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Global Food Production under Alternative Scenarios

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Abstract

The aim of this study is to compare the conceivable baseline or "business as usual" scenario to four extreme alternative scenarios over the next two decades. The alternative extreme scenarios present the question of "what if" an extreme policy is implemented, what would be the forecasted impact on global food production and how the impact would differ from the plausible scenario. The baseline scenario includes the WTO draft proposal for the Doha Round, the Kyoto Protocol targets to reduce greenhouse gases emissions, and the scheduled reforms on the EU Common Agricultural Policy. The alternative scenarios are prolonged world economic recession, climate change mitigation policies with higher targets, complete removal of only EU agricultural subsidies, and total trade liberalisation for agriculture worldwide. The goal is to foresee the future under plausible and extreme circumstances or policy implementations in a rapidly changing environment for decision makers, interest groups, agribusiness firms and managers in order to support the process of policy and strategy planning.

Keywords: global food production, agriculture trade liberalisation, climate policy, EU agricultural subsidies, economic recession.

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Introduction

Food is vital in our lives, but it is more than just survival. Our relationship with food is intertwined with trade policies, politics, economics, and environmental concerns, in addition to culture and science. The future of food production is in a path filled with dilemmas. Infectious animal diseases that lead to food safety concerns, energy crisis, declining biodiversity, natural resources depletion, pollution, and global climate change are all intervening in the path in different ways at different levels. The use of arable land for food production will compete with biofuel production. Migration from rural to urban areas continues worldwide, and population growth soars over the next decades. Demand for food will rise in the coming decades as a result of population growth as well as increasing affluence due rising income. Growing affluence in population rich countries such as China and India will prompt more people to eat a resource intensive diet, rich in meat and dairy products. This increases demand for crops used as animal feedstock instead of food straight for human consumption. We will have to confront the paradox of the coexistence of obesity and malnutrition, as inequality grows between the rich and poor.

Food-price and economic shocks have further jeopardized the food security of developing countries and poor people, pushing the estimated number of malnourished people over one billion. Food security risks appear to be on the rise and governments are paying more attention to this issue. Increasing uncertainties raise critical questions on how to manage these risks. The poor, particularly those who depend on food purchases, both in rural and urban areas, are highly vulnerable to market risks such as the rapid escalation of food commodity prices from 2006 to 2008.

The global financial crisis and economic recession have placed additional stresses on the impoverished countries, where the result is decreased economic growth, reduced inflow of foreign direct investment, and reduced remittances. The global and national food systems are complex systems, which are vulnerable to sudden disruptions and changes that are difficult to predict. Policy shocks, such as trade policies and climate change mitigation policies, have serious impacts on the poor and the rich as well. Therefore, the impacts of four policy shocks on global food production are explored:

1) Economic recession will lead to the loss of employment and will have an impact on the demand for agricultural commodities. The economic crisis policy shock is to mimic the impact of a prolonged economic recession worldwide.
2) Global climate change will affect food production and aggravate food security risks due to the increase in extreme weather events such as droughts and floods combined with the possibility of declining yields in developing countries. Carbon dioxide is the main gas believed to contribute to global warming. The climate change mitigation policy shock is to limit the emissions of greenhouse gases such as carbon dioxide (CO2) due to fossil fuels usage.
3) Agricultural subsidies have been a thorny issue in the World Trade Organisation (WTO). The policy shock involving the elimination of all agricultural subsidies in the European Union (EU) is to apply the concept of a unilateral removal of agricultural subsidies from a major agricultural producer and subsidiser.

4) Trade liberalisation in agriculture is one of the major issues in the WTO. The policy shock concerning the global removal of all agricultural subsidies and tariffs is to apply the notion of a multilateral trade liberalisation for agriculture.

The aim of this study is to compare the conceivable baseline or "business as usual" scenario to four extreme alternative scenarios over the next two decades. The alternative extreme scenarios present the question of "what if" an extreme policy is implemented, what would be the forecasted impact on global food production and how the impact would differ from the plausible scenario. The alternative extreme scenarios are prolonged world economic recession, climate change mitigation policies with higher targets, complete removal of only EU agricultural subsidies, and total trade liberalisation for agriculture worldwide. Food production in different countries and regions are projected until 2030 whereby three groups of food products are analysed in this study -- bovine meat, poultry & pigmeat, and coarse grains.

Methodological Framework of the Study

The GTAP Model and Database

The simulations in this study employ the Global Trade Analysis Project (GTAP) model and database. The model is a recursive-dynamic applied general equilibrium model extended to better analyse energy and environment issues and take into account the various forms of agricultural subsidies.

The standard GTAP model (Hertel and Tsigas 1997) is a comparative-static, multi-region, multi-sector, computable general equilibrium model, with perfect competition and constant returns to scale. Bilateral trade is handled via the Armington (1969) assumption. Model results are derived from assumptions of firms and consumers optimising their behaviour within constraints given by endowments (land, labour, capital, natural resources) and policies (e.g. taxes). In the equilibrium solution, all markets are in equilibrium, i.e. demand equals supply.

The modified model used in this study is based on GTAP-Dyn model (Ianchovichina and McDougall 2001) and GTAP-E model (Burniaux and Truong 2002). The GTAP-Dyn model permits a recursive solution procedure, a feature that allows easy implementation of dynamics without imposing limitations on the model's size. Adding to the standard GTAP model, it incorporates international capital mobility, capital accumulation, and accounting that keep track of foreign capital ownership with an adaptive expectations theory of investment. The GTAP-E model includes energy substitution, which is absent from the standard GTAP model. It also incorporates carbon emissions (CO2) from the combustion of fossil fuels and provides a mechanism to trade these emissions internationally. This allows the analysis of various climate policy measures.

Trade policy instruments are represented in the GTAP database as ad valorem taxes and subsidies. For agricultural commodities, domestic support levels are calculated from the OECD (2008) Producer Support Estimate (PSE), and components for market price support are excluded to avoid double counting with the tariffs in the database. The total PSE of a country is translated into a form that is compatible with the database and into four categories of subsidy payments:

output payments, intermediate input payments, land based payments and capital based payments. In this study, the GTAP model has been modified to consider agricultural subsidy payments in a way that allows an easy manipulation of subsidy payments in monetary terms that correspond to the policy measures of the EU Common Agricultural Policy. This allows the analysis of subsidy payments to agricultural production and trade.

GTAP model applications are widely used in research (Hertel et al. 2010, Valenzuela et al. 2009, Telleria et al. 2009, Martin et al. 2008, Walsh et al. 2007, Dimaranan et al. 2007) particularly in a broad scope of international trade. The GTAP 7 Database (Narayanan and Walmsley 2008) has been used in this study, representing the world economy for a given reference year -- 2004. The database comprises several types of data: behavioural parameters that include elasticities of substitution between domestic and imported goods, and elasticities of substitution between sources of imports (Armington elasticities). The main data file is derived from regional input-output tables, bilateral trade flows and protection data (taxes and subsidies). The database represents the world economy as flows of goods and services measured in millions of 2004 US dollars. Additional data is provided for capital stocks, population and savings. The database includes five endowments (i.e. production factors) -- land, skilled labour, unskilled labour, natural resources, and capital -- with 113 countries/regions and 57 commodities/sectors. In this study, the database is aggregated into 11 countries/regions and 20 commodities/sectors, including 12 agricultural commodities and food sectors (Table 1).

Table 1. The GTAP 7 Database is aggregated into 11 countries/regions and covering 12 agricultural commodities/sectors

Countries/Regions	*Agricultural Commodities/Sectors*
EU-27[1]	Wheat
EFTA[2]	Coarse grains (Other grains)
Mercosur[3]	Vegetables, fruits, nuts
Oceania[4]	Other crops
LDCs[5]	Raw milk
Developing countries[6]	Bovine animals
Developed countries[7]	Animal products n.e.c.
United States of America (USA)	Bovine meat products
Russia	Poultry and pigmeat (Other meat products)
China	Dairy products
India	Sugar
	Other food products

[1] Finland, France, Germany, Austria, Belgium, Netherlands, United Kingdom, Ireland, Denmark, Luxembourg, Sweden, Spain, Italy, Portugal, Greece, Poland, Malta, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Slovakia, Slovenia, Bulgaria, Romania.
[2] Switzerland, Norway, Iceland.
[3] Brazil, Argentina, Paraguay, Uruguay.
[4] Australia, New Zealand, the Pacific Islands
[5] Least developed countries in Africa.
[6] The rest of developing countries.
[7] The rest of developed countries.

The regions that are relevant in this study are the world's top agricultural producers such as the EU, USA, China, India and Mercosur. The EU and USA are not only major exporters, but also main importers of food products. On the other hand, the Mercosur region is one of the most competitive agricultural producers in the world, especially in meat production. The LDCs region

is also important to examine due its status of being a net food importer and as the poorest region in the world. Russia being a key food importer is interesting due to its energy intensive agricultural and food industry. Population rich and increasingly affluent countries such as China and India will be major forces in the international agricultural trade. These emerging superpowers are currently major forces in the WTO negotiations.

Assumptions for the Baseline (business as usual) and Four Scenarios

The baseline or "business as usual" scenario is a hybrid scenario that cuts across conceivable scenarios based on the projected changes in the macro indicators, the Kyoto Protocol targets to reduce greenhouse gases emissions, the scheduled reforms in the EU Common Agricultural Policy (CAP), and the draft proposal for the Doha Round agreement under the WTO.

Assumptions for the baseline under "business as usual":

i) Macro indicators:
World population growth follows the United Nations (2008) medium variant projection, and labour force growth corresponds to the International Labour Organization (ILO 2008) projection. For the European countries, the growth projections have been adjusted according to EUROSTAT (2008) for population projection and Carone (2005) for labour force projection. The medium-term gross domestic product (GDP) growth for the baseline follows the International Monetary Fund (IMF 2009) projection, and longer term productivity growth corresponds to the calibrated estimates based on Carone et al. (2006) and Poncet (2006).

ii) Greenhouse gases emissions:
CO2 emissions in the EU-27 and EFTA regions are constrained to Kyoto targets (8% reduction by 2012 from the benchmark 1990 emission levels and zero reduction after 2012). The regional CO2 tax levels correspond to partial emissions trading in the EU and EFTA regions. The other regions have no limits to CO2 emissions growth. The CO2 emissions in the model are exaggerated because the development and improvement in energy efficient technology is not taken into account. Only carbon emissions (CO2) from the usage of fossil fuels are taken into account; emission of other greenhouse gases are not included in the model.

iii) Domestic support in the EU:
The EU subsidy payments are kept constant in Euro terms, leading to a slight decrease in subsidy rates. Simulation of the CAP reforms from 2005 to 2007 -- decoupling of land and capital based subsidy payments by introducing the Single Farm Payment as generic land subsidy. Subsequently, the "Health Check" reforms of the CAP are implemented in 2010.

iv) Trade policies:
Removal of all tariffs between the EU-15 old member states and the EU-12 new member states. Furthermore, worldwide agricultural tariffs are gradually cut according to the WTO draft proposal for the Doha Round (WTO 2008). The Doha Round is assumed to begin in December 2011 and export subsidies are eliminated at the same time.

After the details are tested on the GTAP model for the baseline or "business as usual" scenario, the conceivable baseline scenario is compared to the extreme alternative scenarios. The four alternative scenarios present the question of "what if" an extreme policy is implemented, what would be the forecasted impact on global food production and how the impact would differ from the plausible scenario (baseline/business as usual).

Assumptions for the four alternative scenarios:

i) Economic crisis:
During the 5-year period from 2009 to 2014, worldwide unemployment grows by 2% annually and worldwide investments are reduced by half. In the subsequent 5 years from 2015 to 2019, unemployment is decreased back to the original levels and investments are increased back to the initial levels.

ii) Climate change mitigation policy:
A more ambitious climate policy will take over from the Kyoto Protocol after 2012. The EU-27 emission target is to reduce CO2 emission by 40% in 2030 from the 2012 emission level. The whole world including the EU reduces CO2 emissions by 10% in 2030 from the benchmark 2012 levels. This corresponds to the rest of the world keeping their CO2 emissions at 2012 levels. The model does not take into account improvement in technology through global funding allocated to the development of clean technologies, thus the predictions may be overestimated.

iii) Unilateral removal of domestic subsidy in the EU:
Removal of all agricultural subsidies in the EU-27 region, implemented in 3 years from 2018 to 2020 and structured as domestic agricultural policy reform.

iv) Multilateral removal of tariff and subsidy for agriculture globally:
Removal of all import duties for agricultural products and agricultural subsidies in all regions, implemented in 3 years from 2018 to 2020 and structured as global trade liberalisation for agriculture.

Impact on Global Food Production

Bovine Meat Production

Who will gain and who will lose from the possible outcome of trade liberalization? Projections for bovine meat production in different countries and regions (EU-27, China, India, USA, LDCs, and Mercosur) are shown in Appendix 1. Total trade liberalisation for agriculture has the largest impact on the production of bovine meat in the EU -- bovine meat production in the EU would decrease dramatically compared to the baseline (business as usual) and other scenarios. The current trend in EU beef production can justify the projected decline in EU bovine meat production. The major factors influencing the medium to longer term projections for the EU beef sector are the gradual decrease in the EU dairy herd, the origin for two thirds of EU beef, and the

continued impact of decoupling domestic support payments to EU beef producers[1]. These factors combined with rising cereal or feedstock prices will reduce the incentives for intensive beef production systems and unprofitable production, thus the overall EU beef production will decline. The EU cattle herd is predicted to contract in the medium and long term (EU Commission 2009, USDA 2009a). The EU self sufficiency rate has decreased to 96 percent and total EU beef imports have increased 14 percent year-on-year in 2009 (TheBeefSite 2009). Furthermore, the competitiveness of the EU beef industry is weak. EU beef is highly sensitive to tariff reductions (Huan-Niemi et al. 2009). Presently, the EU is able to control its beef imports through prohibitive tariffs imposed on the imports of bovine meat products and import quotas with considerably lower tariff rates. However, an increasing volume of beef is imported outside the quotas by paying the full tariff rate. Consequently, the elimination of tariffs for EU beef would force the least competitive EU beef producers to stop cattle-raising for beef. The removal of border protection for EU beef would give a strong advantage to the exports of low cost beef producers in the world, and the growth in beef imports would directly have a substantial impact on EU domestic prices for beef. Brazil, Argentina, and Uruguay have been the main supplier to the EU beef market.

In contrast, bovine meat production in India would increase tremendously under total trade liberalisation. The projected striking increase in Indian bovine meat production can be debated. How India can meet the challenges arising out of growing requirements of other countries due to deficit in their beef production levels would depend on India's export capabilities and available surpluses for exports. There is no doubt that the total bovine meat production in India has increased tremendously in the past decade. India has a large population of livestock. Animal rearing has remained traditionally a small scale undertaking for the production of milk. So far a very small percentage of the total Indian cattle herd is slaughtered since the majority of the Indian population does not eat beef due to religious bias. Hinduism, a religion that constitutes a majority of the Indian population, considers cows as sacred and regards slaughtering of cows as offensive. On the other hand, slaughtering of buffaloes is allowed in India unlike slaughtering of cows. Therefore, most of the Indian bovine meat supply is from the water buffalo. Meat from buffaloes is primarily processed for exports. Buffalo meat is the largest meat segment exported out of India and international demand for buffalo meat is growing. Buffalo carcases have less fat and bone, but a higher proportion of muscle. There is favourable export demand due to the lower cost and lean meat. India is cost competitive in producing buffalo meat, but further improvement is needed in India's cold chain infrastructure in order to increase competitiveness (USDA 2008). India has remained a big exporter of buffalo meat to Southeast Asia (Philippines, Malaysia, Vietnam), the Middle East (Saudi Arabia, Kuwait, Jordan), and Africa (Angola, Congo, Ghana). At the moment, certain areas in India are infested with contagious cattle and livestock diseases. The ones that are free from diseases are not certified by the World Organisation for Animal Health (formerly known as the OIE -- Office international des épizooties). Many countries resist importing bovine meat from India due to this reason. The GTAP model results have indicated

[1] The EU system of direct payments (domestic support payments) influences farmers' production decisions, where payments are paid on a per head basis for livestock and a per hectare basis for crops. If the current system of direct payments is decoupled, production levels would be expected to adjust downwards to reflect the underlying profitability of alternative enterprises. According to Moss et al. (2002), a greater decline in projected livestock numbers is observed in the United Kingdom compared to projections for the EU, when decoupling occurs. In this study, all the EU direct payments are decoupled in the baseline; hence the simulations indicate a declining EU beef production.

that most of the growth in Indian bovine meat exports is flowing into the EU market. This can be questioned because the model can only estimate the impact of tariff elimination. The impact of tariff barriers can be measured by the model but not the impact of non-trade barriers in the EU such as food safety, guaranteed quality, labelling & traceability, and animal welfare. Labelling and tracking the meat through the food chain and control of animal diseases would be the most daunting challenges. In addition, EU consumers must acquire a preference for buffalo meat compared to the consumption of cattle meat.

Concerning the least developed countries (LDCs), bovine meat production would decline the most under total trade liberalisation compared to the baseline. The drop in production is caused by the escalating and huge amount of imports competing with domestic production due to the loss of border protection. Furthermore, there is a considerable decrease in exports due to preference erosion and the end of preferential treatment from the highly protected markets of developed countries. Compared to the baseline, the economic crisis scenario in the LDCs has a short term impact in reducing production due to lower domestic consumption; the scenario for climate change mitigation policy in the LDCs has a positive impact by boosting domestic production due to decreasing imports; and the EU subsidy removal scenario has no impact on production in the LDCs.

Bovine meat production in the Mercosur would be decreasing compared to the baseline due to climate policy measures that caused a substantial decline in exports. The USA and China would face only minor changes in bovine meat production for all the four scenarios compared to the baseline. Overall, the EU-27 and LDCs regions have a declining trend for bovine meat production until 2030, whereas the other countries and regions examined in this study have an upward trend. This indicates that in the long term the EU and LDCs would not be able to compete with the other countries and regions, hence producing less bovine meat in 2030 compared to 2009. The advanced developing countries that are experiencing high economic growth in recent years such as China, India, and Brazil (Mercosur) would increase bovine meat production significantly to meet rising domestic consumption and expanding export market.

Poultry and Pigmeat Production

The per capita incomes of consumers in Brazil, Russia, India, and China (BRIC countries) have risen clearly, and as a result, dietary patterns have shifted away from staple grains and starches toward animal proteins. When people move to cities or towns, they tend to consume less grain but more meat, processed foods, and restaurant meals. In 2000, China's household surveys showed that per capita red meat consumption in urban areas was 40 percent higher than in rural areas, and egg and poultry consumption was more than 2.5 times higher than in rural areas (Hsu et al. 2002). Continued urbanization, income and population growth in many developing countries will further expand meat consumption. Over two-thirds of world meat production consists of poultry and pigmeat production. China, EU, USA, and Brazil (Mercosur) are currently the world major producers of poultry and pigmeat.

Who will be the major meat producers in the future? EU-27, China, USA, and Mercosur would remain the key players in the world production for poultry and pigmeat according to the different policy scenarios shown in Appendix 2 (EU-27, India, LDCs, China, USA, and Mercosur). The

results indicate that India and the Mercosur would increase production tremendously compared to the baseline under total trade liberalisation for agriculture. However, the increase in poultry and pigmeat production is small in scale for India (from USD 50 to 350 million) compared to the growth in production for the Mercosur (from USD 12 to 25 billion) even though the rate of production growth is higher in India. The increase in production for both regions is driven by escalating exports under trade liberalisation, especially the exports of poultry and pigmeat from the Mercosur region to the EU-27 region. Consequently, poultry and pigmeat production in the EU-27 region is declining compared to the baseline because rising imports from the Mercosur region is depressing domestic production. Currently, statistics are showing similar production trend whereby EU contribution to global poultry meat production decreased from 22.6% in 1970 to only 12.4% in 2002 (Windhorst 2003). Indian poultry and pigmeat producers would gain the most and experience a higher income level due to the enlarging export market. On the contrary, the LDCs would encounter decreasing production for poultry and pigmeat because of competition from the huge amount of imports due to the loss of border protection for domestic production under trade liberalisation.

The climate change mitigation policy scenario would decrease poultry and pigmeat production in China and Mercosur compared to the baseline. The decrease is caused by the increase in production cost as a result of rising feedstock prices. Climate policies have an impact on the price level of feedstock due to the usage of fertilisers, energy and transport. Conversely, climate policies would boost domestic production in the EU and LDCs because of a reduction in imports. The economic crisis scenario compared to the baseline in the LDCs, USA, and Mercosur would affect domestic production only in the short term.

The most interesting scenario is the “business as usual” scenario depicting the baseline for China. By 2030 in the baseline, one-third of the increase in production for China is induced by exports. China’s export of poultry and pigmeat is projected to increase from USD 1.5 to 41.5 billion whereas import of poultry and pigmeat is merely at USD 1.3 billion. This result showing China as the top net exporter of poultry and pigmeat in the world is a widely debated issue among the agricultural economists (Yijun Han and Hertel 2003). Some analysts believe that China will become an important net importer of livestock products, while others argue that China will become a major net exporter. A third set of estimates stresses the wide range of possible outcomes for China’s net trade position, depending on the productivity growth in China’s pig and poultry production and the rate of economic growth in China (Nin et al. 2004). The third set of estimates indicated that China could be a substantial net exporter owing to high livestock productivity growth and a slow-down in the economic growth of China; on the other hand, slow productivity growth in livestock production and a rapidly growing macro-economy could transform China into a major net importer for poultry and pigmeat. In the simulations, the assumed productivity growth for agriculture in China is high, thus by 2030, the model projects China as a major net exporter for poultry and pigmeat.

Certainly, according to Lohmar and Gale (2008), China has been a net food exporter for most of the last three decades. China dominates world markets in a variety of products areas, including garlic, apples, apple juice, mandarin oranges, farm-raised fish and shrimp, and vegetables. Sometimes, it seems that China has suspended the law of scarcity by raising production in many sectors without having to sacrifice production in other sectors. More recently, however, the law

of scarcity is applying mostly in the form of rising commodity and input prices, more expensive labour, restrictions on land developments, and a reversal of China's pro-export policies. Various hidden costs are beginning to emerge, including dangerous chemical residues on food and related food safety problems, falling groundwater tables, polluted water, and overall environmental degradation.

Agricultural production gains in China stemmed from gains in production efficiency rather than expansion and mobilization of additional resources. There is a decline in area sown to grain and an increase in land devoted to non-grain crops and livestock production. China's dramatic increase in animal protein consumption would not have been possible without a rapid expansion of its domestic livestock industry: China's pigmeat production has increased to over 48 million tons in 2004 compared to 24 million tons in 1990 -- over five times the level in the USA (Windhorst 2005). China is expected to increase pigmeat production and contribute more than 50% of global production. It is questionable whether China is able to produce sufficient feed for the predicted increase in meat production. According to Lohmar and Gale (2008), there is still scope to achieve further growth in meat production, despite future gains in China's agricultural production will not come as easily as in the past. In fact, developed countries such as the EU and USA have faced similar resource and environmental constraints and still maintained robust growth in agricultural production, and at the same time, production is changing into more environmental friendly practices. China, however, with very large and diverse agricultural sector is developing at a much higher speed compared to the developed countries. Therefore, China has to establish supporting institutions to facilitate this transition while increasing the efficiency of production.

Production of poultry and pigmeat in developed countries such as the EU and USA is intensive and concentrated in large-scale commercial units, and this production method is spreading in Asia and Latin America. There will be increased problems related to welfare and environmental concerns. Regulations formulated from these concerns will continue to increase the cost of production in developed countries and major exporting countries. Diseases related to human and food safety issues are the main risks of the increase in poultry and pigmeat production (swine flu and bird flu for example). The large amounts of meat that are being traded globally are increasing the dissemination of infectious diseases. Exporting countries must have excellent control of diseases because the global market has no tolerance for serious disease outbreaks.

Coarse Grains Production

Coarse grains make up a common trade category that includes corn, sorghum, barley, oats, and rye. Corn is by far the largest component traded, accounting for about three-quarters of global coarse-grain trade in recent years. Most of the corn that is traded is used for livestock feed, while smaller amounts are traded for industrial use and human consumption. The expanding use of corn for ethanol production, particularly in the USA, remains the principle driving factor behind the growth in industrial usage of coarse grains. The top coarse grain producers in the world are the USA, China, EU, Brazil, India, Russia, Mexico, and Canada. Appendix 3 is showing the course grains production in key producing countries and other regions until 2030 (EU-27, Russia, LDCs, China, USA, and Mercosur). The USA produces half of the global corn production and also dominates the global corn trade; however, exports account for only a

relatively small portion of production -- about 15 percent. This means that corn prices are largely determined by the supply and demand for corn in the USA market, and the rest of the world must adjust to prevailing prices in the USA. Subsequently, world market price for corn is greatly affected by the biofuel policies in the USA. Global population increases and rising demand for meat products will continue to support the expanding feed grain exports in the long term. The USA, Argentina, Brazil, and Ukraine are the main exporters of corn meanwhile Japan, Mexico, South Korea, and Egypt are the major importers of corn.

The climate change mitigation policy scenario would reduce coarse grains production in Russia and Mercosur by 2030 compared to the baseline because production in Russia and Mercosur is energy intensive with high usage of fertiliser and transport; also production in the LDCs would decline slightly because the higher prices for fertilisers will have an impact on production. Alternatively, if the use of coarse grains is taken into account for biofuel production, the results may be different from this simulation because the generation of energy by using biofuels is not incorporated in this simulation. The economic crisis scenario would have an influence on coarse grains production in most of the countries and regions compared to the baseline, but the decrease in production is only for short term due to the short term decline in meat consumption affecting the demand for feed grains.

China would undergo a tremendous growth in production for coarse grains by 2030 due to the need to feed its ever increasing livestock production, and all the other scenarios do not differ much from the baseline or “business as usual.” According to the USDA (2009b), China has been a principal source of uncertainty in global corn trade, swinging from being the second-largest exporter in some years to occasionally importing significant quantities of corn. China's corn exports are largely a function of government export subsidies and tax rebates because corn prices in China are mostly higher than those in the world market. Large corn stocks are expensive for the government to maintain, and Chinese corn export policy has fluctuated with little relationship to its production, making China’s corn trade difficult to predict. Agricultural land in China is increasingly giving way to the expanding base for industrial production. China’s declining comparative advantage in grains and other land intensive crops should lead to increased grain imports in the future. Due to the fast growth in demand for meat, the shift from food to feed grains seems apparent. The simulation results indicate that by 2030 the usage of feed grains would increase by 590%, while grains for human consumption would increase by only 70%. Merely 1.5% of coarse grains production in China goes into human consumption by 2030. According to Fuller et al. (2002), the predominantly specialized households farms and commercial livestock farms will have to increasingly rely on imported corn and soybeans to feed their growing livestock numbers because arable land is scarce in China and its capacity to expand land-intensive feed grain crops is limited. Without increasing feed grains imports for its livestock, land scarcity will limit China’s ability to continue increasing its livestock production to meet the growing domestic demand or become a major net exporter of meat in the world market.

Conclusions

The aim of this study is to compare the conceivable baseline or “business as usual” scenario to four extreme alternative scenarios over the next two decades. The alternative extreme scenarios

present the question of "what if" an extreme policy is implemented, what would be the forecasted impact on global food production and how the impact would differ from the plausible scenario. The baseline or "business as usual" scenario includes the WTO draft proposal for the Doha Round (the Doha Round is assumed to begin in December 2011), the Kyoto Protocol targets to reduce greenhouse gases emissions by 2012, and the scheduled reforms on the EU Common Agricultural Policy. The alternative extreme scenarios are prolonged world economic recession, climate change mitigation policies with higher targets, complete removal of only EU agricultural subsidies, and total trade liberalisation for agriculture worldwide. Food production in different countries and regions are projected until 2030 whereby three groups of food products are analysed in this study -- bovine meat, poultry & pigmeat, and coarse grains.

The impact of the economic crisis scenario on food production is only for the short term compared to the baseline. The drop in consumption for meat products is generally higher in developing countries compared to the developed countries, therefore the decline in meat production is more pronounced for example in the LDCs and Mercosur. The decrease in consumption of meat would directly affect the demand for coarse grains as feed for livestock, thus lowering the production of coarse grains worldwide only for the short term.

The climate policy measures would have a negative impact on food production that is energy intensive with high usage of fertiliser and transport such as in Russia and the Mercosur. The climate change mitigation policy scenario would decrease poultry and pigmeat production in China and Mercosur compared to the baseline due to the increase in production cost as a result of rising feedstock prices. Conversely, climate policies would boost domestic poultry and pigmeat production in the EU and meat production in the LDCs because of a reduction in imports.

The EU subsidy removal scenario has barely any impact on food production in the LDCs or other countries/regions in the world compared to the baseline. The impact on world food market is insignificant because there is no change in border protection for EU domestic production and border protection worldwide. The removal of EU subsidy is changing the production patterns within the EU-27 regions by transferring production from high cost producers to low cost producers in the EU. The elimination of EU domestic agricultural subsidies would lower the cost of land and the income of EU farmers.

Meat production in the LDCs would decline the most under total trade liberalisation compared to the baseline. The plunge in meat production in the LDCs is caused by the escalating and huge amount of imports competing with domestic production due to the loss of border protection under trade liberalisation. Furthermore, there is a considerable decrease in bovine meat exports from the LDCs due to preference erosion and the end of preferential treatment from the highly protected markets of developed countries. Total trade liberalisation for agriculture has the largest impact on the production of bovine meat in the EU -- bovine meat production in the EU would decrease dramatically compared to the baseline. The elimination of border protection for EU beef would give a strong advantage to the exports of low cost beef producers in the world, thus forcing the least competitive EU beef producers to stop cattle-raising for beef. Moreover, poultry and pigmeat production in the EU would decline without border protection compared to the baseline due to rising imports from the Mercosur. Under trade liberalisation, the increase in meat production in the Mercosur is exports driven, and other studies (for example Gomes Pereira et al.

2009) have shown similar results. The simulation results indicate that by 2030 the usage of feed grains in China would increase by 590%, while grains for human consumption in China would increase by only 70%. Merely 1.5% of coarse grains production in China goes into human consumption by 2030. The results may be different if the use of coarse grains is taken into account for biofuels production. The use of coarse grains to produce biofuels is not incorporated in this simulation because this study is showing results driven by the demand for food and not for energy. Future studies can be conducted to examine the effects of both food and energy demand on coarse grains production, and show the separate effects of food demand compared to energy demand.

The simulations demonstrate that large and highly populated countries like China and India have the potential to be large net exporter of meat products. India is projected to be a major bovine meat exporter, and China is projected to be the main poultry and pigmeat exporter under trade liberalisation. Nevertheless, the ability of these countries to increase meat production at such a rapid rate and conquer the export market can be debated due to the numerous constraints and non-trade barriers face by these countries. Further research can simulate the impact of these constraints and non-trade barriers on food production[2]. Hence, the forecasted results would be a better information kit for agribusiness firms and managers or policy and decision makers. This study is conducted to anticipate the future of the global food production in the realm of changing global agricultural, trade and climate policy and uncertain world economic growth. The goal is to foresee the future under plausible and extreme circumstances or policy implementations in a rapidly changing environment for decision makers, interest groups, agribusiness firms and managers in order to support the process of policy and strategy planning. The GTAP model is able to forecast the long term (e.g. 20 years) until 2030, but unable to provide qualitative details of the future. Future research using the Delphi method based on panels of expert opinions can significantly strengthen the results and more emphasis can be paid to the details in understanding the alternative developments of the future.

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[2] Non-trade barriers refer to the wide range of policy interventions other than border tariffs that affect the trade of agricultural products. Non-trade barriers have gained importance as tariff levels have been reduced worldwide. Common measures of non-trade barriers are tariff-equivalents of these policy interventions (Beghin 2006). The tariff-equivalents of the non-trade barriers are subsequently used in trade models to assess the trade or welfare effects of the measured non-trade barriers. For example, Gonzalez–Mellado et al. (2010) have evaluated the role of non-trade barriers on agrifood trade between the EU and Africa by utilising the GTAP model, first by transforming the non-trade barriers into tariff-equivalents and later introducing the tariff-equivalents into a computable general equilibrium (CGE) model to study the effects of their presence and removal.

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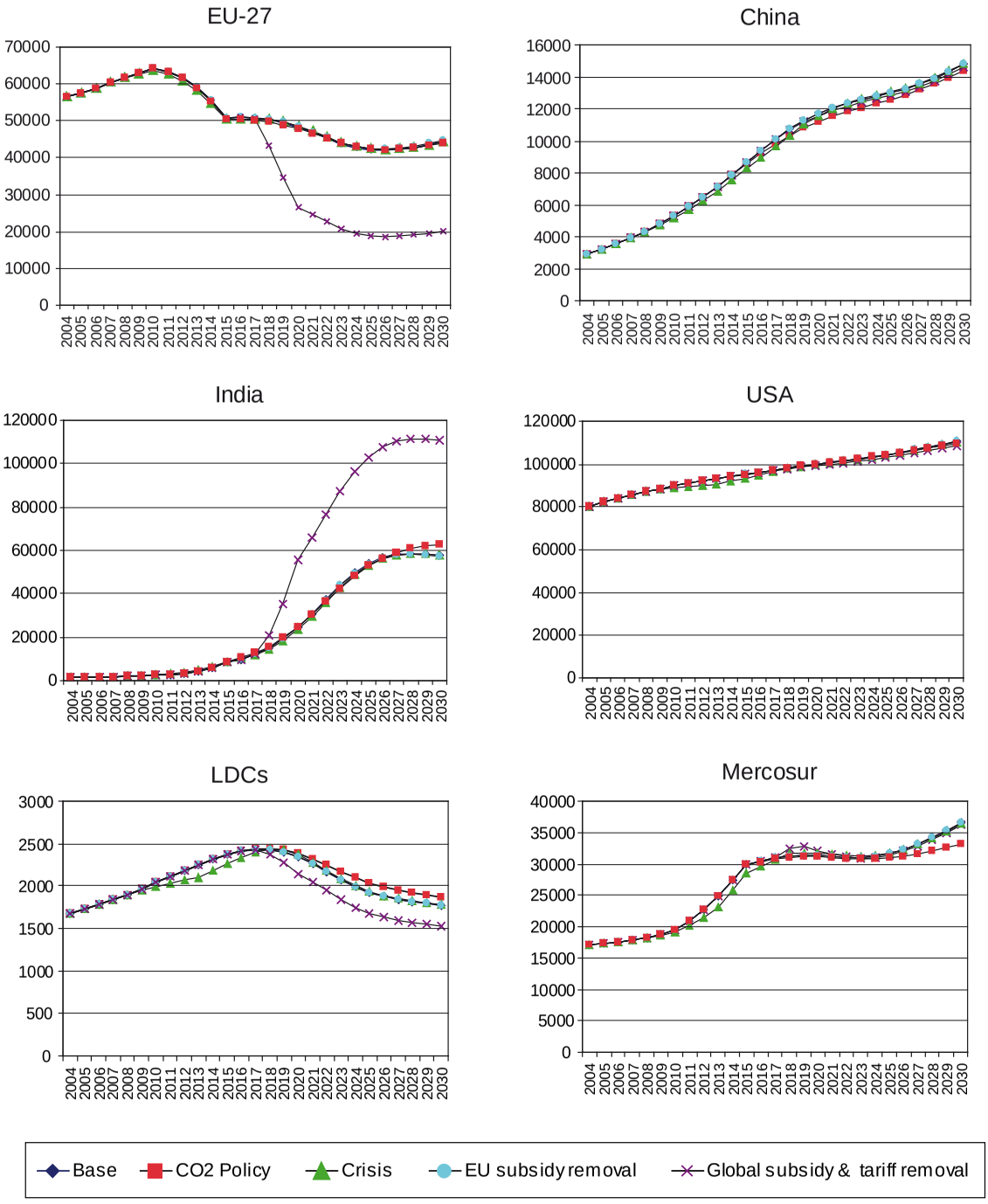
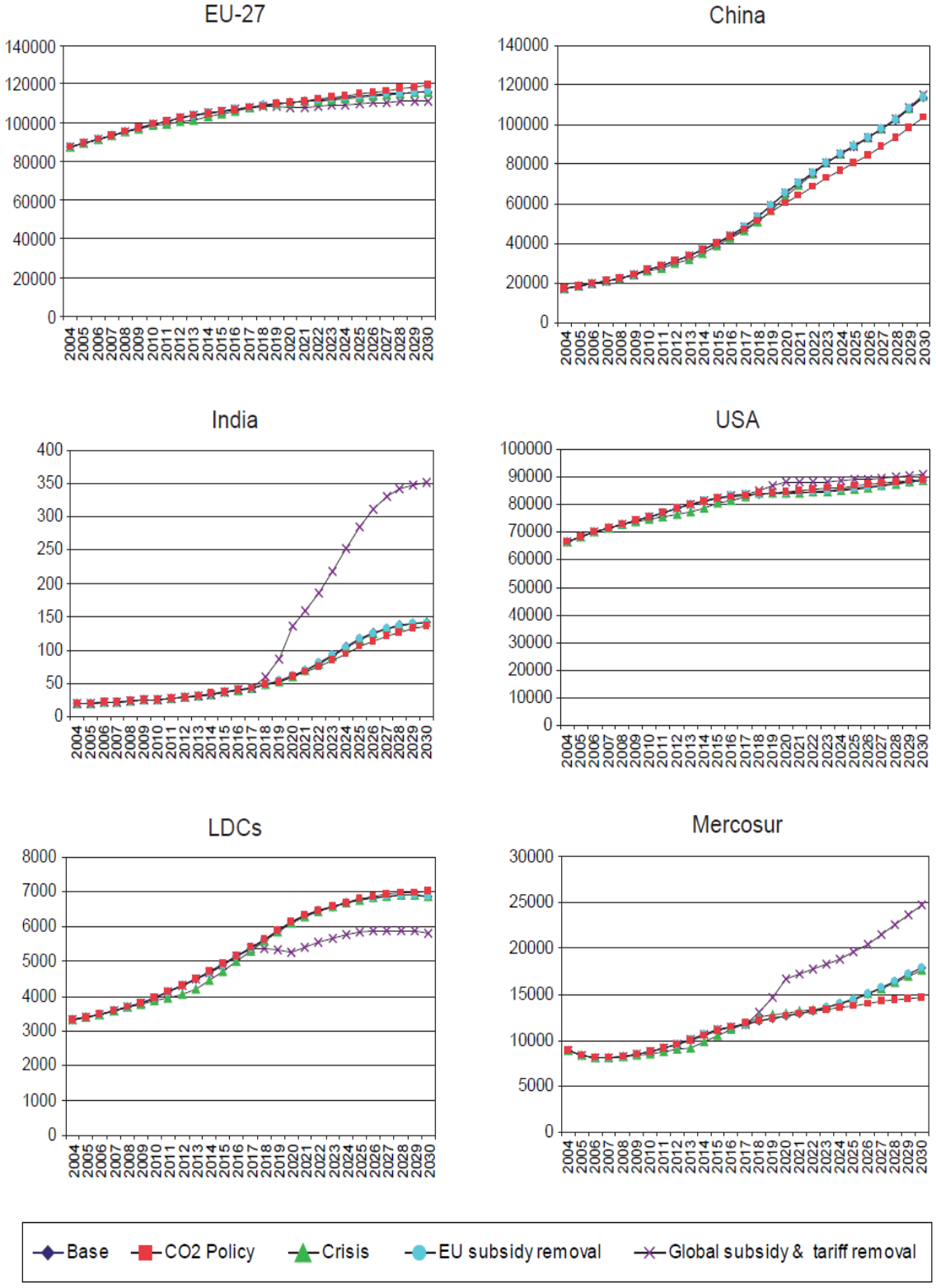
Appendix 1

Bovine meat production in millions of US dollars: Projections until 2030 for the baseline and four alternative scenarios in different countries and regions.



Appendix 2

Poultry and pigmeat production in millions of US dollars: Projections until 2030 for the baseline and four alternative scenarios in different countries and regions.



Appendix 3

Coarse grains production in millions of US dollars: Projections until 2030 for the baseline and four alternative scenarios in different countries and regions.