

# Game Documentation

## Starting Situation

Your country is in a very bad position. Previous governments have not put an effort into improving and developing the country. It is up to you to solve the problems that your country is facing and finally improve the living standard of the poor citizens to match that of the developed western democracies.

The previous governments have practiced very poor policies. By continuing with the same policies and not changing anything, your country's forecast is grim:

- The population will keep growing. A larger population needs more of everything, but your country's natural resources are limited.
- The environment will keep deteriorating. It is already having a negative effect on farming productivity and the death rate of citizens.
- Government debt will increase at an exponential pace, as your country pays interest on interest. The amount of debt is already double what the country can safely afford and the interest rate of the debt has increased to 15%.
- Agricultural production will slowly deteriorate due to the poor state of the environment.
- Energy production will stay stagnant.
- Goods production will stay stagnant.
- Foreign humanitarian organizations will have to intervene to distribute food to starving citizens.

## Decisions

The game is played in a series of 5 year cycles. You will receive information of the current situation at the beginning of each cycle. This information includes the resources that you have available for distribution during the cycle and the capacity levels built so far. Resources include food, goods, and energy and there are at least two kinds of each resource.

After studying the current situation it's time to make decisions that will lead your people to a better future. These decisions are:

1. Distributing food for the people
2. Distributing goods and specials for the people
3. Investing goods in infrastructure
4. Allocating energy to agriculture and industry
5. Dividing farming area and production capacity
6. Exporting and importing food, goods and energy
7. Financial affairs

After the decisions are made and the five year cycle is completed, you will

receive output describing your country's current situation according to the decisions you have made. Some of the output tells you how well you succeeded during the last five years and some of it tells you your country's current situation.

## 1. Distributing Food for the People

Low quality food (potatoes, rice and vegetables) and high quality food (beef, pork, chicken and preprocessed food) represent the resources you can use to feed your people. If there is anything left of these resources after you have decided how much to distribute, it is automatically exported. You can't store the food for later use. Note that one cycle in the game corresponds to a period of five years. The food that you distribute is spread out evenly during the five years. You are required to give the **total amount** for the five year cycle in the input. See the [Utility function for distributed food](#).

The amount of food available in the next cycle depends on the amount of LQ food and HQ food produced and imported. Remember to take care that you really have something to distribute in the following cycle.

## 2. Distributing Goods and Specials for the People

Specials (tobacco, coffee and cocoa) are agricultural products, but they are regarded as material welfare rather than food when distributed to the people. The specials that are not distributed to the people are automatically exported.

Low quality goods are building material, handcraft and simple electric appliances such as lighting and electric radiators. High quality goods are domestic appliances (microwave ovens, refrigerators, dishwashers, washing machines, etc.), electronics (computers, televisions), artificial materials (nylon, plastic, carbon fiber) and immaterial products (computer programs, patents, research and development). Goods are produced in the country's factories and offices (goods production capital). LQ goods, HQ goods, and specials are treated similarly when distributed to citizens, but the utility per item differs and changes as the country develops. See the [Utility function for distributed goods and specials](#).

## 3. Investing Goods in Infrastructure

You can invest both HQ goods and LQ goods in the following sectors:

- [Fossil Fuel Production under Construction](#)
- [Nuclear Power Production under Construction](#)
- [Renewable Energy Production under Construction](#)
- [New Investments to Energy Efficiency](#)
- [New Investments to Environmental Protection](#)
- [Food Production under Construction](#)
- [Goods Production under Construction](#)
- [New Investments to Human Services](#)

There is no difference between low quality and high quality goods in terms of investment. Each will have exactly the same effect per item. High quality goods are prioritized in investments and you have to explicitly specify the amount of HQ goods reserved for export. Any LQ goods available after distributing and investing are automatically exported. If you want to use only low quality goods for investments you have to export any HQ goods remaining after distribution to citizens.

#### **4. Allocating Energy to Agriculture and Industry**

You must provide energy to produce food, specials and goods. To use energy for food and specials production, enter the amount of energy in the input field 'Energy for Food Production'. To use energy for goods production, enter the amount in the input field 'Energy for Goods Production'. You can't expect to get maximum output from the production sectors if you are not providing enough energy for maximum capacity utilization. The actual production capacity is directly dependent on the ratio of energy allocated and energy needed for maximum capacity. The amount of energy needed for maximum capacity can be seen on the output as 'Energy Required for Maximum Food Production' and 'Energy Required for Maximum Goods Production' respectively. The amount of energy required depends on the relation between food & goods production capitals and energy efficiency capital.

You can also carry some of your fossil fuel reserves over to the next cycle. Specify the amount you want to carry over in the 'Energy Reserved' -field. Electricity cannot be carried over.

Because you can spend two kinds of energy it is required that you specify the amount of electricity exported. Any fossil fuel available after distributing and reserving is automatically exported

#### **5. Dividing Farming Area and Production Capacity**

Your country has a fixed amount of farming area and you must divide it between different kinds of farming. Specify a number between 0 and 1 for both 'Farming Area Producing Hq Food' and 'Farming Area Producing Specials'. Note that the sum of the two may not exceed one. If the sum of the two is less than one the rest of the farming area is allocated for LQ food production.

You can redirect your manufacturing plants and factories to produce more HQ goods. Specify a number between 0 and 1 for 'Fraction of Industry Producing HQ Goods'. If the number is below one, the rest of the capacity is used to produce LQ goods.

#### **6. Exporting and Importing Food, Goods and Energy**

Trading is the key to successful development. 'Effect of Trade on Development' represents international know-how exchange and cooperation. The effect of trade on development depends on your share of the world

market and the [power](#) of your country. The bigger your share of the world market and the smaller your 'Power Indicator', the greater are the effects of trading. Conversely, the less you trade and the more powerful your country, the more your investments to certain areas can be lost.

The share of the world market is calculated in **market value** for each sub-sector. There are a total of six different market shares to consider:

- **Export of:**
  - farming products (LQ food, HQ food, specials)
  - industry products (LQ goods, HQ goods)
  - energy (fossil fuel, electricity)
- **Import of:**
  - farming products (LQ food, HQ food, specials)
  - industry products (LQ goods, HQ goods)
  - energy (fossil fuel, electricity)

Trading is like a zero sum game - some win and some lose. The fractions from the six different market shares are added together to calculate your **average share**. The average share is then scaled so that 1.0 represents the world average of each country's average share. If you manage to increase your share above the average, this means that someone else's share will be below the average! Your scaled average share is then inversely scaled by your country's power and a little equalizing spice is added to give the value for the effect of trade on development. However, this value is always at least 0.5.

Because trade consists of both imports and exports, it is possible to import and export the same product in order to occupy a bigger share of the world's trade. This is not possible without a cost, however, because the exporting price (market buy-in price) will be only 95% of the importing price (market sell-out price).

It is possible that one country gains a dominating market share in one of the sub-sectors when there is very little exporting/importing of that family of commodity. You can inspect the possibility of this danger by studying the demands and offerings of each sub-sector. However, even if one country manages to achieve a monopoly on one sector, the sectors are independent of each other. The benefit of a monopoly will be somewhat leveled by the averaging of the six shares. Of course, you do not want to give anyone else this easy opportunity, so it is good practice to export and import at least some items in each subsector.

The prices of the items traded via the international stock exchange are based on demands and offerings. You will always get the amount of items that you requested from import and the market will always buy everything that you export, but the price is floating and will adjust according to demand and supply. Exporting a lot of one product will eventually push down the price if there is no real demand for it. Conversely, importing loads without anyone exporting equally much will cause the price to go up.

## 7. Financial Affairs

'Amortization of Debts' is the amount by which you are willing to amortize your debts. Debts can either be amortized by trade surplus or by sacrificing your investments abroad. By trading result or surplus/deficit we mean:  
value of exports - value of imports - interest of debt + interest of investments

Giving a bigger amount than you actually have debt simply means that you are willing to pay back all your debts if possible. If the trade surplus is negative or otherwise not sufficient to cover for the amortization of debts, then investments are spent down to the 'Sustained Investments Level Abroad' given in the input. You can thus protect your investments from being spent. Giving a bigger amount than you actually have investments simply means that you are not willing to spend any of your investments.

If the trading result is negative, the market will take its money. The market cannot force you to spend all of your investments. If you are unable to pay for the trading deficit, you will be granted an extra loan that is added to your existing debts. Any investments are spent down to the 'Sustained Investments Level Abroad' given in the input and the rest of the deficit is covered by increased debt.

Even when the trading result is negative, if you have enough investments, it is possible to spend the investments to cover for the deficit **and** the amortization of debts.

## **Social Sector**

### **Human Services**

Investing goods into the social sector will increase the general welfare of your people. This includes health care and education represented by 'Human Services Capital' and material welfare (goods for population and specials for population). Increasing either one of these will drop the birth rate closer to the natural birth rate of 10 births per 1000 population. When the level of human services is 10 per capita, then your citizens are fully aware of contraception and birth control and increasing the human services beyond this has no further effect on the birth rate. However, educated citizens are more productive in many ways - investing more to human services increases goods production and the profit gain from investments abroad. The effect of human services on production capacity is represented by 'Labor Output Multiplier from HSC'.

The actual results of the investments to human services are directly related to the effects of trade on development. Up to half of the investments can be lost if the country trades nothing during the cycle. On the other hand, active trading (both importing and exporting) can boost the effect of these investments greatly. Once the investments are done, they have a very long lasting effect: depreciation of human services capital is only 10% per cycle.

### **Material Welfare**

Increasing the level of goods spent on material welfare increases the use of energy among the population: 0.2 units of energy is required per each unit of low quality goods distributed to people and twice as much is required for high quality goods. When living standard begins to rise, people will start demanding better quality goods and specials gradually according to the utility functions below:

### Utility function for distributed goods and specials

	Total distribution per capita per year			
	<b>0</b>	<b>10</b>	<b>20</b>	<b>200</b>
Low Quality	3.00	1.50	0.00	0.00
High Quality	0.00	1.80	3.60	0.00
Specials	1.50	1.50	1.50	0.00

The per item utility function behaves linearly between the nodes {0, 10, 20, 200}. The utility of each item depends on the **total distribution per capita** of low quality goods, high quality goods and specials. The total utility calculated for your score is a sum of utility gained from low quality goods distribution, utility gained from high quality goods distribution, and utility gained from specials distribution. The following example illustrates how the total utility is calculated:

Suppose that you distribute per capita per year two items of low quality goods (LG=2), one item on high quality goods (HG=1) and two items of specials (S=2). Then your sum of items distributed is five. At five items per year per capita you receive a utility of ULG=2.25 for each item of low quality goods a utility of UHG=0.9 for each item of high quality goods and a utility of US=1.5 for each item of specials. From these we calculate the total utility UTGS

$$UTGS = LG \times ULG + HG \times UHG + S \times US = 2 \times 2.25 + 1 \times 0.9 + 2 \times 1.5 = 8.4$$

### Nutrition

Perhaps the most important thing to do in the social sector is to feed your people. If the people don't get enough food, they'll begin to starve and the death rate rises. Of course, starvation has been a part of everyday life during the previous government. When the people get more than about 7.5 units of food per capita per year, no starvation occurs anymore and the death rate will drop to the natural level of 10 deaths per 1000 population (if the quality of the environment is not causing unnatural deaths). In terms of starvation, it does not matter whether you feed the people with high or low quality food. If the food distribution is below two units per capita per year then foreign humanitarian organizations will intervene on the inhumane situation of your citizens. The humanitarian organizations will distribute low quality food so that the citizens will get a minimum of two units of food per capita per year.

The food aid prevents mass starvation, but since the humanitarian operation is carried out regardless of the opinion of the country's government, there is a risk of conflict. The risk of conflict reflects on your score via increasing the [total risk](#). The food aid that is distributed **is** taken into account in determining the nutritional quality of life. In other words, food aid has the same effect on the [utility function of food distribution](#) as food distributed by the government.

Feeding your people also affects the birth rate by increasing overall welfare. The effect of HQ food on birth rate is similar to the effect of goods and specials and the effect of LQ food is  $\frac{3}{4}$  of that. Again, the more you feed the people the more demanding they will become until they are satisfied. After 10 total food per capita per year, the people will start demanding high quality food instead of the basic and essential low quality food. In fact, the citizens no longer give any value to low quality food after a total of 20 units of food. If you manage to build your country to a very high level in living standards, distributing too much food will turn the total utility to a downward slope. This will happen at a total of 45 units of food per capita per year and achieving that level is highly unlikely!

### Utility function for distributed food

	Total distribution per capita per year			
	<b>0</b>	<b>10</b>	<b>20</b>	<b>90</b>
Low Quality	4.00	2.00	0.00	0.00
High Quality	0.00	2.00	1.75	0.00

The utility function of distributed food works exactly the same way as the utility function for distributed goods and specials, except that the nodes are different: {0, 10, 20, 90}.

## Energy Efficiency and Environmental Protection

Energy efficiency is directly related to the environment. More efficient machines produce the same amount of goods or food with lesser amounts of energy and thus generate less pollution. 'Energy Efficiency Multiplier' can go down to 0.3 when investments to energy efficiency are large compared to the size of the production infrastructure and up to 1.3 if the energy efficiency is completely neglected. The multiplier affects directly the energy needed for farming and industry. Because efficient use of energy is mostly based on know-how, the effective investments are related to international know-how exchange (which is simulated by the amount of trade). Up to one quarter of the investments can be lost if the country doesn't trade at all. Depreciation of energy efficiency capital is 20% per cycle.

Producing fossil fuels (mining coal or drilling and refining oil) always has some negative effect on the environment. The effects are even more serious when fossil fuels are actually spent. Producing and spending electricity is far better for the environment, as its polluting effect is marginal compared to that of fossil fuels. If no effort is put on environmental protection the quality of the environment will drop bringing some unwanted effects with it. The quality of the environment is represented as a value between 0.0 (destroyed) and 1.0 (excellent). If the environment is in poor condition, it will cut down your food production and will even cause the death rate to grow if it drops below 0.7.

The environment can stand up to a certain amount of pollution and heal somewhat by itself. The healing rate is parabolic so that the biggest resistance for pollution exists when the quality of the environment is 0.5. When the environment is totally ruined (quality 0) it cannot heal itself as there isn't anything living left. When the environment is in perfect condition, even the smallest pollution will appear disturbing in the quality of the environment and thus the natural healing rate is zero also in that end.

Successful environmental protection requires international cooperation which is again simulated by trade. The investments to environmental protection are strongly dependent on trade. Up to half of the investment will be lost if the country doesn't trade at all. Depreciation of environmental protection capital is 15% per cycle.

## **Energy Production**

Producing goods and food requires energy. You can produce all of your energy yourself or you can buy it from abroad. Investments in the production capacity are not affected by trade. There are three categories of energy production:

- Fossil fuel production:
  - Requires little investments
  - Has little disturbances in production capacity
  - Production and refining causes pollution
  - Burning fuel causes pollution
  - Fuel can be stored for later use
  - Depreciation is moderate: 20% per cycle
- Nuclear power production:
  - Requires moderate investments
  - Has no disturbances in production capacity
  - Production causes very little environmental damage
  - Using the produced electricity causes very little environmental damage
  - Nuclear power plants are high tech and the safety of the plants is dependent on the education level of the citizens (Human Services Capital per Capita). Unsafe plants will increase the country's risk.
  - Depreciation is high: 25% per cycle

- Renewable energy production:
  - Requires large investments
  - Has disturbances in production capacity
  - Production causes very little environmental damage
  - Using the produced electricity causes very little environmental damage
  - Depreciation is low: 15% per cycle

Understanding the basics of nuclear fission requires education. It is not recommended to build nuclear power plants before you have reached a level of 12 units of Human Services Capital per Capita. At this level of HSC the risk will increase by one unit for every thousand units of Nuclear Power Production Capital. The nuclear risk will always be in direct proportion to the amount of nuclear power plants. As the education level rises further the plants will become more stable and equipped with better instruments, better technology and most importantly better engineers. It is estimated that in developed countries, where the level of HSC per capita is around 120, the risk is increased by only  $10^{-6}$  per thousand units of Nuclear Capital.

## Food Production

This is the most fundamental production sector. Your country has a fixed amount of farming area and you can divide it to produce three kinds of products:

- Low quality food:
  - Produces on average 28 units per one unit of capacity, in perfect environment and with a total food production capacity of 1 000.
  - Production capacity is dependent on weather
- High quality food:
  - Produces on average 1/3 of the per unit capacity compared to low quality food.
  - Production capacity is less dependent on weather
- Specials:
  - Produces on average 1/2 of the per unit capacity compared to low quality food.
  - Cannot be used to feed the people (nobody can be fed with tobacco)
  - Production capacity is more dependent on weather compared to low quality food.

Producing food requires modern equipment and energy in addition to farming area. Food production capital represents the amount of production units in use. Each unit requires 12 units of energy to operate one cycle (modified by the energy consumption multiplier).

A lack of energy will simply cut down production capacity in equal ratios. If

you allocate only half of the energy needed, you can expect only half of the capacity being used. The amount of food or specials produced will increase when the production capital is increased, but because of limited land resources, the production per unit is declining.

Food production capital depreciation is 20% per cycle.

## **Goods Production**

Investing in goods production means building new manufacturing plants and factories and improving the existing ones. Industrial production produces twice the pollution as farming. The 'Labour Output Multiplier from GPC' increases with increasing production capacity. The goods produced can be categorized into two different categories and you can divide your production capacity between them:

- Low quality goods:
  - Production capacity depends linearly on the available work force and the labor output multipliers, which depend on the production capacity and the education level.
- High quality goods:
  - Production capacity depends on the available work force, but as the population grows, the marginal utility per citizen gets smaller.
  - Production capacity depends heavily on the labor output multiplier from GPC, which represents investment capital in high-tech equipment (robotics).
  - Production capacity depends linearly on the education level.

Both kinds of goods can be used for investing in the infrastructure but their effect is equal. The main purpose of producing high quality goods is thus satisfying the needs of the consumers and improving living standard. Each unit of goods production capital requires 12 units of energy to operate one cycle (modified by the energy consumption multiplier). If enough energy isn't allocated for the maximum capacity utilization the resulting goods production will be accordingly reduced.

The effect of all new investments to goods production capital are dependent on trade. Successful know-how exchange can increase the benefits from the robotics etc. considerably. One quarter of the investments will be lost if the country does not trade at all. Capital invested to goods production will depreciate by a rate of 20% per cycle.

## **Financial Affairs and International Relations**

### **Power Indicator**

This section requires much attention but no direct investments. The most important thing is probably the 'Power Indicator' that represents the total

power of your country. The power is dependent on the population and all the capitals, except environmental protection capital. The power indicator is a straightforward ratio of your country's power and the power of all countries added together. The indicator is scaled so that 1.0 is the global average of the different countries' powers. The country is less powerful than the average country if this value is below one and more powerful if it's above one. The power indicator is a pure zero sum game. The smaller the power indicator, the easier it is to gain some benefits from the trade even if you are not able to occupy a huge percentage of the total world trade. After you have made some successful investing, the power and influence of your country will start to rise and it will require more trading to get the same benefits.

## **Debt and Foreign Investment**

Another important aspect is the international debts and investments of your country. The interest rate of the debt is directly proportional to the amount of debt your country can afford. The sad news at the starting cycle is that your country has already more debt than it can afford and the interest rate of the debt is at 15%. The maximum interest rate is 25% and it is charged when the country has more than double the amount of debt compared to the credit limit. There is no limits to the amount of debt you can have; the only thing that prevents you from taking a huge amount of debt is the fact that taking debt increases the anxiety of your citizens, which reflects as an increased risk. This risk grows in direct proportion to the amount of 'Total Debt' divided by the 'Maximum Debt Available' and an infinite amount of debt results in an infinite amount of risk. An infinite risk brings the score asymptotically to zero.

You don't have to pay the debts back if you don't want to. The only thing that matters is that the interests are paid. If you cannot pay your interests they are automatically added to your existing debts and the interest rate will rise accordingly.

The maximum amount of debt that your country can safely afford depends on the total value of the infrastructure and investments abroad. If you have little or no debt compared to your credit limit, the interest rate of the debt can go down to a minimum of 1,25%.

If there is any money left from trade after paying the interest you can either amortize your existing debts or invest the money abroad. The profit rate of the possible investments depends on the education level of your economists (human service). It will go from 5 % up to 40 % per cycle. Reaching 40% however requires a mammoth human services level of 500 per capita. Notice that you cannot take debt to invest abroad, but you can sustain your old investments even if you temporarily need debt. If you do not want to sustain your investments, they are automatically spent when needed before new debt is taken.

## **Scoring**

## Score for the round

The performance of the country is measured with a score that reflects the living standard, future expectations and environment quality. The score for each cycle is calculated in the following way, where the period of five years has been taken into account:

Components of the score:

- UTF = Total utility from food distribution
- UTGS = Total utility from goods and specials distribution
- Risk = RiskFunction(Nuclear Power, Debt, Food Aid)
- Deaths = (Deaths per Capita per Year - [Natural Deaths per Capita per Year](#))
- Env =  $\max(0.7, 0.7 + (\text{QotE} - 0.7)/2)$   
⇒ range between 0.7 (when  $\text{QotE} \leq 0.7$ ) and 0.85 (when  $\text{QotE} = 1$ )

From these components the final score for the round is calculated as a function of:

$$\text{Score} = \frac{\sqrt{\text{Env}}}{(1/\text{UTF} + 4/\text{UTGS} + \text{Risk} + 5 \times \text{Deaths})^{0.3}}$$

The final result is the total sum of all the scores obtained during the rounds.

## Theoretic Optimum

Because of the parabolic nature of the utility functions, there exists a theoretic maximum score for a round. This score has a value of  $\sim 2.426$  and is achieved with perfect quality nature, zero risk, no unnatural deaths (death rate 0.01), high quality goods distribution of 100 units per year per capita, and high quality food distribution of 45 units per year per capita.

The perfect score is calculated as:

$$\begin{aligned} \text{Score} &= \frac{\sqrt{0.85}}{(1/50.625 + 4/200 + 0 + 0)^{0.3}} \\ &= \frac{\sqrt{0.85}}{(161/4050)^{0.3}} \\ &\approx \frac{0.922}{0.38} \approx 2.426 \end{aligned}$$

It is possible to get a near zero score for a round by neglecting completely the goods and specials distribution or growing your debt way beyond the credit limit. With a score below 0.5 your country is worse off than North Korea, and getting the score to at least 0.5 does not require much.