China Grain Model:
A Tool for Education and Participatory Discussion

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I. Introduction and objectives

In his book *Who Will Feed China?* Lester R. Brown, President, Worldwatch Institute asserted that over the next quarter century a population- and prosperity-driven surge in Chinese import demand for grain will far surpass total global grain exports available. Major research centers in the world, including the United Nations Food and Agriculture Organization (FAO), the United States Department of Agriculture (USDA), the World Bank, and the International Food Policy Research Institute (IFPRI) have also done research on China's food production projections but have arrived at very different conclusions. Conferences on these differences have not been effective in achieving consensus.

Because of the importance of the issue to all grain importing and exporting countries, we decided to convert the underlining mental model of Brown into a transparent computer model, to facilitate discussions among researchers and decision makers.

II. Conversion process and major assumptions

What we did first was to piece together a 16 page summary of Brown's mental model and data from material scattered throughout the 160 page of the book. This was not enough, as a computer model needs to quantify all details, including such "minor" estimate as the average width of highways to be built in China. After several hours of face-to-face discussion with Brown, all the required data were available from either the book, other reference materials, or Brown's personal estimates.

The conversion of the summary and data into a formal system dynamics model, the China Grain Model, using Vensim®, required only a few hours. Major assumptions of the model are:

1. Per capita grain demand in the year 2030 will be 400 kg/person, which is the 1995 level in Taiwan. The per capita grain demand for 1995 was 294 kg/person.

2. The only factor that will negatively affect grain yield is water shortage, especially in northern part of China. By 2030, the overall north-south combined negative factor will reach 90% (i.e., water shortage will cause a 10% decrease in grain yield).
3. The only positive factor that will increase yields is the introduction of new grain varieties. Yields will grow to 125% by the year 2030, i.e., an average 25% increase for all three grains of rice, wheat, and coarse grain.
4. Increasing the use of fertilizer will not raise yields by more than 10%, so this factor can be neglected.
5. The multicrop index was 1.56 in 1995, and will go down with the increase of per capita GDP to 1.31 in 2030.
6. Grainland converted to other crops is assumed to be 50% of the actual rate of conversion for the period 1979 to 1993, based on USDA data.
7. Land loss is the sum of three factors: new factories (including all non-farm work space), new housing, and new roads. It is further assumed that 30% of land loss is grainland loss.

III. The user-interface program and major functions of the model

A user-interface program, or VenApp™ as it is called in Vensim, was later developed to enable non-Vensim users to run the China Grain Model. All the assumptions of the model are presented in two screens of the program. Figure 1 shows one of them. Users can easily and quickly change any of the assumptions and generate their own scenarios (stories). If no changes are made, the model projects over 300 million tons of grain imports will be required by the year 2030 (Figure 2).

Some users may argue that fertilizer is an important factor in China's food production, and should not be neglected in the model. To add the factor of fertilizer into the model takes only a few minutes, if its consequences are know or can be estimated. Similarly, other factors which are currently not included in the model can be added easily.

The model can also be dissaggregated into regions or provinces, as China is a big country and food production conditions vary widely from one province to another.

With the User interface program, it is convenient to do causal tracing, i.e., to trace to the variables which caused the difference in the scenarios BASE and DEMO. Figure 4 is the start of the causal tracing, in which *grain imports required* is the active variable, which is the left hand side of the equation at the top let corner of screen. On the right are three graphs. The first graph presents the trends of the left hand side variable, and the following graphs show the trends of the right hand side variables *grain demand* and *total grain supply*. By double clicking on any of the graph titles representing the right hand side variables, such as *grain demand*, the user can trace down one level, where *grain demand* becomes the left hand side of the equation, and its trend will be shown in the first graph on the right. The new right hand side variables will appear below the first graph. In this fashion the user can quickly trace further down to the variables which cause the differences.

IV. Conclusions

The China Grain Model does produce the results Brown developed with his mental model, which means that the mental model is fundamentally consistent and its differences with other models are not the result of a logical error in Brown's work.

The model shows, however, that by changing a few assumptions, the result of the model could be dramatically different. If we change the per capita grain demand for 2030 from 400 kilograms to 300 kilograms, and further assume that the new grain variety contribution to yield will be 50% for 2030 instead of 25%, then China's grain import demand will be significantly reduced by 2030, to about 150 million tons, as Figure 3 shows. Even this level of imports, however, could be seriously disruptive to world food trade.

V. Further research

Although models on China's agricultural production exist in several major research institutions, such as FAO, USDA, the World Bank, and IFPRI, and it is a well known fact that these models make dramatically different projections on China's food shortage in the future, little success has been achieved in promoting the discussions among modelers and resource and environmental experts like Brown.

One possible reason of such failure is that models are usually complex, opaque, and large in size, and it takes so much effort to study another person's model that so far no one has done a thorough quantitative study of all these major models. What we want to do next is to excerpt major structures and parameters from each of the major agricultural models to form smaller, simpler, and transparent models that generate similar results. We will then submit these models to its original developers for review and comments. After modifying the models based on the feedback we obtain, we may be able to identify the key factors that differ, or even develop a model which is basically acceptable to all. This is our ultimate objective.

V. References

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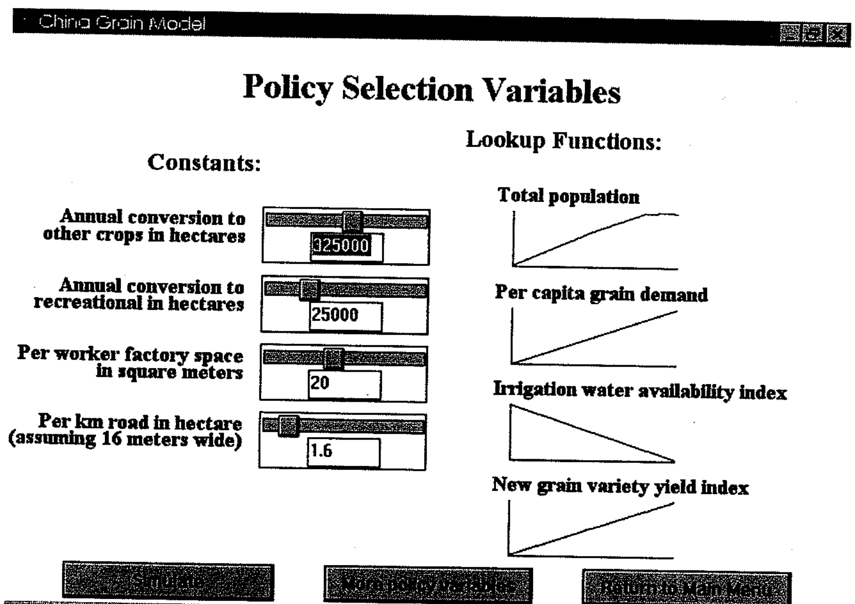

Figure 1. Sample of model assumptions

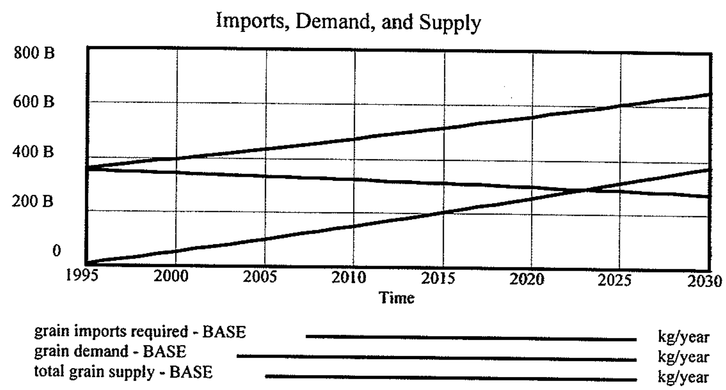

Figure 2: Sample of model output

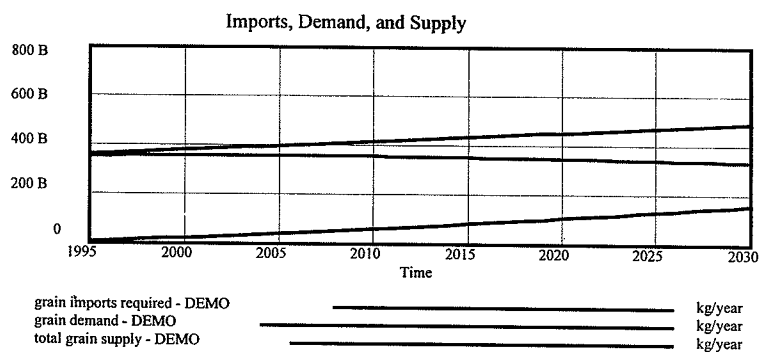

Figure 3: Output of a different scenario (DEMO)

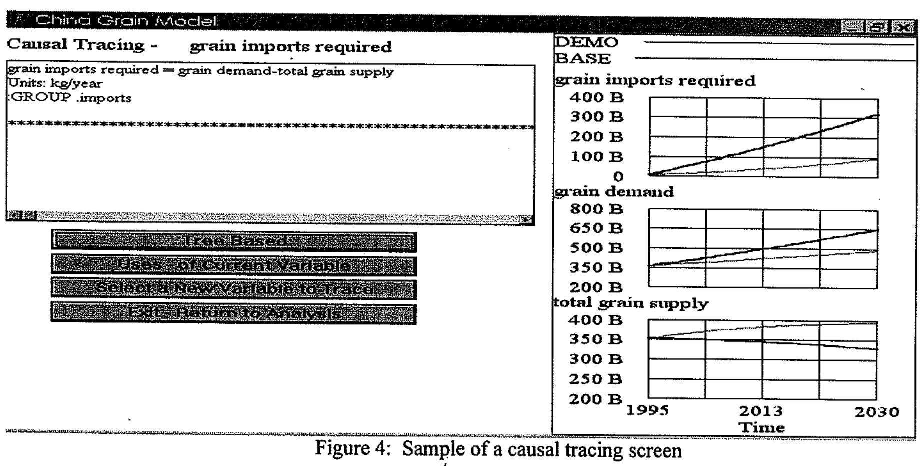

Figure 4: Sample of a causal tracing screen