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T3 _____	Problem Chosen	F3 _____
T4 _____	**F**	F4 _____

2017 MCM/ICM Summary Sheet.

Model about Martians and Their Society

If some of the people are selected to move to Mars, what kind of them would be chosen? What would the new society on Mars be like? In this paper, we propose some ideas about the great migration - how to determine the demographic characteristics of immigrants, reasonable arrangements in the new society of income, education, for social equality, and so on.

Firstly, we define parameters that can describe measures of income, education, and social equity. We have also determined the optimal demographic characteristics of immigrants that can achieve outcomes which are mentioned. **In income**, we **use the Gene coefficient to describe** the degree of fairness of income distribution, and **find out the theoretical optimal value of Gini coefficient**. And then we use the **"five group" method** and introduce the notion of a negative index to represent the ratio of the incomes of the two extreme income groups. According to the optimal value of the adverse index, the minimum wage and wage distribution are determined. **In education**, Mars workers are divided into knowledge labor and skilled labor by us. They are divided into different schools, which are general schools (university, graduate education) and vocational schools. The level of development of education can be determined by an assessment of enrollment, per capita facility area and education level. In terms of social equity, we have learned from Iceland's maternity and paternity leave system so that female employees are not discriminated against because of their gender. Our objectives of Mars society are: social distribution is reasonable, the level of income is greatly improved; basic education coverage rate reached 100%, higher education coverage rate of 95%, the educational facilities are well established; the status of women in labor is guaranteed.

Secondly, we give the demographic characteristics of 10,000 people and the distribution of citizens in terms of factors. Furthermore, we examine the interdependencies of the three determinants, and propose more detailed policies and programs. We discover education and social welfare have diminishing marginal returns. Based on these relationships, we use **linear programming** to give the scale factor and integrate income, education and social justice into a model that gives the best minimum wage and salary distribution for Mars residents, and the best parenting and paternity / maternity leave strategies. Then, we find that the Gini coefficient will decrease spontaneously over time, so we need to develop policies to stabilize the Gini coefficient and the bad index, so that the Mars Society to maintain good development and distribution order. We consider the impact of time on GDP and investment in education and social welfare, and give the corresponding impact. What's more, the social division of labor is realized in the form of groups. Adjust the resources of different functional groups in order to achieve the maximum productivity of each group.
Thirdly, look into the next few years. In a number of programs similar to Population Zero, we have revised the original model and made it more sustainable.

Finally, we are faced with the task of moving as many Earth people as possible to Mars. The original model was further amended, while the advantages and disadvantages of the model has also been tested.

Introduction

Problem background

In this year of 2095, the international agency, Laboratory of Interstellar Financial & Exploration Policy (LIFE), has recently completed a series of short-term planned living experiments on our neighbor planet, Mars. With advanced technology, the first wave of migration, called Population Zero, which would include 10,000 people, will soon migrate to Mars by 2100. As the first wave of migration, Population Zero will enjoy a lot of optimal conditions in many workforce and social living factors. The mission of Population Zero is to create a sustainable society by maximizing both economic output (GDP) and happiness in the work place for its citizens. After Population Zero, LIFE plan to move more people to Mars gradually in the next 100 years. Thus, with the goal of creating an optimal workforce for the 22nd century to give all people on Mars the greatest quality of life with a vision of sustainability, the LIFE agency launched a project called UTOPIA. At the same time, scientists discover a threat of a collision of Earth with a planet sized comet. Most of people o earth will migrate to Mars.

To create a more sustainable world on Mars, the International Coalition on Mars (ICM) government is searching a series of policy. Therefore, following tasks are asked:

- A set of measurements that can measure a degree of social development of peace, cooperation and equality in a long time.
- A reasonable choice of immigrants' program.
- Some practical advice for sustainable development of society, who has a huge size of the population, but own quite rational index.

Our work

Considering the existent research, our research focus on sustainability measurement, reasonable prediction, as well as sustainability control and adjustment. Detail work is as follows:

1) We define parameters that can describe measures of income, education, and social equity. After that we examine the interdependencies of the three determinants, and propose more detailed policies and programs.
2) We determine the optimal demographic characteristics of immigrants that can achieve outcomes which are mentioned, and give the demographic characteristics of 10,000 people and the distribution of citizens in terms of factors.
3) We have revised the original model and made it more sustainable in the future view, which enable our program more universal, no matter in terms of various types of population or a long time.

Model Overview

A sample model of 10,000 people

In order to achieve the UTOPIA's goal, we put forward reasonable requirements of the population structure, which also is aim at the ten thousand people who migrated to Mars.

1) According to the theory of population Pyramid, **a stable population of Pyramid** (the young age-based structure) not only can ensure high GDP growth, but also no harm which

is caused by the aged tendency of population. It means a society has more mature man, but less children and older.

2) We must try our best to ensure that the people in the sample have certain production value. Because the migration to Mars in small (only ten thousand people), but the society has to have high social output. According to the labor supply of the life cycle theory, the impact of age on the probability of employment shows an inverted "U" shape trend, namely the individual probability of employment increases gradually with the increase of age; but when the age increased to a certain extent (male is 44 years old, female is 38 years old), the individual probability of employment began to decline. (Baker, 1999) Therefore, we simply put the population **at the age of 5-70 years old**.
3) In order to build a fair and happy society, the **sex ratio** of ten thousand people can be idealized as **1:1**.
4) With the aim of achieving high-quality education on Mars, the **average level of education** in Zero Population is bound to be higher.
5) We must ensure the diversity of other factors in the selection process, such as race, culture, occupational categories etc. These contributes to the integration of multi-cultural

In summary, based on the overall goal of building a harmonious, equal and cooperative quality society in the plan, the structure of the population migrating to Mars must be robust, sustainable, scientific and rational. In order to achieve better results, we refer to the Canadian demographic characteristics. Based on the population structure characteristics of Canada, we use matlab2016a to optimize the samples provided, and generate a sample of ten thousand people on Mars. The specific demographic characteristics of the sample are as follows:

- The age of the population is between 5-70 years old, of which 5-20 years old account for 13.3% in the total sample population, 20-60 years old account for 81.4%, 60-70 years old accounted for 5.38%.
- The ratios between girls and boys in all age are about 1:1.
- People's education level is high, more than 51% people had enjoyed higher education. The average level of education is university.
- Race has available and reasonable scale with white and colored.

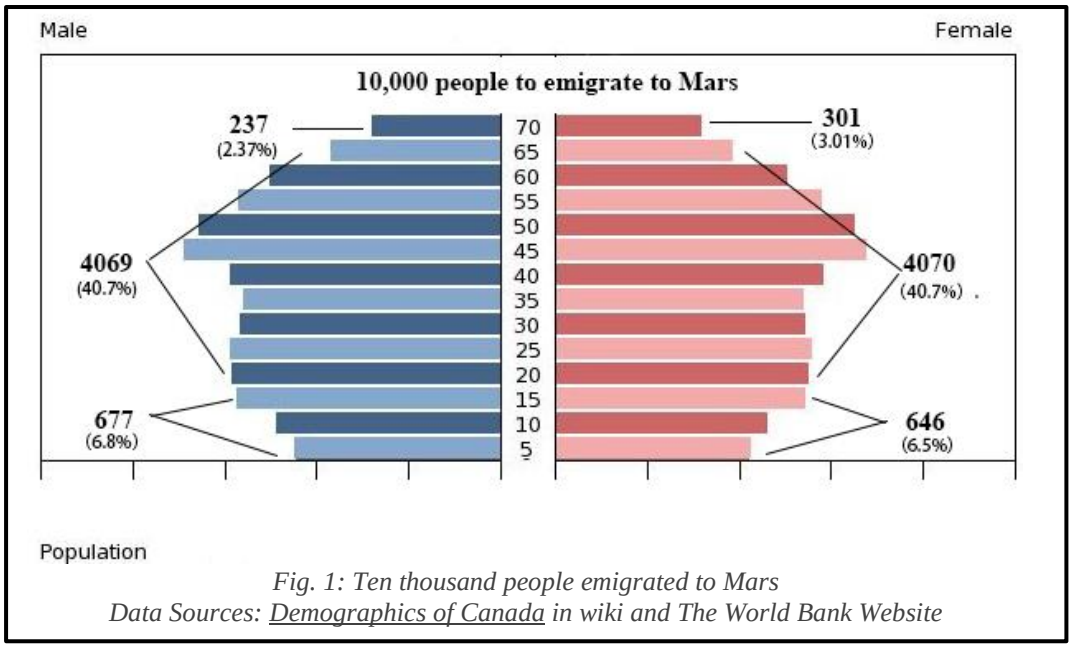


Fig. 1: Ten thousand people emigrated to Mars
Data Sources: Demographics of Canada in wiki and The World Bank Website

income

The **indicators** needed to measure the income situation on Mars, includes the **minimum wage and wage distribution**. The minimum wage reflects the lowest income in Mars society in the lowest income of the population, and a reasonable wage distribution can control the gap between rich and poor within a reasonable range. The combination of these two parameters can be a whole reflection on the national income in Mars society.

Assumptions:

- **P** is the annual output attributable to each citizen on Mars, namely the Per capita Gross National Income
- **n** is the total number of immigrants to Mars
- **GNI** is gross national income on Mars
- **G** is gene coefficient
- **K** is bad index
- $\boldsymbol{P_k}$ is capital productivity
- $\boldsymbol{Q}$ is output
- $\boldsymbol{L}$ is the lowest income in society
- **H** is the highest income in society

By definition, we can easily learn that

$$GNI=nP;$$

According to the relationship between the Gini coefficient and Lorenz curve, on the condition of the Lorentz curve is monotone increasing and convex features (Kakwani,1980), we can get the formula of Gini coefficient:

$$G=\frac{1}{n}\sum_{i=2}^{n}\sum_{1=j<i}(P_i-P_j)=\frac{1}{n}\sum\sum(\frac{I_i}{I}-\frac{I_j}{I})=\frac{1}{nI}\sum\sum(I_i-I_j)\text{(Hu Zuguang,2004) (1)}$$

where:

I_i expresses the i's income;
I expresses the income of all members in society;

According to our analysis of social members' income from low to high sequence, and we know the income of the poorest members is minimum wage, which is a constant, so we can get the approximate solution of Gini coefficient when the number of members in society tends to infinity, which is 0.33. Thus, 0.33 is the best theoretical value of Gene coefficient.

Thus, we can define the best theoretical value of Gene coefficient on Mars is 0.33. At the same time, we divide income into five categories with the "five-group" method (Hu Zuguang,2004), which is the lowest income group, lower income group, middle income group and upper income group and the highest income group. Then we can get a simple calculation formula of Gene coefficient:

$$g=P_5-P_1 \quad (2)$$

where:

g expresses approximate Gene coefficient;
P_5 expresses the income in the highest income group to total revenue ratio;
P_1 expresses the income in the lowest income group to total revenue ratio;

The measurement of capital productivity is investment efficiency. When the investment capital productivity growth rate is positive, investment rate and consumption rate tend to coordinate. And, the larger rate, the higher degree of coordination, the better quality of economic growth. When the growth rate of capital productivity is negative, it shows that the investment rate is too high, the consumption rate is low, the investment rate and consumption rate tend to be uncoordinated, the larger the negative value, the more uncoordinated, the worse the quality of economic growth. (He Jian, 2016). In this problem, **K can represent capital stock.** According to the definition of capital productivity, we can get:

$$P_k = \frac{Q}{K} \quad (3)$$

$$\frac{\Delta Q}{Q} = \frac{\Delta P_{k,t}}{P_{k,t-1}} + \frac{\Delta K_t}{K_{t-1}}$$

Bad index is to put all the population or family income from low to high, equal to five, and each part of population or households is 20%. Divide the income share of 20% of the highest income households or the population by the minimum income of the family or population of the 20%, we can get the bad index K. The minimum K is 1. The bigger the K, the greater the income gap. According to the optimal judgment standard, the urban residents' bad index is more than 3 times more than 5 times. So we define $\mathbf{3 \leq K \leq 5}$.

Assuming that the lowest income of 20% of the total income of Martian residents accounted for x% in total national income on Mars, so the highest income of 20% of the total income of Martian residents accounted for (x+33) % in total national income on Mars Combining these two relationships, there are:

$$\mathrm{K} = \frac{x+33}{x}\% = \frac{x+33}{x}$$

$$\mathrm{x} = \frac{33}{\mathrm{k}-1}$$

$$\mathrm{GNI} = \frac{33\mathrm{nP}}{100(\mathrm{K}-1)}$$

$$\mathrm{L} = \frac{33\mathrm{P}}{20(\mathrm{K}-1)}$$

$$\mathrm{H} = \frac{33\mathrm{KP}}{20(\mathrm{K}-1)}$$

Thus, we can learn the minimum wage has nothing to do with the total number of people.

Result

We search data from website of world bank, in 2014 the U.S. national per capita income is $55200, ranking highest in Norway is $103050. Assuming that the per capita income of the Martian society is at the 2014 Norway level. Through calculation, we get a result:

Table 1: Ideally, income on Mars

P/ dollar	K	Lowest income(L)/dollar per year	Highest income(H) dollar per year
103050	5	42508.13	212540.63

According to the above data, we can conclude that the **specific income target of Mars Society** is controlling K between 3 and 5, at the same time Gene coefficient reaches about 3.3. **The overall goal** is the social distribution is relatively average, the gap between the rich and the poor is reasonable, and the income level of residents has been greatly improved.
So how do we measure the society of Mars really reach the goal we set up after the arrival of Mars?

Since the national per capita income is not a fixed value, it is meaningless to only compare the national average income and the lowest income. Because Gene coefficient and bad index can reflect the gap between rich and poor well, so **we advise that** government can get the national average income per capita and the lowest income through the actual statistics and census. Then According to these data, the Gini coefficient and the bad index are calculated. Compared with the previous target, If the value is in the appropriate range of the original target, the income of Mars society is healthy. Otherwise, it is necessary to adjust the policy, to make national income return to the right track.

education

We need to provide high quality education for the Martian population, so as to prepare the citizens for the needs and challenges in the twenty-second Century. Preparing students to be successful for the future requires a robust and flexible learning infrastructure capable of supporting new types of engagement and providing ubiquitous access to the technology tools that allow students to create, design, and explore. [7]

We propose to **examine the distribution of labor skills from the perspective of Education**. In this regard, we do two aspects of the definition:

- The level of education can be divided into illiteracy, primary school, junior high school, high school, college degree or above. We **define**
  a). illiteracy is low skilled labor
  b). the labor force with primary school, junior high school and high school (defined as the combination of junior high school and high school) is defined as medium skilled labor
  c). the labor with high educational level above is defined as highly skilled labor.
- We divide education and training into two categories: one is **general education**, the other is **vocational education**. Among them, the general education is what we usually refer to the primary school, junior high school and senior high school, college and graduate education, this kind of education focus on basic education and theoretical education; occupation education is divided into two types, one is the occupation school education, one is the enterprise training, this kind of education focused on specific skills the education.

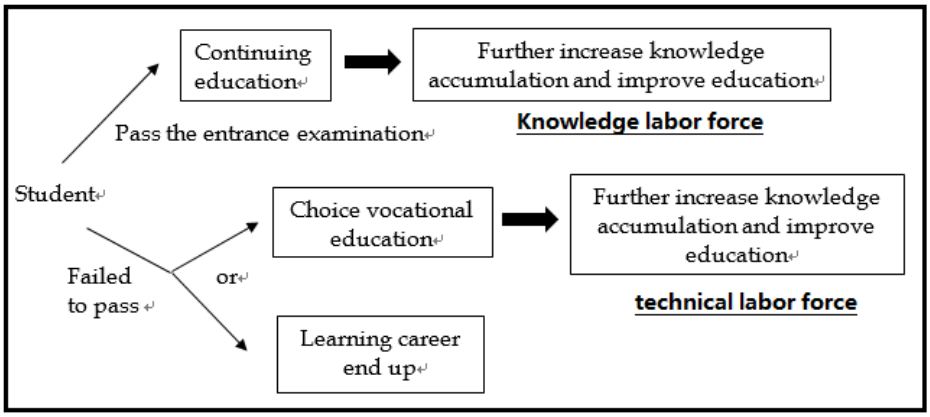


Fig.2: Knowledge labor force and technical labor force flow chart

General education generally through rigorous entrance examination to the selection of students, then this will divide the students into two categories, one is through the entrance examination students, one is not through the entrance examination students. Students who pass the entrance exams can continue to receive education and further increase their knowledge and qualifications, while those who do not pass the exam may end their academic careers. In general, we are more inclined to accept general education, pass the general education examination in the case will choose vocational education, vocational education as a skill extension to make up the way. Thus, vocational education provides an additional avenue for students to accumulate knowledge and improve their skills for those students who fail to pass the entrance exams and thus fail to continue to gain knowledge from general education schools. That is to learn skills from vocational education schools and to obtain corresponding Of the academic degree. In this sense, vocational education is equivalent to an increase in the accumulation of skills to obtain a way to ease the gap between the knowledge and skills of the labor force continues to expand the effective way. [8]

In governance, **the government can control the proportion of students who receive general education and vocational education by controlling the elimination rate of the entrance examination**, then achieve the ideal state of the whole society needs the proportion of knowledge labor and technical labor. Therefore, we can get some quantitative relations.

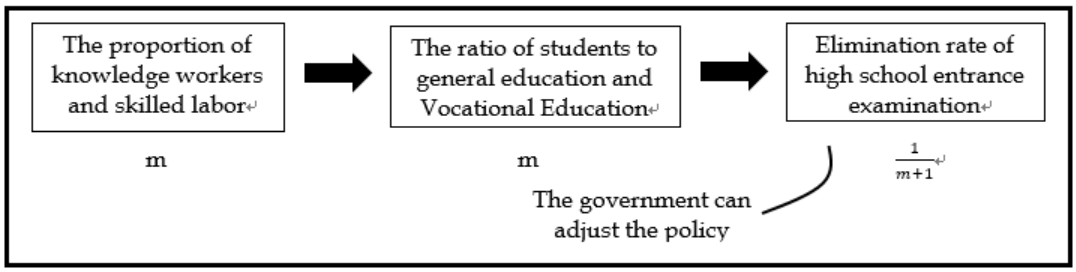


Fig.3: The relationship between the proportion of knowledge workers and skilled labor and policy

Result

On the whole, Martian workers need to acquire knowledge, skills, or technical skills, **so they can be divided into knowledge workers and skilled workers. They are divided in the process of high school education, corresponding to the basic facilities are general schools (referring to university, graduate education) and vocational schools.** By the end of 2009, the population coverage rate of China's nine-year compulsory education (primary and junior secondary education) reached 99.7%. [9] In 2009, the US gross enrollment rate of higher education reached 89%. [10] Therefore, we assume that the education objectives of Mars society: 100% coverage of basic education, higher education coverage rate is 95%, school hardware and software facilities, greatly improve the quality of education.

How to assess whether the education level of Mars Society has reached the goal? We believe that we should start from the following aspects:

a) Enrollment rate
Define the enrollment rate is the ratio of school attendance to the number of school-age children or young people, namely

$$\text{Enrollment rate} = \frac{Number\ of\ students}{School-age\ population}$$

Where:

- schools can be primary, junior, high school, university, graduate or vocational school. The school enrollment rate can be calculated separately

for each type of school, and the enrollment rate for all types of schools can be added to account for the education situation of the whole society.

- Enrollment rate can be expressed in the Martian education at all levels of coverage. It is an easy to quantify and calculate the value for future statistics and assessment.

b) Per capita area

The area of per capita facilities is defined as the ratio of the total area of various types of educational facilities to the number of students enrolled. As with school enrollment, schools can be defined as elementary, junior high, high, university, graduate or vocational schools, which can be calculated separately or in combination with schools; and they are easy to quantify and facilitate calculation.

c) Education level evaluation

In terms of the level of education, the accreditation standards for the Western American Community and Junior College accreditation committees are as follows: college aim, college integrity, college benefit, education project, student support and development, information and learning resources, teaching and administrative staff, sports facilities, funding resources, management and Administration.

Our vision is to evaluate and rate the Mars education system according to the above evaluation, or score according to the follow table:

Table 2: Mars education system assessment criteria

Indicator	Weighting	Elaboration
Graduate and retention rates	22.5%	• Six years graduation rate of 80% • Sophomore retention rate of 20% On the one hand, the graduation rate of six years, can explain whether the whole school resources can support students to complete the whole college; on the other hand, how many sophomores still return to the school shows whether the school accord with the application expectation
Undergraduate Academic Reputation	22.5%	• Academic peer score 80% • High school counselor score 20%
Faculty Resources	20%	• Size of Class (Highest: within 20, then 20-29,30-39,40-49 and more than 50 means 0) • Professor compensation 35% • The professor's highest degree 15% • Teacher-student ratio 5% • full professor ratio 5%
Student Selectivity	12.5%	• Score of SAT/ACT 65% • Grade the top 10% or the top 25% students • Acceptance Rate 10%
Financial Resources	10%	• Financial situation reflects the school's ability to invest in teaching, research projects, student services, etc..
Graduation Rate Performance	7.5%	• Show the teaching quality of the school
Alumni Giving Rate	5%	• Indirect description of student satisfaction

The above three evaluation criteria can be in the form of numbers and scores, a comprehensive and intuitive description of the Martian education level. As long as the goal is also quantified, that is, a number of indicators specified, you can form a convenient evaluation system.

equality

Iceland is the leader in promoting gender equality in five Nordic countries. Iceland introduced and implemented "3 + 3 + 3" parental leave policy in 2003, which provided to the mother and father each 3 months holiday, while the two jointly enjoy 3 months of parental leave.

Draw lessons from Iceland's fair policy, Iceland's maternity protection provides universal health care and cash assistance. Parents' insurance is provided in Iceland and a parental insurance is provided for the childbearing family. The maternity cash benefit covers employees and self-employed persons residing in Iceland, as well as parents.

- Maternity leave and allowances: The allowances during the maternity leave period are either 80% of their average salary or the average income of the last two years. If the insured person's job is part-time, between 25% and 49% of the time, the minimum grant is 82,184 kronor, while the employment time is 50% -100%, the minimum subsidy is 113,902 kronor per month. The maximum subsidy is 300,000 crowns per month.
- Sources of funds: For parental benefits provided in parental insurance, employees are not required to contribute; Self-employed persons are required to pay 2.2% of their income; the employer is required to pay 2.2% of the total wage income; the government does not pay
- The flexibility of childbirth leave: Parents are free to use 13 weeks of unpaid parental leave until the child reaches the age of eight.[16]

Result

Calculated based on the above data (2005 data), the ratio of subsidies to GDP per capita is (3 + 3 + 3) * 80% / 12 = 60%. In other words, in Iceland, where the maternity leave system is relatively well developed, the government needs to pay 60 percent of its annual income to citizens who take maternity or paternity leave.

The social equity objective of the Martian society can be set as: Maternity leave and paternity leave are of equal length, with men and women enjoying equal length of parental leave, at least 80 per cent of the average income of the last two years.

Model including the three identified factors

Gross national income refers to gross domestic product (GDP) plus factor income from abroad, and minus the expenditure on foreign factors, which can be written as:

$$\text{Gross national income} = \text{Gross domestic product} + (\text{Factor income from abroad} - \text{Expenditure on foreign elements})$$

Among them, the factor income from abroad refers to the remuneration, interest, bonus, etc. of laborers' remuneration obtained by their resident units from abroad. Because there is no country on Mars, the income from foreign factors and expenditure are both 0, so the gross national income and gross domestic product of Mars is equal. By simplifying the model of gross national income and expenditure in Martian society, and assuming that labor and capital are substitutable and the substitution rate is equal to 1, the following equation can be obtained:

$$\text{Gross Domestic Product (GDP)} = \text{total gross salary of Mars residents} + \text{welfare expenditure} + \text{education expenditure} \quad (4)$$

In other words, all the values produced by the inhabitants of Mars are spent on their wages and on the expenses of their infrastructure and welfare benefits in the very simplified model. Since education and social equity both require investment, we are going to discuss the specific investment in these two areas.

a. Education expenditure

In brief, the following simplified relationship can be given:

Education Expenditure $\propto$ Enrollment rate * Years of schooling * Educational quality

The proportion of low-educated workers in the GDP of the labor force is declining, while the share of highly-educated workers in the gross domestic product (GDP) created by the labor force is on the rise. With the development of time and education, the main force of creating GDP will change from secondary education workers and higher education workers to higher education workers and graduate education workers. [12] This paper attempts to measure the inequality of education by using the Gini coefficient calculation method proposed by Vinod Thomas et al in the 1999 World Bank study. They improve the Gini coefficient of income formula, and get the following formula:

$$E_L = \left(\frac{1}{U}\right)\sum_{i=2}^{n}\sum_{j=1}^{i-1} P_i|y_i - y_j|P_j$$

$$\mathrm{U}=\sum_{i=1}^{n} P_i Y_i$$

Where:

E_L is the educational Gini coefficient
U is the average number of years of schooling
P_i is the proportion of the population with education at one level in the total population
Yi is the number of years of schooling for which the population is educated.

In their calculations, the duration of education is divided into seven levels. Since the formula is sensitive to the population size when the population is small, they are multiplied by the adjustment coefficient $\mathrm{n} / \mathrm{n} - 1$ on the basis of the above equation. Another Gini coefficient is calculated as follows:

$$\mathrm{E} = [\frac{\mathrm{N}}{\mathrm{N}-2}]\,\mathrm{E_L}$$

Gini coefficient and junior high school enrollment rate, per capita level of education and per capita GDP levels were significantly negatively correlated. The higher the per capita years of schooling, the lower the Gini coefficient. The degree of education inequality is closely related to the level of economic development. [13] From this, we can see that the higher the education penetration rate, the higher the quality and the grade, and the higher the contribution to GDP. That is, if the level of education is defined as:

level of education = enrollment rate * years of schooling * the quality of education

then in our simplified model, the level of education is both proportional to education expenditure and positively related to GDP.

b. Welfare expenditure

Welfare expenditure is to ensure that people can stay in the labor force, while improving the status of women in labor. In our model, we only consider the expenditure of the Government on child care, maternity leave and paternity leave. The total amount of maternity and paternity benefits is determined by the length of the leave, the rate of wages and allowances, which means:

total amount of maternity (paternity) benefits = staff wages * allowance * days of maternity (paternity) benefits

Welfare Expenditure = Maternity Allowance + Paternity Allowance + Parental Allowance

Appropriate welfare can increase the enthusiasm of the staff. We assume that it is positively related to GDP to some extent. When there is no expenditure, that is, neither the construction of education nor the distribution of welfare, define the gross domestic product at the very time as Basic GDP. There comes:

Basic GDP = total resident salaries

At the same time, two coefficients p and q are introduced to show the influence of education level and welfare level to GDP respectively. Thus, the correction equation is:

GDP = Basic GDP + p * education expenditure + q * welfare expenditure = total wage + education expenditure + welfare expenditure

Simplification is

Basic GDP = Total wage of the inhabitants + (1 - p) * Expenditure on education + (1- q) * Welfare expenditure

In our model, education level is directly proportional to education expenditure and welfare expenditure is positively related to social equality. As a result, the above equation may also reflect the income level, education level, social equality level of Mars inhabitants in numerical form, and the balance of the three.

Table 3: An example

Time and index	2005	2007	2010
Total GDP	2385.48	2841.4	3693.75
GDP created by the worker with primary education and following	0.45	0.43	0.4
GDP created by the worker with secondary education	11.73	12.18	12.89
GDP created by the worker with higher education	42.33	50.09	64.49
GDP created by the worker with postgraduate education	9.82	16.2	43.31
Revenue	117.92	140.5	182.74
Education expenditure	21.12	25.17	32.73
Total investment in Education	107.76	128.39	166.98
Per capita investment in Education	0.1	0.12	0.15
Household income	1038.42	1234.66	1600.69
Family education expenditure	85.59	103.17	134.18
Total population	1066.56	1080.42	1101.55
Number of primary school students	76.33	74.17	71.05

Number of junior high school students	38.44	37.39	35.87
Number of high school and technical secondary school students	26.03	26.04	26.06
Number of University and College Students	36.86	40.14	45.61
Number of postgraduate students	4.27	5.29	7.28
Number of primary and following workers	44.79	42.75	39.86
Number of junior high school education workers	171.83	171.32	170.56
High school and secondary vocational education	225.11	254.67	306.43
Number of secondary education workers	396.95	425.99	476.98
Number of workers with higher education	201.38	237.01	305.5
Number of workers with Graduate education	16.94	27.93	59.16

Data Sources: Analysis and Application of Mathematical Models on Contribution of Education Serice to Regional Economy

According to the above table, fit the relationship between GDP and total expenditure on education:

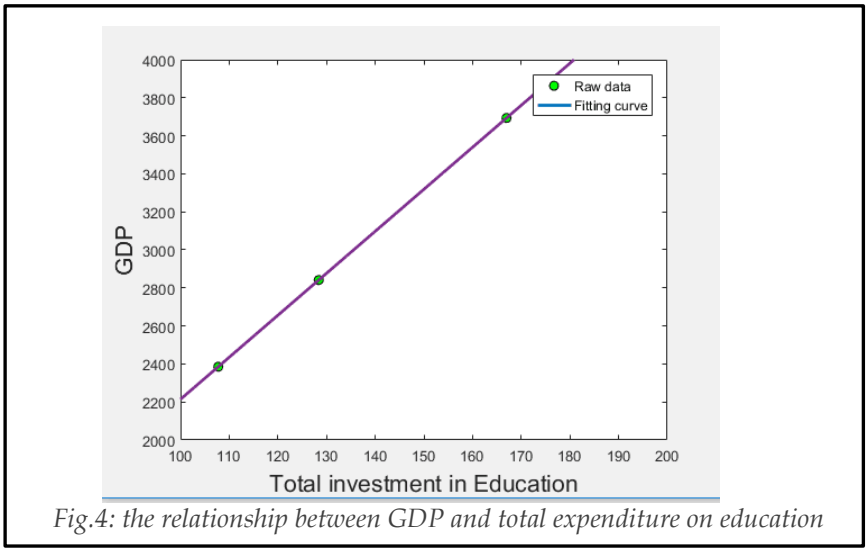


Fig.4: the relationship between GDP and total expenditure on education

The fitting result is Y = 22.091X + 5.0104. Linear fit variance is very small, so we can see P is indeed a certain value.

As mentioned before, Mars's GDP and GNI are equivalent, so the data and calculations used in 4.1.1 still assume that the national income of the Martian population is $ 103,050. For 10,000 samples of Mars, GDP is $1030.5 million. According to the previous fitting results, it can be calculated that the expenditure on education is **23967226 USD**.

According to the calculation in 4.1.3, the Government is required to pay 60 per cent of their annual income to citizens on maternity or paternity leave. As previously assumed, the annual birth rate of Mars is about 1.1%, can be obtained welfare expenditure:

Welfare Expenditure = Population * Annual Birth Rate *2 (Both Parents Leave) * Per Capita GDP * 60%

=10000*1.1%*2*103050*60%

=13602600 USD

Thus, the total wage is

$$1030500000-23967226(1-p)-13602600(1-q) = 992930174+ 23967226p+ 13602600q$$

Since within a decade, social equity and education have minimal impact on GDP, p and q can be approximated to zero, and the total social income is $ 99,293,017. According to the method mentioned in former, the Gini coefficient is approximately 0.33 and the badness index is between 3 and 5, and a reasonable wage distribution is made.

Gini coefficient will change with time and slow spontaneous reduction. The specific performance of the following figure [14] :

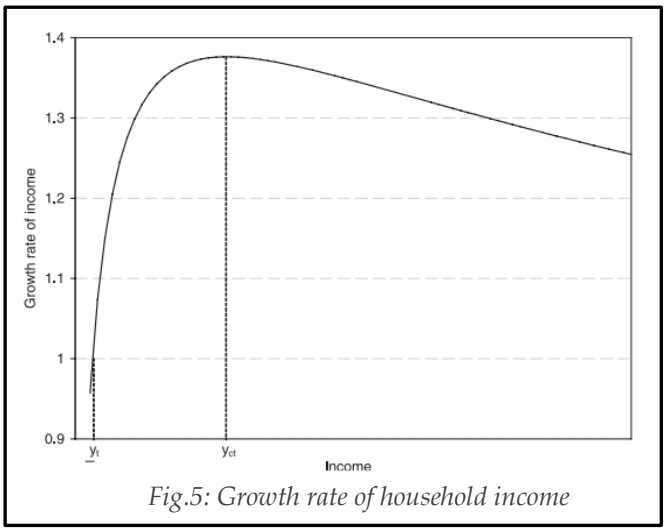


Fig.5: Growth rate of household income

As can be seen from the chart above, the income growth rate of low-income people is very high, and the lower the income, the higher the growth rate. However, the incomes of high-income groups tend to not increase or even negative growth. This shows that, taking into account the time effect, the Gini coefficient will be reduced spontaneously, that is, social income distribution will tend to average. Policy interventions are particularly important in societies where our model is so small. In order to prevent the slowdown in economic growth, it is appropriate to widen the income gap, the Gini coefficient and the adverse index maintained in a conducive to the development of safe range. Considering that the GDP and population base are changing over the course of a decade, and the annual mortality rate in this model is 0.76%, the welfare expenditure is further optimized as:

$$\text{Welfare Expenditure} = 2 * 60\% * \Sigma \text{ Births per year} * \text{Per capita GDP per year}$$

Considering the growth of education investment and the assignment of P and Q, the above equation will become more complicated.

Since all parameters are changed on a year-by-year basis, and considering that the UTOPIA program has just started, we recommend that the model **be evaluated once a year**.

Model Ⅱ

Now we have created models for the three factors, we'll proceed to merge these models into a global model in details. For small groups of Mars labor in our model is mainly **high-income men, high-income women, low-income men, low-income women.** With the understanding that each group will have a different set of needs, perspectives, and criteria for success, we

analyze how closely their needs are met in terms of income, education, and equality. We use regression discontinuity design (Thistlethwaite, Campbell, 1960) to study the model.

$$D_i = \begin{cases} 1 & if\ x_i \le x_0 \\ 0 & if\ x_i > x_0 \end{cases}$$ (Jia Peng,2012)

Where:

- D_i is a dummy variable which evaluate whether the individual i is affected by the minimum wage increase (Affected is 1, otherwise 0)
- x_i express the relative wage level of the individual (Ratio of individual wages to minimum wages)
- x_0 is a break point of relative wage.

The expected employment conditions in the absence of and under the influence of the minimum wage increase can be expressed as

$$\mathrm{E}[Y_{0i}|x_i]=\alpha + \beta_{01}\tilde{x}_i + \beta_{02}\tilde{x}_i{}^2 + \cdots + \beta_{0p}\tilde{x}_i{}^p \quad (1)$$

$$\mathrm{E}[Y_{1i}|x_i]=\alpha + \beta_{11}\tilde{x}_i + \beta_{12}\tilde{x}_i{}^2 + \cdots + \beta_{1p}\tilde{x}_i{}^p$$

$$\tilde{x}_i = x_i - x_0,\ \beta_1^* = \beta_{11} - \beta_{01},\ \beta_2^* = \beta_{12} - \beta_{02},\ \beta_p^* = \beta_{1p} - \beta_{0p}$$

Where:

- Y_{1i} is the potential employment status of individual i in the case of the minimum wage increase
- Y_{0i} is the potential employment status of individual i without being affected by the minimum wage increase

Only the data in $[x_0 - \Delta,\ x_0 + \Delta]$are examined, Δ is a small positive number

$$\lim_{\Delta\to 0} E[Y_i|x_0 - \Delta < x_i \le x_0] - E[Y_i|x_0 < x_i \le x_0 + \Delta] = E[Y_{1i} - Y_0|x_i = x_0]$$

Using the regression design method mentioned above, the employment equation and the working time equation are set to

$$\Pr(e_i = 1)=\phi(\alpha_0 + \alpha_1 z_i^{\theta} + \alpha_2 r\omega_i^1 + \cdots + \alpha_{p+1} r\omega_i^p + \alpha_{p+2} d_i + \alpha_{p+3} dr\omega_i^1 + \cdots \alpha_{2p+2} dr\omega_i^p)$$

$$h_i = \gamma_0 + \gamma_1 z_i^h + \gamma_2 r\omega_i^1 + \cdots + \gamma_{p+1} r\omega_i^p + \gamma_{p+2} d_i + \gamma_{p+3} dr\omega_i^1 + \cdots \gamma_{2p+2} dr\omega_i^p + \varepsilon_i^h$$

Where:

- $\Pr(e_i = 1)$is the probability of employment of individual i
- $\phi(-)$ is the Cumulative Distribution Function of Standard Normal Distributio
- z_i^{θ} is factors influencing individual employment
- h_i is week of work for individual i
- z_i^h is factor vector influencing individual working time
- $\varepsilon_i^h \sim \mathrm{N}(0, \sigma)$ is random error term
- $r\omega_i$ is the relative wage of individual i (the ratio of the wage of individual i to the minimum wage in the area)
- d_i is virtual variable which expresses whether the relative wage of individual i is less than or equal to 1.0
- $dr\omega_i$ is cross terms of $r\omega_i$ and d_i

Education

First of all, the educational model of Mars Society is analyzed. From the preceding analysis, we have learned that education contributes to individual employment and wage acquisition.

Table 4: The individual characteristics of the relative salary

Per capita income level	Average per capita income(dollar)	average education year	rate of reto(%)
High income area (Per capita income above $9266)	23463	9.4	7.4
Middle income area (Per capita income is between $755 and $9265)	3025	8.2	10.7
Low income area (Per capita income of less than $755)	375	7.6	10.9
World	9160	8.3	9.7

Data Sources :George Psacharopoulos & Harry Anthony Patrinos (2004)

This is a table of the number of years of schooling and the rate of return on education by income level in different parts of the world. It can be seen that the higher the income level, the longer the average number of years of education is, but the corresponding rate of return on investment But the lower the income level, the shorter the average years of education, the higher the rate of return on investment, which again shows that education investment has the characteristics of diminishing marginal rate of return.（Feng Yun, 2014）

It is concluded that, on the one hand, the improvement of educational level will help to raise the income level of residents. On the one hand, when the average level of education has reached a certain level, it will continue to raise the average level of education of the population. Although there is still an effect of increasing income, the efficiency is decreasing. Therefore, while ensuring high quality and high level of social education, the government should also take into account that continuing to raise the average level of education will have a negative impact. **For low-income groups, the protection of years of education is to shorten the gap with the high-income people an important factor**.

Equality

After estimating the employment and working time equation of different sexes, the micro-survey data of China's health and nutrition survey from 1997 to 2009 and the minimum wage adjustment data of different provinces and cities were used to make further numerical estimates. The results are as follows.

Table 5: Estimation results of the employment equation and the working time equation

variable	Male		Female	
	Employment equation	Working time equation	Employment equation	Working time equation
Age	0.05*	0.41	0.08**	1.14
Square of age	-0.11***	-0.59	-0.15***	-1.82
years of education	0.03**	-0.10	0.02*	0.16
householder	0.18*	-1.20	-0.01	-2.11
married	0.39**	1.36	0.10	-0.60
have children	-0.18	-3.10	-0.06	-1.33

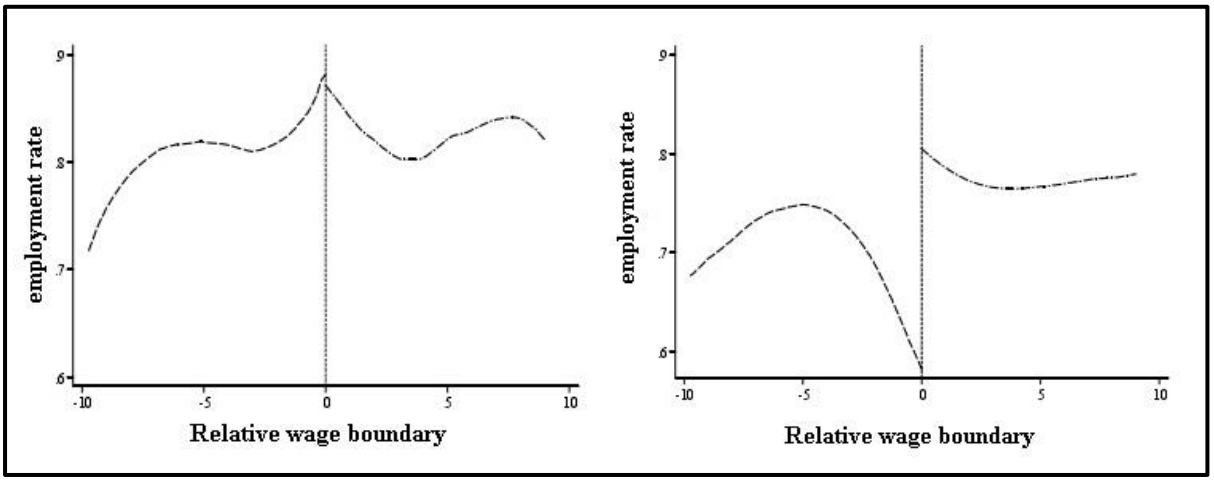
Data Sources： China Health and Nutrition Survey, CHNS

It can be seen from the figure that, with the exception of the "household" variable, other variables have the same effect on both male and female employment. Households and married status significantly increased the probability of male employment, but there is no significant impact on female employment, indicating that male heads of households usually bear greater family responsibilities, employment tendencies strong. Although the minimum wage promotion has no obvious effect on male employment, it has a significant negative impact on female employment. And the higher the level of women's wages, the greater the probability of unemployment.

This suggests that maternity leave is a priority for women in high-income groups in an economically developed society. For low-income female groups, the government should be more concerned about child care, to adopt policies to provide more social subsidies. Thus, the issue of social equity, the Mars government not only to ensure that society as a whole, women enjoy a reasonable maternity leave policy, worry-free child care and fair working conditions, but also focus on high-income women to a stronger maternity protection, to low-income women more welfare protection.

Income

Using the local polynomial fitting method, according to the impact of the minimum wage increase on the employment of men and women (Jia Peng,2012)



For lower-income men, the employment rate tends to increase with the increase of relative wage, mainly because the higher the relative wage, the smaller the impact of the minimum wage adjustment on its wage changes, and hence the impact on the employment rate. Small, in line with economic theory is expected. In the discontinuity point, the male employment rate did not show significant changes. On the contrary, the male employment rate on the left side of the discontinuity point is slightly higher than the male employment rate on the right side of the discontinuity point, indicating that the minimum wage increase will not have a significant negative impact on male employment.

For women, the employment rate of lower-income groups with the relative wage changes show the first rise and then decline, "inverted U" -shaped, mainly depends on the implementation of the minimum wage standards. There are obvious changes in the female employment rate at the discontinuity point, which shows that the minimum wage promotion may have a negative impact on female employment.

For the government of Mars, in developing the economy, raising the minimum wage, to protect people's basic life, but also take into account the possible negative impact on low-income women groups.

Sensitivity Analysis

Our model is based on the same demographic characteristics as the Canadian population. What will happen to the model results when the migratory characteristics chosen are changed? We will do a brief analysis from the income, education and social equity point of view.

Income

We have already worked out the optimal solution in the previous income model

$$L = \frac{33P}{20(K-1)}, \quad G=0.33$$

But this is the optimal solution that can be obtained under the condition that the population age structure is stable. If the group of immigrants is growing or declining, the population at both ends of the population structure will be reduced because of the inability to compete with the young and middle-aged population in the middle of the population structure, resulting in a larger Gini coefficient.

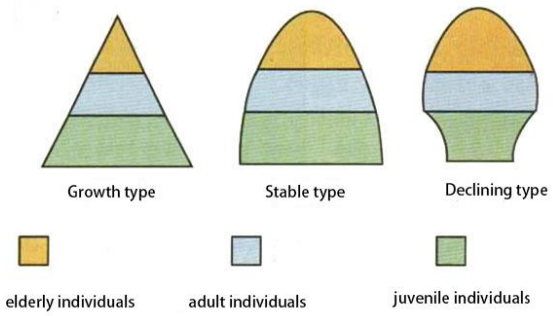


Fig.6: Population pyramid

In the optimization model, we mentioned that the high minimum wage will have a negative impact on female employment, if the proportion of men and women is no longer 1: 1, the minimum income should also change.

Equality

Maternity and paternity leave system as an important regulation of social justice in this model, highlighting the equality system of men and women, rely on huge welfare expenses to protect.

Welfare Expenditure = Population * Annual Birth Rate * 2 (Both Parents Leave) * Per Capita GDP * 60%

If the birth rate is affected by the change of the birth rate, the welfare expenditure will change accordingly.

Conclusions

We have built a set of models for income, education, social equality, and demographic distribution for this exciting planet of Utopia on Mars.

In terms of income, we find that 0.33 can be regarded as the theoretical optimal value of the Gini coefficient by assuming that the income distribution of the members of society is in a staircase shape. At the same time, by defining adverse indicators, the ratio of the share of income of the top 20 percent of the population to the share of the 20 percent of the population with the lowest incomes, according to the optimal judgment standard, it is concluded that the urban residents' bad index is more than 3 times and less than 5 times is the best. By assuming the number of samples and per capita income, calculated when the national per capita income reached 100,000 US dollars, the minimum annual income of residents is 42,000 dollars; Put forward the goal within ten years: The social distribution is relatively average, the gap between the rich and the poor is reasonable, and the income level of the residents is greatly improved. Relatively large population size can guarantee the stability of the model while the diversity of the age structure and occupational categories, which is dominated by young and middle-aged adults, favors the development of income models.

In terms of education, we suggest that Mars workers need to acquire knowledge or technical skills by analogy with modern education systems. They are also divided into knowledge labor and technical labor. They are divided in the process of high school education, respectively, into the general schools (referring to university, graduate education) and vocational schools. By drawing on China's basic education and the US gross enrollment rate of higher education, we presume that the educational goal of Mars society is 100% coverage of basic education, higher education coverage of 95%, the perfect school hardware and software facilities, the greatly improved quality of education. We have also developed an assessment system that includes enrollment rates, per capita facilities area and a set of education scoring systems. Different cultural backgrounds contribute to the integration and development of education. The age structure dominated by adolescents is also conducive to the popularization of education.

In terms of social equality, by comparing the length of leave between men and women, we find that gender equality can only be maximized when men and women are equal in length of maternity and paternity leave. We decided to learn from Iceland's "3 +3 +3" reproductive holiday system, maternity leave 3 months, paternity leave 3 months and 3 months of parental leave parental leave. The goal of social equity in the Martian society is to set the goal of maternity leave equal to that of paternity leave, with men and women having equal length of parental leave, at least 80 per cent of the average income of the last two years. Social equality requires that the sex ratio of Mars residents be close to 1: 1.

In terms of population, we give the demographic characteristics of 10,000 people and the distribution of citizens in terms of factors. Furthermore, we examine the interdependencies of the three determinants, and propose more detailed policies and programs. We discover education and social welfare have diminishing marginal returns. Based on these relationships, we use **linear programming** to give the scale factor and integrate income, education and social justice into a model that gives the best minimum wage and salary distribution for Mars residents, and the best parenting and paternity / maternity leave strategies. Then, we find that the Gini coefficient will decrease spontaneously over time, so we need to develop policies to stabilize the Gini coefficient and the bad index, so that the Mars Society to maintain good development and distribution order. We consider the impact of time on GDP and investment in education and social welfare, and give the corresponding impact. What’s more, the social division of labor is realized in the form of groups. Adjust the resources of different functional groups in order to achieve the maximum productivity of each group.

We also integrate the three key elements into a unified whole. By assuming that the level of education is directly proportional to education expenditure, welfare expenditure is positively related to social equality and introducing the coefficients p and q, which represent the degree of influence of education level and welfare level on GDP, we established the equation. We still assume that Mars society's national per capita income is 103,050 dollars, and then get the

education expenditure of 23,967,226 dollar, welfare expenditure of 13,602,600 dollar, and the total wage of residents is approximately 99,293,017,4 US dollars. Then we discuss the impact of time on p, q, Gini coefficient, GDP, education expenditure and welfare expenditure to further refine the model. Taking into account that the UTOPIA program has just started, we recommend that the model be evaluated once a year.

Strengths and Weakness

Strengths

The specific policy recommendations have been given, the salary distribution is solved exactly, and it is highly computable. What will happen to the model results when the migratory characteristics chosen are changed? We will do a brief analysis from the income, education and social equity point of view.

Weakness

Without quantitative consideration of the time value of money, the correlation between income, education and social equity is rather rough.

Letter

Dear Sir or Madam:

It has been our pleasure to give policy recommendation to you. We hope that the advice generated by our model will make some change.

We have analyzed some of the successful policies on Earth, and also learned some lessons from the failed policies。After integrating the population of the Population Zero migration, we developed a model，through what we can get some recommendable advice.

In terms of income, we suggest that the income distribution system on Mars should be made to keep the Gini coefficient of the whole society at around 0.33. At 0.33, low-income people can live with dignity while society can also be more competitive. Too low or too high can not let Mars society develop successfully.

In terms of education, in order to adapt to the rapidly developing and changing society in the twenty-second Century society, we propose to increase investment in education. The coverage rate of basic education should reach 100%, and the higher education should reach to 95%.

In terms of social justice, especially in terms of gender equality, we propose to draw on Iceland's maternity and paternity leave policy. Father should have enough paternity leave to take care of his wife and child after the baby is born

Of course, these three are not isolated from each other, but interact with each other. Their ultimate goal is to improve the economic output and people's living standards in Mars society. We found that women received higher income after receiving higher education than men, excessively increasing in the minimum wage is not conducive to women's employment and equality between men and women contribute to social well-being index.

Different composition of the population will have a different effect on the formulation and implementation of the policy, so we recommend the selection of people living on Mars in accordance with the ideal population structure. And we believe that when the size of population grow moderately, the recommended policy above won't fail.

We hope it sincerely that the advice can help build a rich and happy society on Mars.

Yours sincerely.

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