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T21 China: An Initial Application and Analysis

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Abstract

The purpose of this paper is to demonstrate the uses and capabilities of the Threshold 21 (T21) model through an application to China. The first section, "Results for the Baseline Scenario," provides the baseline projections for China to the year 2020. In the "baseline" scenario, it is assumed that the past policy and a peaceful condition continue, and the scenario shows what is likely to happen over the next 20 years in five areas: population, prices and income, production, environment, and social issues. The second section, "Results for Alternative Scenarios," provides scenario analysis, or "what-if" analysis for a number of alternative policy scenarios, including two child per family policy, stricter pollution control policy, and HIV/AIDS policy. The major results of the policy change are compared to the baseline projection.

Contents

Introduction

The purpose of this paper is to demonstrate the uses and capabilities of the Threshold 21 (T21) model through an application to China.

T21 is a computer simulation model designed as a tool for national long term development planning. It includes economic, resource, environmental and social sectors in an integrated system. Compared to all other national planning models, it is more transparent, easier to understand, and easier to be applied and transferred to any country.

The T21 model is not for making precise predictions of the future. Rather, it is a tool for exploring alternative policy scenarios in an effort to identify sets of policies that may improve conditions in the future.

Overall, the T21 model is a system of products: The T21 Core and a collection of individual sectors. T21 Core is the nucleus of the system, a highly aggregated, model with three parts: population, economy/production, and simplified non-renewable and pollution sectors (indices). Other sectors are ready to be added to T21 Core as need arises. They include: unemployment, income distribution, education, health care, HIV/AIDS, nutrition, energy, land, forest, water, water pollution, air pollution (greenhouse gas emission), and government debt. A variety of output indicators used by the World Bank, IMF, UN agencies, and many governments, can be added. For further details on the T21 Core model, see the Attachment: An Overview of T21.

For the preparation of this paper, three sectors were added to the T21 Core: unemployment, income distribution, and HIV/AIDS.

The first section, "Results for the Baseline Scenario," provides the baseline projections for China to the year 2020. In the "baseline" scenario, it is assumed that the past policy and a peaceful condition continue, and the scenario shows what is likely to happen over the next 20 years.

The second section, "Results for Alternative Scenarios," provides scenario analysis, or "what-if" analysis for a number of alternative policy scenarios. The major results of the policy change are compared to the baseline projection.

With the T21 Core model, users can analyze a wide variety of scenarios. The scenarios presented in this paper are only a small sample of what is possible.

In application, the T21 model is used to simulate the past decade or more and the simulation results are compared to available data. Data came from three international sources, including the World Bank's World Development Indicators, UN Population Data, and UN Food and Agriculture Organization Agricultural Data.

In the following sections, historical data are included for reference purposes: the World Bank's World Development Indicators is identified by "WDICHN00" in the graphs; the UN Population Data is identified by "PopCHN" in the graphs; and UN Food and Agriculture Organization data is identified by "FAOCHN" in the graphs.

There are many limitations of both the T21 model presented here and the analysis in this paper. China is a huge, diverse country, not easily represented in a nationally aggregated model. While China has achieved great success over the last 20 years, it still faces huge problems. Some of the important sectors to China, such as education, water, energy, land, forest, and social stability, are not even included in the current model. The analysis presented here is incomplete and much more can be said and added to each of the graphs by way of using the model and using expert knowledge in each of the topics. However, for the purpose of demonstrating the uses and capabilities of T21, we hope what follows are adequate to make the point clear.

This work has been supported by grants or contracts from the General Motors Corporation and several US foundations.

Results for the Baseline Scenario

Population:

The following graphs show that total population will be 1.42 billion by the year 2020, if total fertility rate continues a slow decrease from 1.9 (2000) to 1.7 (2020). Life expectancy will continue to increase from 72 for female and 69 for male at present to about 76 for female and 73 for male by 2020. Age structure will also change, resulting in a growing proportion of older population.

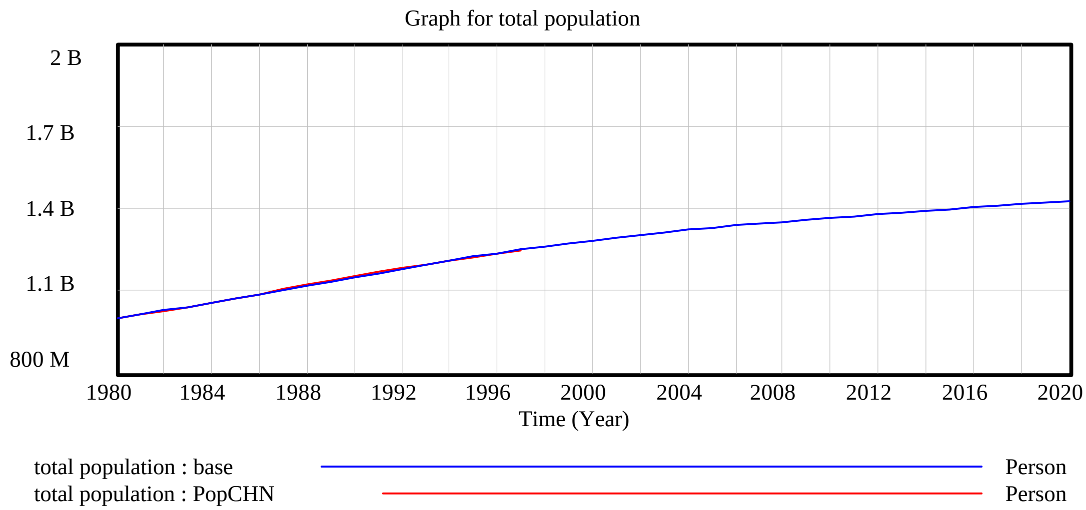


Figure 1: Total population (The simulation result and the data line are overlapping)

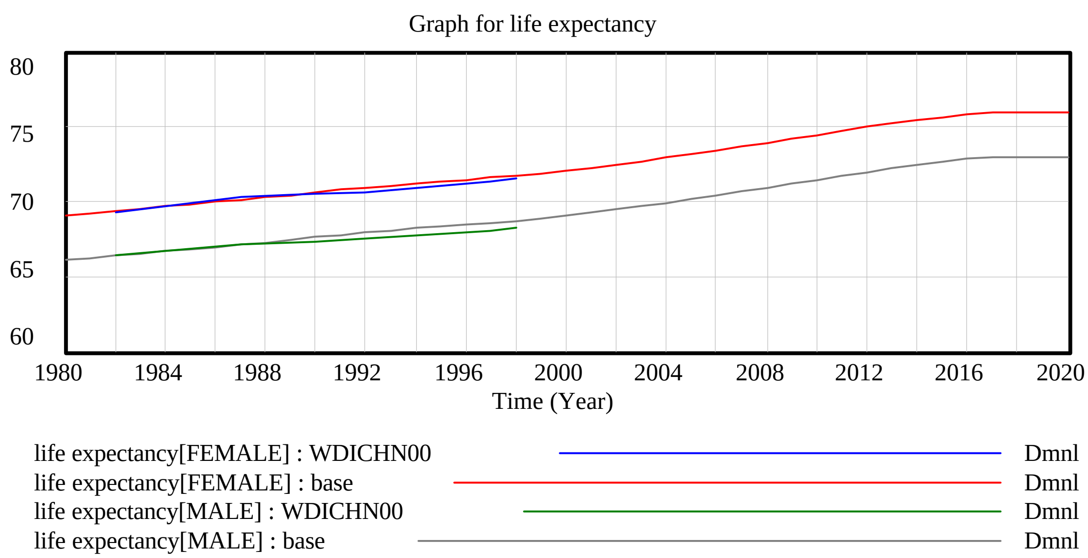


Figure 2: Life expectancy:

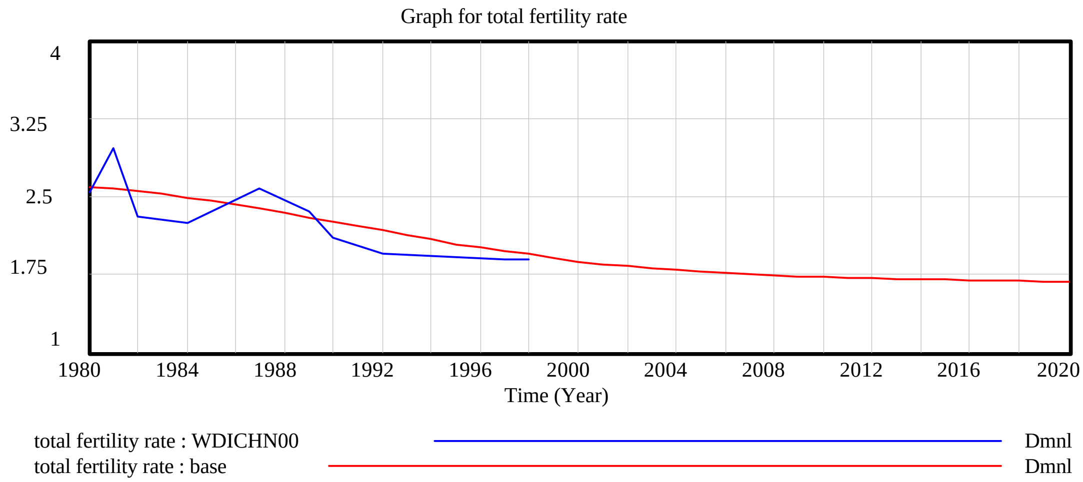


Figure 3: Total fertility rate:

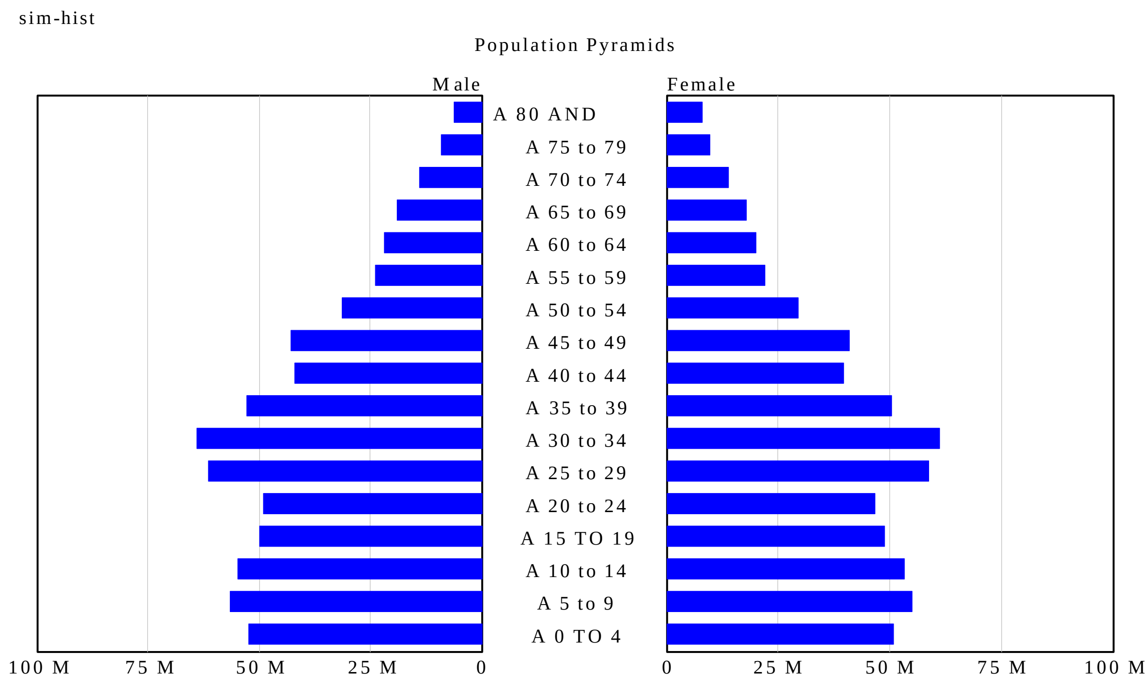


Figure 4: Age structure for 2000:

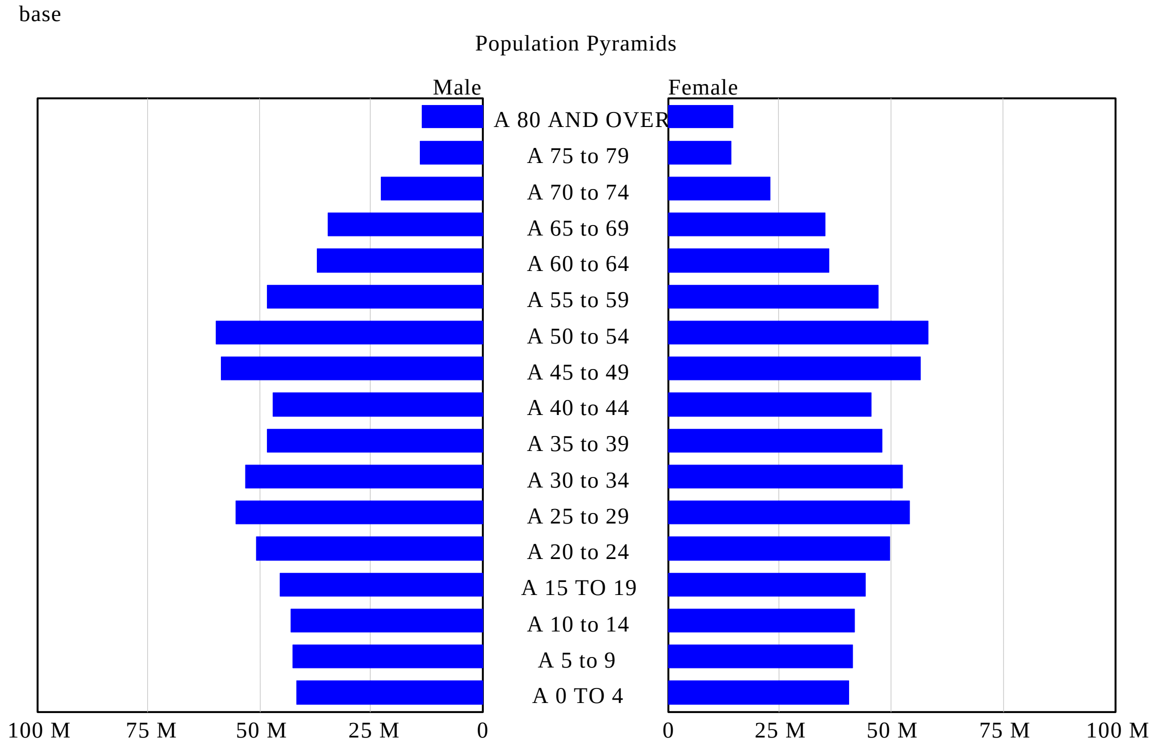


Figure 5: Age structure for 2020

Economy

Producer price index (value equal to 1 for all three sectors): It is interesting to notice that agricultural price index grows to be highest, and the reason is that when Chinese people get better off, they first improve their diet.

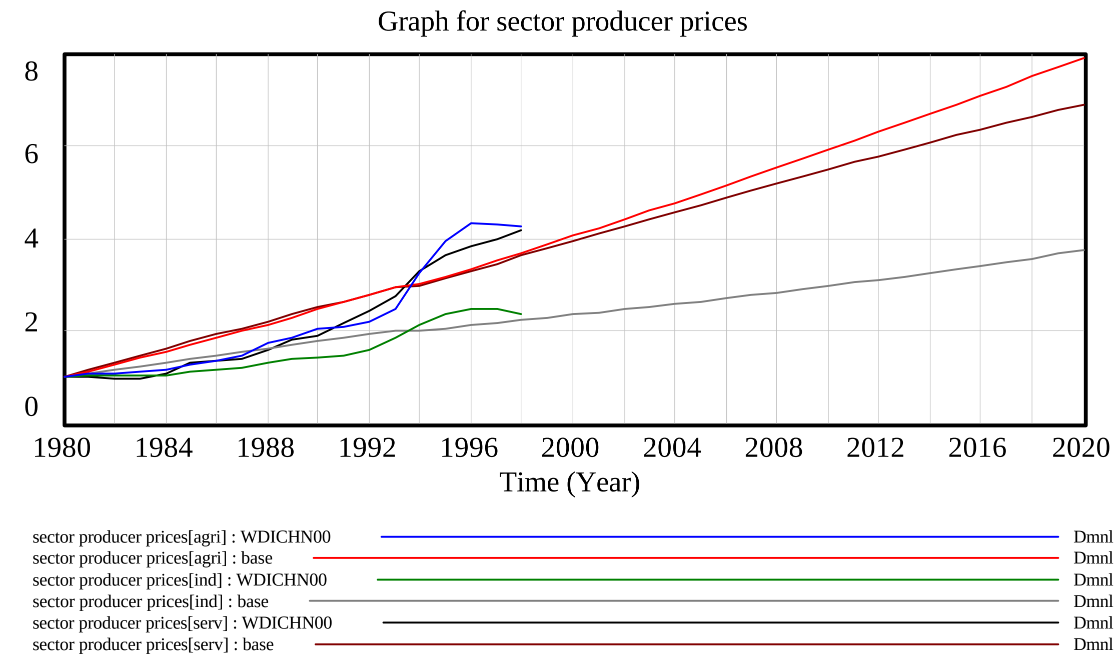


Figure 6: Producer price index

Relative price index is derived from producer price index, and is shown in Figure 7 below.

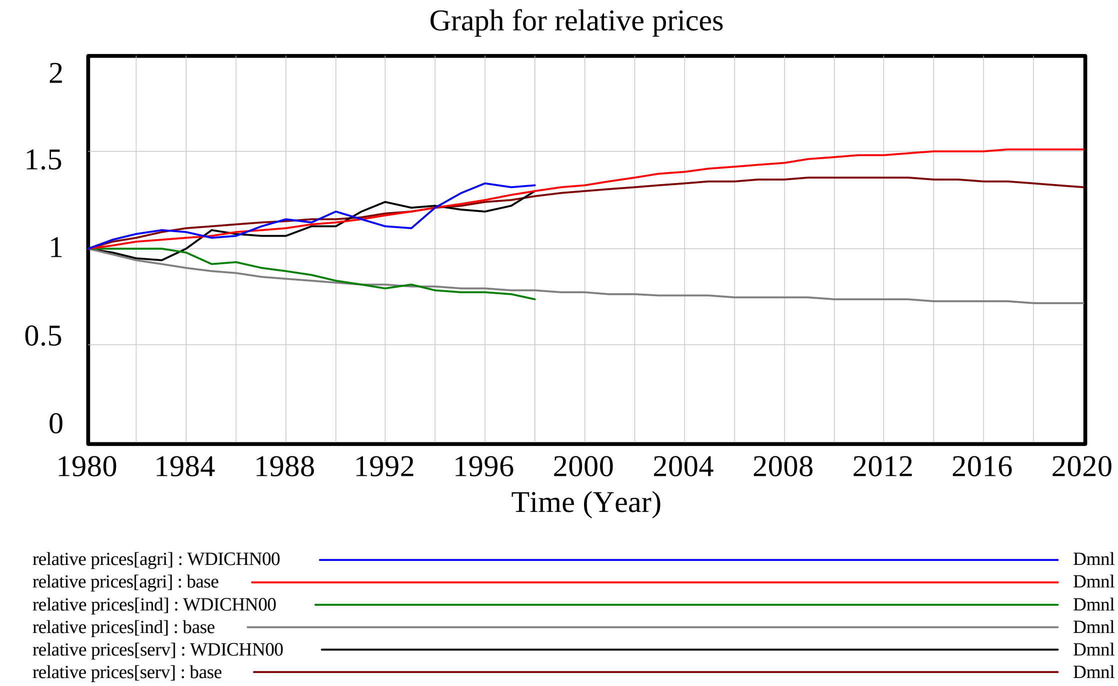


Figure 7: Relative prices

Real GDP: From 1980 to 2000, China's real GDP increased almost 6 times. In the next twenty years, China's real GDP will grow at an average rate of 5% per year, or about 265% in 20 years.

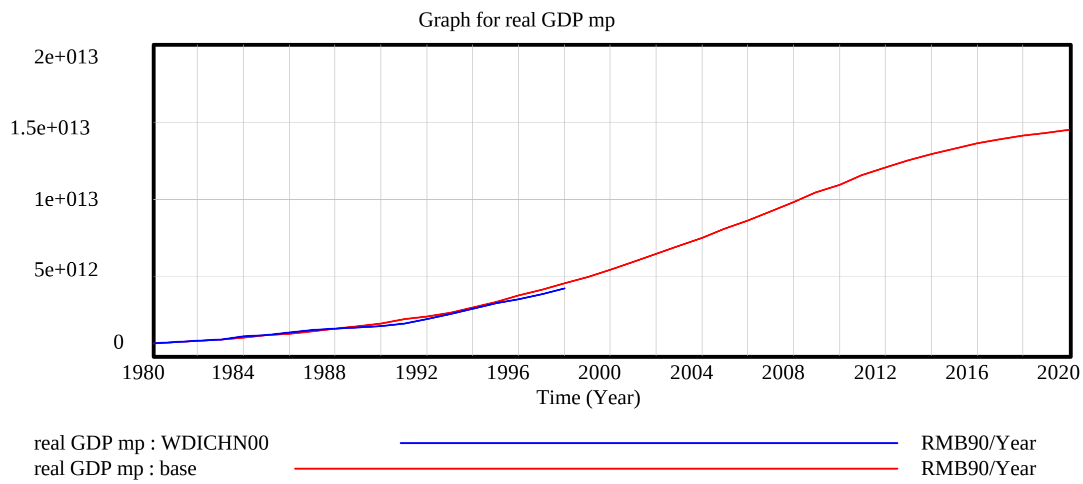


Figure 8: Real GDP

With the GDP growth, per capital real disposable income will also grow, from a little over 2,000 RMB90 at present to over 6,000 by 2020.

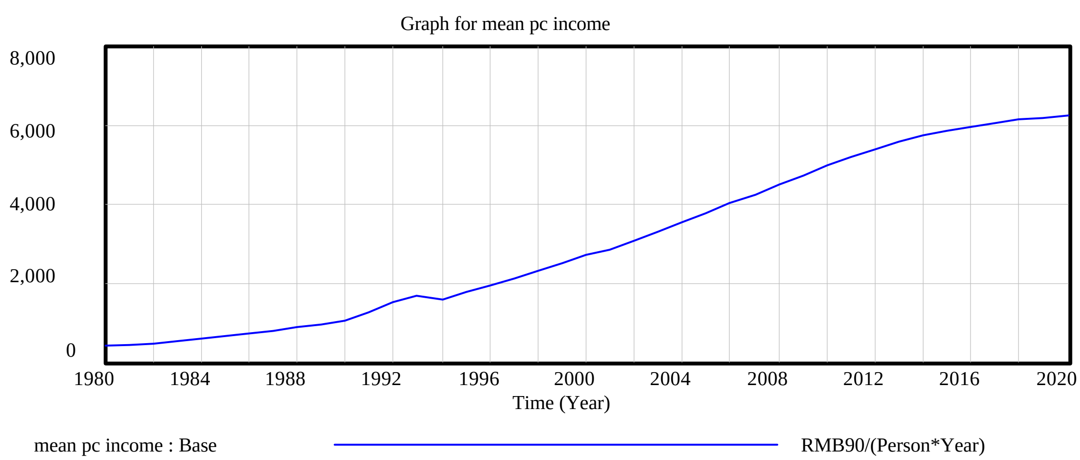


Figure 9: per capita disposable income

Central government revenue and total government (including local and central) are expected to grow as well.

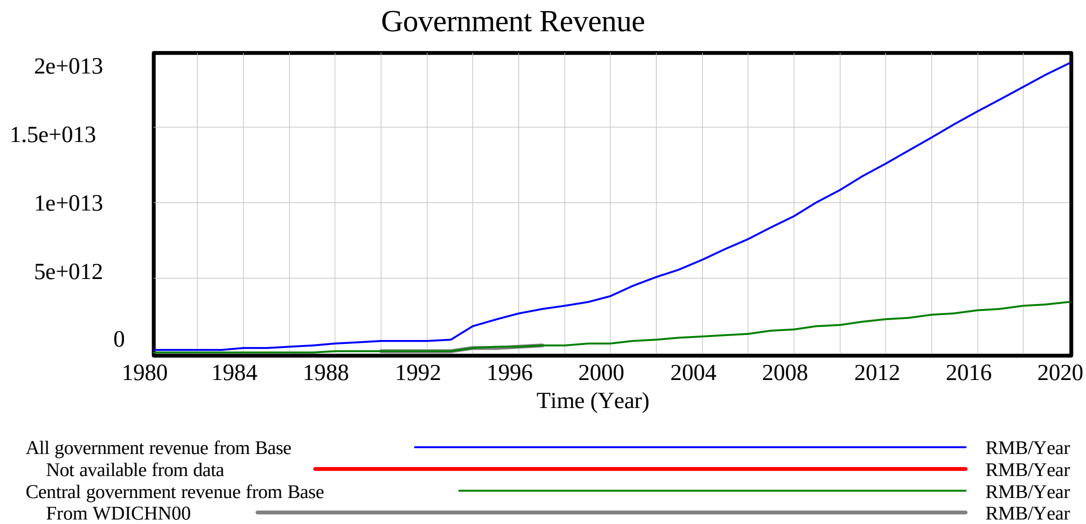


Figure 10: Central and total government revenue

International trade is quite difficult to project, as the model only includes domestic components. By setting world real prices as constants, and world GDP growth at a constant rate, the model estimates imports and exports:

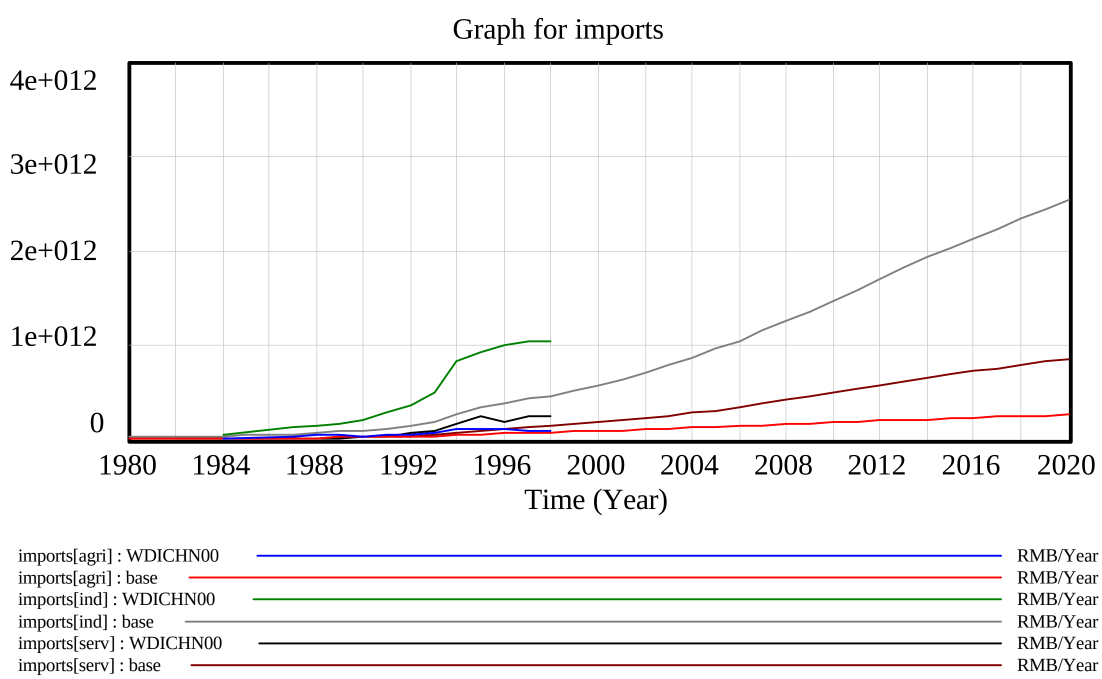


Figure 11: Imports

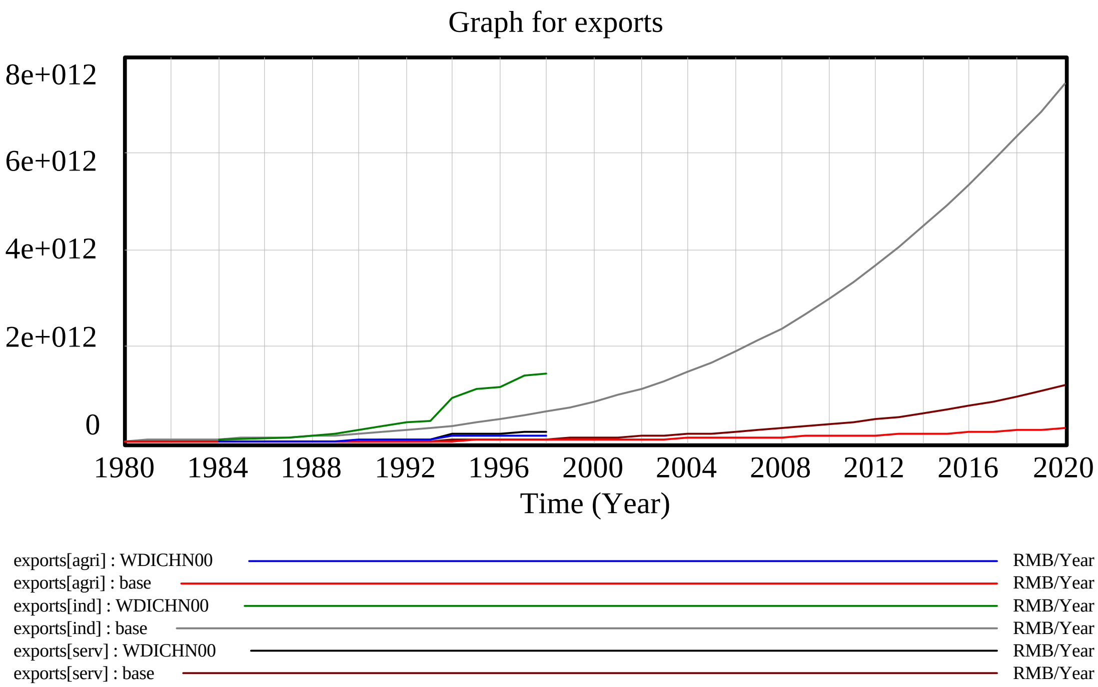


Figure 12: Exports

Production

Labor productivity (per worker output) in industry and services increased tremendously over the 1980-2000 period, and will continue to grow.

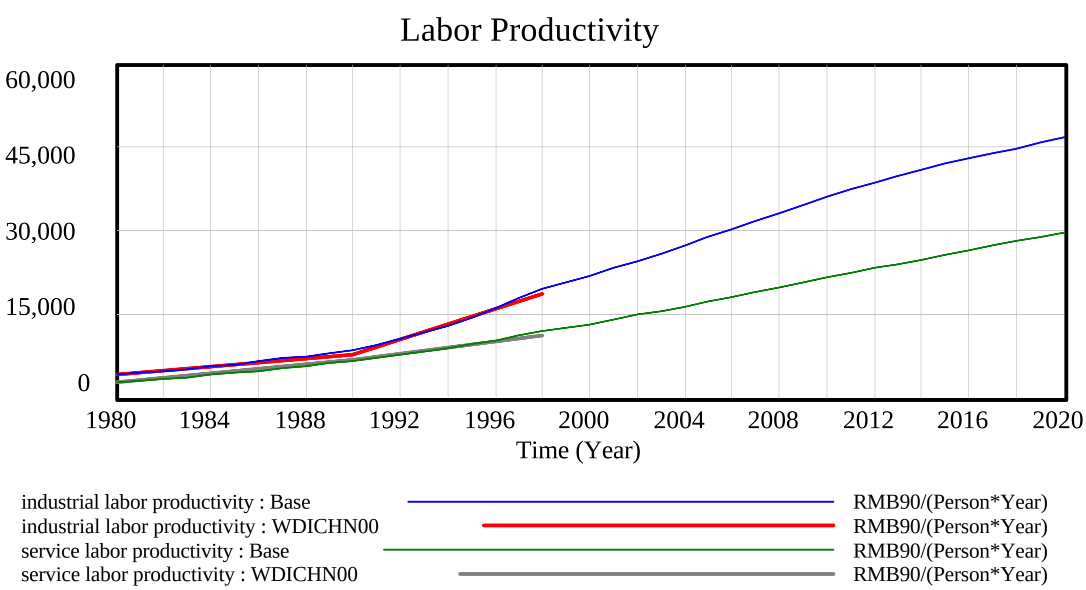


Figure 13: Labor productivity

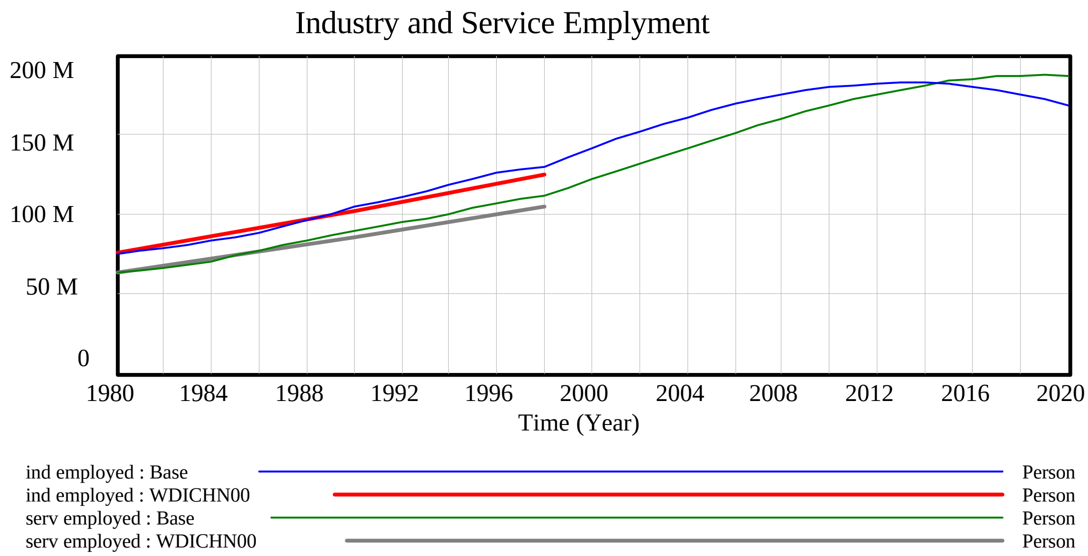


Figure 14: Employment in industry and services

Grain yield will grow to 5.4 ton/hectare, about 720 Jin/Mu as a nation wide average. Two critically important factors facing China's agriculture are water availability and soil erosion. These two factors are included in the model only as placeholders. Currently they do not have any consequences on yield because we do not have enough data to develop an appropriate algorithm.

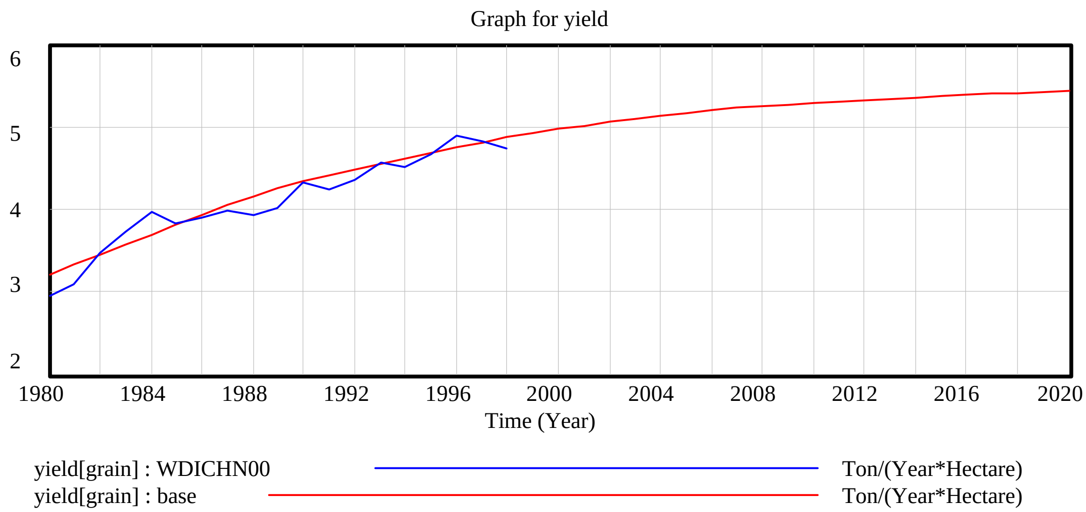


Figure 15: Grain yield

Agricultural land is a scarce resource, and is probably going to shrink in the future due to urbanization and soil erosion. In the model it is assumed that agricultural land will stay constant. It is also assumed (following FAO) that 58% of agricultural land will be used to grow grain, and the crop intensity index for grain is kept at a constant level: 1.56.

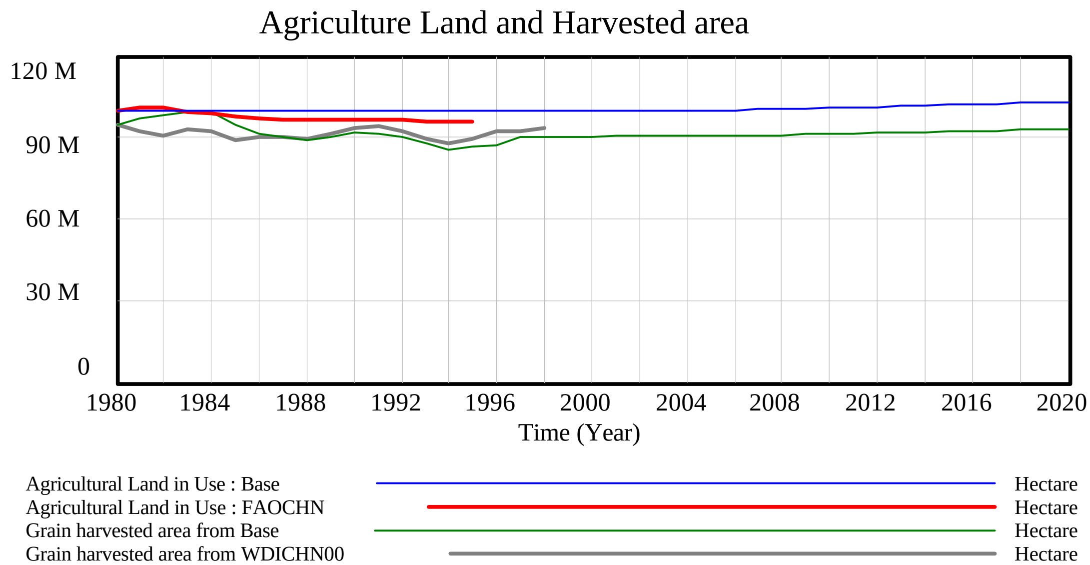


Figure 16: Agricultural land and grain harvested area

Environment and non-renewable resources

There are many types of pollutants, such as chemicals, heavy metal, radioactive material, greenhouse gases, and SPM (Suspended Particulate Matter). Instead of modeling each of them separately, the T21 Core model uses a single index to represent the weighted sum of all the pollutants. In cases where more detailed analysis is needed, there are separate sector models available to be added to the T21 Core.

It is assumed that the generation of pollution is related to production levels (represented by real GDP) and technology. The higher the real GDP becomes, the higher the rate of pollution generation grows. Technology has an opposite effect: the higher the technology, the lower the pollution generation. Assimilation half-life is assumed to be 5 years.

Pollution index is standardized to be of the value 1 for 1980. By 2020, it increases to almost 4.5, or 4.5 times as bad as in 1980, as the following picture shows.

When pollution index grows high, the model assumes that people's health will be affected and their life expectancy will be shortened. Such developments could also push the government to adopt tighter emission regulations, forcing industries to spend more on emission control, and thus less on direct production.

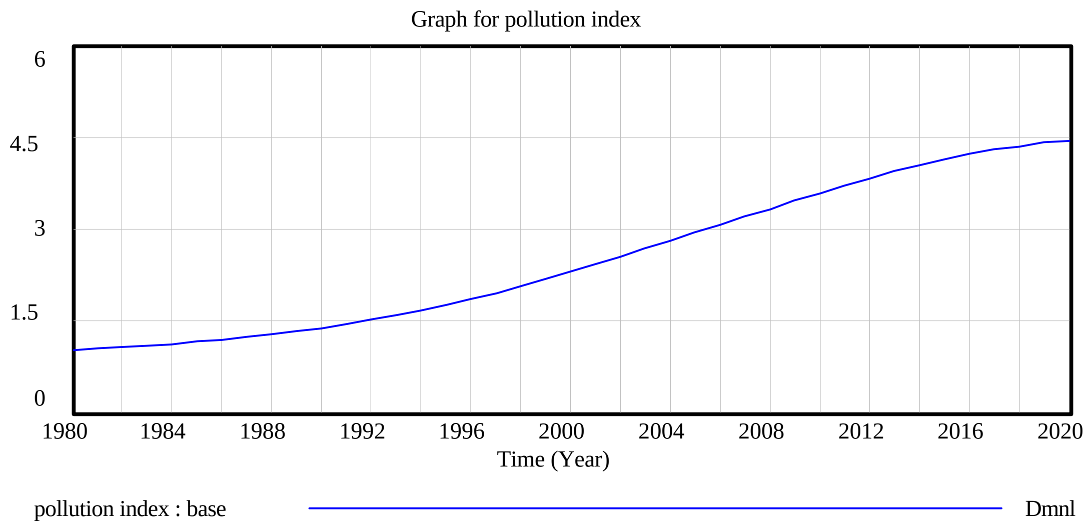


Figure 17: Pollution index

Non-renewable (NR) resource means fossil fuels and metals in this model. We use a single index to represent the weighted average of all. It is assumed that at the beginning of the simulation in 1980, NR resources are available in such an amount that it can last for 200 years at the use rate of 1980. Again, more detailed natural resource sectors are available to add to the T21 Core model.

The model uses the variable "fraction NR resource remaining" to measure the NR remaining fraction of the 1980 total. When this fraction goes under a certain margin (60%), part of the production capital will become unproductive, because it will be used to develop substitute, or to develop infrastructure to handle more imports, or to develop higher efficiency technologies.

Because of the fast growth of China's economy and similar growth in NR resource use, natural resources are depleted quite rapidly. By 2020, only about 20% of the original 1980 total is left.

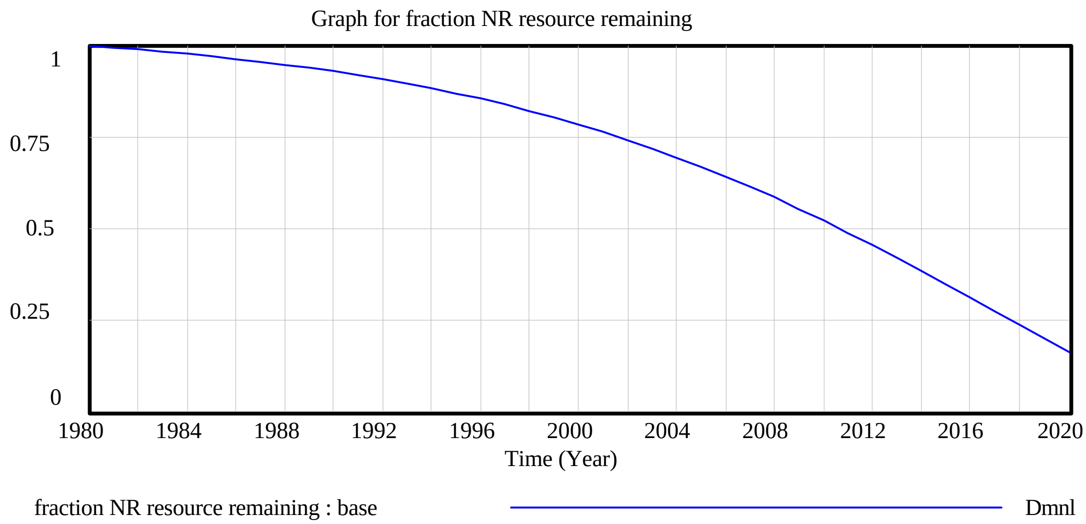


Figure 18: Fraction of remaining non-renewable resources

By 2020, a substantial part of capital in industry will be used for seeking substitutes or developing new technologies, thus growth will be slowed. Further to the future, we may even see a negative growth of real GDP.

Social issues

This model assumes that industry and services only employ people in the urban area. It also assumes that by 2020, urban population will be 45% of total population, as the following graph shows.

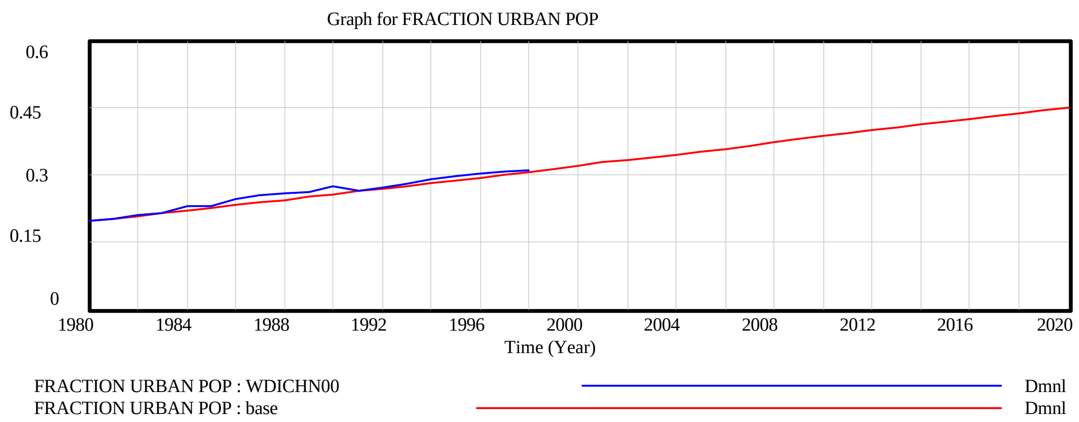


Figure 19: fraction of population living in urban area

Based on these two assumptions, unemployment in cities is not a problem until about 2014, where urban unemployment start to emerge and will reach 10% by 2020.

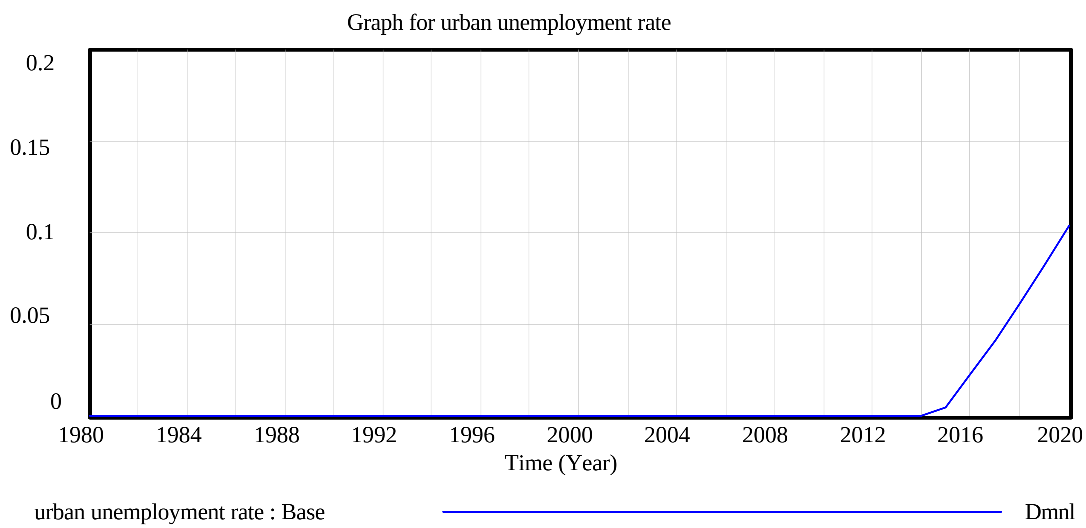


Figure 20: Urban unemployment rate

In 2000, the income distribution in urban China looks like the following.

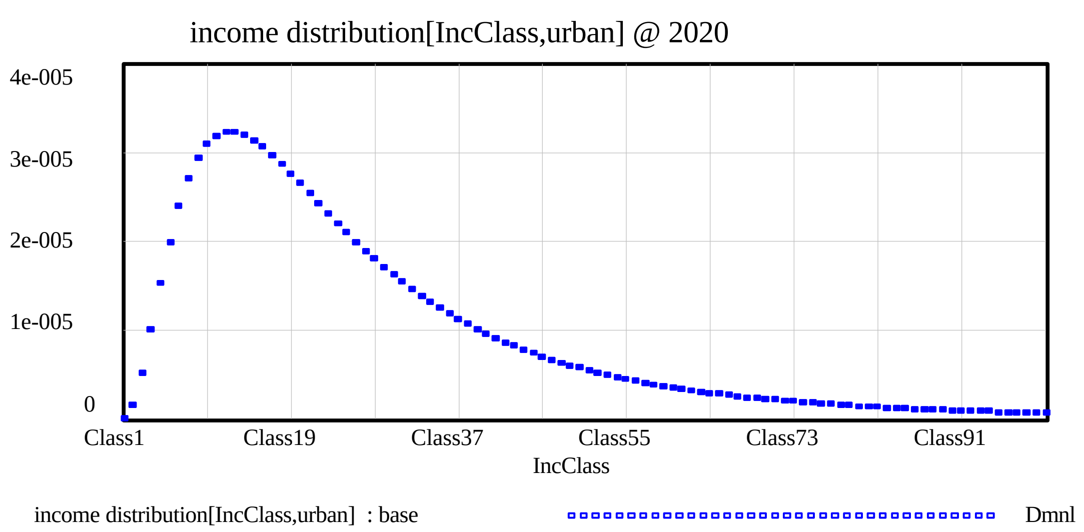


Figure 21: Urban income distribution in year 2020

The horizontal axis is the income, with each class representing 1000 RMB90/year, so Class19 means the income level of 19,000 RMB90/year. The vertical axis is the probability density function.

Using 2,000 RMB/Year as the poverty line, the income distribution shows that there are about 0.5 million urban families and 3 million rural families that are still under poverty in 2000. It also shows that 20% of urban households are living below 6,700 RMB90/Year at the year 2000.

Total grain production measured in tons is shown below.

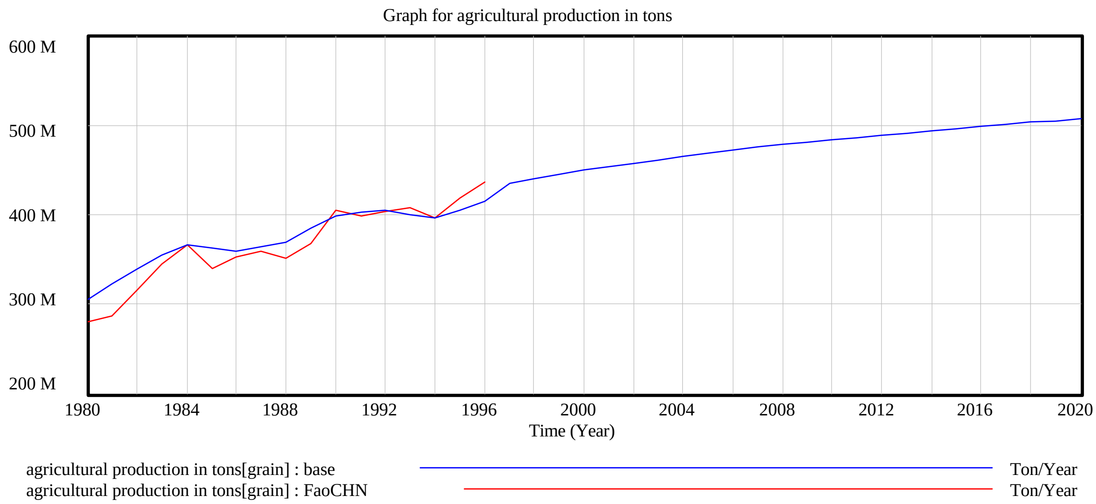


Figure 22: Grain production in tons

Per capita grain from domestic production stays around 350 kg per year as the following picture shows.

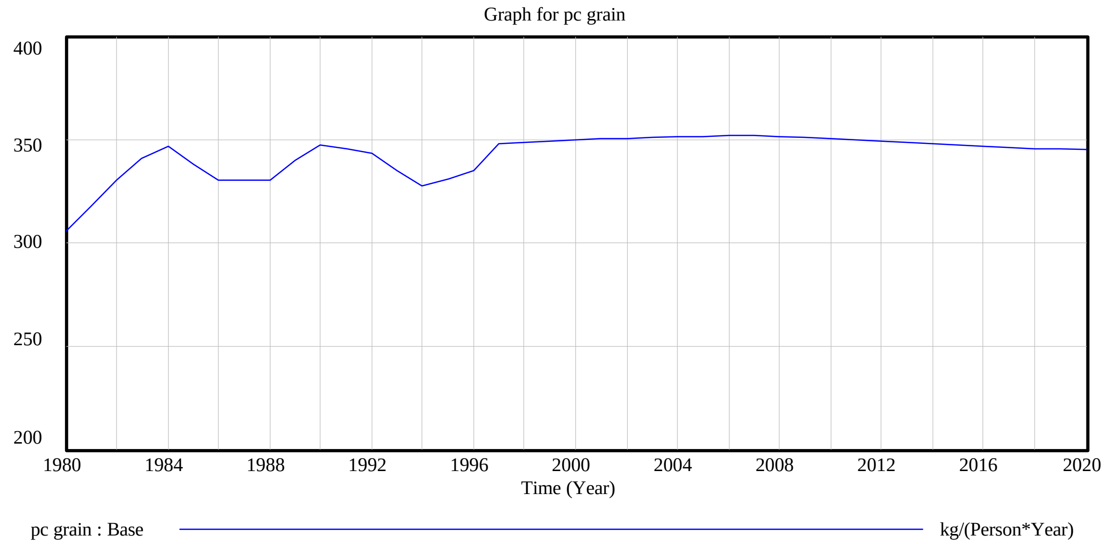


Figure 23: Per capita grain production

Per capita meat demand (including pork, beef, lamb, poultry, fish, egg, and milk) is going to grow after 2000, but the growth rate may slow down, as the following picture shows.

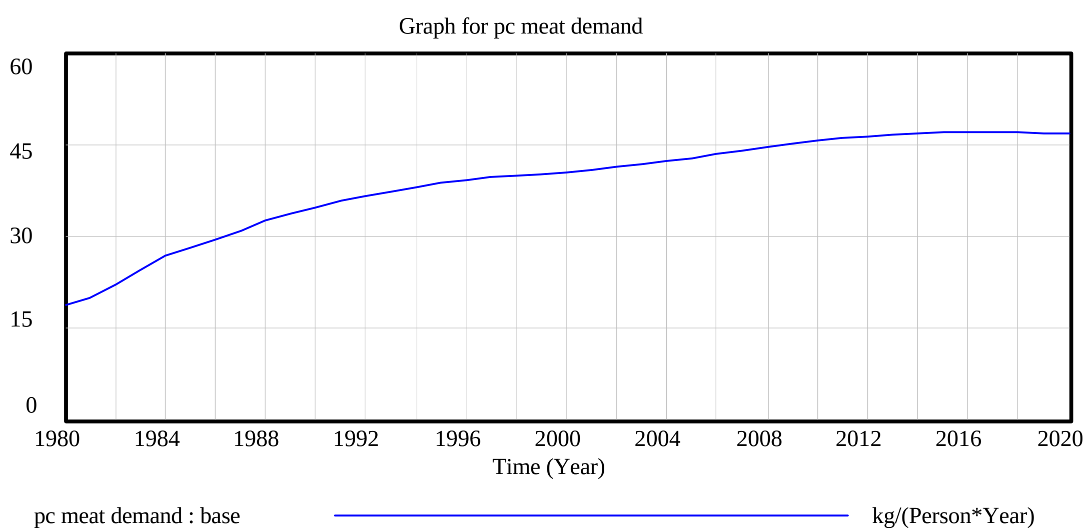


Figure 24: Per capita meat consumption

Can China produce all the meat for domestic demand? Does China have the range land to feed the livestocks? Does China have enough grain to feed its livestocks? If not, should China import meat, or import grain? With some additions to the current model, it will be able to address these issues.

HIV/AIDS is beginning to emerge in China. The first case was discovered in 1985, and UNAIDS estimated that by the end of 1999, the cumulative number of adults and children living with HIV/AIDS is 500,000.

It is assumed in the model that the Chinese government will do a very good job and in five years from now, in 2005, HIV infection will start to fall as the following picture shows. Annual infection will reach 128,000 persons and then gradually fall. Even so, cumulative AIDS death will reach 2 million of China's most active and productive people. AIDS orphans (at least one parent died of AIDS) will exceed 600,000, and annual expenditure on HIV/AIDS care will exceed 6 billion RMB.

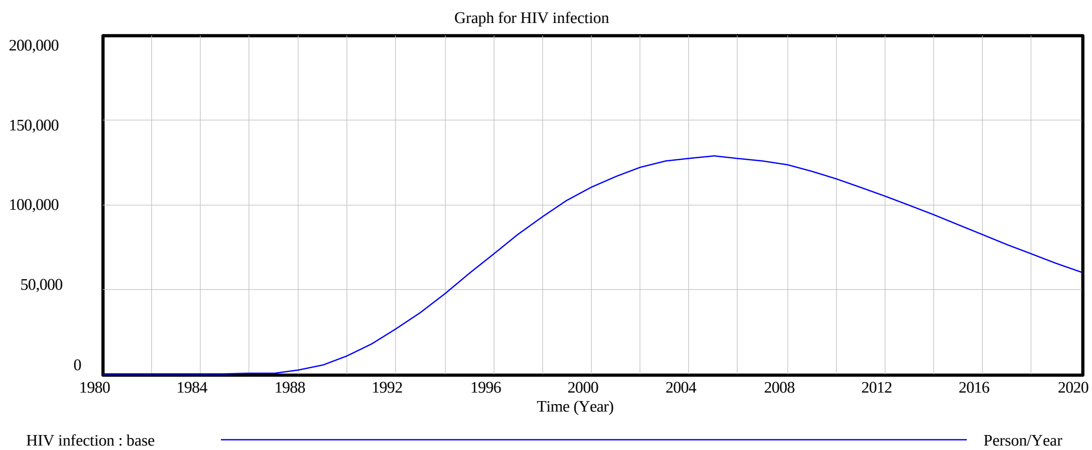


Figure 25: HIV annual infection rate

Results for Alternative Scenarios

The previous section described the projected results for the Baseline Scenario, which assumes past policies and peaceful conditions continue. This section explores some alternative scenarios.

Two child family policy.

In this alternative, it is assumed that, starting from 2000, the government changes its one-child policy to a two-child policy. Due to policy implementation difficulties, it is assumed that by 2005, total fertility rate will grow to 2.5 nationally, and then stays at 2.5 through to 2020. The new scenario, called HighTFR, will have much higher population then the baseline scenario. Total population will change from 1.42 billion to 1.56 billion in 2020. The difference is equal to about half of US's current population, and they are all under the age of 20!

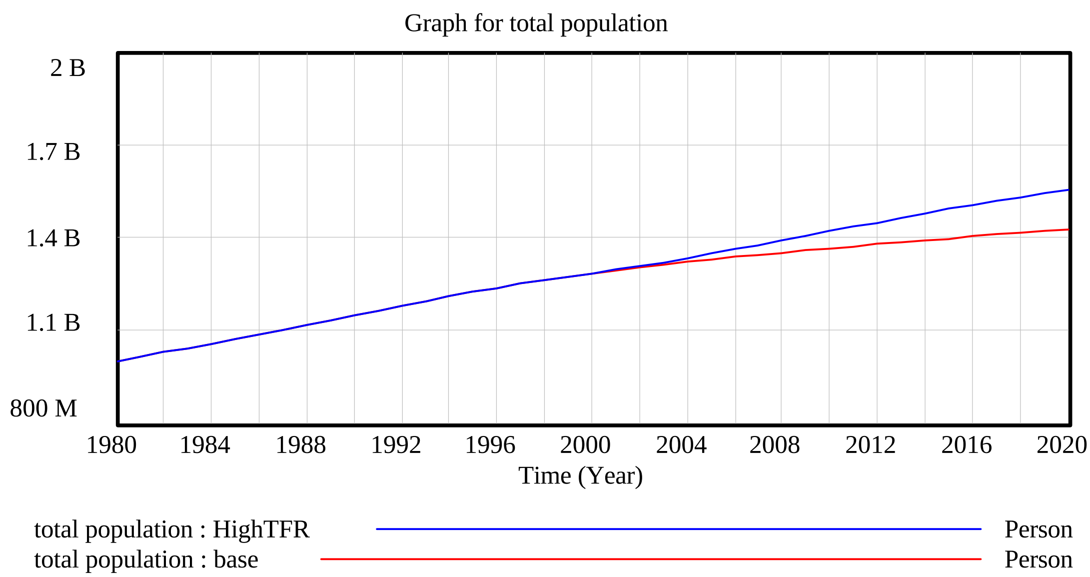


Figure 26: Total population comparison

Agricultural land loss scenario

If we allow agricultural land to be lost to urbanization and other purposes at a rate of 0.5% per year, or 500,000 hectares (7,500,000 mu) per year, by the end of 2020, we will have lost 10% of our arable land. Per capita grain from domestic production will be lower than the base case as the following picture shows. This is a scenario we certainly want to avoid.

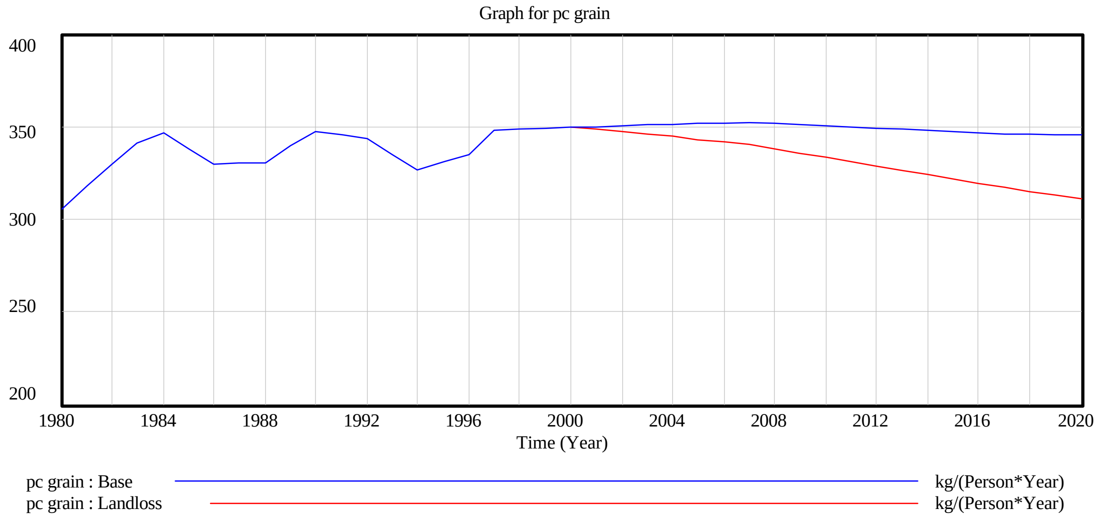


Figure 27: Per capita grain production comparison

Non-renewable (NR) resource scenario

It is assumed that when fraction NR resource remaining decreases, an increasing amount of capital will be used to seek substitutes or develop technologies for more efficient use of the NR resources. In the following picture, the horizontal axis represent fraction NR resource remaining, and the vertical axis is the fraction of capital that will be used for non-productive us.

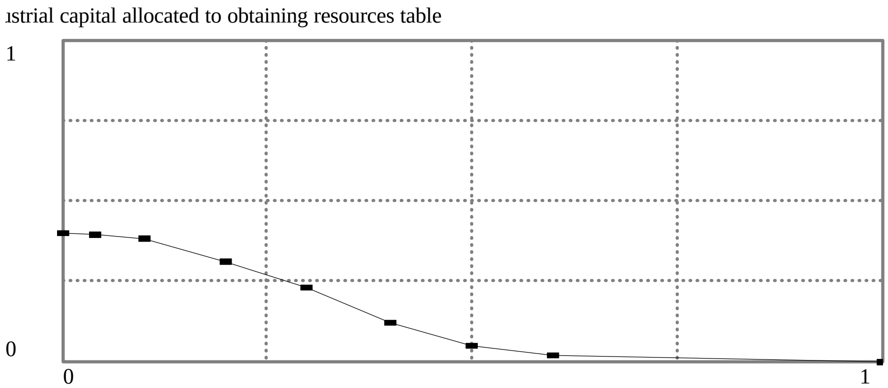


Figure 28: Table function relating industrial capital and fraction of remaining non-renewable resources

If it turns out in the future that more capital, 50% more, will be needed to deal with the shortage of NR resources, the industrial and service production in this HighNR scenario will be considerably lower than the base scenario.

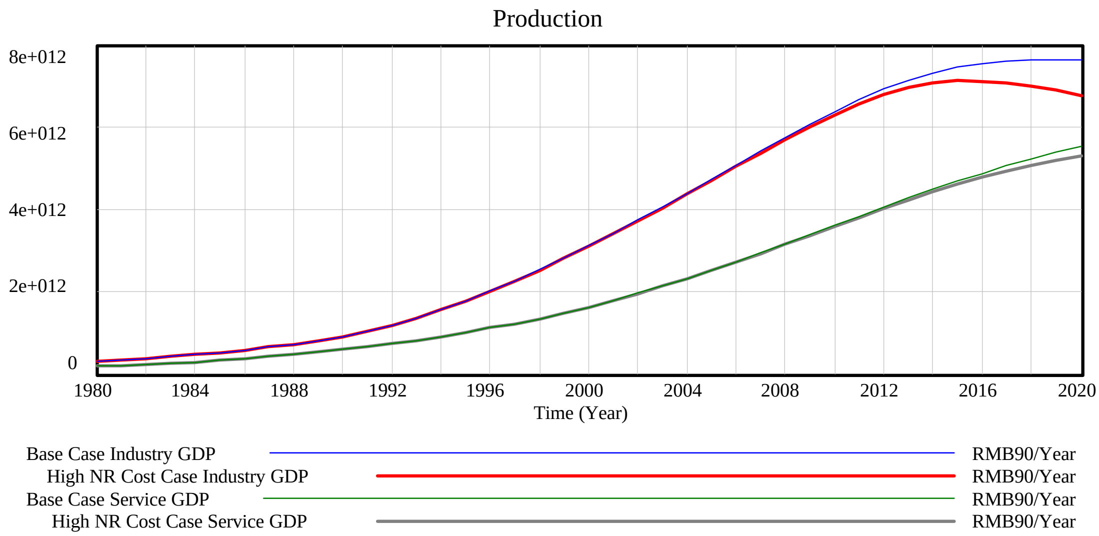


Figure 29: Comparison of production due to non-renewable resources

The industry GDP for the HighNR case is already declining before 2020, as then almost 50% of the capital in the sector needs to be used on non-renewable resources, thus becoming not directly productive. The difference in service between the two scenarios is much smaller, as service is less resource intensive.

Stricter pollution reduction scenario
Cleaning up pollution after it is produced and reducing emission both takes away valuable investment from production, but they also produce many benefits. If the Government issues more strict pollution regulations, all production sectors have to spend more on emission control, and less on direct production. The resulting pollution index is much lower now, which produces benefits for health and life expectancy:

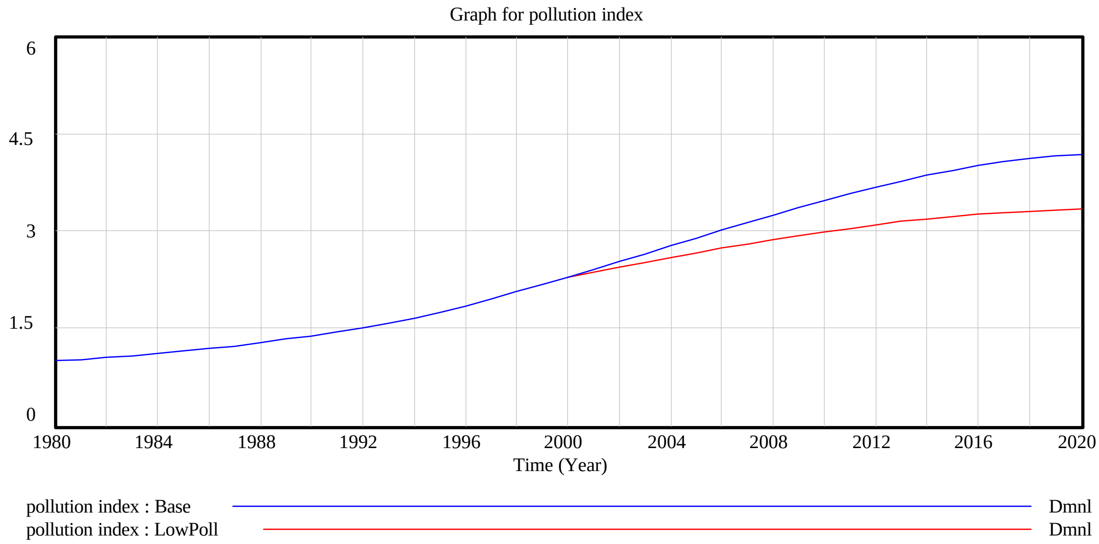


Figure 30: Comparison of pollution index

Industrial production will also be lower as the following picture shows.

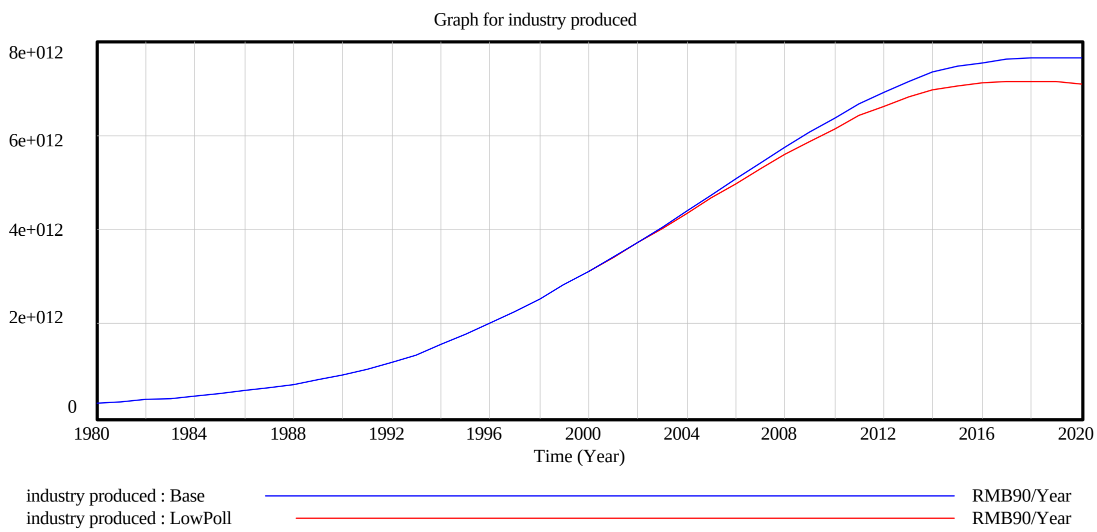


Figure 31: Comparison of industrial production due to pollution

HIV/AIDS scenario.

If the government is inefficient or slow to in adopting effective measures to stop the spread of HIV infection, the peak infection will be delayed 5 years until 2010, and the consequence will be quite startling compared with the baseline scenario. The following is the annual HIV infection rate.

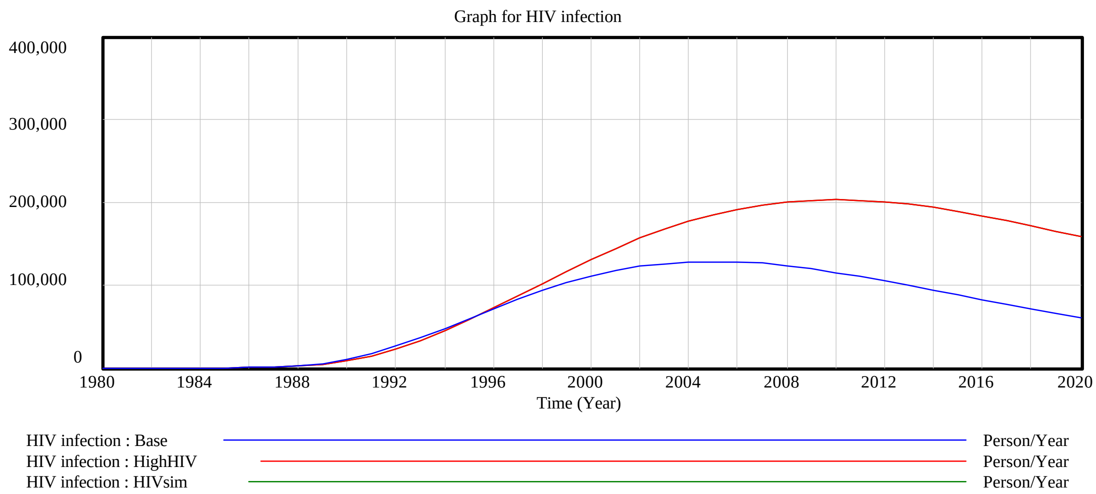


Figure 32: Comparison of HIV annual infection rate

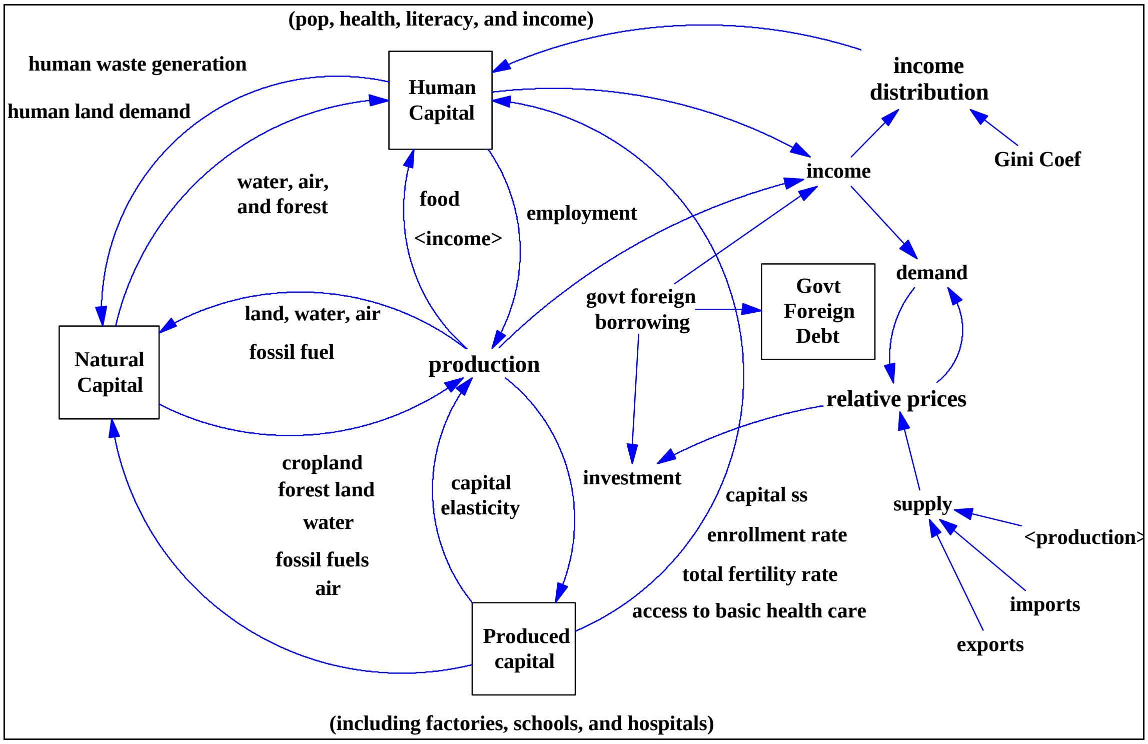
Cumulative AIDS death will reach almost 3 million (compared to 2 million in the baseline scenario), AIDS orphans will exceed 1 million (compared to 600,000 in the base case), and annual expenditure on HIV/AIDS care will be doubled in 2020, about 12 billions.

So far five scenarios have been presented and compared to the baseline scenario. These five scenarios are only a small sample of what T21 model can do to help national planners see the possible consequences of various policy choices.

Attachment: An Overview of T21

The T21 Core model is based on the culmination of more than 20 person-years of work collecting, studying, and developing national development models. Almost all the sectors are inspired and based on respected models and documentation, such Computable General Equilibrium (CGE) economic models(“From Stylized to Applied Models: Building Multisector CGE Models for Policy Analysis”, Devarajan, Lewis, and Robinson), the Intergovernmental Panel on Climate Change’s (IPCC) Greenhouse Gas Inventory Workbook, the US Department of Energy’s Fossil2 model and the IDEALS model, the Population Council’s FIV-FIV model, the RIVM’s (National Institute of Public Health and Environmental Protection of the Netherlands) Targets model, the DICE Integrated Climate-Economy model, and the US Department of Agriculture’s CPPA model.

The figure below presents a conceptual overview of the components in the T21 core model and their inter-linkages. The diagram focuses on three general types of capital—human capital, natural capital and produced capital—with economic production in the center. The arrows are meant to convey the causal effects between the different types of capital. For example, human capital affects economic production through the employment of workers, and economic production, in turn, affects human capital by providing food and income.



The figure provides insight into some of the key concepts found in the T21 core model including the following:

- Economic production is affected by each of the three types of capital – human capital, natural capital and produced capital.
- Economic production, in turn, affects the three types of capital - income and food affect human capital, investment affects produced capital and pollution and resource depletion affect natural capital.
- Production also affects the income distribution (in the top right corner) and supply (lower right corner). The model uses the log normal distribution to approximate income distribution. It uses the Gini coefficient and the mean household income to drive the log normal distribution.
- Imports and exports of the production sectors are endogenously determined. Together with production, they determine the supply of goods and services.
- Both income and relative prices are used to determine demand for goods and services.

- Relative prices change with the imbalance between demand and supply. The change of relative prices will affect the distribution of investment between sectors and further affects the production and supply of the sector.

- The government obtains revenue from domestic sources (tax and non-tax income) and foreign sources (grants and loans).

- Government expenditure includes public consumption, public investment, and interest payments. If expenditure exceeds revenue, the government needs to borrow either from domestic or from foreign sources, thereby increasing its debt and future interest payments.

For further information, see www.threshold21.com, or contact the Institute using the information on the cover page of this paper.

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