China's Food Demand, Supply and Trade in 2030: Simulations using the Chinagro II Model

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Contribution to CATSEI Synthesis Report, May 2011[1]

The report describes prospects and challenges for Chinese agriculture up until 2030 under different scenarios, using the Chinagro welfare model. A scenario is defined as a coherent set of assumptions about exogenous driving forces (farmland, population, non-agricultural growth, world prices etc.), derived from the literature and our 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.

1. Introduction

As explained in the previous section by Huang et al. (this issue), China's agricultural economy will have to cope with many challenges in the coming decades. Rising incomes outside agriculture and further urbanization will continue to push up demand for feed and meat, while the tight energy situation is leading to increasing calls for the cultivation of biofuel crops. At the same time, the government wants to secure the domestic supply of major grains at stable, affordable prices, which will be a complex undertaking in the rather liberal agricultural trade environment in which China has operated since joining the World Trade Organization (WTO) in 2001. Agriculture itself also has to adjust. Sustained labor outflow and mechanization will be necessary to prevent further increases in urban-rural income gaps. Furthermore, measures must be taken to reduce the environmental damage caused by nutrient pollution (emissions and leakages) and to fight water shortages in the northern regions.

These transition processes are precisely the topics that lie at the heart of the CATSEI project, and we have studied them in two ways. First, the project addresses transition processes in separate studies that focus on specific fields. Second, the project applies a general equilibrium welfare model, the Chinagro model, to integrate findings from the various fields into one comprehensive analysis. In this way, the project seeks to gain quantitative insights into the trends that are likely to emerge. core

China is not the only country in transition, of course; worldwide, one can also observe significant changes. Since 2005, world agricultural prices have been more volatile than in the past, and it is predicted that raw materials will become scarcer. This analysis applies equally

[1] The core of this report coincides with the presentation at the CATSEI Final Policy Forum, Beijing, November 19th, 2010.

well to food, feed, fuel, fibers and fertilizer, collectively known as 'F5'. Figures 1 and 2 show recent price trends for cereals and meat, respectively.

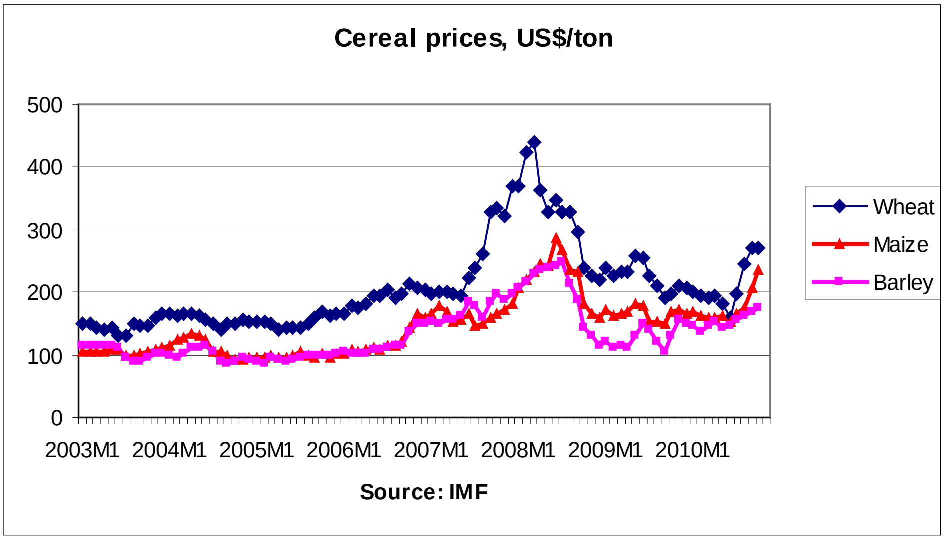

Figure 1. World cereal prices, 2003-2010

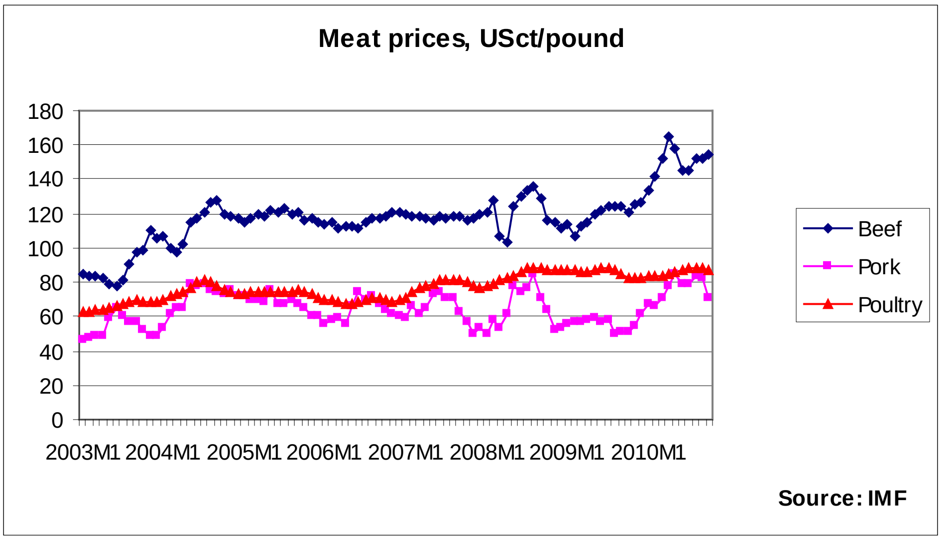

Figure 2. World meat prices, 2003-2010

Given these tensions on the world markets, a central question is whether China's ambitions can indeed be met and, if so, which pressures it will impose on other countries. Below, we present the main outcomes of simulations on this and related issues, using the Chinagro model and for the period up until 2030.

2. Chinagro

The first version of the Chinagro model was developed and used for agricultural policy analysis in the CHINAGRO project, the predecessor of the CATSEI project, which was also funded by the EU. The model's structure is described in Keyzer and Van Veen (2005), while a comprehensive list of classifications and the database are documented in Van Veen et al. (2005). The model has been designed so as to represent the following five aspects of agricultural planning in sufficient detail:

(1) the constraints placed by 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 impact of policy on farm incomes and on regional disparity,
(5) the environmental impact of agriculture.

The Chinagro model is a 17-commodity, eight-region general equilibrium welfare model. Farm supply is represented at county level (2,433 in the first version, virtually all of China's counties). For every county, the model accommodates the outputs of 28 activities and nine land-use types and livestock systems. Consumption is depicted at regional level; it is depicted separately for the urban and the rural populations, each of which are divided into three income groups. Domestic trade is interregional.

The 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 systems, at exogenously specified land resources, stable capacities and levels of technology, while taking the buying and selling prices in the county as given. In addition to purchased inputs, local inputs such as crop residuals, grass, organic manure and household waste contribute to the production process. Consumers maximize their utility at given prices, by optimally allocating their expenditure according to a utility function that is quasilinear; that is, linear with unit coefficient in part of non-food consumption and obeying a linear expenditure system in food commodities and the remainder of non-food consumption.

Trade between China's regions and with the rest of the world is cost-minimizing at given world prices and import and export tariff rates. Due to 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.

At the beginning of the CATSEI project, the first version of the model was still being used (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, from Chinagro I to Chinagro II, and to introduce two major innovations at the same time.

The database was updated from 1997-2003 to 2005-2010, with associated change in the county list from 2,433 to 2,885, and associated new county maps. The need to update the database hardly requires comment, but as Chinagro is the most detailed model of Chinese agriculture available, such an update constitutes a major task. This is particularly due to the fact that data from diverse sources needs to be reconciled, since there have been significant changes in China's partitioning into counties since 1997 (as can be seen from the increase in the number of counties), and since most published data are only available by province.

Regarding model specification, world price functions were added to the model covering the reaction of world prices to changes in China's net trade flows. In Chinagro I, world prices were simply exogenous. The current scarcity in world markets, with China being a major importer of protein feeds and carbohydrates, explicitly calls for this adjustment. The functions were estimated from price data collected by computing solutions from the GTAP[2] model for a sample of China's net trade flows.

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 activities can now be represented under Chinagro II, as 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 unique in its capacity to accommodate such physical balances in terms of volume, while maintaining continuous responses to price changes and allowing for full calibration to, and hence, complete replication of a comprehensive database.

3. Scenario simulation

A model with such a level of detail in classifications is not designed to represent truly endogenous dynamics, as this would inevitably lead to a serious accumulation of prediction errors over time. Therefore, we opted for a formulation that assumes an exogenous value for a wide range of driving variables, and provides separate static solutions for the endogenous variables for each year of simulation, 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 played by these driving forces requires us to make a careful and coherent specification of future trends, derived from the literature and our own assessments.

Chinagro II is a tool for policy simulation over the 2005-2030 period. Current applications distinguish six types of scenario, each of which reflects 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. Below, we will discuss the baseline and four of these policy variants.

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[2] Global Trade Analysis Project; see Hertel (1997).

4. Baseline scenario

In the baseline scenario, the main driving forces through to 2030 are: (i) sustained growth of non-agricultural output, albeit at a lower annual rate (average of 6-7%) than the double-digit rates of recent years; (ii) moderate population growth (to 1436 million people by 2030), with urbanization rising to 60%; (iii) moderate cropland losses; (iv) continued intensification of the livestock sector, with higher feed efficiency but less based on residuals; (v) steady improvement of input efficiency and yields in cropping; (vi) further trade liberalization; (vii) abolition of farm taxes; (viii) introduction of grain price support; and (ix) no significant biofuel use of crop output. The trends in world food and feed prices are based on the joint projections of the UN Food and Agricultural Organization and the Organization for Economic Cooperation and Development (FAO-OECD, 2009), but with upward adjustments for grains, feed and meat. They can nevertheless be characterized as modest in terms of their assumed rise in meat and biofuel demand worldwide.

The discussion of the outcomes of this baseline scenario begins with the average annual growth rates of production and consumption over the whole 2005-2030 period, shown in Figure 3. Wheat and rice consumption growth is very limited, since demand for these staple foods is more or less satisfied and even decreases in per capita terms due to urbanization. Still, partly due to the grain subsidies, the crops are sufficiently attractive for farmers to let production growth outpace consumption growth. Demand for maize grows faster, at more than 1% annually, since it includes feed. Although maize output does not do too badly, it is not enough to keep up with demand. The same applies to the cash crops, edible oils and sugar. For fruits and vegetables, however, production grows faster than consumption, allowing for an increase in exports. Compared to the other food items, consumption of vegetables grows at a relatively low rate, since current levels of consumption are already quite high. The largest growth rates of consumption are found for meat, milk, eggs and fish, ranging from 2- 4% annually, due to the steady increases in income. Although production of these commodities also adjusts rapidly, it is not enough to fully meet the increased demand.

Hence for most commodities, demand rises faster than production. The exceptions are rice, wheat, fruits and vegetables. These trends are reflected in the net export levels shown in Figure 4, which shows increasing imports for edible oils (from 10 to 15 million tons), sugar (from 1 to 2.5 million tons), pork and poultry (taken together as white meat, and going from small exports in 2005 to 2.5 million tons of import in 2030) and, in particular, dairy (from 1 to 12.5 million tons). Regarding dairy, it should be mentioned that the amounts are expressed here in their fresh milk equivalents. In terms of the products that are actually traded, such as milk powder, condensed milk, butter or cheese, the volumes would be considerably lower (say, a factor of five to six). On the other hand, rice exports rise from almost nothing to close to 3 million tons; wheat imports disappear, resulting in a regime of autarky; and exports of fruits and vegetables increase considerably, from 8 to over 20 million tons. A special caveat applies to the latter, however, since the increase presumes that other countries will not use sanitary and phytosanitary (SPS) measures as non-tariff barriers to trade, while China can also find the regional niches to realize its export potential. Fish exports remain moderate, reaching 1.2 million tons in 2030.

The scenario has been designed such that meat demand is largely met by China's own production, since the livestock sector is an important source of farm income. Consequently, China increases its reliance on the world market for animal feed, especially since the availability of traditional feed (such as crop residuals, grass and household waste) cannot expand at the same rate as the livestock sector. Figure 5 shows the increases in tradable feed imports, classified into three commodities, namely maize, carbohydrate feed and protein feed. Maize was actually exported in 2005, albeit at subsidized prices to get rid of excess stock. For 2030, however, the baseline projects a switch to substantial import volumes, at around 16 million tons, presuming that government tariff policies will indeed allow large volumes of imports at relatively low tariff rates. Carbohydrate feed covers feed types other than maize that are relatively rich in carbohydrates, such as those based on tubers and minor grains, while protein feed covers feed types that are relatively rich in proteins, such as oilseed cakes and wheat and rice bran. Imports of carbohydrate feed go up from 1 to 14 million tons, expressed in grain equivalents, and protein feed imports rise from 24 to 58 million tons, expressed in term of cake equivalents. While the latter flow is particularly huge, world trade in soybean cake alone is already quite large, with about 125 million tons in 2008 (of which 65 million tons as part of whole beans, when applying a cake content of 0.82).

Considered as a share of the demand in China, these import volumes are not excessive. The largest shares are to be found for edible oils and protein feeds, at 52% and 42% respectively. All other shares are below 20%. Neither do the imports pose financial problems for China, given the country's large non-agricultural trade surplus.

For the world market, however, the amounts are substantial. China's efforts to secure part of its agricultural imports via leasing or obtaining land in other continents (a practice that has become known as 'land grabbing') must be seen in this context. Especially for carbohydrate and protein feed, China's imports may imply a claim to 30-40% of total world trade, while for maize and edible oil, the share could amount to 15-20%. Based on separate simulations using the worldwide GTAP model, the effect of China's import increases on world feed prices is estimated at about 5%. This is a significant effect that will indeed be noticed by farmers and consumers worldwide, but it will not necessarily lead to turmoil.

Turning to revenues, Figure 6 shows that the future of livestock farmers promises to be better than the future of crop farmers. While the incomes of the latter rise by an average of about 2.3%, livestock farm earnings increase by 4-7%, depending on the region. For all farmers together, the annual increase is between 3% and 3.5% in most regions. Although farm labor decreases and the incomes per laborer consequently rise at a faster rate than absolute earnings (nationwide by 4.1%), the gap compared to industry and services becomes larger. From the point of view of containing the urban-rural income disparity, this trend is of serious concern, since urban incomes are already much higher than rural incomes.

Figure 7 gives more detail on the pattern of consumption of cereals and meat in the coming decades (of which the totals are shown in Figure 3 above). Figure 7a shows that cereal consumption in rural areas stagnates at about 180 kg per person per year. Urban cereal consumption is much lower at just above 110 kg, and increases slightly due to processed wheat and cakes. Since the degree of urbanization rises, average per capita cereal consumption falls, from 150 to 139 kg per person per year. The pattern for meat is much more dynamic, as shown in Figure 7b. Larger incomes lead to rising consumption in both rural and urban areas. By 2030 average meat consumption (excluding eggs) is about 75 kg per person per year (measured in terms of carcass weight), with consumption in urban areas still much higher than in rural areas (89 kg versus 54 kg).

Total consumer energy intake (not shown here) is adequate on average, with 2892 kcal per person per day in 2030 in urban areas, and 2784 kcal per person per day in rural areas. In 2005 these figures were 2548 kcal and 2606 kcal for urban and rural areas respectively, as derived in the model's base year dataset. Hence, the baseline scenario projects a moderate, satisfactory increase in energy intake, with urban consumers catching up with and even overtaking rural consumers.

Finally, the environmental pressure from cropping is shown in Figure 8. The detailed representation of agricultural production in the Chinagro model allows calculation of nutrient balances for nitrogen (N), phosphate oxide (P_2O_5) and potassium oxide (K_2O). On cropland, the nutrient supply comes from chemical fertilizer, organic manure of both animal and human origin, and (in the case of nitrogen) from fixation from the air. The difference between the total supply and the uptake by the crop (subtracting the nutrients in crop residuals that are recycled and remain on the land after the harvest) is defined as the net nutrient surplus. If this is negative, it means that the plant must extract additional nutrients from the soil. If it is positive, it means that there is a potential danger of nutrient pollution.

Figure 8 shows that nitrogen and phosphate have a steady positive surplus (150 and 50 kg per hectare of cropland, respectively), while potassium is increasingly mined from the soil (from 30 kg per hectare in 2005 to 40 kg per hectare in 2030). What happens to the positive surplus? Part of it will run off to surface water, part of it will leach into the groundwater and, in the case of nitrogen, part will be emitted into the air. The remainder will be absorbed by the soil.

Due to their significant size, each of these three net surpluses poses a serious environmental challenge. Nitrogen surpluses may be emitted as greenhouse gas (nitrous oxide), leach into the groundwater with a potential toxic effect on drinking water (formation of nitrites) or cause eutrophication in surface water (due to nitrates). Phosphate surpluses may well also lead to eutrophication, enhancing the concentration of algae in lakes and rivers. On the other hand, sustained potassium deficits may result in reduced crop yields in specific areas, since soil mining cannot go on forever. In short, these outcomes call for more efficient application of nutrients in farming. For phosphates, the need for efficiency is even greater, since there are serious concerns about the looming worldwide scarcity of this crucial nutrient.

5. The regional dimension

The geographical differences underlying the aggregate baseline outcomes can be shown in county maps. Here, we present four such maps: one on output, one on income and two on environmental challenges. In general, these pictures reveal that the effects can be quite different across the regions, and regional development must take these differences into account.

More specifically, Figure 9 shows how the growth of maize output (on average 0.81% annually, in spite of some decline in the sown area on rain-fed land) differs by county. The figure shows steady growth rates throughout China. In absolute terms, more than half of the output increases are realized in the major producing areas in the North and Northeast. In terms of growth rates, however, these regions do not stand out, with the exception of some irrigated areas in Northeast. Figure 10 illustrates the differences in farm income growth, with the highest rates in the regions where livestock is relatively important. Figures 11 and 12 show the distribution of the net surpluses of phosphate and potassium oxide over the counties in 2030. Not surprisingly, the national average sign is also the dominating phenomenon in most counties, although there are exceptions. The excessive application of phosphates is most severe in the Center and the South, while the depletion of potassium is prevalent in most regions of the country, except for the South and the Plateau.

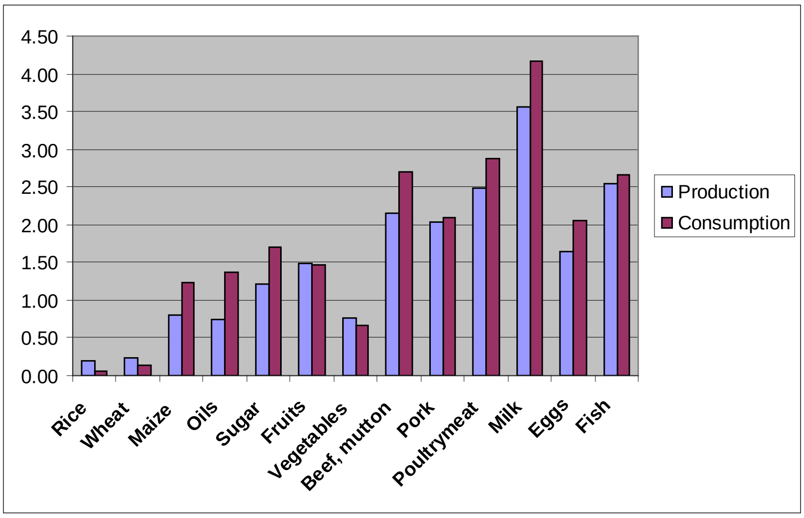


Figure 3. Annual growth rates of production and consumption in the baseline, in %, 2005-2030

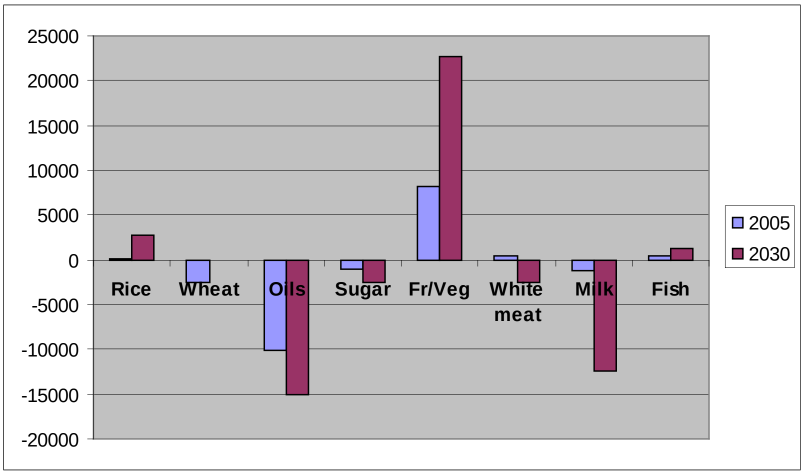


Figure 4. Net export levels for food in the baseline, in 1000 ton, 2005 and 2030

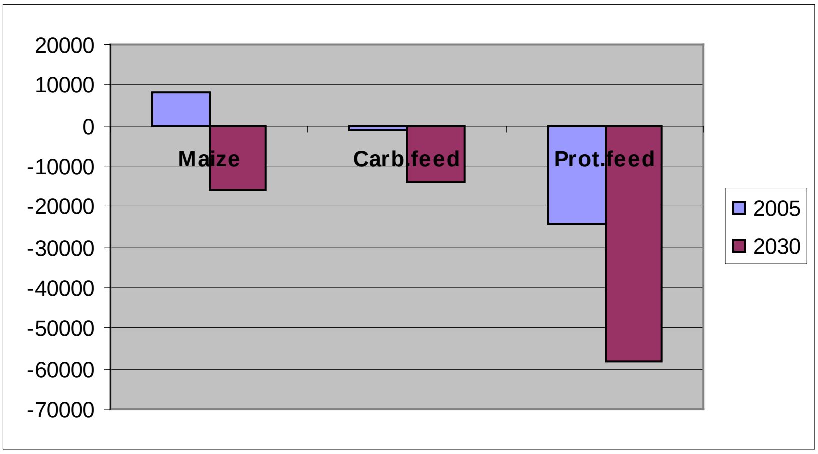


Figure 5. Net export levels for feed in the baseline, in 1000 ton, 2005 and 2030

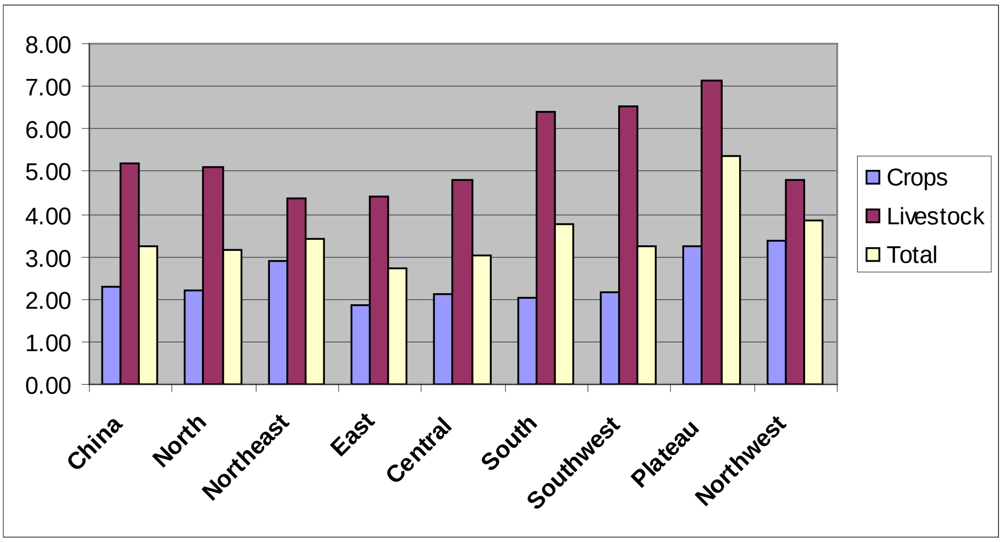
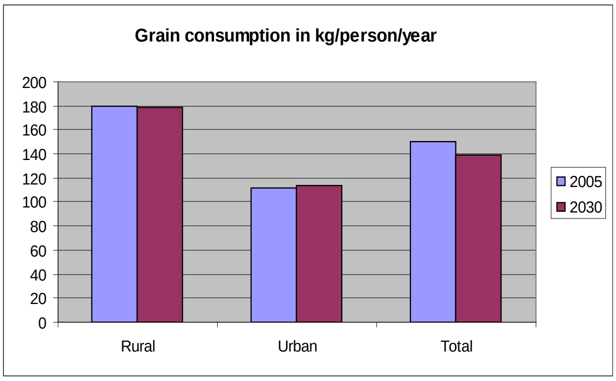


Figure 6. Annual growth rates of farm value added in the baseline, by region, in %, 2005-2030



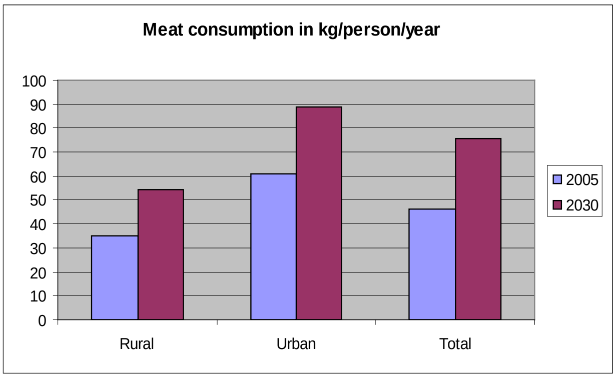


Figure 7. Household consumption in the baseline, in kg/person/year, 2005 and 2030: a) grain and b) meat

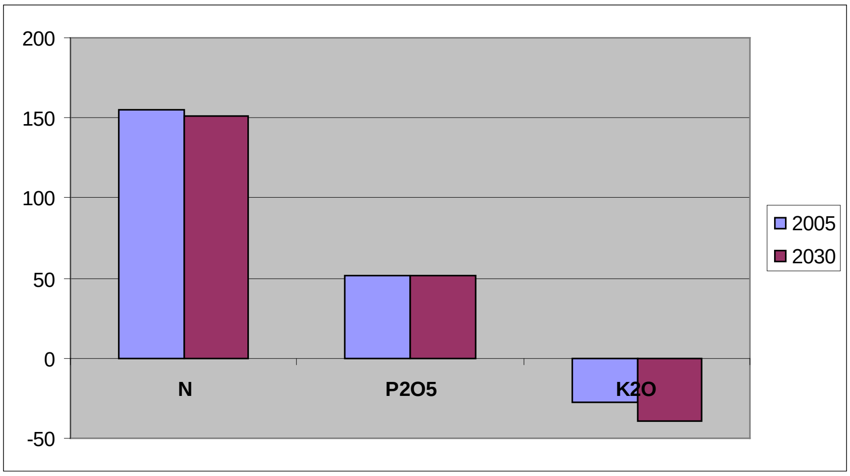


Figure 8. Net nutrient surpluses in the baseline, in kg per ha cropland, 2005 and 2030

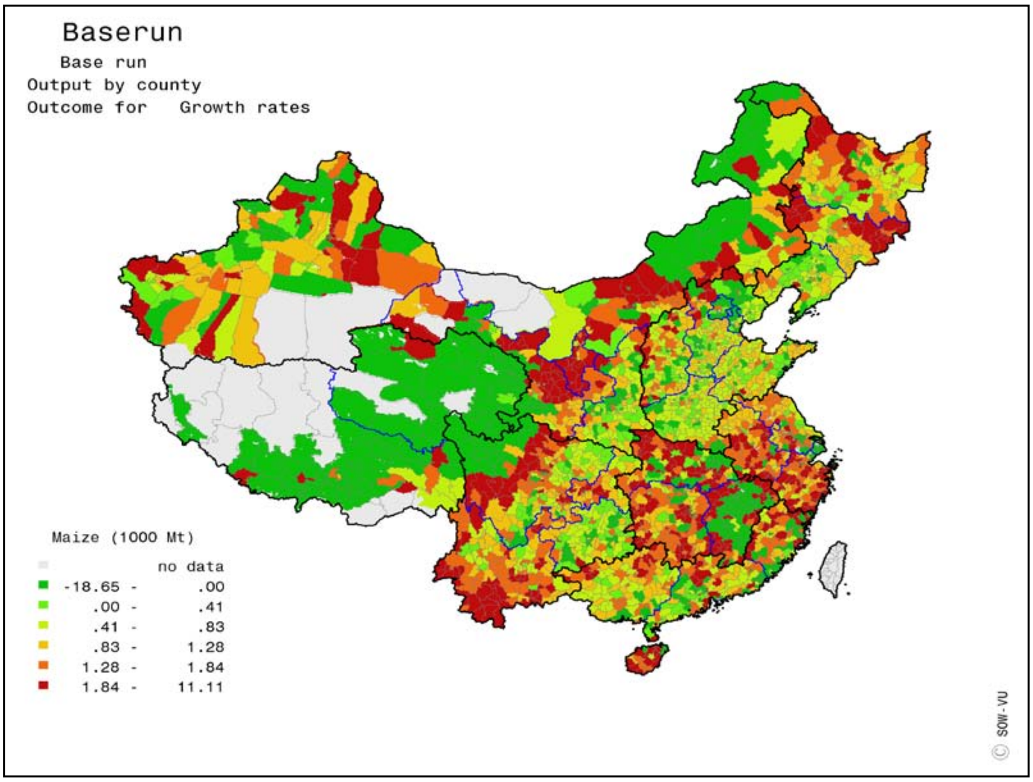


Figure 9. Baseline, annual growth of maize output, by county, in %, 2005-2030
'Steady growth in maize output throughout the country'

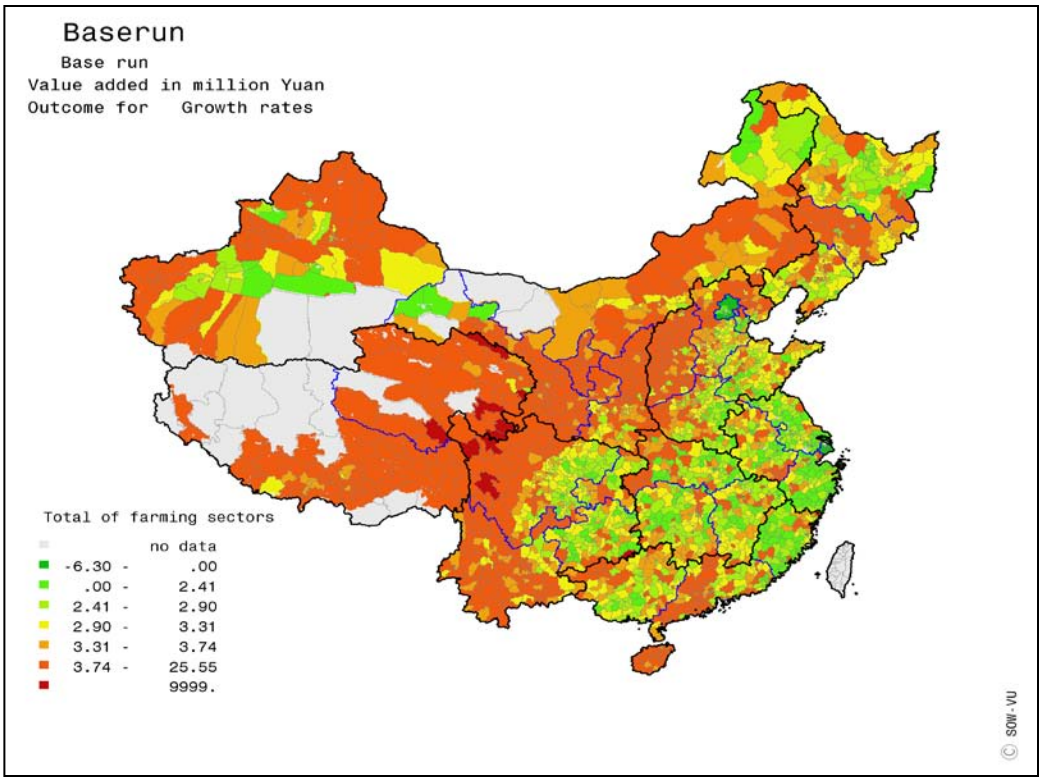


Figure 10. Baseline, annual growth farm value added, by county, in %, 2005-2030
'Highest growth rates where livestock is relatively important'

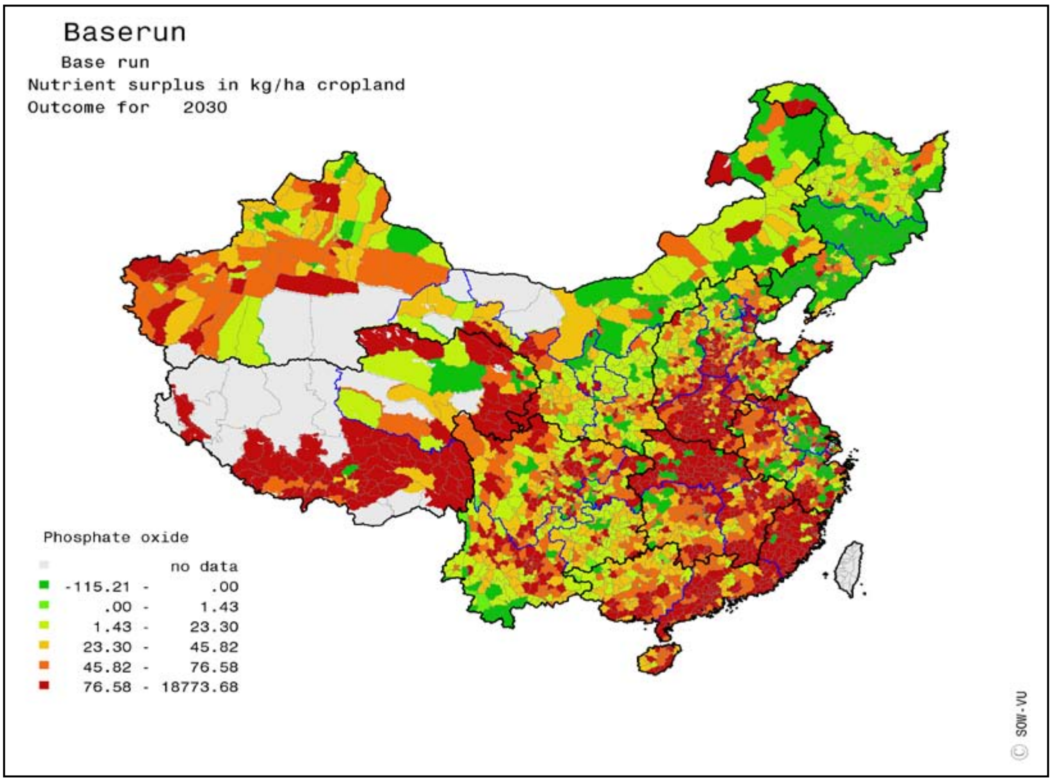


Figure 11. Baseline, net surplus of P-oxide on farmland, by county, 2030, in kg/ha
'Excessive application of P more common than deficit'

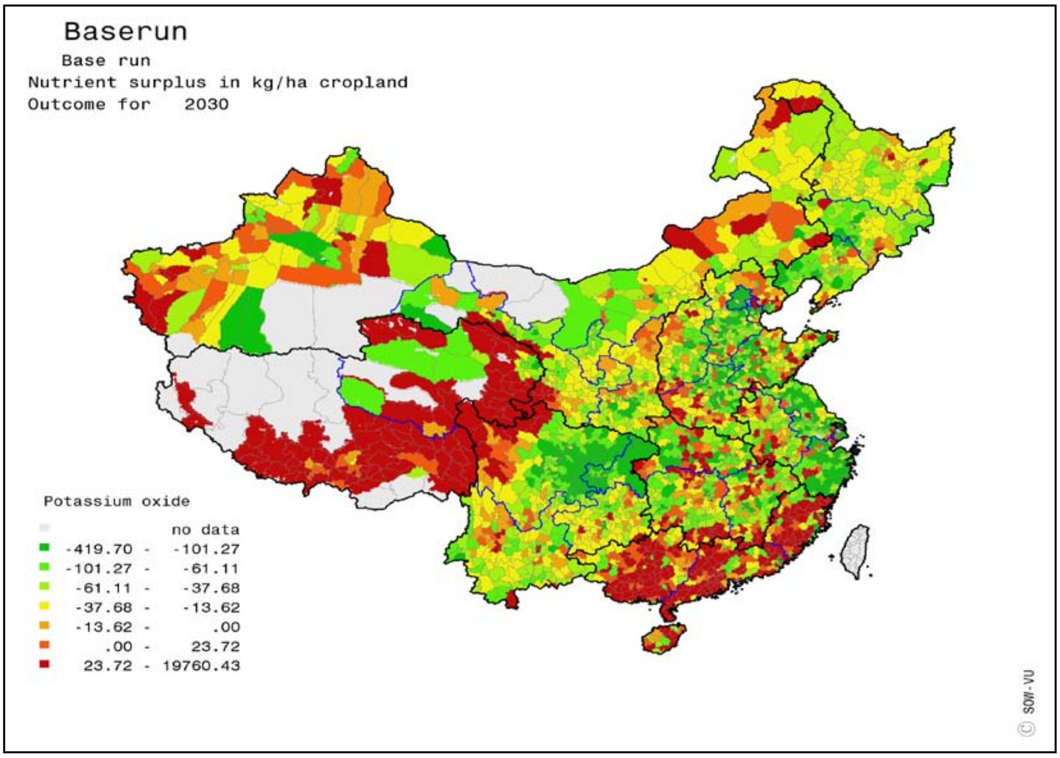


Figure 12. Baseline, net surplus of K-oxide on farmland, by county, 2030, in kg/ha
'Soil mining of K dominates'

6. Policy variants

Four policy variants are considered:

- Liberal: all tariffs on foreign trade are strongly reduced after 2010 and abolished after 2020
- Margbio: 10 million tons of biofuel by 2020 (not cereal-based), instead of 1.5 million tons, with use of marginal land
- Irrigup: enhanced irrigation (location-specific), with the same total of seasonal cropland
- Lowgrow: lower growth of non-agricultural incomes, with less rural-to-urban migration and less technical progress in agriculture

The outcomes of these policy variants are discussed below, scenario by scenario. A few selected figures illustrate the outcomes. Three of these are shown as charts, which compare all of the scenarios in one view. County maps provide regional detail for specific scenarios.

Liberal scenario. In this scenario both official tariffs and non-trade barriers are reduced, leading to more foreign trade. As direct consequence of these reductions, imported commodities become cheaper and exported commodities more expensive. For crop farmers, these price changes have mixed effects. Rice, fruits and vegetables become more profitable, but other crops in general become less profitable. Livestock farmers face both lower output (meat, milk) prices and lower input (feed) prices, but the net effect is clearly negative. Hence, the scenario shows a shift away from livestock to cropping, and within the cropping sector, a shift towards rice, fruits and vegetables. Consumer reactions are the exact opposite, leading to more imports of livestock products, vegetable oil and sugar, and more exports of rice, fruits and vegetables. Demand for feed is reduced, but the effects on net trade are less clear *a priori*, since the maize supply is generally also lower (due to the price effect); whereas for carbohydrate feed and protein feed, mixed effects are possible (due to the composite character of these commodities).

All of these effects are tempered somewhat by the reactions of world market prices to changes in China’s trade volumes. In the end, the effect on the output of cereals appears to be rather small (Figure 13). Meat and milk imports clearly increase (by 2 and 6 million tons, respectively). For feed, however, a mixed picture results, with more imports for maize and fewer imports for carbohydrate feed and protein feed, albeit that these changes are relatively small (Figure 14). Effects on farm incomes are more pronounced. Compared to the baseline scenario, value added in the livestock sector is 6% lower in 2030. The total effect for cropping is also negative, albeit less than 2% (Figure 15). Figure 16 shows the regional differences behind this decline in crop value added: the counties that mainly produce fruits and vegetables benefit, whereas many of the other ones lose. Finally, Figure 17 (a map by main region) reveals the real winners in this scenario: the consumers. The picture refers to rural meat consumption, but similar trends apply to most other commodities, also in urban areas.

Biofuel scenario. This scenario implements the government plan to obtain 10 million tons of bioethanol output by 2020, instead of keeping it at the current level of 1.5 million tons, on the condition that feedstocks for the additional bioethanol should not consist of wheat or maize, but of secondary crops such as sorghum and root crops, preferably grown on marginal land. This plan is promoted via government subsidies to factories. The scenario sets the availability of suitable marginal land at 3.2 million hectares, as estimated by the Chinese Academy of Agricultural Engineering (CAAE, 2007), based on information from the Ministry of Land and Resources (MLR, 2004). The scenario specifies that this new marginal land can provide feedstocks for 35% of the bioethanol target for 2020. The remaining feedstocks must come from competition with other crops on existing cropland. Finally, the scenario assumes that biofuel targets are also raised worldwide, leading to higher world prices of biofuel feedstocks.

The main price impact of the scenario is that animal feed becomes more expensive, since it competes with biofuel for similar crops. This effect is negative for livestock farmers, but positive for crop farmers, particularly for crop farmers on newly used marginal land. On aggregate, crop incomes turn out to be 3% higher in 2030 and livestock incomes 2% lower (Figure 15). For the farm sector as a whole, this means a slight increase of 0.7%. Figure 18 shows how the gains and losses are distributed over the counties.

Although livestock farming becomes less attractive, the impact of production shifts on meat and milk imports remains very moderate, as shown in Figure 14, partly since consumers adjust their purchases in response to the (slightly) higher prices. At the same time, feed demand becomes lower, leading to reduced imports. Although for carbohydrate feed this effect is offset by the biofuel feedstock demand that competes for the same crops, the import increase of carbohydrate feed also remains moderate, since domestic production procures the bulk of the required additional biofuel feedstock. Figure 13 shows that grain output is hardly affected, implying that the supply of the additional feedstock crops is not at the expense of major grains.

In summary, the scenario has a positive impact on crop farmers but negative effects on livestock farmers and consumers, whereas part of the burden is also shifted to the world markets. The negative effects remain moderate, however. In this sense, we might call the bioethanol target of 10 million tons a prudent target. At higher volumes the negative effects would be disproportionately stronger, since marginal land is limited and must be cultivated cautiously. Yet, neither does the biofuel expansion mean a real boost for farm incomes, and it makes only a very limited contribution to energy supply, in spite of the government subsidies.

Enhanced irrigation scenario. The scenario assumes that 5.4 million hectares of rain-fed land are converted into well-irrigated land, while the total amount of cropland remains the same. This conversion changes the resulting cropping pattern, leading in particular to more rice, wheat and vegetables at the expense of most other crops. Figure 13 clearly confirms the effects on rice and wheat output, whereas Figure 14 shows that feed imports rise to compensate for lower domestic supply. However, the effect on farm incomes from cropping is not spectacular and is even negative (Figure 15), since increased supply leads to lower prices! This figure demonstrates what is more often found in simulations of increased technical progress in agriculture, namely that much of the benefit does not end up in farmers' pockets, but leaks away to consumers. Indeed, average energy intake in 2030 rises from 2850 to 2872 kcal per person per day.

Low-growth scenario. Lower growth in non-agricultural incomes means a lower increase in consumer demand for meat and milk. At the same time, the scenario assumes more labor and less technical progress in agriculture. The reduced demand for meat and milk leads directly to lower imports of these commodities and indirectly, via lower prices and production shifts from livestock to crops (for grain shown in Figure 13), to lower feed imports (Figure 14). As could be expected, the effect on livestock value added is quite negative, 9% less in 2030. The outcome for crop farmers also appears to be negative, however, as shown in Figure 15. Apparently, the increased crop output is not sufficient to offset the effect of the lower crop prices that result from the ample availability of crops.

This scenario serves as warning. Agriculture relies upon strong growth in industry and services in order to achieve sufficient income growth per laborer. In the baseline scenario, agriculture already had problems keeping up with non-agriculture, and here the gap becomes even larger, in spite of the lower growth in industry and services. Figure 19 shows that also in absolute terms, farm incomes only rise in a limited set of counties.

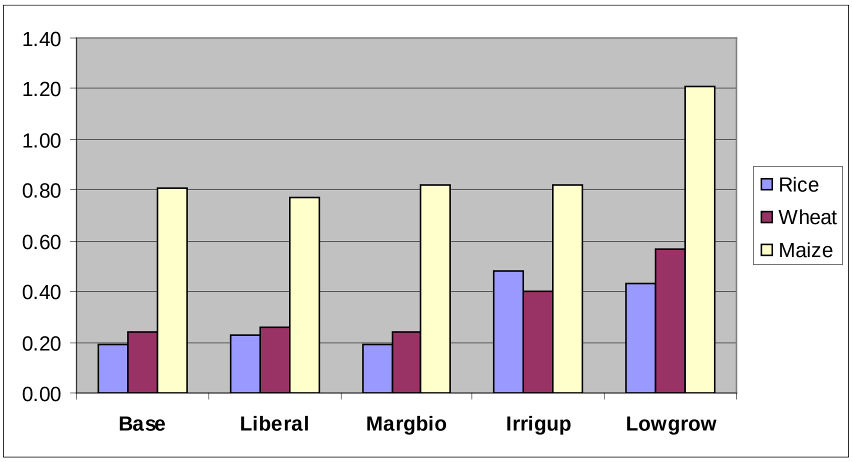


Figure 13. Annual grain output growth rates for different scenarios, in %, 2005-2030

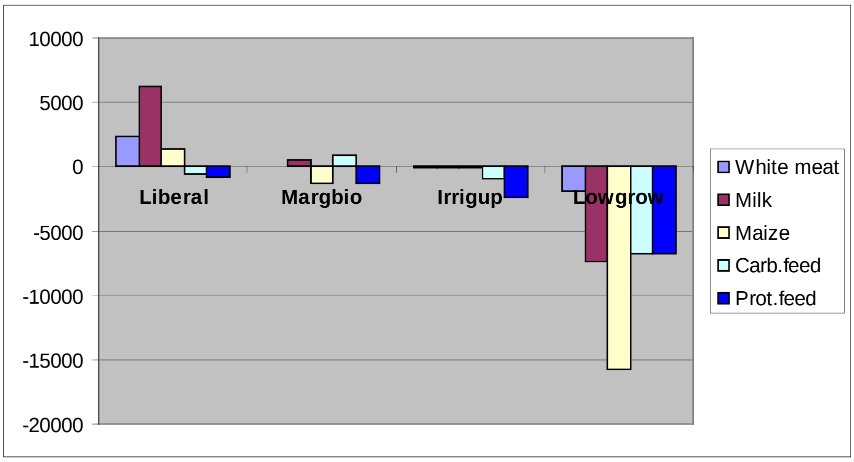


Figure 14. Imports of feed, milk and meat in 2030: difference from baserun in 1000 ton

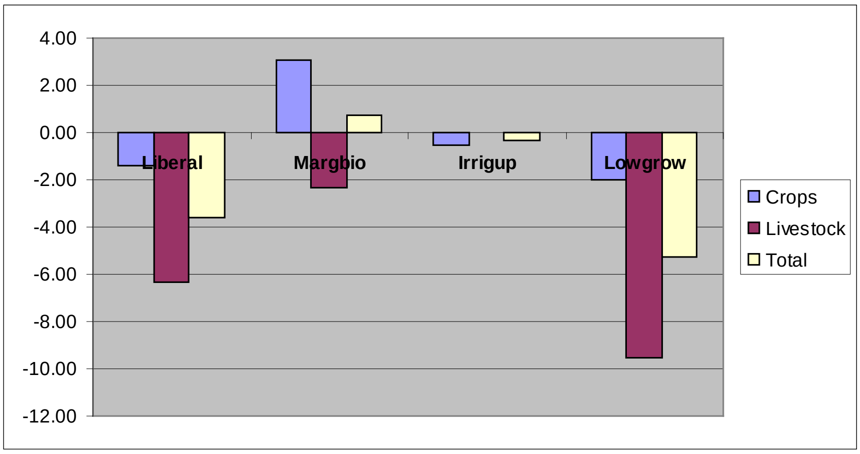


Figure 15. Farm value added in 2030: relative difference to baserun in %

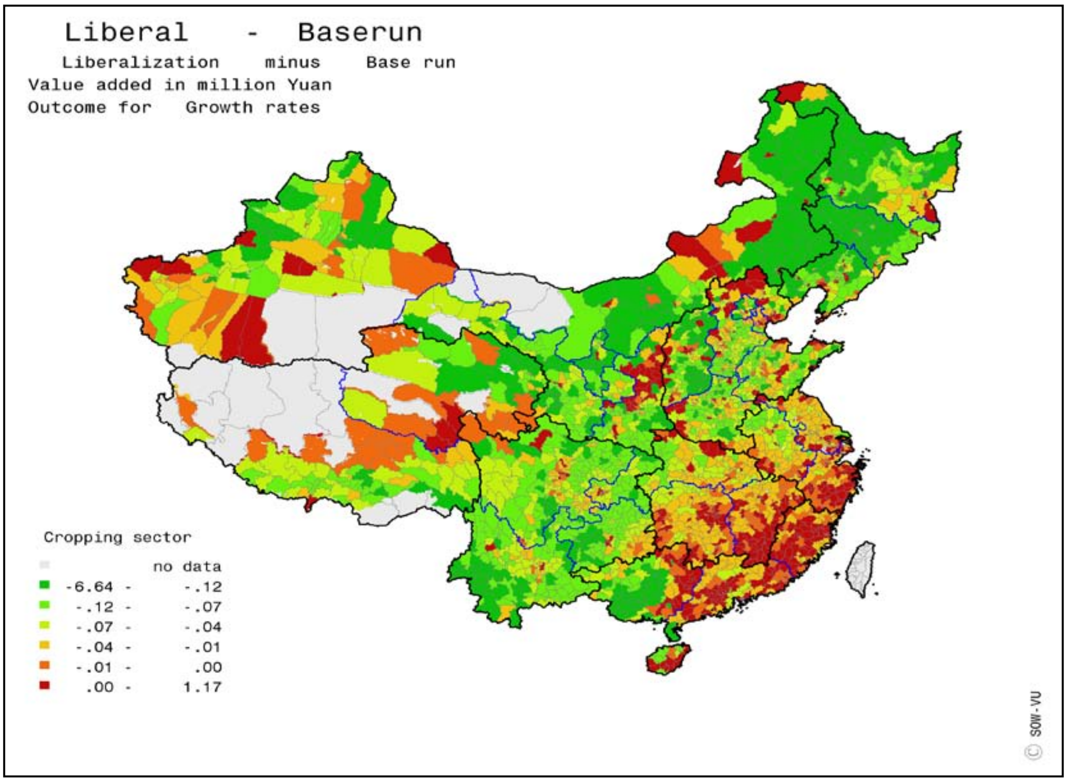


Figure 16. Liberal, crop value added: growth difference from baseline, in %-point ‘Livestock feed shrinks, fruits and vegetables expand’

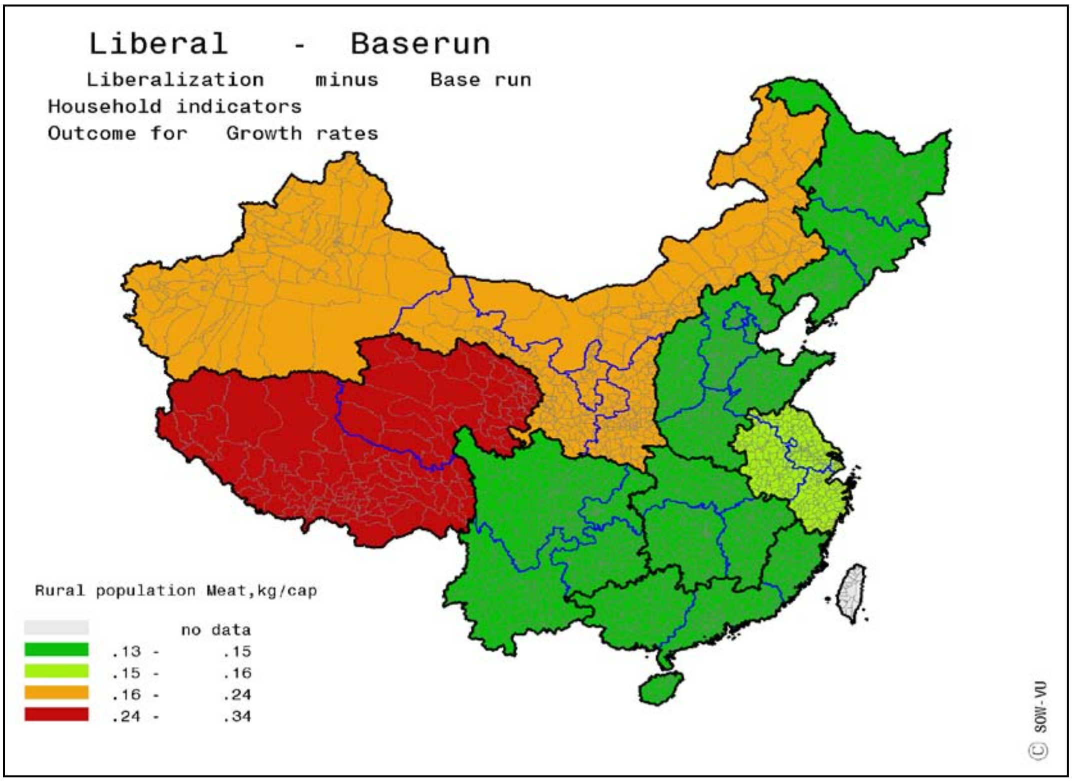


Figure 17. Liberal, rural meat consumption: growth difference from baseline, in %-point
‘Rural consumers gain from lower prices’

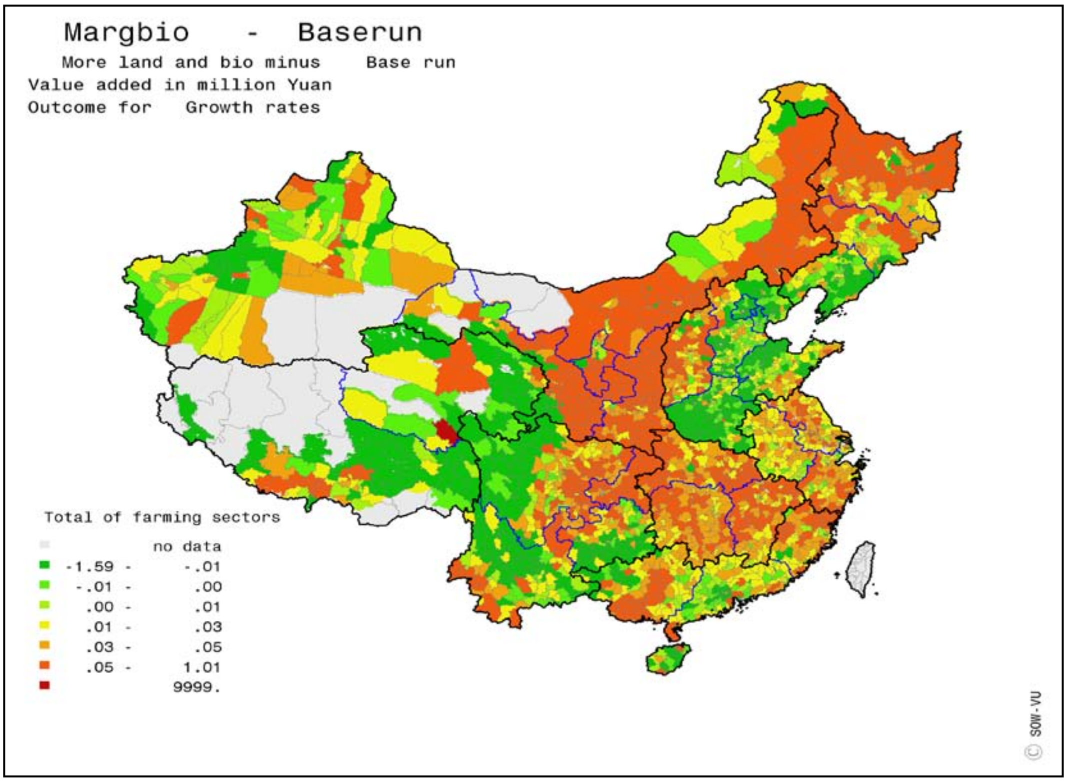


Figure 18. Scenario with more biofuel, also from marginal land, farm value added: growth difference from baseline, in %-point
'Marginal lands and feed-producing areas gain, while livestock-producing areas lose'

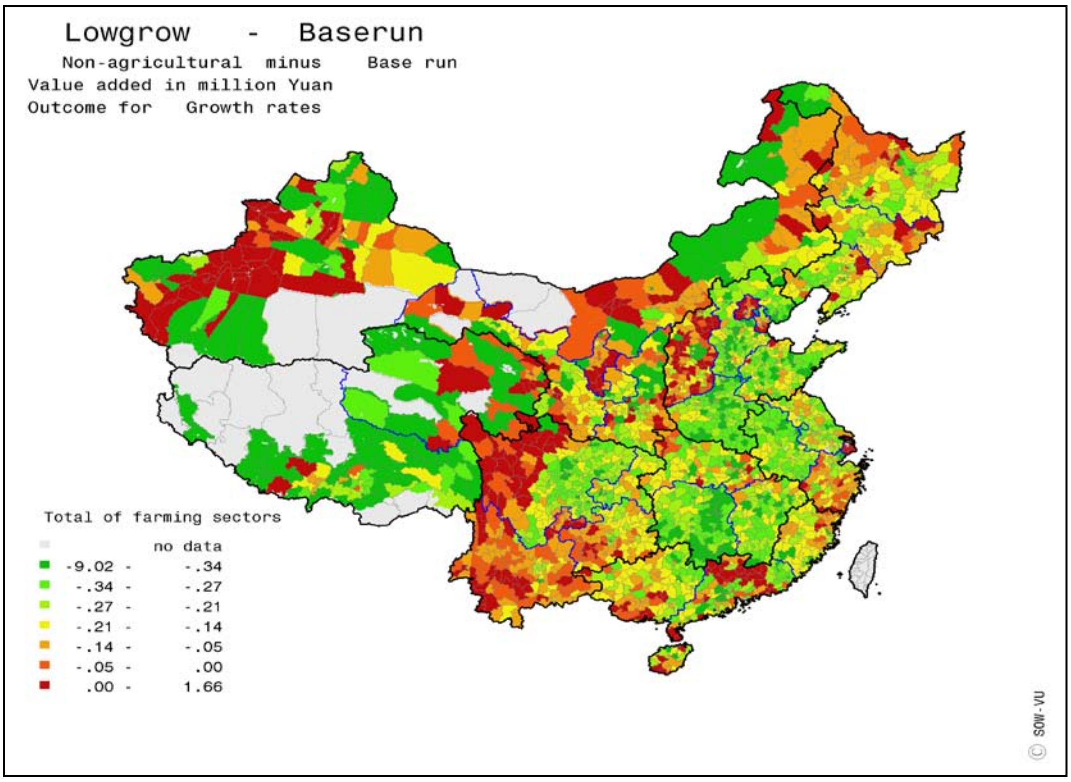


Figure 19. Scenario with low growth, farm value added: growth difference from baseline, in %-point
'All lose, except counties where higher labor supply compensates for lower prices'

7. Summary of findings

The outcomes from the *baseline scenario* seem reassuring for China, in that foreign imports remain moderate relative to the country's size, although they constitute quite a large fraction of world trade. It would be possible to feed both people and animals without resorting to excessive imports. There is even potential for significant export flows of vegetables and fruits. Regarding concerns, the trends in per capita agricultural value added are problematic, because in all regions, they remain behind per capita value added outside agriculture, albeit rising steadily. This leads to growing disparity in per capita incomes within and across regions. The mounting environmental pressure from nitrogen and phosphate surpluses and potassium deficits on cropland is another cause for concern.

The second scenario, the *trade liberalization scenario,* appears to hurt farm incomes more than it benefits them and to increase the gap with non-agriculture, due to the fact that food becomes cheaper in urban areas. It thus highlights the difficult choice that is often faced by agricultural policymakers, between economic efficiency and poverty alleviation. Under the *low income growth scenario*, the per capita income gap between rural and urban widens as lower out-migration 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 and consumer welfare improve, but farmers have to cope with drops in prices, and those who do not benefit from land improvement experience losses through falling prices.

Finally, the *biofuel scenario* with part of the biofuel feedstocks produced on new marginal lands indicates that the government target of 10 million tons of bioethanol by 2020 would appear a prudent one. It would cause 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 partly shifted to the world market, which raises the import prices. In fact, however, the gains in farm incomes are not large either. Naturally, this policy 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. Food consumers and livestock farmers face the negative consequences of the additional feedstock demand, albeit limited ones.

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 would possibly expand its import of maize for animal feeds, largely from North and South America, Australia, and possibly Central Europe. This would definitely lead to more pressure on the world markets for these commodities, but the effects would remain limited (even under full trade liberalization or higher growth of incomes in industry and services), since China's agriculture would also adjust itself. However, any expansion of the currently modest biofuel targets would increase the pressure. 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, which is also due to the dietary shift away from staples towards fruits, vegetables and livestock products. While it seems clear that China's 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 broad 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, and is in fact the major source of income growth. This is partly due to the loss of cropland to urbanization, and has been facilitated by rising incomes and the shift to a more urban, and hence meat and dairy-intensive, lifestyle. Yet, for pork, poultry and eggs, the risk of pandemics that may affect 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.

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

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