intersection of rays and the polygon to represent the international average. X_i is the average level of a specific country.

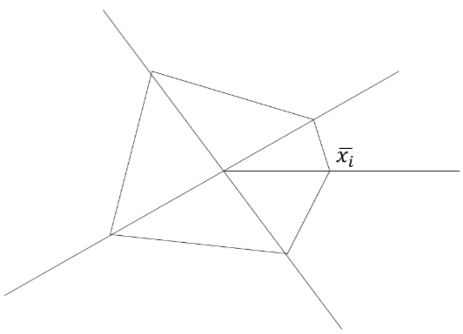


Figure 7 Weight multidimensional map

The method of weights calculation:

$$P_j = \frac{\bar{x_i}}{x_i}\ ,\ \overline{P_j} = \frac{P_j}{\sum_i P_i}$$

Where P_i is absolute weight and $\overline{P_j}$ is relative weight.

7.2 Dynamic weight-distribution matching model

For a single indicator, we consider its weight change. Under normal circumstances, when the current level of development below the international average, the state will increase the intensity of their investment, so the weight will increase, otherwise decrease. Accordingly, we purpose the dynamic weight-distribution matching model based on elliptical curve. The calculation process is as follow:

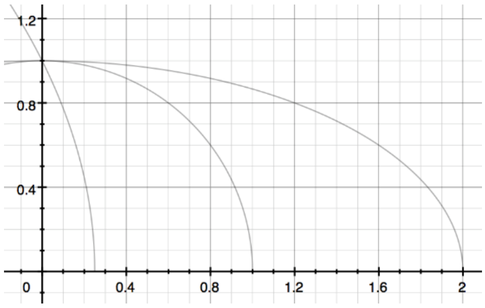


Figure 8 Weights of elliptic curve

$$x = \frac{s}{\bar{s}}\ ,\ a = \frac{x^*}{\bar{x}},\ y = \sqrt{1 - \frac{x^2}{a^2}}$$

Where x is satisfaction, $\bar{s}$ is the international average; s is the national average, x^* is expected development level.

8 References

[1] Dalal-Clayton B, Sadler B. Sustainability appraisal: a sourcebook and reference guide to international experience[M]. Routledge, 2014.

[2] Singh R K, Murty H R, Gupta S K, et al. An overview of sustainability assessment methodologies[J]. Ecological indicators, 2009, 9(2): 189-212.

[3] NATIONAL REPORT TO THE UNITED NATIONS CONFERENCE ON SUSTAINABLE DEVELOPMENT (RIO+20)

https://sustainabledevelopment.un.org/content/documents/1032mozambique.pdf

[4] Sustainable Development Report on Africa - Rio+20

http://www.uncsd2012.org/content/documents/SDRA1%20managing%20land-based%20resources.pdf

[5] Sustainable Society Index (SSI): Taking Societies' Pulse Along Social, Environmental and Economic Issues[M]. Publications Office, 2012.

[6] Böhringer C, Jochem P E P. Measuring the immeasurable—A survey of sustainability indices[J]. Ecological economics, 2007, 63(1): 1-8.

[7] Singh R K, Murty H R, Gupta S K, et al. An overview of sustainability assessment methodologies[J]. Ecological indicators, 2009, 9(2): 189-212.

[8] Calculation formulas of the Sustainable Society Index, SSI-2014 http://www.ssfindex.com/ssi2014/wp-content/uploads/pdf/calculation_formulas-2014.pdf

[9] World Bank’s Data (http://data.worldbank.org)

[10] NCAA. College Baseball. Championship History. [2014-2-7]. (http://www.ncaa.com/history/baseball/d1.)

9 Appendix

9.1 The SM value rank of the world

Rank	Name	Abbreviation	SM value
1	Switzerland	CHE	7.878669
2	Norway	NOR	7.617902
3	Sweden	SWE	7.587849
4	Denmark	DNK	7.580811
5	Austria	AUT	7.386732
6	Finland	FIN	7.353098
7	Canada	CAN	7.24978
8	Netherlands	NLD	7.222707
9	Australia	AUS	7.186028
10	Germany	DEU	7.151694
11	United Kingdom	GBR	7.145517
12	New Zealand	NZL	7.139826
13	Ireland	IRL	7.062593
14	Japan	JPN	6.988374
15	France	FRA	6.902893
16	Belgium	BEL	6.813485
17	United States	USA	6.682675
18	Iceland	ISL	6.632724
19	Spain	ESP	6.62978

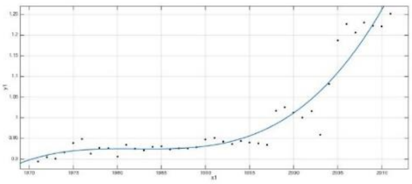
20	Slovenia	SVN	6.518145
21	Portugal	PRT	6.510594
22	Czech Republic	CZE	6.450118
23	Italy	ITA	6.139143
24	United Arab Emirates	ARE	6.130137
25	Croatia	HRV	5.870681
26	Hungary	HUN	5.822326
27	Greece	GRC	5.813746
28	Costa Rica	CRI	5.795076
29	Estonia	EST	5.781127
30	Uruguay	URY	5.761024
31	Malaysia	MYS	5.760019
32	Chile	CHL	5.73906
33	Poland	POL	5.71825
34	Israel	ISR	5.649935
35	Latvia	LVA	5.412809
36	Lithuania	LTU	5.399467
37	Saudi Arabia	SAU	5.042834
38	Panama	PAN	4.982174
39	Albania	ALB	4.944468
40	Bulgaria	BGR	4.937297
41	Turkey	TUR	4.887599
42	Tunisia	TUN	4.806201
43	Mexico	MEX	4.638145
44	Serbia	SRB	4.558217
45	Brazil	BRA	4.554604
46	Ecuador	ECU	4.546676
47	Colombia	COL	4.523043
48	Jordan	JOR	4.472224
49	Armenia	ARM	4.416538
50	Azerbaijan	AZE	4.314485
51	Georgia	GEO	4.296744
52	Algeria	DZA	4.253747
53	Peru	PER	4.208294
54	Trinidad and Tobago	TTO	4.122615
55	Kazakhstan	KAZ	4.103772
56	Thailand	THA	4.103108
57	El Salvador	SLV	4.086312
58	Russian Federation	RUS	3.949303
59	China	CHN	3.914023
60	Philippines	PHL	3.892856
61	Sri Lanka	LKA	3.873661
62	Guatemala	GTM	3.828168

63	Ukraine	UKR	3.824339
64	Jamaica	JAM	3.790083
65	Morocco	MAR	3.765069
66	Lebanon	LBN	3.717527
67	Botswana	BWA	3.702949
68	Bolivia	BOL	3.543308
69	Dominican Republic	DOM	3.51071
70	Indonesia	IDN	3.485405
71	Moldova	MDA	3.454349
72	Paraguay	PRY	3.364874
73	South Africa	ZAF	3.157377
74	Namibia	NAM	3.154089
75	Nicaragua	NIC	3.12633
76	Honduras	HND	3.047439
77	Tajikistan	TJK	2.717467
78	Mongolia	MNG	2.442149
79	Ghana	GHA	2.390135
80	Nepal	NPL	2.354516
81	Bangladesh	BGD	2.219964
82	India	IND	2.179096
83	Senegal	SEN	2.174787
84	Pakistan	PAK	1.772567
85	Cambodia	KHM	1.728769
86	Cameroon	CMR	1.722354
87	Kenya	KEN	1.621075
88	Angola	AGO	1.567009
89	Benin	BEN	1.447869
90	Zambia	ZMB	1.170528
91	Nigeria	NGA	1.063374
92	Mozambique	MOZ	0.992775
93	Tanzania	TZA	0.924777

9.2 Curve fitting

1. TPEP / TPEC (net energy importer)

- Tendency function



f(x) = p1*x^3 + p2*x^2 + p3*x + p4

Coefficients (with 95% confidence bounds):

p1 = 1.587e-05 (7.729e-06, 2.401e-05)

p2 = -0.09437 (-0.143, -0.04574)

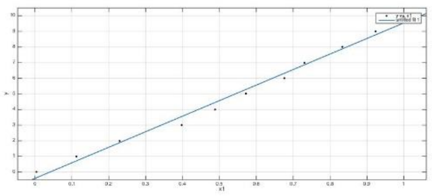
p3 = 187.1 (90.25, 283.9)

p4 = -1.236e+05 (-1.879e+05, -5.935e+04)

Goodness of fit:

SSE: 0.04121
R-square: 0.9169
Adjusted R-square: 0.9102
RMSE: 0.03337

- Scoring function

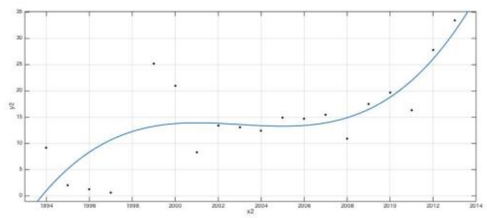


f(x) = p1*x + p2
Coefficients (with 95% confidence bounds):
p1 = 9.945 (9.181, 10.71)
p2 = -0.4042 (-0.8844, 0.07603)

Goodness of fit:
SSE: 1.129
R-square: 0.9897
Adjusted R-square: 0.9886
RMSE: 0.3542

2. Fuel exports (% of merchandise exports)

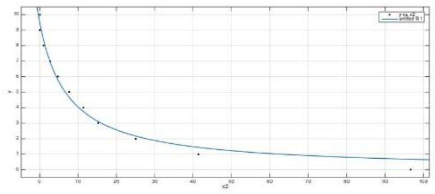
- Tendency function



f(x) = p1*x^3 + p2*x^2 + p3*x + p4
Coefficients (with 95% confidence bounds):
p1 = 0.02019 (0.0006535, 0.03973)
p2 = -121.3 (-238.8, -3.898)
p3 = 2.43e+05 (7749, 4.783e+05)
p4 = -1.623e+08 (-3.194e+08, -5.136e+06)

Goodness of fit:
SSE: 519.8
R-square: 0.6136
Adjusted R-square: 0.5364
RMSE: 5.887

- Scoring function

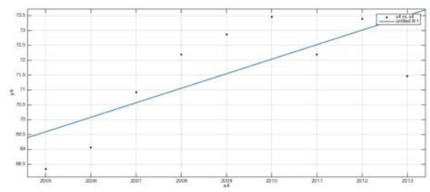


f(x) = (p1) / (x + q1)
Coefficients (with 95% confidence bounds):
p1 = 70.49 (57.35, 83.63)
q1 = 7.433 (5.81, 9.056)

Goodness of fit:
SSE: 1.483
R-square: 0.9865
Adjusted R-square: 0.985
RMSE: 0.406

3. Access to electricity (% of population)

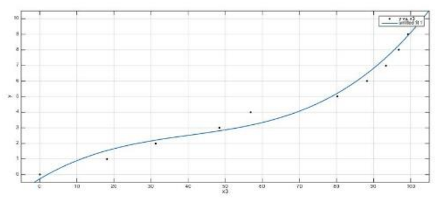
- Tendency function



f(x) = p1*x + p2
Coefficients (with 95% confidence bounds):
p1 = 0.4281 (-2.227, 3.083)
p2 = -846.7 (-6156, 4463)

Goodness of fit:
SSE: 8.731
R-square: 0.8076
Adjusted R-square: 0.6153
RMSE: 2.955

- Scoring function

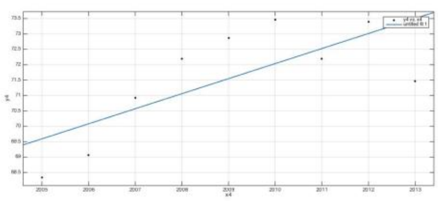


f(x) = p1*x^3 + p2*x^2 + p3*x + p4
Coefficients (with 95% confidence bounds):
p1 = 2.193e-05 (2.387e-06, 4.148e-05)
p2 = -0.00267 (-0.005669, 0.0003279)
p3 = 0.1416 (0.01799, 0.2652)
p4 = -0.2769 (-1.663, 1.11)

Goodness of fit:
SSE: 2.574
R-square: 0.9766
Adjusted R-square: 0.9666
RMSE: 0.6064

4. CPIA building human resources rating

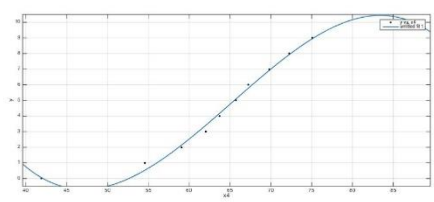
■ Tendency function



f(x) = p1*x + p2
Coefficients (with 95% confidence bounds):
p1 = 0.4889 (0.0853, 0.8925)
p2 = -910.6 (-1721, -99.82)

Goodness of fit:
SSE: 12.24
R-square: 0.5396
Adjusted R-square: 0.4738
RMSE: 1.322

■ Scoring function

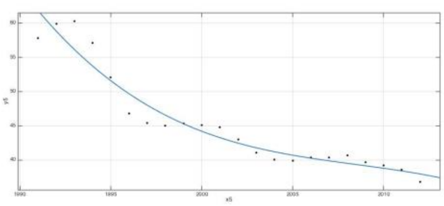


f(x) = p1*x^3 + p2*x^2 + p3*x + p4
Coefficients (with 95% confidence bounds):
p1 = -0.0004639 (-0.0005583, -0.0003696)
p2 = 0.09083 (0.07248, 0.1092)
p3 = -5.468 (-6.623, -4.313)
p4 = 103.8 (80.38, 127.3)

Goodness of fit:
SSE: 0.538
R-square: 0.9951
Adjusted R-square: 0.993
RMSE: 0.2772

5. Prevalence of undernourishment (% of population)

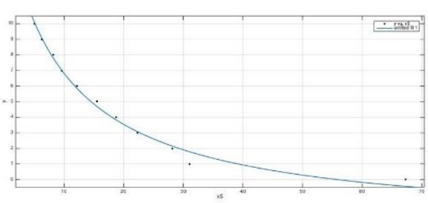
■ Tendency function



f(x) = p1*x^3 + p2*x^2 + p3*x + p4
Coefficients (with 95% confidence bounds):
p1 = -0.00306 (-0.007617, 0.001496)
p2 = 18.44 (-8.919, 45.8)
p3 = -3.704e+04 (-9.18e+04, 1.772e+04)
p4 = 2.48e+07 (-1.174e+07, 6.133e+07)

Goodness of fit:
SSE: 73.26
R-square: 0.9344
Adjusted R-square: 0.9234
RMSE: 2.017

■ Scoring function

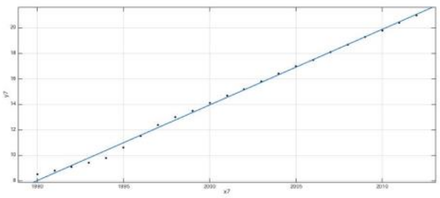


f(x) = (p1*x + p2) / (x + q1)
Coefficients (with 95% confidence bounds):
p1 = -2.942 (-4.51, -1.374)
p2 = 164.4 (111.4, 217.3)
q1 = 9.798 (4.744, 14.85)

Goodness of fit:
SSE: 1.065
R-square: 0.9903
Adjusted R-square: 0.9879
RMSE: 0.3649

6. Improved water source (% of population with access)

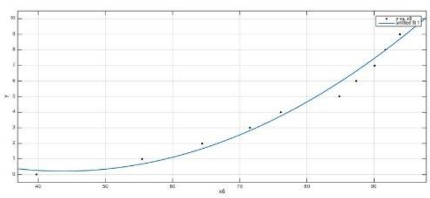
■ Tendency function



f(x) = p1*x + p2
Coefficients (with 95% confidence bounds):
p1 = 0.7308 (0.7098, 0.7519)
p2 = -1421 (-1463, -1379)

Goodness of fit:
SSE: 2.175
R-square: 0.996
Adjusted R-square: 0.9958
RMSE: 0.3219

■ Scoring function

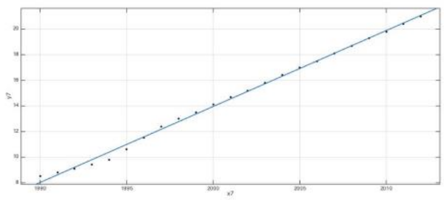


f(x) = p1*x^2 + p2*x + p3
Coefficients (with 95% confidence bounds):
p1 = 0.003378 (0.001884, 0.004872)
p2 = -0.2955 (-0.505, -0.08609)
p3 = 6.683 (-0.2982, 13.66)

Goodness of fit:
SSE: 2.755
R-square: 0.975
Adjusted R-square: 0.9687
RMSE: 0.5869

7. Improved sanitation facilities (% of population with access)

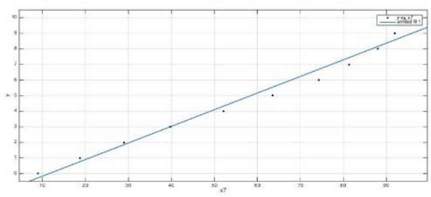
■ Tendency function



f(x) = p1*x + p2
Coefficients (with 95% confidence bounds):
p1 = 0.5935 (0.5782, 0.6088)
p2 = -1173 (-1204, -1142)

Goodness of fit:
SSE: 1.154
R-square: 0.9968
Adjusted R-square: 0.9966
RMSE: 0.2345

■ Scoring function



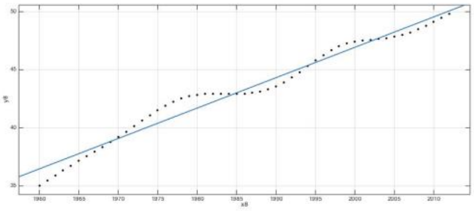
f(x) = p1*x + p2
Coefficients (with 95% confidence bounds):
p1 = 0.1066 (0.09413, 0.1192)
p2 = -1.232 (-2.05, -0.4139)

Goodness of fit:
SSE: 2.602
R-square: 0.9763

Adjusted R-square: 0.9737
RMSE: 0.5376

8. Life expectancy at birth, total (years)

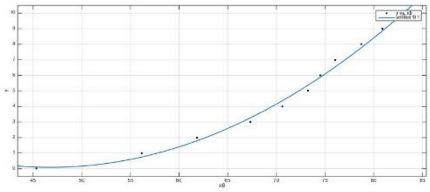
■ Tendency function



f(x) = p1*x + p2
Coefficients (with 95% confidence bounds):
p1 = 0.2618 (0.2489, 0.2747)
p2 = -476.7 (-502.2, -451.1)

Goodness of fit:
SSE: 25.96
R-square: 0.9704
Adjusted R-square: 0.9698
RMSE: 0.7135

■ Scoring function

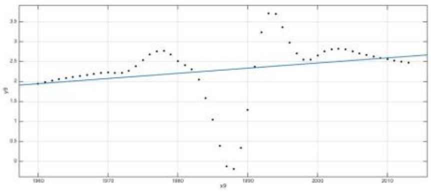


f(x) = p1*x^2 + p2*x + p3
Coefficients (with 95% confidence bounds):
p1 = 0.007541 (0.005797, 0.009286)
p2 = -0.7055 (-0.9331, -0.4779)
p3 = 16.59 (9.333, 23.84)

Goodness of fit:
SSE: 0.8019
R-square: 0.9927
Adjusted R-square: 0.9909
RMSE: 0.3166

9. Population growth (annual %)

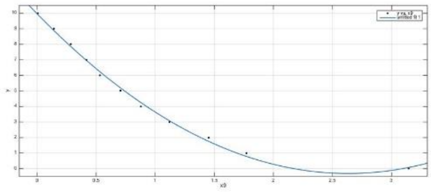
■ Tendency function



f(x) = p1*x + p2
Coefficients (with 95% confidence bounds):
p1 = 0.01294 (-0.0004952, 0.02638)
p2 = -23.42 (-50.11, 3.275)

Goodness of fit:
SSE: 30.58
R-square: 0.06702
Adjusted R-square: 0.04908
RMSE: 0.7669

■ Scoring function

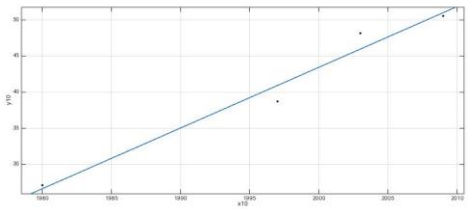


f(x) = p1*x^2 + p2*x + p3
Coefficients (with 95% confidence bounds):
p1 = 1.483 (1.325, 1.641)
p2 = -7.81 (-8.313, -7.306)
p3 = 9.969 (9.687, 10.25)

Goodness of fit:
SSE: 0.3164
R-square: 0.9971
Adjusted R-square: 0.9964
RMSE: 0.1989

10. Literacy rate, adult total (% of people ages 15 and above)

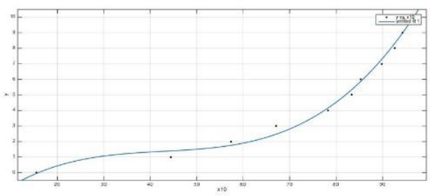
■ Tendency function



f(x) = p1*x + p2
Coefficients (with 95% confidence bounds):
p1 = 0.8407 (0.3938, 1.288)
p2 = -1638 (-2531, -745.4)

Goodness of fit:
SSE: 10.11
R-square: 0.9704
Adjusted R-square: 0.9556
RMSE: 2.249

- Scoring function

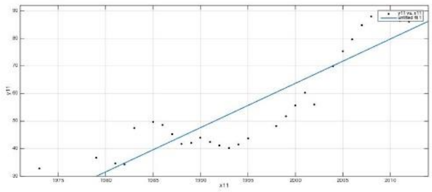


f(x) = p1*x^3 + p2*x^2 + p3*x + p4
Coefficients (with 95% confidence bounds):
p1 = 4.946e-05 (2.134e-05, 7.757e-05)
p2 = -0.006332 (-0.01114, -0.00153)
p3 = 0.286 (0.04592, 0.5261)
p4 = -3.147 (-6.368, 0.07417)

Goodness of fit:
SSE: 1.162
R-square: 0.9894
Adjusted R-square: 0.9849
RMSE: 0.4074

11. School enrollment, primary (% net)

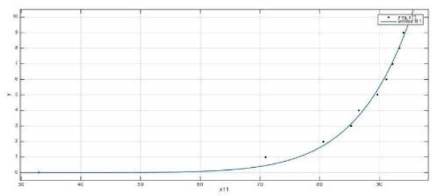
- Tendency function



f(x) = p1*x + p2
Coefficients (with 95% confidence bounds):
p1 = 1.608 (1.302, 1.914)
p2 = -3153 (-3763, -2542)

Goodness of fit:
SSE: 2089
R-square: 0.8056
Adjusted R-square: 0.7986
RMSE: 8.637

- Scoring function

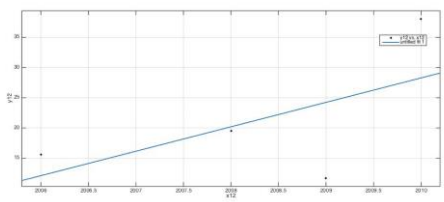


f(x) = a*x^b
Coefficients (with 95% confidence bounds):
a = 2.066e-20 (-9.468e-20, 1.36e-19)
b = 10.45 (9.22, 11.69)

Goodness of fit:
SSE: 0.8816
R-square: 0.992
Adjusted R-square: 0.9911
RMSE: 0.313

12. Researchers in R&D (per million people)

- Tendency function



f(x) = p1*x + p2

Coefficients (with 95% confidence bounds):

p1 = 4.042 (-12.75, 20.83)

p2 = -8096 (-4.182e+04, 2.562e+04)

Goodness of fit:

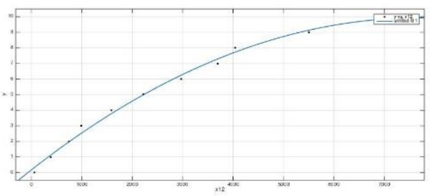
SSE: 266.5

R-square: 0.3491

Adjusted R-square: 0.02371

RMSE: 11.54

- Scoring function



f(x) = p1*x^2 + p2*x + p3

Coefficients (with 95% confidence bounds):

p1 = -1.647e-07 (-2.053e-07, -1.24e-07)

p2 = 0.002534 (0.002235, 0.002833)

p3 = 0.1747 (-0.2427, 0.5921)

Goodness of fit:

SSE: 0.6597

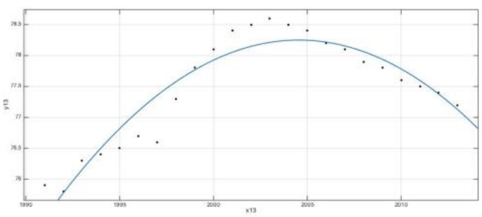
R-square: 0.994

Adjusted R-square: 0.9925

RMSE: 0.2872

13. Employment to population ratio, 15+, total (%) (modeled ILO estimate)

- Tendency function



f(x) = p1*x^2 + p2*x + p3

Coefficients (with 95% confidence bounds):

p1 = -0.0157 (-0.01906, -0.01234)

p2 = 62.94 (49.49, 76.4)

p3 = -6.301e+04 (-7.648e+04, -4.954e+04)

Goodness of fit:

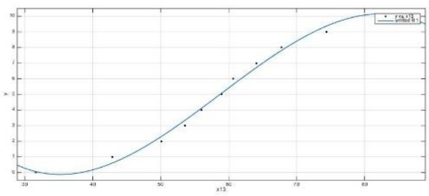
SSE: 1.838

R-square: 0.8921

Adjusted R-square: 0.8813

RMSE: 0.3032

- Scoring function



f(x) = p1*x^3 + p2*x^2 + p3*x + p4

Coefficients (with 95% confidence bounds):

p1 = -0.0001957 (-0.0002586, -0.0001327)

p2 = 0.0345 (0.02334, 0.04565)

p3 = -1.701 (-2.329, -1.073)

p4 = 25.53 (14.35, 36.71)

Goodness of fit:

SSE: 0.7685

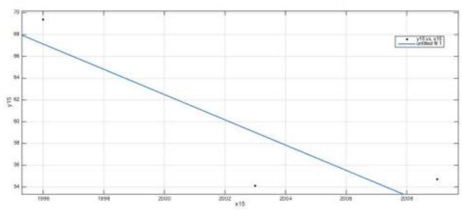
R-square: 0.993

Adjusted R-square: 0.99

RMSE: 0.3313

14. GINI index (World Bank estimate)

- Tendency function



f(x) = p1*x + p2

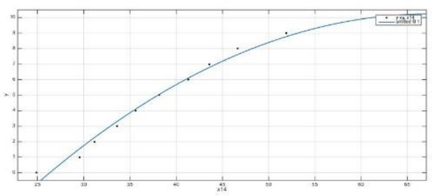
Coefficients (with 95% confidence bounds):

p1 = 0.09783 (-2.144, 2.339)

p2 = -150.2 (-4639, 4339)

Goodness of fit:
SSE: 2.635
R-square: 0.2352
Adjusted R-square: -0.5296
RMSE: 1.623

- Scoring function

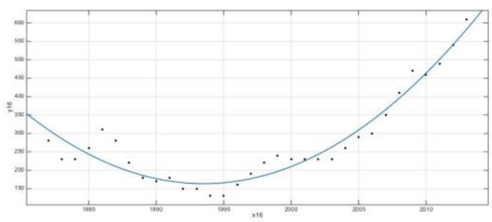


f(x) = p1*x^2 + p2*x + p3
Coefficients (with 95% confidence bounds):
p1 = -0.006062 (-0.00803, -0.004094)
p2 = 0.8174 (0.6402, 0.9947)
p3 = -17.32 (-21.11, -13.53)

Goodness of fit:
SSE: 1.303
R-square: 0.9882
Adjusted R-square: 0.9852
RMSE: 0.4036

15. Poverty headcount ratio at national poverty lines (% of population)

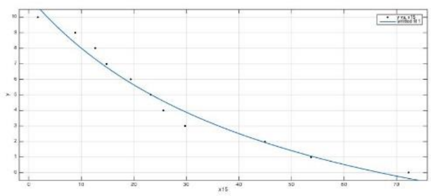
- Tendency function



f(x) = p1*x + p2
Coefficients (with 95% confidence bounds):
p1 = -1.16 (-9.478, 7.158)
p2 = 2382 (-1.428e+04, 1.904e+04)

Goodness of fit:
SSE: 36.28
R-square: 0.7584
Adjusted R-square: 0.5168
RMSE: 6.024

- Scoring function

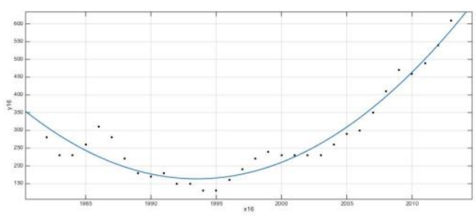


f(x) = (p1*x + p2) / (x + q1)
Coefficients (with 95% confidence bounds):
p1 = -8.357 (-15.03, -1.688)
p2 = 558.6 (192.9, 924.3)
q1 = 49.35 (12.17, 86.53)

Goodness of fit:
SSE: 2.883
R-square: 0.9738
Adjusted R-square: 0.9672
RMSE: 0.6003

16. GNI per capita, Atlas method (current US$)

- Tendency function

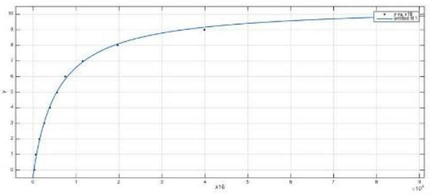


f(x) = p1*x^2 + p2*x + p3
Coefficients (with 95% confidence bounds):
p1 = 1.105 (0.9497, 1.261)
p2 = -4407 (-5029, -3785)
p3 = 4.393e+06 (3.772e+06, 5.014e+06)

Goodness of fit:
SSE: 3.118e+04
R-square: 0.9336
Adjusted R-square: 0.929

RMSE: 32.79

- Scoring function

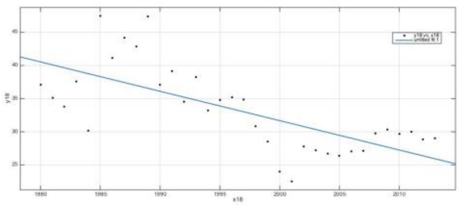


f(x) = (p1*x + p2) / (x + q1)
Coefficients (with 95% confidence bounds):
p1 = 10.52 (10.2, 10.84)
p2 = -1749 (-3284, -213.6)
q1 = 5711 (4972, 6450)

Goodness of fit:
SSE: 0.1764
R-square: 0.9984
Adjusted R-square: 0.998
RMSE: 0.1485

17. Energy use (kg of oil equivalent) per $1,000 GDP (constant 2011 PPP)

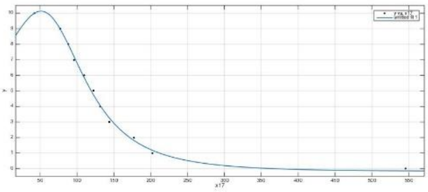
- Tendency function



f(x) = p1*x + p2
Coefficients (with 95% confidence bounds):
p1 = -26.77 (-28.93, -24.61)
p2 = 5.422e+04 (4.989e+04, 5.854e+04)

Goodness of fit:
SSE: 1.905e+04
R-square: 0.9708
Adjusted R-square: 0.9694
RMSE: 30.86

- Scoring function

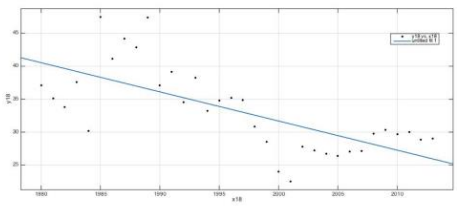


f(x) = (p1*x + p2) / (x^2 + q1*x + q2)
Coefficients (with 95% confidence bounds):
p1 = -185.5 (-359, -11.95)
p2 = 6.805e+04 (3.693e+04, 9.917e+04)
q1 = -120.5 (-133.1, -108)
q2 = 9330 (6714, 1.195e+04)

Goodness of fit:
SSE: 0.2811
R-square: 0.9974
Adjusted R-square: 0.9963
RMSE: 0.2004

18. Agriculture, value added (% of GDP)

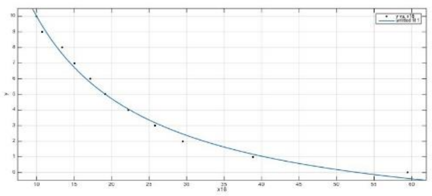
- Tendency function



f(x) = p1*x + p2
Coefficients (with 95% confidence bounds):
p1 = -0.442 (-0.6097, -0.2743)
p2 = 915.7 (580.9, 1251)

Goodness of fit:
SSE: 709.8
R-square: 0.4739
Adjusted R-square: 0.4575
RMSE: 4.71

- Scoring function



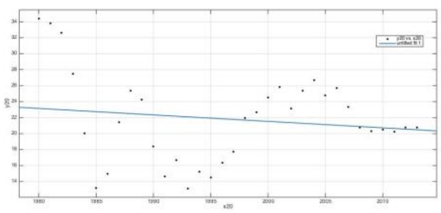
f(x) = (p1*x + p2) / (x + q1)
Coefficients (with 95% confidence bounds):

p1 = -3.745 (-5.42, -2.071)
p2 = 198.1 (136.3, 259.8)
q1 = 6.056 (0.9808, 11.13)

Goodness of fit:
SSE: 0.868
R-square: 0.9921
Adjusted R-square: 0.9901
RMSE: 0.3294

19. Manufacturing, value added (% of GDP)

- Tendency function

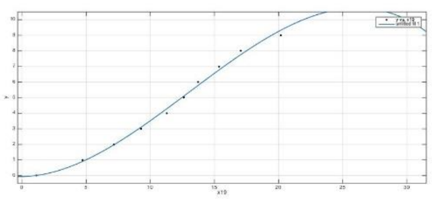


f(x) = p1*x + p2
Coefficients (with 95% confidence bounds):

p1 = 0.1938 (0.0511, 0.3366)
p2 = -375.8 (-661.5, -90.07)

Goodness of fit:
SSE: 119.9
R-square: 0.265
Adjusted R-square: 0.2316
RMSE: 2.334

- Scoring function



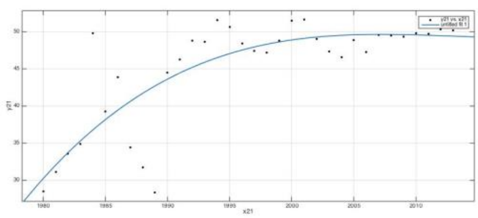
f(x) = p1*x^3 + p2*x^2 + p3*x + p4
Coefficients (with 95% confidence bounds):

p1 = -0.001187 (-0.001507, -0.000867)
p2 = 0.04634 (0.0313, 0.06138)
p3 = 0.01375 (-0.1771, 0.2046)
p4 = -0.06336 (-0.7318, 0.605)

Goodness of fit:
SSE: 0.3731
R-square: 0.9966
Adjusted R-square: 0.9952
RMSE: 0.2309

20. Industry, value added (% of GDP)

- Tendency function



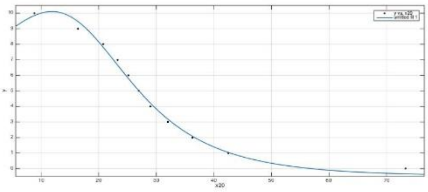
f(x) = p1*x + p2

Coefficients (with 95% confidence bounds):

p1 = -0.08101 (-0.278, 0.1159)
p2 = 183.5 (-209.7, 576.8)

Goodness of fit:
SSE: 979
R-square: 0.02146
Adjusted R-square: -0.009114
RMSE: 5.531

- Scoring function

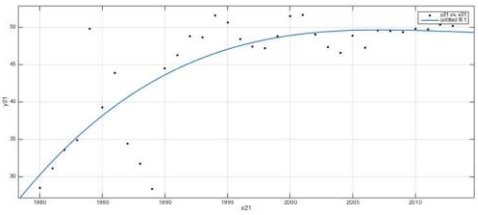


f(x) = (p1*x + p2) / (x^2 + q1*x + q2)
Coefficients (with 95% confidence bounds):
p1 = -75.42 (-126.5, -24.36)
p2 = 4300 (2277, 6322)
q1 = -31.2 (-35.21, -27.19)
q2 = 566.5 (394.1, 738.9)

Goodness of fit:
SSE: 0.6231
R-square: 0.9943
Adjusted R-square: 0.9919
RMSE: 0.2984

21. Services, etc., value added (% of GDP)

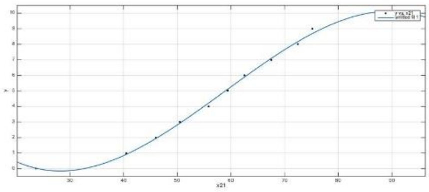
- Tendency function



f(x) = p1*x^3 + p2*x^2 + p3*x + p4
Coefficients (with 95% confidence bounds):
p1 = 0.0005867 (-0.001601, 0.002775)
p2 = -3.543 (-16.65, 9.563)
p3 = 7132 (-1.903e+04, 3.33e+04)
p4 = -4.786e+06 (-2.22e+07, 1.263e+07)

Goodness of fit:
SSE: 638.2
R-square: 0.6359
Adjusted R-square: 0.5995
RMSE: 4.612

- Scoring function

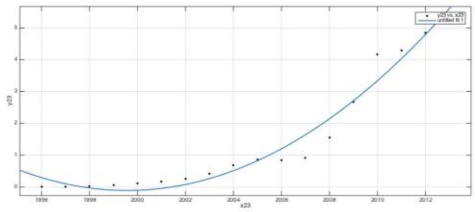


f(x) = p1*x^3 + p2*x^2 + p3*x + p4
Coefficients (with 95% confidence bounds):
p1 = -8.884e-05 (-0.0001045, -7.316e-05)
p2 = 0.0157 (0.01294, 0.01846)
p3 = -0.6737 (-0.824, -0.5235)
p4 = 8.359 (5.855, 10.86)

Goodness of fit:
SSE: 0.2218
R-square: 0.998
Adjusted R-square: 0.9971
RMSE: 0.178

22. Road density (km of road per 100 sq. km of land area)

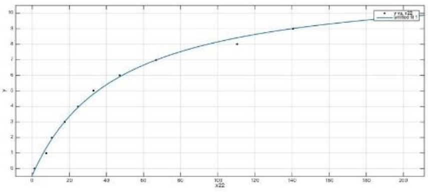
- Tendency function



f(x) = p1*x + p2
Coefficients (with 95% confidence bounds):
p1 = -0.001005 (-0.002306, 0.0002961)
p2 = 5.813 (3.203, 8.423)

Goodness of fit:
SSE: 5.103e-07
R-square: 0.9897
Adjusted R-square: 0.9795
RMSE: 0.0007144

- Scoring function



f(x) = (p1*x + p2) / (x + q1)

Coefficients (with 95% confidence bounds):

p1 = 12.11 (11.26, 12.96)

p2 = -19.97 (-38.93, -0.996)

q1 = 46.03 (35.33, 56.73)

Goodness of fit:

SSE: 0.4244

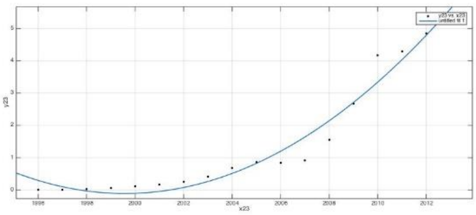
R-square: 0.9961

Adjusted R-square: 0.9952

RMSE: 0.2303

23. Internet users (per 100 people)

- Tendency function



f(x) = p1*x^2 + p2*x + p3

Coefficients (with 95% confidence bounds):

p1 = 0.03172 (0.02386, 0.03957)

p2 = -126.8 (-158.3, -95.35)

p3 = 1.268e+05 (9.525e+04, 1.584e+05)

Goodness of fit:

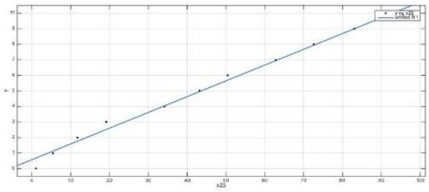
SSE: 2.105

R-square: 0.9648

Adjusted R-square: 0.9601

RMSE: 0.3746

- Scoring function



f(x) = p1*x + p2

Coefficients (with 95% confidence bounds):

p1 = 0.1014 (0.09405, 0.1088)

p2 = 0.5759 (0.1817, 0.9701)

Goodness of fit:

SSE: 1.01

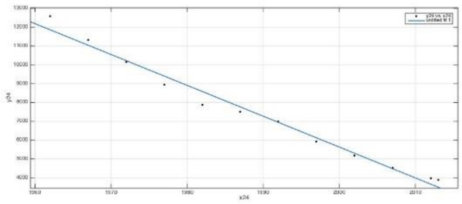
R-square: 0.9908

Adjusted R-square: 0.9898

RMSE: 0.3351

24. Renewable internal freshwater resources per capita (cubic meters)

- Tendency function



f(x) = p1*x + p2

Coefficients (with 95% confidence bounds):

p1 = -163.9 (-179.8, -148.1)

p2 = 3.335e+05 (3.019e+05, 3.651e+05)

Goodness of fit:

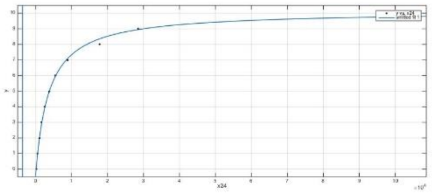
SSE: 1.711e+06

R-square: 0.9815

Adjusted R-square: 0.9796

RMSE: 413.7

- Scoring function

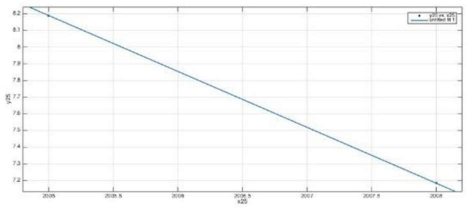


f(x) = (p1*x + p2) / (x + q1)
Coefficients (with 95% confidence bounds):
p1 = 10.14 (9.823, 10.45)
p2 = -1652 (-2750, -553.2)
q1 = 3598 (3075, 4121)

Goodness of fit:
SSE: 0.2144
R-square: 0.9981
Adjusted R-square: 0.9976
RMSE: 0.1637

25. GEF benefits index for biodiversity (0 = no biodiversity potential to 100 = maximum)

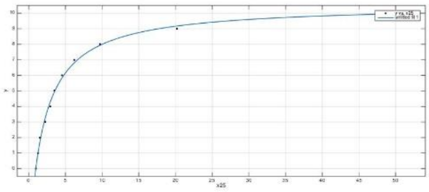
- Tendency function



f(x) = p1*x + p2
Coefficients:
p1 = -0.3355
p2 = 680.9

Goodness of fit:
SSE: 1.399e-27
R-square: 1
Adjusted R-square: NaN
RMSE: NaN

- Scoring function

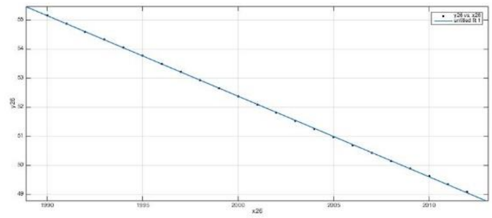


f(x) = (p1*x + p2) / (x + q1)
Coefficients (with 95% confidence bounds):
p1 = 10.55 (10.17, 10.92)
p2 = -10.26 (-11.12, -9.4)
q1 = 1.909 (1.499, 2.32)

Goodness of fit:
SSE: 0.2485
R-square: 0.9977
Adjusted R-square: 0.9972
RMSE: 0.1762

26. Forest area (% of land area)

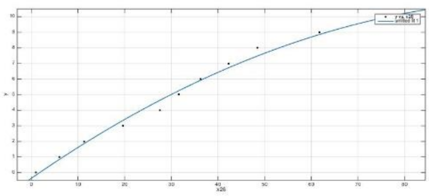
- Tendency function



f(x) = p1*x + p2
Coefficients (with 95% confidence bounds):
p1 = -0.2772 (-0.2781, -0.2763)
p2 = 606.8 (604.9, 608.7)

Goodness of fit:
SSE: 0.004325
R-square: 0.9999
Adjusted R-square: 0.9999
RMSE: 0.01435

- Scoring function



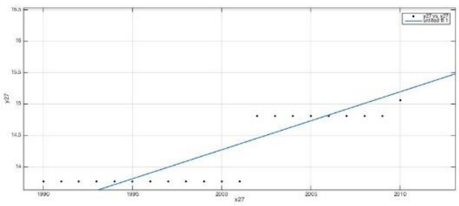
f(x) = p1*x^2 + p2*x + p3
Coefficients (with 95% confidence bounds):
p1 = -0.000942 (-0.001384, -0.0004998)
p2 = 0.2076 (0.1714, 0.2437)
p3 = -0.366 (-0.9831, 0.251)

Goodness of fit:
SSE: 1.104
R-square: 0.99
Adjusted R-square: 0.9875
RMSE: 0.3715

27. Terrestrial and marine protected areas (% of total territorial area)

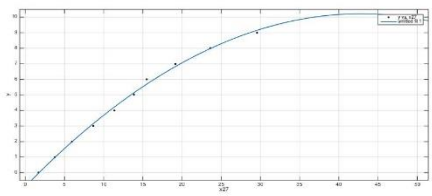
- Tendency function

f(x) = p1*x + p2
Coefficients (with 95% confidence bounds):
p1 = 0.09227 (0.06664, 0.1179)
p2 = -170.3 (-221.6, -119)



Goodness of fit:
SSE: 2.74
R-square: 0.7382
Adjusted R-square: 0.7251
RMSE: 0.3702

- Scoring function



f(x) = p1*x^2 + p2*x + p3
Coefficients (with 95% confidence bounds):
p1 = -0.006065 (-0.00667, -0.00546)
p2 = 0.5193 (0.4882, 0.5503)
p3 = -0.8969 (-1.193, -0.6008)

Goodness of fit:
SSE: 0.2483
R-square: 0.9977
Adjusted R-square: 0.9972
RMSE: 0.1762