China's Food demand, supply and trade in 2030: simulations with Chinagro II model

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The presentation describes prospects and challenges for Chinese agriculture until 2030 under different scenarios, using the Chinagro welfare model. A scenario is defined as a coherent set of assumptions about exogenous driving forces (farm land, population, non-agricultural growth, world prices etc.), derived from the literature and own assessments. Under these assumptions, simulations with the Chinagro model analyze the price-based interaction between the supply behavior of farmers, the demand behavior of consumers and the determination of trade flows by merchants.

The outcomes from the *Baseline scenario* seem reassuring in that foreign imports remain moderate relative to China's size, though quite large as fraction of world trade. It would be possible to feed people as well as animals without excessive imports. There is even a potential for significant export flows of vegetables and fruits. Regarding concerns, the trends in per capita agricultural value added are problematic, because they stay in all regions behind per capita value added outside agriculture, albeit that they are rising steadily. This leads to growing disparity in per capita incomes within and across regions. The mounting environmental pressure from fertilizer losses and unused manure surpluses is another cause of concern. The second scenario, the *Trade liberalization scenario*, appears to hurt farm incomes more than it benefits them and to raise the gap with non-agriculture, also because food becomes cheaper in urban areas. Hence, it highlights the difficult choice between economic efficiency and poverty alleviation that agricultural policy makers often face. The *High income growth scenario* reinforces the national food self-sufficiency result of the baseline simulation. Even with meat demand higher than under the baseline, levels of imports remain manageable. Under the *Low income growth scenario* the per capita income gap between rural and urban widens as lower outmigration keeps large numbers of workers dependent on agriculture, and reduces farm revenue because of lower demand and depressed prices, not to mention the reduced remittances not explicitly considered in the model. The *Enhanced irrigation scenario* shows outcomes similar to those often found in scenarios with high technical progress. The agricultural trade balance improves and consumer welfare improves, but farmers have to cope with drops in prices, and those who do not benefit from land improvement, only experience losses through falling prices.

Finally, the two *Biofuel scenarios*, one with production on the regular cropped area, the other including production on marginal lands indicate that the government target of 10 million tons of bioethanol by 2020 seems a prudent one, causing no major disturbances in national food security, and no aggravation of pollution via fertilizer, essentially because the burden of supplying the additional biofuel feedstocks is largely shifted to the world market, which raises the import prices a little but not much. In fact, the gains in farm incomes are not large either. Food consumers and livestock farmers face negative consequences of the additional feedstock demand, albeit limited.

The option of cultivating biofuels on new marginal land would certainly further limit these negative domestic effects, and also reduce the pressure on the world market. But it does not really change the picture of agricultural supply and incomes, at least not in terms of national averages. Naturally, it will result in positive income effects that are significant for specific poor segments of the rural population in remote areas. However, the availability of such marginal lands is limited.

More specifically, regarding trade volumes, the conclusion would seem to be that China is likely to become an even greater importer of vegetable oils, carbohydrates and protein feeds than it is today, and possibly expand its imports of maize for animal feeds, largely from North and South America, Australia, and possibly Central Europe. Any expansion of the currently modest biofuel targets strengthens this tendency. At the same time, biofuels have little to contribute to farm incomes.

On the export side, the opportunities for fruits and vegetables stand out both as agricultural export commodities and as a source of rural income, also because of a dietary shift away from staples towards fruits and vegetables and livestock products. While it seems clear that foreign competitors, Europe in particular, currently enjoy technological advantages and benefit from a mild climate, China can offer a rich variety of products many of which are new on the international market. It would seem that major two-way traffic may emerge in horticultural products generally, and that there is good scope for joint ventures for exports to other continents.

Regarding livestock products the situation is much less clear. On the one hand livestock remains a major source of farm income in China, in fact the major source of income growth, partly due to the loss of crop land to urbanization, and made possible by rising incomes, and a shift to a more urban, and hence meat and dairy intensive lifestyle. Yet, for pork, poultry and eggs, the risk of pandemics that may impact on the urban population, would suggest relegating such operations to regions of low population density. However, such regions may find it harder to compete with imports, particularly in coastal cities.

For dairy products the options are even more diverse, as the advantages of mild climate and proximity of cities may outweigh the ample availability of grazing land at greater distance, whereas for imports compliance with food safety requirements is checked more easily. This finds expression in widely different import levels of dairy under various Chinagro scenarios.

Annex. Brief introduction to the Chinagro model and the transition from Chinagro I to Chinagro II

The CATSEI-project is the successor of CHINAGRO, also an EU funded project, during which the Chinagro (I) model was developed and used for agricultural policy analysis The model structure is described in Keyzer and Van Veen (2005), while a comprehensive list of classifications and the data base are documented in Van Veen et al. (2005). It has been designed so as to represent the following five aspects of agricultural planning in sufficient detail:

(1) the constraints of geophysical and natural resource conditions on agriculture production,
(2) the market forces determining the distribution of agricultural activities,
(3) the spatial spread and social diversity of China's population,
(4) the impacts of policy on farm incomes and on regional disparity,
(5) the environmental impacts of agriculture.

During the CATSEI project this model was used still (Fischer et al. 2007) but to remain valid and capable of addressing the relevant questions, such a tool needs maintenance and modification at regular intervals. Hence it was decided to engage in a full update and to introduce two major innovations.

Chinagro II is a 17-commodity, 8-region general equilibrium welfare model. Farm supply is represented at the level of 2,885 counties (virtually all, 2433 in Chinagro I), and accommodates for every county outputs of 28 products and 14 land use types and livestock systems. Consumption is depicted at regional level, separately for the urban and the rural population, each divided into three income groups, and domestic trade is interregional.

The Chinagro-model describes the price-based interaction between the supply behavior of farmers, the demand behavior of consumers and the trade flows connecting them. Farmers maximize their revenue by optimally allocating labor and equipment to cropping and livestock activities, at exogenously specified land resources, stable capacities and levels of technology, while taking the buying and selling prices in the county as given. Consumers maximize their utility, at given prices, by optimally allocating their expenditures according to a utility function that is quasilinear, i.e. linear with unit coefficient in part of non-food consumption and obeying a linear expenditure system in agricultural commodities and the remainder of non-agricultural consumption, which acts as numeraire.

Trade between regions in China and with the rest of the world is cost minimizing at exogenously given world prices and import and export tariff rates. Through its significant geographic detail, the model can incorporate location-specific information on climate, resources and technology while its equilibrium structure enables it to represent coordination flows among the various agents and describe market clearing at different levels.

A model with such a level of detail in classifications is not designed to represent truly endogenous dynamics, as this would inevitably lead to serious accumulation of prediction errors over time. Therefore, a formulation was opted for that assumes an exogenous value for a wide range of driving variables, and statically solves for the values of the endogenous variables for each year of simulation separately, given the assumed values of the driving variables. Together these exogenous variables define a simulation scenario.

Major driving forces are non-agricultural output growth, population growth, urbanization and interregional migration, international prices, changes in land and water resources and stable capacities, adjustment of food preferences, technical progress and trade liberalization. The important role of these driving forces requires a careful and coherent specification of their future trends.

Chinagro II is a tool for policy simulation over the period 2005-2030. Current application distinguish scenarios of six types, each of which reflecting specific pathways for the major driving forces: (i) baseline, (ii) trade liberalization, (iii) rapid or slow economic growth, (iv) high agricultural R&D investment, (v) enhanced irrigation efforts, and (vi) various modes of implementation of biofuel policies.

Transition from Chinagro I to Chinagro II

Update of the database and modification of the model specification were major activities during the CATSEI project, leading to the transition from Chinagro I to Chinagro II, as follows:

- Database update from 1997-2003 to 2005-2010
  - with associated change in county list from 2433 to 2885 and associated new county maps
  - use of NSBC household surveys
  - as in Chinagro I, 100% replication of base year data by model after multiple plausibility checks

- Changes in model specification
  - Chinagro I:
    - world prices given by scenario
    - labor, land and stable capacity allocation across farm-types, crop and livestock output by farm-type obeying a (CES-)profit function
  - Chinagro II
    - price adjustment on world market via import and export functions, estimated on basis of simulations with GTAP-model
    - also land and stable capacity balances by crop/livestock type within each farm type, and with it explicit yields
      - allowing for technical progress by crop/county/farmtype
      - with possibility of abandoning crops and allowing for new crops
    - detailed nutrient accounts (N,P,K) for crops and manure

The need for the update of the database hardly needs comment but as Chinagro is the most detailed model of Chinese agriculture available, this update is no major task, particularly since it requires reconciling data from diverse sources, and the partitioning into counties changed significantly since 1997, witness the increase in their numbers, and since most published data are available by province only.

Regarding model specification, with hindsight after the food crisis the need for some changes seems evident as well, but this was less clear in 2006 when the CATSEI-project was formulated. First, features such as scarcity on world markets, and China being a major importer of protein

feeds and carbohydrates, are now well accepted, calling for explicit price adjustments. To this effect, price data were collected by computed solutions of the GTAP model, for given net trade of China and trade functions were estimated.

Second, the Chinagro I formulation was found to be insufficiently explicit regarding the physical constraints within each farm-system. Specifically, the competition for land across crops, and for stable capacity across livestock types can now be represented under Chinagro II, and so is yield improvement by crop and livestock. This also makes it possible to follow nutrient balances by crop and manure discharges by animal type. Apart from its degree of spatial and social detail Chinagro II is now unique in its capacity to accommodate such physical balances in volume terms while maintaining continuous responses to price changes and allowing for full calibration to and hence complete replication of a comprehensive database.