For office use only	Team Control Number	For office use only
T1 _____	59015	F1 _____
T2 _____		F2 _____
T3 _____	Problem Chosen	F3 _____
T4 _____	F	F4 _____

2017
MCM/ICM
Summary Sheet

Utopia on Mars

The migration to Mars of 10 thousand people has been put on the agenda, and our target is to create a sustainable society by maximize the average GDP per capita and happiness. We created Social Success Index (SSI), in order to estimate the Comprehensive Development Level of a society, which includes Economic Development Level and Happiness Level. They are comprising of Income Level, Education Level and Social Equality Index. After that, we used 7 index which are easy to observe and record (Minimum wage, Engel's coefficient, Average Year of Education, Tertiary Gross Enrolment Ratio, the Proportion of Women in the Workforce, Gini Coefficient, out-of-school Rate of Children of Primary School Age) in order to measure our model in first step.

With the target to ensure the first batch of people a better living experience, we generated a sample population of 10 thousand people randomly in the top 10 Human Development Index countries to migrate, beginning to build the optimized society.

Firstly, in order to objectively demonstrate the contribution of various factors to social success, we use the Fuzzy Analytic Hierarchy Process to determine the weight of each factor to their last layer and we compare the real GDP per capita to average GDP per capita the model predicts to illustrate the rationality. Finally we get the factors weight table, **TABLE 4**. This allows us to have a quantitative standard to measure the level of social comprehensive development.

Secondly, in order to make specific decisions, we build a decision model. To simplify the model, we divide the population into three categories: skilled labor, unskilled labor and the population who can not work. Skilled labor has a high wage output ratio and enjoy a high average salary. Unskilled labor has a lower wage output ratio and enjoy the minimum hourly wage. People who cannot work do not produce but enjoy the social welfare. At the same time, the establishment of innovation coefficient makes people have the incentive to innovate. By making full use of social resources and ensuring sustainable social development, we get the minimum wage, wage distribution plan and welfare standard to maximize social success index,**TABLE 5,6.** Based on the recursive formula of social output, we can measure the degree of sustainable development of a society in economy.

Thirdly, considering about the difference which three groups of people have on their priorities on various factors, we've created a formula to quantize their degree of satisfaction. At the same time, we've presented the optimization model which can optimize the degree of satisfaction of each subgroups while maximum the Social Success Index.

Fourthly, when considering the subsequent migration, we further extend the model to investigate the sensitivity of the change in labor distribution to the model. When taking additional migration phased, Social Success Index will be sensitive with Technical Labor Ratio, which means we need to make sure that we have a strict recruitment standard. When it comes to large-scale migration, we've selected three countries to respectively represent developed, developing and backward countries by K-means algorithm, calculated the distribution of the world average labor force, and studied the influence of the deviation of labor force ratio to the applicability of our model.

At last, we analyzed the advantage and weakness of our model and gave our suggestions to LIFE. Further, the accuracy of our model needs improving.

Key words： Fussy Analytic Hierarchy Process, Linear Programming

Content

1 Background

Laboratory of Interstellar Financial & Exploration Policy (LIFE), the international agency, has completed a series of short-term planned living experiments on our neighbor planet, Mars. It will soon enable human beings to live on Mars with the new technology. The first wave of migration, called Population Zero, will include 10,000 people. It aims to create a sustainable society by maximizing both economic output (GDP) and happiness in the work place for its citizens.

To create an optimal workforce for the 22nd century to give all people the greatest quality of life with a vision of sustainability for the next 100 years, the LIFE agency launched project UTOPIA: 2100.

To achieve them and create a sustainable life-plan, our task is to build a policy model and give a set of policy recommendations including balancing factors such as: income, education and equality.

2 Problem Restatement

The problems that we need to solve in this paper are:

- Define parameters and specific outcomes related to the three priority factors (income, education, and social equality) in Population Zero. Identify and define the specific outcomes that would indicate positive results across the three factors for the next decade (years 2100-2110). Consider what the goal is for each of these factors.
- Identify and analyze the demographic characteristics of this simulation of Population Zero. Analyze and describe demographic distributions, such as gender, ethnicity, age, and education levels.
- Build a model that includes the three identified factors (income, education, & social equality).
- Proceed the model in task 3 to merge these models into a global model.
- LIFE has planned additional migration phased over the next 100-years. How does this affect the model?
- In shocking news, scientists discover a threat of a collision of Earth with a planet sized comet. We need to evacuate planet Earth and move as many people as possible to Mars to live in enlarged manufactured cities.

3 Terminology

3.1 Terms

- **Engel's Coefficient:** The proportion of total food expenditure to total personal consumption expenditure.
- **Gini Coefficient:** An important index which examines the different status in the internal distribution of income in the international community.
- **The Proportion of Women in The Workforce**: Female labor force as a percentage of the total show the extent to which women are active in the labor force.[1]
- **The Out-of-school Rate of Children of Primary School Age:** The number of children of official primary school age who are not enrolled in primary or secondary school, expressed as a percentage of the population of official primary school age. Children enrolled in pre-primary education are excluded and considered out of school.[2]
- **Tertiary Gross Enrolment Ratio:** regardless of age, expressed as a percentage of the total population of the five-year age group following on from secondary school leaving.[3]
- **Average Year of Education:** This index is one of the important indexes to reflect the

education level of a country or region.[4]

3.2 Symbols

Symbol	Describe
SSI	Social Success Index
GDP .p. c.	GDP per capita
GNH	Gross National Happiness
B1	Income level
B2	Education level
B3	social equality index
C1	minimum wage
C2	Engel's coefficient
C3	average year of education
C4	tertiary gross enrolment ratio
C5	the proportion of women in the workforce
C6	Gini coefficient
C7	the out-of-school rate of children of primary school age
G1	skilled labor population
G2	unskilled labor population
G3	non-working population
	the total expenditure on welfare and wages in year
Q	the weighted impact integration of C2-C5 on SSI
	the weight of C1 to SSI
	the weight of C6 to SSI
	the weight of C7 to SSI
	innovation coefficient
	average maximum hourly wage
	minimum hourly wage
W	material benefits

4 General Assumptions

- Assume that everyone can adapt to the society of Mars without training.
- Assume that inflation does not inflate.
- Assume that all of the people who are 15-64 years old can work.

5 Three Factors

In this section, we define parameters and specific outcomes related to the three priority factors (income, education, and social equality) in Population Zero. For each factor we define parameters to represent it and get the specific outcomes. We also predict what the goals are of each factor.

5.1 Income

For income, we define two parameters: minimum wage and Engel's Coefficient of every country to represent it.

The formula of Engel's Law is:

This formula reflects that as a household incomes increase, the proportion of household income (or total expenditure) used to purchase food will decrease according to the changes in salary distribution.

The minimum wage system is a policy tool that regulates the distribution of income in the initial distribution. Raising the minimum wage allows the worker to receive higher remuneration in the initial distribution, so raising the minimum wage can promote a more equitable distribution of incomes.

Considering this factor is to reduce poverty rate and promote income distribution to be fair.

5.2 Education

For education, we define two parameters: average year of education of every country, and the tertiary gross enrolment ratio.

The average year of education means the level of education of all citizens, while the tertiary gross enrolment ratio reflects the highest level of the technical works.

Taking this factor into account is to raise the educational level of the whole people in the world and improve the level of the popularity of compulsory education.

5.3 Social Equality

For social equality, we define three parameters: Gini coefficient, the proportion of women in the workforce, and the out-of-school rate of children of primary school age.

The formula is:

Where:
G: Gini coefficient
: From group 1 to the group i, the total income is accounted for the proportion of total population income.
n: Assuming a certain number of population by income from low to high order queue and divide them into n groups.

According to Gini coefficient, we can draw a conclusion: The smaller the Gini coefficient is, the more uniform the income distribution is, and the bigger the Gini coefficient, the more uneven the income distribution.

The proportion of women in the workforce reflects gender equality. The higher the proportion is, the fairer the society is.

The out-of-school rate of children of primary school age can partly reflect that the right of being educated can’t be guaranteed totally, and the lack of compulsory education in some areas and countries. We suggest that it is a basic element for a sustainable society to have a low out-of-school rate of children.

Considering this factor is to ensure the fairness of society and different people’s rights and interests.

6 Preliminary Sample Selection

In order to create the best workface and provide the highest quality of life for all the people, we choose ten counties, Norway, Australia, Swiss Confederation, Denmark, Netherlands, Germany, Ireland, The United States, Canada and New Zealand, as the selected population samples according to the Human Development Index (HDI). They are the top ten countries. We think they can provide optimal conditions.

6.1 Local Terms

- **Human Development Index (HDI):** A measure of the level of economic and social development of the Member States of the United Nations.
- **Sex Ratio:**

6.2 Demographic Characteristics

Because we extract population samples from ten countries, the demographic characteristics are not the same. As a result, we have collected demographic data on different aspects of each country.

6.2.1 Population Distribution

According to the data, we have the total population of each country in 2015.We show them in the **TABLE 1**.

TABLE 1: The total population of each country[5]

Country	Norway	Australia	Swiss Confederation
Total(thousands)	5,195.92	23,781.17	8,286.98
Country	Germany	Ireland	The United States
Total(thousands)	81,413.15	4,640.70	321,418.82
Country	Denmark	Netherland	
Total(thousands)	5,676.00	16,936.52	

We can calculate the proportion of the population of ten countries .Then take the population with the same proportion from each country and finally generate a sample population of 10,000 people. The number of population we generate from each country are in the **TABLE 2**.

TABLE 2: The number of population from each country

Country	Norway	Australia	Swiss Confederation	Denmark	Netherland
Number	102	468	163	112	334
Country	Germany	Ireland	The United States	Canada	New Zealand
Number	1603	91	6330	706	91

6.2.2 Other Population Distributions

In this section, we will analyze and describe the population distribution from eight aspects: C1, C2, C3, C4, C5, C6, C7 and sex ratio.

- We show the data of all aspects from each country in the **TABLE 3**.

TABLE 3.1: The data of each country

	C1($/h)	C2 [6]	C3(year)	C4 (%) [7]	C5 (%)	C6	C7 (%) [8]	Sex ratio
Norway	22.4	0.11	12.6	77	47.1	0.259	0	1.004
Australia	16.88	0.11	12	87	45.4	0.3494	3	0.999
Swiss Confederation	21.97	0.145	11	57	46.2	0.3164	1	0.969
Denmark	16.85	0.114	11.4	82	47.7	0.2908	1	0.984
Netherland	10.05	0.114	11.6	79	46.1	0.2799	3	0.984
Germany	11.85	0.109	12.2	65	45.9	0.3013	1	0.966
Ireland	12.58	0.125	11.6	73	44.5	0.3252	0	0.99
The United States	7.25	0.07	12.4	87	45.8	0.4106	8	0.983
Canada	9.75	0.096	12.1	88	47.1	0.3368	1	0.984
New Zealand	8.84	0.173	12.5	81	47.27	0.35	2	0.964

TABLE 3.2: The standardization formula of each index

C1	C2	C3	C4	C5	C6	C7

- When it comes to the feature of the sample, according to the data of reality we calculate that: The proportion of 0-14 age bracket is 0.176108, 15-64 age is 0.662448 and over 65 age is 0.161443.

On one hand, we can get that the most people of the sample are in the 15-64 age bracket and it guarantees that productive forces can keep in a high level. On the other hand, we insist that at least there have to be part of children and the elder in the sample, because we consider that children and the elder can ensure the completeness of families in order to increase the aware of happiness.

- The average years of education is 11.94 years and the minimum percentage of the tertiary gross enrolment ratio is 57%. It shows that the most people in the sample get high education so the creativity is high.

7 Social Success Assessment Model

In this section, we use the parameters that we created in section 5 to build a model which includes the three identified factors (income, education, & social equality). This model can allow us to solve a series of questions.

7.1 Fuzzy Analytical Hierarchy Process (FAHP)

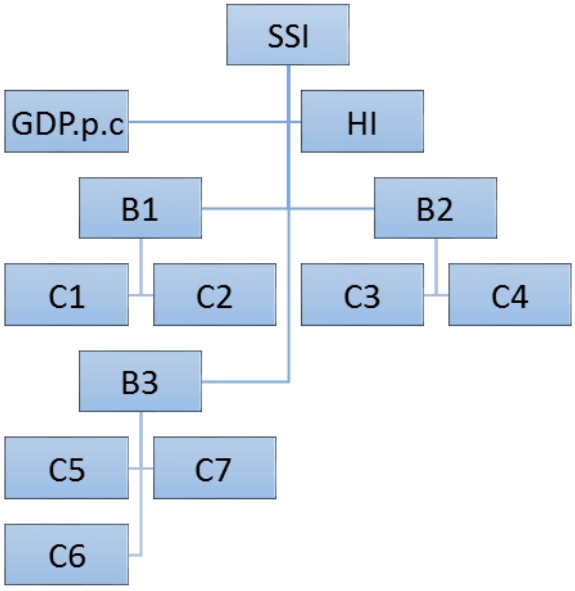
Based on the requirements, we use a method which is similar to Analytic Hierarchy Process (AHP) to weight parameters. We finally make sure the decision layer – SSI, two first-grade index, three second-grade index and 7 third-grade index. Using the weighting method given by the United Nations Development Program (UNDP), consulting from relevant experts and our experience and our judgement of the importance of each indicator and calculate the weight coefficients of each second-grade index to first-grade index and the decision layer with Analytic Hierarchy Process (AHP). Then we get the final decision-making.

Via comparing the results to the data of countries in the sample in recent years, we will find whether the comprehensive evaluation system we establish is reasonable and feasible.

7.1.1 General Assumptions

- Assume that all data is true, reasonable, and scientific.
- Assume that other extraneous variables and other weaker effects are not considered.

7.1.2 Hierarchical graph



7.1.3 Decision-making Process

The priority relation matrix of GDP p. c to B layer is:

The importance ranking index is:

Fuzzy consistency judgement matrix is:

Satisfy:

Get the sort vector by standardization method:

$$\begin{pmatrix} 0.383 \\ 0.367 \\ 0.25 \end{pmatrix}$$

Two test indicators are

$$\delta = \max\{|\,a_{ij} - b_{ij}\,|\} = 0.125 < 0.2$$

$$\sigma = \frac{\sqrt{\sum_{1\le i,j\le 3}(a_{ij} - b_{ij})^2}}{3} = 0.0687 < 0.1$$

So the model is stable.

.

(b1=0.383, b2=0.367, b3=0.25)

The Judgment Matrix of GNH to B layer is:

The importance ranking index is:

$$\begin{pmatrix} 1.8 \\ 1.2 \\ 1.5 \end{pmatrix}$$

Fuzzy consistency judgement matrix is:

Satisfy:

$$r_{ij} = r_{ik} - r_{jk} + 0.5$$

Get the sort vector by standardization method:

$$\begin{pmatrix} 0.383 \\ 0.283 \\ 0.333 \end{pmatrix}$$

Two test indicators are:

$$\delta = \max\{|\,a_{ij} - b_{ij}\,|\} = 0.05 < 0.2$$

$$\sigma = \frac{\sqrt{\sum_{1\le i,j\le 3}(a_{ij} - b_{ij})^2}}{3} = 0.0289 < 0.1$$

So the model is stable.

.

(b1'=0.383, b2'=0.283,b3'=0.333)

And

,

So

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Each B1 is weighted by the C-level indicator.

TABLE 4 shows each weight.

TABLE 4

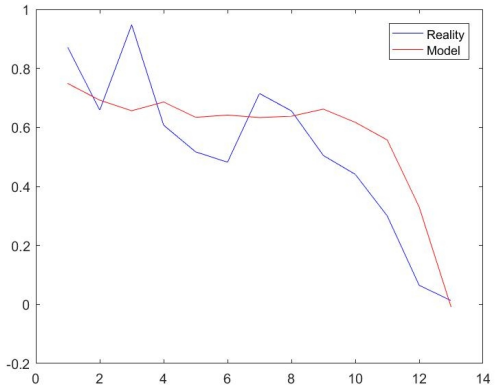
The Decision Layer	Layer A		Layer B			Layer C			
index	index	SSIW	index	SSIW	AW	index	BW	AW	SSIW
SSI	GDP.p.c	0.5	B1	0.383	0.383 0.383	C1	0.4	0.153 0.153	0.153
	GNH	0.5				C2	0.6	0.23 0.23	0.23
			B2	0.325	0.367 0.283	C3	0.667	0.245 0.189	0.217
						C4	0.333	0.122 0.094	0.108
			B3	0.292	0.25 0.333	C5	0.375	0.094 0.125	0.11
						C6	0.25	0.063 0.083	0.073
						C7	0.375	0.094 0.125	0.11

(The upper one of AW refers to GDP.p.c. while the lower one refers to GNH.)

7.1.4 Comparison between Our Model and the Reality

We compare the GDP.p.c. data from ten countries with our results. **Figure 1** shows the comparison between our model and the reality.
(*The last three countries in figure 1 (Spain, Thailand, Yemen) are not considered in this section but in **8.2**)

Figure 1



7.2 Limiting factors

- **Productive forces**

In our sample of 10,000 people, productivity is inadequate. Since we are sampling according to the Human Development Index, the selected countries are all developed countries. In the production system of developed countries, most of workers are the foreign

cheap labor force and the majority of local people are high-tech talents. So this leads to a low productivity.

7.3 The Optimal Minimum Wage and Salary Distribution

Now we think about how to allocate resources to achieve goals of social success in the case of limited expenditure.

7.3.1 General Assumptions

- All of the data is true, scientific and real.
- The per capita GDP of the sample population in 2100 is equal to the current per capita GDP which is 52873.01 in the ten countries we have chosen. Based on the average level of sample countries, we believe that total wages and benefits account for 77.7% of GDP.
- The workers work 22days a month and 8 hours a day. The wage-to-output ratio of skilled and unskilled labor force is 4: 1. And the ratio of the amount wages and material benefits for the next year in the production of technical labor force to the salary in last year is 2.
- To calculate easily, we use instead of the Gini coefficient to measure whether the allocation is fair
- In order to ensure the efficient functioning of the society and to stimulate the working passion of those who have the ability, we stipulate that the level of welfare cannot be higher than half of the minimum wage.

7.3.2 Specific Strategies

We know that the allocate spending of a society is limited. These expenditure and their distribution will greatly affect the enthusiasm of people's attitude to work and the level of social justice. They are crucial to the sustainable development of the economy. We will find out the balance point between efficiency and fairness by linear programming.

In order to simplify the model, we divide the sample into three groups, technical labor force, unskilled labor force and people who cannot work. We have no difference in the category of processing. The skilled labor force has a higher wage-to-output ratio and enjoys a higher wage; the unskilled labor force has a lower wage-to-output ratio and enjoys the minimum wage; the non-working population does not produce but enjoys social welfare. We will continue to use the previous model of the indicators and weights in linear programming. Among them, we will let minimum wage, wage distribution, welfare levels be corresponding to C1, C6, C7 indicators, where we temporarily control the constant C2-C5 index. Our goal is to maximize the social success index.

Our target:

$$\max \ SSI = Q + SSI_1 \times \frac{S_L}{22.4} + SSI_6 \times (1 - \frac{S_H - S_L}{TC}) + SSI_7 \times \frac{W}{0.38 \times TC}$$

The constraint condition:

$$TC_{(k)} = G_1 \times S_H + G_2 \times S_L + G_3 \times W$$

$$2 \times G_1 \times S_H + 0.5 \times G_2 \times S_L > TC_{(k)}$$

$$S_L \geq 2W$$

$$S_H > S_L > W > 0$$

$$\alpha = 1$$

We can get the recursive formula:

$$TC_{(k+1)} = 2\alpha \times G_1 \times S_H + 0.5 \times G_2 \times S_L$$

Through the operation with MATLAB, TABLE 5 shows the result of the wage distribution and the welfare we get.

TABLE 5

Year	1	2	3	4	5	6
aggregate expenditure	194518.6021	194518.9032	194518.9034	194518.9036	194518.9037	194518.9038
average maximum hourly wage	33.995	33.995	33.995	33.995	33.995	33.995
minimum hourly wage	19.6147	19.6147	19.6147	19.6147	19.6147	19.6147
welfare	9.8073	9.8074	9.8074	9.8074	9.8074	9.8074
Year	7	8	9	10		
aggregate expenditure	194518.9040	194518.9042	194518.9044	194518.9046		
average maximum hourly wage	33.995	33.995	33.995	33.995		
Year	19.6147	19.6147	19.6147	19.61487		

We find that when the innovation coefficient is 1, the social development is extremely stable with sufficient conditions for sustainable development through the parameters of hypothesis.

Considering the innovation of technical workers, when the innovation coefficient in the first year is 1.05, 1.1, 1.15, 1.2 with calculation, the change of the wage distribution in the second year is in the **TABLE 6**.

TABLE 6

The innovation coefficient	1	1.05	1.1	1.15	1.2
Aggregate expenditure	194518.9032	202130.0718	209741.5414	217353.011	224964.4805
Average maximum hourly wage	33.995	35.3252	36.6554	37.9856	39.3158
Minimum hourly wage	19.6147	20.3822	21.1497	21.9172	22.6847
welfare	9.8074	10.1911	10.5748	10.9586	11.3424

Therefore, we can conclude that innovation can raise the income level of the whole society, so as to continue to promote social innovation.

7.4 The Best Childcare and Paternity/Maternity Leave Strategie

In our opinion, children who do not have any productivity can receive a welfare fund which can be used for education, food and clothing.

As for maternity leave, the Maternity Protection Convention from The International Labor Organization (ILO) has stipulated that maternity leave should not be less than 14 weeks and we get that the most maternity leave is 57 weeks. The median we take from 14 to 57 is 35. During this period, pregnant women cannot work, so they can receive benefits which are equivalent to part of the salary.

7.5 Sample Population Classification

As in section 7.3.2, we divide the sample into three groups, technical labor force, unskilled labor force and people who cannot work.

7.5.1 The Main Priorities and Needs of Each Group

Let us look at the satisfaction degree of the needs of three groups from the society. Based on the factors we consider in our model, we set three main considerations for each group.

We believe that the primary concern of the technical labor force is the high education which determines their production and innovation level. In addition, due to the low acceptance of women on high-end occupation fields on earth, we underestimate the advantages of women in these fields so we think that the ratio of female labor force is an essential factor which should be considered. Moreover, the high-level people need some unskilled labor force works for works of low comparative advantage to increase their time efficiency so the setting of minimum wage will influence hiring strategies.

The unskilled labor force mainly considers the needs of the minimum wage, the demand for basic education and the care for the labor force who cannot work.

In order to get a comfortable and have a satisfying spirit in their lives, the labor force who cannot work mainly focus on Engel's coefficient, the gap with the income of labor population and whether they can get education.

According to these factors and the index in our model, **TABLE 7** shows the data we get.

TABLE 7

population	factors	index	order
Skilled labor force	High education level	C4	1
	Female's advantages	C5	2
	Minimum wage	C1	3
Unskilled labor force	Minimum wage	C1	1
	Need for basic education	C3	2
	Care for the people who can not work	C7	3
The labor force who can not work	Engel's coefficient	C2	1
	The gap in the income	C6	2
	Whether they can get education	C3	3

7.5.2 The Best Result

Taking into each group has its own priorities for happiness, we quantify the impact of priority numbers on their happiness according to the following rules, that is, the extra weight to index of C layer to social welfare index GNH.

Priority Ordinal	Extra Weight
1	0.3
2	0.2
3	0.1
>3	0

It should be noted that this extra weight only influences GNH of each group instead of the whole GNH and the sum of each weight is going to 1.6 of each group. **TABLE 8** shows this result.

TABLE 8

Index				SSIW
C1	0.253	0.453	0.153	0.153
C2	0.23	0.23	0.53	0.23
C3	0.189	0.389	0.289	0.217
C4	0.394	0.094	0.094	0.108
C5	0.325	0.125	0.125	0.11
C6	0.083	0.083	0.283	0.073
C7	0.125	0.225	0.125	0.11

Where:
: The weight of group I to the GNH in itself.

When the index in level C changes, the GNH of each group will be calculated according to the weight in **TABLE 8**.

In order to maximize the priority outcomes of the subgroups without significantly reducing the global outcomes, we decide to improve the first model: increasing the constraint conditions of the happiness index, that is, stipulating and adjusting the lower limit of , .

$$\min GNHW = \left(\min GNHW_{G1}, \min GNHW_{G2}, \min GNHW_{G3}\right),$$

$$0 < \min GNHW_{Gi} < 1.6 .$$

At the same time, maximize the social success index (SSI).

$$\max SSI = \sum_{1 \le i \le 7, i \in Z} Ci * SSIW_i .$$

The constraint condition is

$$\begin{pmatrix} 0.253 & 0.453 & 0.153 \\ 0.23 & 0.23 & 0.53 \\ 0.189 & 0.389 & 0.289 \\ 0.394 & 0.094 & 0.094 \\ 0.325 & 0.125 & 0.125 \\ 0.083 & 0.083 & 0.283 \\ 0.125 & 0.225 & 0.125 \end{pmatrix}^T \begin{pmatrix} C1 \\ C2 \\ C3 \\ C4 \\ C5 \\ C6 \\ C7 \end{pmatrix} \geq (\min GNHW)^T,$$

$$0 < Ci \leq 1, 1 \leq i \leq 7, i \in Z.$$

In conclusion, we can calculate the current social success index, social satisfaction index and the degree of satisfaction through the index in C layer of the sample. At the same time, we can obtain more satisfactory results and ensure the sustainable development of society by adjusting the satisfaction of the minimum standards of each group according to the linear programming.

8 Various Migration Phases and Mass Migration

8.1 Various Migration Phases

According to the real GDP.p.c. growth in the sample countries (about 1.45%), we know that the true innovation index is about $1.02. Considering that if LIFE has planned additional migration phased over the next 100-years, we want to know how sensitive our model is for the proportion of population change.

8.1.1 General Assumptions

- Assume that minor changes in aggregate output are not considered from innovation index because of the short duration.

8.1.2 Concrete Solving Process

Assume that the proportion of skilled labor force changes and the proportion of unskilled labor force changes. (When m or n is positive number it's going up and when m or n is negative number it's going down.)

Considering the following linear programming model we improved. Assume .

Our target:

$$\max \ SSI = Q + SSI_1 \times \frac{S_L}{22.4} + SSI_6 \times (1 - \frac{S_H - S_L}{TC}) + SSI_7 \times \frac{W}{0.38 \times TC}.$$

The constraint condition:

$$TC_{(k)} = (G_1 + m) \times S_H + (G_2 + n) \times S_L + (G_3 - m - n) \times W$$

$$2 \times (G_1 + m) \times S_H + 0.5 \times (G_2 + n) \times S_L > TC_{(k)}$$

$$S_L \geq 2W$$

$$S_H > S_L > W > 0$$

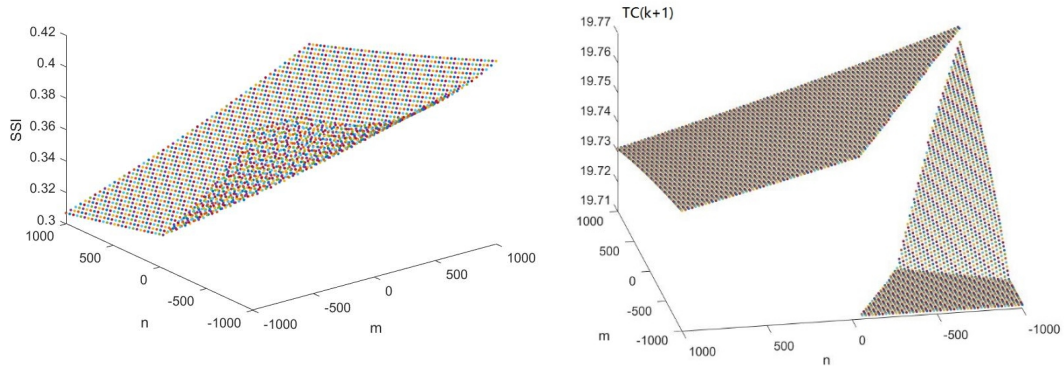
$$\alpha = 1.02$$

The recurrence formula is

$$TC_{(k+1)} = 2\alpha \times (G_1 + m) \times S_H + 0.5 \times (G_2 + n) \times S_L$$

Take m, n as independent variables, and use MATLAB to draw the relationships of m, n with SSI and respectively. **Figure 2** and **3** show their relationships.

Figure 2 (SSI) Figure 3 ()



In various migration phases, we still seek to maximize social success index. Because the initial sample of the population is extracted from the top ten countries based on HDI, with the increase of the migration, the proportion of skilled and unskilled labor population will gradually change and the population distribution will gradually change, too.

The following **TABLE 9** shows the effect of the changes in (m, n)=(0,0) vicinity of population distribution to SSI and on the change in the vicinity.

TABLE 9

Figure	Observation Results	Interpretation of Result
SSI		Increase in the proportion of skilled labor force leads to a significant increase in social success index.
		Increase in the proportion of unskilled labor force leads to a slight decline in social success index.
		Increase in the proportion of skilled labor force leads to a slight increase in the level of social output.
		Increase in the proportion of unskilled labor force leads to a slight decline in the level of social output.

Therefore, the changes in the proportion of technical labor force has a greater impact on the change of SSI, that is, SSI is more sensitive to the proportion of skilled labor force. But the sensitivity of SSI and the social output to the unskilled labor force are relatively weak. After each population migration, it is necessary to reconsider the minimum wage and wage distribution in order to achieve the social optimum.

In order to achieve sustainable social development within 100 years and to achieve a sustainable vision for the 100 years, we should ensure that the population of skilled labor is

maintained at a high level and ensure the selection of skilled labor strict to maintain a desirable level.

8.2 Mass Migration

When the population of the earth is moving in a large scale, the proportion of all kinds of labor will have a great deviation to the average level of the earth so we will consider not only the effect of the changes in (m, n)=(0,0) vicinity of population distribution to SSI and on the change in the vicinity in **Figure 2** and **3**. So in this section, we proceed to merge the model in section 7 into a global model. We use the K-means to choose 3 countries, Spain, Thailand and Yemen, into the sample according to the HDI of 188 countries in the whole world. To simplify the calculation, we let these three countries represent the world. According to the three countries' data, we estimate the average level of labor force in the earth.

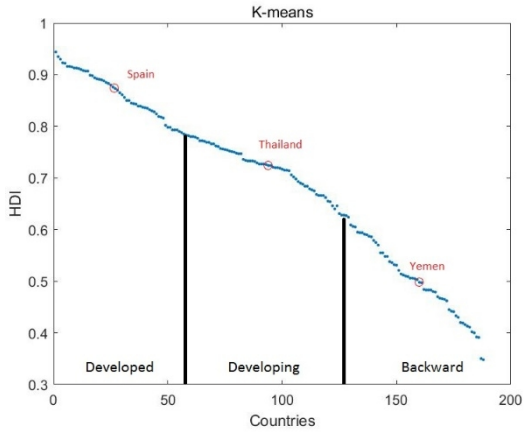
8.2.1 Local Terms

- **K-means:** It is a kind of statistical analysis method to study classification problem, and it is also an important algorithm of data mining.

8.2.2 The Result of K-means

Figure 2 shows the result of K-means.

Figure 2



We show the data of all aspects from three countries in the **TABLE 4**.

TABLE 4

	C1	C2 [7]	C3(year)	C4 (%) [8]
Spain	5.57	0.17	10.4	89
Thailand	1.11	0.3	6.6	53
Yemen	0	0.585	2.5	10
Spain	C5 (%)	C6	C7 (%) [7]	Sex ratio
Thailand	45.65	0.3589	2	0.976
Yemen	45.5	0.3785	4	0.5

We estimated average labor force distribution in the earth with the three representative countries' labor force distribution of the developed countries, developing countries and the backward countries. We finally conclude that the proportion of the labor force who can not work is 35%, the proportion of skilled labor is 14.9%, the proportion of unskilled labor is 50.1%, that is, m=-749， n=697.

When migrating to Mars massively, (m, n) will move to (-749,697) from (0,0). As we can see from **Figure 2** and **3**, in the shifting process, SSI and will reduce. When the

offset is large enough to cause sequence to reduce, the constraint conditions fail so the model will not provide valid results. But at the same time, because of the influence of innovation coefficient, the level of social output and capital accumulation will increase, wages and benefits will increase and the sensitivity of the new labor distribution will decrease.

Therefore, the later the migration time is, the stronger robustness of the model are. It is more sensitive to short-term mass migration, and the sensitivity of long-term mass migration is a little weak.

So the strengths of the model are that rate of change in population distribution is small, the subsequent migration time is late and the single migration scale is small.

9 Strengths and Weaknesses

Via our analysis towards the model and comparison between the real data of each sample and our prediction, we find out the strengths and weaknesses of our model.

9.1 Strengths

- We simplify the impacts of GDP .p. c to 7 indicators achieve the goal of quantitative evaluation, which will bring convenience for social assessment.
- We can calculate simply and obtain the data easily in our model.
- Our model is dynamic. We can make the next year's decision via recursion. The next year's data will also affect the evaluation model's outcome. The outcome will continuously affect the decision so that a dynamic circle has formed.
- Our model has good expansibility. You can change or increase coefficients to meet your requirements.

9.2 Weaknesses

- Through the comparison of the original data, we find that some other factors have some influence on the real GDP. Like:

i. In the figure we found that the Swiss real per capita GDP is high. we found that the college enrollment rate is far lower than that of other countries by viewing the original data. Referring to the relevant literature we find that although the gross enrollment rate of Switzerland is low, the quality of education and innovation index is very ideal. This is reflected that the tertiary gross enrolment ratio is high and at the same time, the per capita resources of education may decline, resulting in the efficiency of education as unexpected.

ii. Due to the traditional concepts, the impact of women's education is low and the number of women who work in the high-end fields is small. It leads that the index of the proportion of women in the workforce is not as wish.
This may affect our model's accuracy to some extent.

Policy recommendation letter to LIFE

Dear Sir or Madam,

It is our pleasure to give policy recommendation to LIFE. For a period of time, our group have focused on building a model to design a sustainable and highly active society. Population Zero is such an amazing and extraordinary plan, we tried our best, and we believe that we've already got the result which all of us are expecting.

As a 10 thousands people's society, value system still has it essentiality to quantify the works and goods. At the same time, as an advanced civilization, we must support those who cannot earn their lives. How to divide salary and welfare is our first problem

In order to ensure the efficient functioning of the society, we stipulate that the amount of welfare cannot be higher than half of the minimum wage. The welfare need to ensure the basic consumption at least, and it should be provided for children, the elder, the disabled, the pregnant women and so on.

For those workers, " to each according to their works" is the basic principle of distribution. Work harder and earn more, equally and sensibly. However, the gap between the minimum wage and the maximum should be controlled, and according to our calculation, nearly 2:3 is a reasonable ratio, which can produce more value as well as keep citizens in happiness.

When it comes to the education, our view is that the government must make sure that every person can have the chance to enjoy the compulsory education, and the enrolment ratio of tertiary education may no less than 50%. Innovation can not only raise the income of the whole society but also push the civilization walk forward, but it will be a joke if we don't have enough education. What's more, discriminate and bully are mostly because of ignorance, which means a high average year of education can partly prevent such things from happening.

We know that even at present, women and girls are particularly disadvantaged sometimes in company, and we hope that Population Zero can be a turn for them. So at least we want to protect their maternity leave, which means they can qualify for about 35 weeks, entitled with full pay. We still have a long way to fight for women's right, and we want to start out small.

If you are interested, you can assess the Social Success Index(SSI) and the GNH of the society or each subgroup on a regular basis via the formula we have provided in the model in order to judge whether the society is developing healthily. In addition, our model can work as a reference for you to decide the minimum wage standard and welfare level. When you decide to implement the next stage of migration to Mars, you have to control the migration scale each time and assess the affects on the new society.

Follow our suggestions, we believe that we can build a peaceful, cooperative and joyful society. However, the people in developed countries may get used to the new lives quickly, while who in developing and backward countries may need more time to be educated. With the times goes by, the society may tend to develop stably where people don't need to worry about illness and poor, they can work hard to earn more, or study intensively to explore further in science.

The policy recommendations above comes from our analysis. we hope that the advice can help you maintain an optimal society!

Yours sincerely

Reference

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