The Impact of U.S. Formula Funding on Agricultural Productivity: A Counterfactual Study

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INTRODUCTION

Agricultural productivity has increased over the past few decades in the United States and around the world. Much of this increase can be attributed to agricultural research, particularly that during the Green Revolution period. Although the growth of public funding for agricultural research in the United States has slowed down in recent years, it has been a significant source of support for many decades. This was particularly true during the 1960s, when more public agricultural research funds were available than private (Alston and Pardey 1996). Public agricultural research was undertaken primarily at the land grant universities and associated state agricultural experiment stations (SAES), with funding provided by federal and state governments.

Land grant universities were established in the United States by the passage of the Morrill Act in 1862. The founding of the land grant system was followed by the creation of state agricultural experiment stations through the Hatch Act of 1887. The Hatch Act provides federal funding for these experiment stations in order to conduct research in various agricultural science disciplines. The initial 1887 Act earmarked $15,000 per year for each experiment station. This was amended in 1955 with a new formula which allocated 20 percent of the funds equally to each state, 26 percent based on the percentage of U.S. farm population, 26 percent based on the state's percent of the total U.S. rural population, 25 percent was allocated to cooperative regional research (or multi-state research), and 3 percent was reserved for administration (Huffman and Evenson 2002).

This federal "formula funding" has been a significant part of the experiment station funding in many states.

Previous studies have found that public agricultural research has had a positive impact on agricultural productivity. While some studies have looked at the impacts of public research funding on state agricultural productivity, few have looked at the spillover and spill-in effects of this research on international agricultural production. In this paper, we use IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) to determine the effect of different levels of formula funding in the U.S. on international commodity production, demand and world trade prices.

We first look at historical trends in international food supply and demand from 1970 to 1997, focusing on cereal and livestock commodities. We then describe the IMPACT model structure and the different assumptions used in the 1970 IMPACT compared to the 1997 IMPACT. Model results and past trends are compared, followed by scenarios estimating the impact of different levels of formula funding on the current food situation.

PAST TRENDS IN FOOD SUPPLY AND DEMAND

Cereals

Cereal production increased dramatically in many regions during the Green Revolution period. As observed in Table 1, production increases were quite significant during the peak-Green Revolution period (1970-1982) for most cereals. Area expansion

accounted for a much larger portion of production growth during the peak Green-Revolution period than during the post-Green Revolution period (1982-1997). Cereal harvested area actually declined in the latter period for developed countries as a whole, with a reduction of 1.2 percent for all cereals combined. Cereal area in the United States also decreased for all cereals, with larger drops for wheat and other coarse grains[1], and a smaller reduction for rice. Maize area in the U.S. remained at the same level over the period.

Developing countries, on the other hand, still experienced cereal area growth from 1982-1997. Harvested area for wheat and rice grew at a slower rate than in the earlier period, with wheat area growth declining from 1.2 to 0.4 percent per year. Maize and other coarse grains experience an increase in growth, however, with maize growth rising from 0.46 to 1.54 percent per year and other coarse grains experiencing a slight increase in growth in the second period after a decline during the first period.

Cereal yield growth also slows down significantly in the second period across many cereals and regions, but hardly the stagnation in yields that are claimed by some observers (Brown and Kane 1994). Wheat yield growth declined significantly in developing countries, from 4.25 percent per year in the first period to 2.69 percent per year during 1982-97. Global wheat yield growth declined at a slower rate, from 2.43 to 1.99 percent per year. Maize yield growth declined significantly worldwide, from 3.64 to 0.87 percent per year. The reduction in the U.S. was similar, from 3.80 to 0.75 percent per year, while developing country yield growth declined to a lesser degree, from 2.61 to 1.89 percent per year. Rice yield growth slowed globally and in developing countries, while the U.S. and developed countries as a whole experienced a slight increase during

[1] Other coarse grains include barley, millet, oats, rye and sorghum.

1970-1982 and 1982-1997. Yield growth for other coarse grains declines globally, with a drop from 1.58 percent annually to 0.41 percent. Developing countries saw a major decrease in other coarse grain yield growth, from 1.82 to 0.01 percent per year. Developed countries as a whole experienced a slight increase, while other coarse grain yields in the U.S. grew at 2.20 percent per year in the earlier period, but fell to 1.06 percent per year after 1982.

In the developed world, the slowdown in crop area, yield, and production growth after 1982 was largely policy-induced, as North American and European governments drew down cereal stocks and scaled back farm-price support programs in favor of direct payments to farmers. The economic collapse and subsequent struggles with economic reform in the former centrally planned economies in Eastern Europe and the former Soviet Union further depressed crop production for developed countries as a whole.

The slowdown in cereal production growth in developing countries since the early 1980s has been due to declining world cereal prices and factors related to the increasing intensification of cereal production. Much attention has been focused on the technological reasons for the slowdown in yield growth. High levels of input use and the achievement of relatively high cereal yields in parts of Asia have made it more difficult to sustain the same rate of yield gains, as farmer yields in these regions approach the economic optimum yield levels. At the same time, increased land use intensity has led to increasing input requirements in order to sustain current yield gains. Less attention has been paid to the crucial role of cereal prices in the drop in yield and production growth rates. Between 1982 and 1995, real world wheat prices declined by 28 percent, rice prices by 42 percent, and corn prices by 43 percent (computed from Mitchell and Ingco

1993). Declining cereal prices have caused a direct shift of land out of cereals and into more profitable cropping alternatives, and have slowed the growth in input use, and therefore yields. Probably more important in the long run, declining world prices have also triggered a slowdown in investment in crop research and irrigation infrastructure, with consequent effects on yield growth (Rosegrant and Pingali 1994; Rosegrant and Svendsen 1993). Perhaps the most remarkable aspect of wheat, maize, and rice yield growth in the developing world since the 1980s is not that growth was slower than in the previous period, but that growth has been as high as it was in the face of steeply declining real cereal prices.

Cereal demand growth has declined globally during the post-Green Revolution period (Table 2). Growth in per capita food demand for wheat has declined at the global level from 0.86 percent per year from 1970-1982 to 0.10 percent annually after 1982. The decline is even more pronounced in developing countries, where per capita food demand growth declines from 3.20 to 0.93 percent annually. Per capita wheat demand growth increased in the U.S. after 1982, with a growth rate for food demand of 1.39 percent from 1982-1997.

Total demand for wheat also declined over the period due to slowing per capita and population growth. Global demand growth declined from 2.7 percent per year during 1970-1982 to 1.7 percent per year after 1982. Total growth in wheat demand in developing countries remains high after 1982 at 2.81 percent per year; however, this is still a significant drop from the 5.25 percent annual growth in the previous period.

Global maize demand continued to grow after 1982, but at a slower rate than in the 1970-1982 period. Growth in per capita food and feed demand both declined at the

global level in the second period. Maize food demand at the global level grew at a rate of 0.72 percent annually during the peak Green Revolution period but declined at a rate of 0.8 percent per year thereafter. Per capita food demand growth increased slightly in developed countries as a whole, from 1.60 percent annually during 1970-1982 to 1.90 percent in the second period. The United States experienced an even greater increase in per capita food demand growth, from 2.05 percent per year in the first period to 3.50 percent after 1982. However, this growth was concentrated between 1982 and 1990, and per capita food demand for maize in the United States has been flat since then.

Total rice demand growth declined globally from the initial 2.87 percent per year to 1.91 percent per year in the second period. Per capita food demand for rice also grew at a slower rate during the second period, dropping from 1.08 to 0.26 percent annually. the developing countries fueled the bulk of this decline with a drop from 0.83 percent annual growth in the first period to a minuscule 0.02 percent annual growth in the period from 1982-1997. This decline in growth was primarily the result of a partial shift in Asian diets away from rice.

Livestock

The most prominent trend in livestock production over the past three decades is the rapid growth in poultry production across all regions. Poultry production increased by 5.4 percent globally during the period from 1970-1982 (Table 3). The percentage increase in production in developing countries was even higher at 7.6 percent (although from comparatively lower initial values). Poultry production in the U.S. and developed countries as a whole grows at slightly slower rates - 3.38 and 4.57 percent, respectively.

This high level of production growth continues for many regions in the period from 1982-1997. Production grows at an even more rapid rate for developing countries, at 8 percent, and the U.S. at 5.3 percent. Globally, poultry production growth slows slightly, but still maintains an impressive growth rate of 5 percent. This growth was fueled primarily by increases poultry numbers, with a global increase of around 5 percent in the first period. Increased yield growth provides an additional boost in the second period, with global yield growth increasing by 0.24 percent, and growth in the U.S. and other developed countries exceeding 1 percent.

Beef production growth has been much slower than growth in poultry production, with a global increase in production of 1.5 percent in the first period and 1.4 percent in the following period (Table 3). Developing countries have shown the most rapid production growth with an annual increase of 2.3 percent from 1970-1982 and an even greater increase of 3.7 percent from 1982-1997. Overall beef production in these countries is still significantly lower than in the developed countries as a whole, however. The bulk of production growth in developing countries comes from substantial numbers growth – 2.2 percent in the first period, and 3 percent after 1982.

Pig meat production grew at a significant rate globally, with a 3.4 percent annual growth rate from 1970-1982 and a 3 percent growth rate from 1982-1997. This growth comes mainly from developing countries, which experience very high levels of growth throughout the period from 1970-1997. Sheep and goat meat experienced much slower production growth than other livestock commodities. Globally, production grew at a rate of 1 percent per year from 1970-1982 and 2.4 percent after 1982. In the developed countries and the U.S., sheep and goat production actually declined throughout both

periods. In developing countries, sheep and goat production grows significantly, particularly after 1982, when annual production growth is 4.2 percent.

Per capita demand for beef, pig meat, and sheep and goat meat in developed countries has declined since 1982. Demand in these countries has shifted to poultry, with per capita poultry demand growing at a rate of 3.6 percent from 1970-1982 and 2.17 percent from 1982-1997 (Table 4). Poultry demand growth was also significant in the U.S. alone, with an increase of 3.6 percent per year in the first period and 2.2 percent per year after 1982. Developing countries experience rapid demand growth across all meat products, with a per capita demand increase of 2.5 percent from 1970-1982 and an increase of 3.7 percent annually from 1982-1997. Developing country demand growth is particularly rapid for poultry and pig meat. From 1970-1982, per capita demand grew by 5.4 percent for poultry and 6.2 percent for pig meat. In the following period, per capita poultry demand grew by 5.9 percent and pig meat grew by 4.2 percent annually.

As observed in Table 2, per capita feed demand increased significantly in developing countries, with a growth rate of 4.3 percent per year from 1970-1982 and a growth rate of 3.3 percent per year thereafter. However, per capita feed demand for maize in developed countries declined by 0.25 percent per year from 1982 to 1997. When compared to the considerably higher rates of livestock production over the same period (see Table 3), these growth rates illustrate an important trend of increasing efficiency in livestock feeding in the developed world. This point can be clearly illustrated by a comparison of total feed demand growth in the United States with total livestock production growth. During the 1982-97 period, meat production grew at 2.5 percent per year, while per capita maize consumption for feed grew at 0.26 percent per

year, and total cereal consumption grew at 1.5 percent per year. The key factors in the feeding efficiency improvement in the United States appear to be the relative shift in the composition of meat production from beef to poultry, which uses less cereal per unit of meat produced; the use of animal growth hormones; and other technological changes that improve feeding efficiency.

THE IMPACT MODEL

The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) was developed at the International Food Policy Research Institute (IFPRI) in the early 1990s. Since the development of the model, many publications have been produced that present results examining the future of global food supply, demand and trade (See, for example, Rosegrant et al., 2001; Scott, Rosegrant and Ringler, 2000; Delgado et al., 1999; Delgado et al., 2003). Although the model has been expanded several times in recent years to include additional commodities and different regional/country groupings, in this analysis we use the structure of the original IMPACT model. The primary differences between IMPACT70 and the original IMPACT are the replacement of the 1997 base year data with 1970 base year data (3-year average centered on 1970) and the calibration of the model to represent the historical trends in yield, area and livestock numbers growth from 1970-1997. A basic description of the IMPACT model is presented below.

The original IMPACT model covers 36 countries or country groups and 16 commodities, including all cereals, soybeans, roots and tubers, meats, and dairy products

(accounting for virtually all of the world's food and feed production and consumption). The model is specified as a set of country-level demand and supply equations linked to the rest of the world through trade. Food demand, including fresh and processed food, is a function of commodity prices, per capita income, and population growth. Feed demand is a function of livestock production, feed prices, and feeding efficiency. Crop production is determined by the area and yield response functions; area is projected as a function of crop price, irrigation investment, and estimated rates of loss of land to urbanization and land degradation. Crop yield is a function of crop price, input prices, investments in irrigation, and yield growth due to technological change. Growth in productivity due to technological change is in turn estimated by its component sources including advances in management research and, in the case of food crops, plant-breeding research. Other sources of growth considered in the model include private sector investments in agricultural research and development, agricultural extension and education, markets, infrastructure, and irrigation (see Rosegrant, Meijer, and Cline, 2002 for additional details on the methodology).

PAST TRENDS VS. IMPACT MODEL RESULTS

While it proves quite difficult to track historical trends exactly using the IMPACT model, the model was able to project 1997 values within a reasonable level of accuracy for most commodities and regions. The projections of production, area and yield for the major cereals as a group for our major regions were all within 10 percent of the historic 1997 values (Table 5). Our projections of wheat, maize and rice production, area and

yield were reasonably close to the 1997 actual values, with most regions within the 10 percent range and all within 15 percent (Tables 6, 7 and 8). Other coarse grains did not match the actual values quite as well as the other cereals, with most countries and regions within 20 percent of the actual values, but many with greater than 10 percent differences (Table 9). The harvested area projections for other coarse grains are closer than the production and yield projections, with all countries and regions within 10 percent of the historic values.

As a group, all livestock products had projected values relatively close to actual values (Table 10). Total production of meat and number of animals slaughtered were within 5 percent for almost all countries and regions reported. Projections for beef production, numbers, and yield matched quite closely to the historic values for all countries and regions (Table 11). The percent difference for beef production and numbers were all less than 5 percent. Beef yield matched even more closely, with all projections within 2 percent of actual historic data. Pork projections are also relatively close to the historic values, although not as close as those for beef. Pork production, numbers, and yield are within 10 percent for almost all countries and regions shown in Table 12. The projections for sheep and goat meat production, numbers and yield were not as close to the actual values as the other livestock commodities (Table 13). At the global level, these projections are relatively close the actual values, with a 14.5 percent difference for production, 5.1 percent difference for sheep and goat numbers, and a 7.4 percent difference for yield. Projections for developing countries as a whole were closer to the actual historic values, with all three projections within 6 percent. The developed countries are where the majority of the difference occurred, with sheep and goat

production and numbers both off by over 30 percent. Projections of poultry production and numbers were quite close to the actual values for 1997, with all values within 5 percent of the historic data (Table 14). Yield projections across all countries and regions showed slightly greater differences than production and number; however, they were still within 10 percent of the actual 1997 data. At the global level, projections of poultry production were within 2.5 percent, numbers within 1.8 percent and yield within 4.4 percent.

Historical prices and baseline price projections for 1997 show greater differences than those shown for much of the production data. For the livestock commodities, world prices under the baseline for both pork and poultry are very close to historic prices. Poultry prices under the baseline are 2 percent lower than historic prices, and pork prices are 7 percent lower. Projected prices for sheep and goat meat, and particularly for beef differ significantly from the historic values. The projected price for sheep and goat meat is 36 percent higher than the 1997 actual world price, while beef price is 106 percent higher. The projected 1997 cereal prices are much closer to the historic values for most commodities. Wheat and rice baseline prices are only slightly lower than the historic prices, at 5 and 6 percent lower, respectively. The percentage difference is greater for maize and other grains, with 15 percent higher maize prices and 33 percent higher other grain prices.

Overall, the performance in tracking annual prices is reasonably good given the difference between long-term projection models and short-term forecasting models. Long-term projections models such as IMPACT do not attempt to project short-term, year-to-year changes in agricultural prices and production. These models do not

incorporate weather variables, nor do they incorporate year-to-year variability in economic growth. Variables such as prices vary widely over the short-run due to such factors, so it is not possible to fully replicate annual outcomes.

SCENARIO ANALYSIS

Federal formula funds have been an important part of the funding of agricultural research at many U.S. universities for many years. But what if those funds were reduced, with funding shifted to competitive grant programs? What would the subsequent reductions in yield growth mean for food demand, supply and trade at the global level? In the following scenario analysis, we look at two scenarios based on the assumption that state agricultural experiment station (SAES) funding is reduced. Scenario 1 was based on a reduction in the productivity of the SAES-USDA system affecting only U.S. agriculture. This simulation utilized the estimates from a study by Huffman and Evenson (2003) of the optimal funding portfolio. It represents a 10 percentage-point increase in the competitive grants share. We estimate that this will reduce agricultural research productivity effectively by 7 percent. Scenario 2 was based on the assumption that the shift in funding sources in the U.S. would affect the U.S. as well as other countries. The rationale behind this scenario is that U.S. applied science and graduate training would be affected by the reduction in funding, which would, in turn, affect the productivity in other countries. Specifically, one half of the reduced productivity of U.S. agricultural research was postulated for other developed countries. In addition, the International Agricultural Research Center contribution to the Green Revolution in developing countries was

postulated to be reduced by 7 percent. The reduction in total factor productivity due to the absence of this contribution is estimated for developing countries/regions in Table 15.

Scenario 1 Results

Cereal harvested area under Scenario 1 in 1997 does not change significantly compared to the baseline. In the United States, rice and other coarse grains harvested area remain almost the same, while wheat area declines by 15,000 hectares and maize area increases by 96,000 hectares. Harvested area in most other regions remained relatively stable between Scenario 1 and the baseline. Most regions did experience some increase in maize area, however, with harvested area increasing between 20,000 and 100,000 hectares for most regions. The impact on cereal yields is more noticeable in the United States under Scenario 1, with a decline for all cereal crops. Maize yields are hardest hit, with a decline of 387 kilograms per hectare (kg/ha). Other grains, rice and wheat also have declining yields in the U.S., with losses of 205, 162 and 60 kg/ha, respectively. Yield across the other regions remains relatively constant, with only slight yield increases for most areas.

Production of cereals in 1997 is also lower under Scenario 1 than under the baseline in the U.S. Maize production undergoes the largest decline, with a drop of 10.3 million metric tons compared to baseline levels. Wheat and other grains production decline by 1.52 million metric tons and rice production in the U.S. is 0.18 million metric tons lower than under the baseline. Production in some other regions increases only slightly, with the largest production increases occurring for maize. In monetary terms, cereal production is expected to reach US$ 38.8 billion in the United States (compared to

US$ 39.7 billion under the baseline), with developing countries reaching US$ 176.6 billion (US$ 174.3 under the baseline) in 1997 under Scenario 1 (Tables 16 and 20).

Net exports have declined in the US compared to the baseline. The volume of cereals exported has declined for all cereals, with a decline of 5.01 million metric tons (mt) for maize, 1.2 million mt for wheat, 0.85 million metric tons for other grains, and 0.18 million metric tons for rice. The total value of U.S. net exports of cereals under this Scenario is US$ 9.75 billion (US$ 0.73 billion lower than the baseline) (Tables 17 and 21).

Scenario 1 results indicate that world prices of most grains would have been 1 to 1.5 percent higher in 1997 than under the baseline. Wheat and rice prices each increase by around 1 percent. Other grains experience a price increase of 1.6 percent. Maize prices would have risen by 2.5 percent because the U.S. is a major producer of maize.

Compared to the 1997 baseline, livestock production tends to increase slightly in most areas other than the U.S. Under Scenario 1, livestock production in the U.S. declines compared to the baseline. Beef, pork and poultry production decline compared to the baseline values, although only slightly, with declines ranging from 1.1 to 2.8 percent (Tables 18 and 22). The value of sheep and goat meat production in the U.S. in Scenario 1 remains the same as in the baseline. Poultry production declines by almost one-half million metric tons, while beef and pork production decline by about 0.25 million metric tons. Sheep and goat production on the other hand only declines by around 0.1 million metric tons. Most other regions do not show a significant difference in production under Scenario 1 compared to the baseline.

Imports of pork and sheep and goat meat increase in the US under Scenario 1 compared to the baseline (Tables 19 and 23). Sheep and goat meat imports increase from 3,000 metric tons under the baseline to 8,000 under Scenario 1. Under the baseline, the U.S. exports 0.11 million metric tons of pork but under Scenario 1, 0.13 million metric tons are imported. In value terms, this indicates a shift from net exports of pork of US$ 0.23 billion to net imports of US$ 0.29 billion under Scenario 1. The United States is still a net exporter of poultry under Scenario 1 but at a lower level than under the baseline (a decline of 0.38 million metric tons). Poultry imports increase in Sub-Saharan Africa and Southeast Asia but decrease in South Asia. Poultry exports also increase in the European Union, Latin America, East Asia, and West Asia and North Africa. In the United States, beef imports increase by 0.21 million metric tons in 1997 compared to the baseline. Beef exports increase in the European Union, Latin America and South Asia under Scenario 1, while imports decrease in Sub-Saharan Africa, West Asia and North Africa, East Asia and Southeast Asia compared to the baseline. The value of total livestock imports in the United States under this scenario is US$ 0.67 billion, compared to US$ 0.93 billion in imports under the baseline.

The number of livestock produced in the U.S. does not change significantly for most commodities under Scenario 1. Sheep and goat, and beef numbers do not change significantly in the U.S. compared to the baseline, with a 2,000 unit increase for beef and a 4,000 unit decrease for sheep and goat meat. The number of pork produced declines by 114,000 units and the number of poultry declines by 6 million units compared to the baseline. The number of beef produced in other regions increased from 7,000 to 71,000 units. The number of pork and sheep and goats also changed compared to the baseline,

with increases in some regions and decreases in others. Poultry production declined in the other regions as well, with the largest declines occurring in Latin America and West Asia and North Africa. Livestock yields in the United States declined for all livestock commodities in the model compared to the baseline. Poultry yields declined by 58 grams per animal, beef by 6 kilograms per head (kg/head), pork by 3 kg/head and sheep and goats by 1 kg/head. There was no appreciable difference in yield for the other regions between Scenario 1 and the baseline.

Meat prices in 1997 under Scenario 1 would have been around 0.5 to 1 percent higher than under the baseline. Beef, pork and poultry prices all increased by around 1 percent over the baseline estimated prices. Prices for sheep and goat meat were estimated to only be around 0.5 percent higher than baseline levels.

Scenario 2 Results

The reduction in productivity modeled under Scenario 2 also results in only marginal changes in production compared to the baseline. Cereal production in the United States in 1997 under Scenario 2 is slightly lower than under the baseline and slightly higher than under Scenario 1. Wheat production is 1.3 percent lower than under the baseline, rice 2.9 percent lower, maize 3.9 percent lower, and other coarse grains 4.1 percent lower. In general, most other regions also show very slight declines under this scenario, although there is a small amount of growth in maize and other coarse grains production in Sub-Saharan Africa and maize production in East Asia. Under Scenario 2, the projected value of U.S. cereal production in 1997 is US$ 40.5 billion, US$ 0.8 billion higher than under the baseline due to the higher grain prices projected under this scenario

(Tables 16 and 24). At a global level, an increase of US$11.3 billion in 1997 is projected under Scenario 2 compared to the baseline.

Wheat harvested area in the United States under Scenario 2 increases slightly compared to the baseline with an increase of around 146,000 hectares – less than a 1 percent increase. In percentage terms, the remaining regions increase at similar levels. All other cereals also experience a slight increase under Scenario 2 compared to the baseline across all regions. The harvested area increase for rice is slightly less than the other cereals at 0.26 percent, while the percentage increase for maize and other grains are very similar at 0.66 and 0.55 percent, respectively.

Cereal yields also decline in the United States compared to the baseline. Maize and other coarse grains decline the most, with yield reductions of 4.5 and 4.7 percent, respectively. Wheat and rice also experience yield declines in the U.S., with reductions of 1.8 and 3.2 percent, respectively. Cereal yields in all other regions also decline under this scenario. Cereal yields in the European Union experience a similar decline to those in the United States, while most other regions show a slightly lower decline in percentage terms.

Net exports of wheat in the United States increase by 0.08 million metric tons under Scenario 2 compared to the baseline. Exports of rice, maize and other grains decline compared to the baseline in the U.S. Maize exports decline by the greatest amount, with a drop of 3.04 million metric tons. Wheat, maize and other grains exports decline in the European Union, and rice exports increase. Under Scenario 2, imports of maize decline in all of the remaining net importing regions. The total value of U.S. net cereal exports is US$ 10.63 billion under Scenario 2, US$ 0.15 billion higher than under

the baseline (Tables 17 and 25). This higher value of exports is due to increased cereal prices under Scenario 2 compared to the baseline.

Grain price increases under Scenario 2 compared to the baseline are greater than those experienced under Scenario 1. All cereal prices are projected to increase by 4 to 6 percent compared to baseline levels. Wheat prices increase by 5.6 percent, rice prices by 4.1 percent, maize prices by 5.9 percent, and other coarse grains prices by 5.4 percent.

For most livestock commodities, production in 1997 is lower under Scenario 2 than under the baseline or Scenario 1 in the United States. Beef production in the United States declines by 2.14 percent or 0.26 million metric tons compared to the baseline. Beef production also declines in the European Union but most of the remaining regions remain relatively stable or experience a slight increase. Pork production in the United States falls by 3.1 percent compared to 1997 baseline values. Production of pork also falls in the European Union and East Asia under Scenario 2, while most other regions stay constant or increase slightly. Sheep and goat production declines from relatively low initial production levels in the United States under Scenario 2. Production declines by 7.1 percent in the United States and 0.78 percent in the European Union, while most other regions remain fairly constant. Poultry production under Scenario 2 falls in most regions compared to the baseline, with the largest drop of 3.4 percent in the United States. The total value of U.S. livestock production under Scenario 2 is estimated at US$ 74.3 billion in 1997, US$ 0.7 billion less than under the baseline (Tables 18 and 26). The production value in developed countries increases from US$ 239.6 billion under the baseline to US$ 240.2 billion under Scenario 2. In developing countries, livestock production value is

also slightly higher than under the baseline, with a value of US$ 259.1 billion under the baseline and US$ 263.6 billion under Scenario 2.

The number of livestock slaughtered in the United States declines compared to the baseline for all livestock commodities. These declines are quite small, with a drop of 0.35 percent for pork and poultry, 0.21 percent for sheep and goat meat, and 0.14 percent for beef. Poultry production declines in most other regions as well, while beef production increases in all other areas other than South Asia. Under Scenario 2, livestock yields decline in the United States compared to the baseline. Pork yields decline by 3.2 percent, poultry and sheep and goat meat both decline by 3.1 percent, and beef declines by 1.9 percent. Livestock yields remain the same in most other regions except for small declines in the European Union for beef and poultry.

Beef imports in the United States increase by 0.35 million metric tons under Scenario 2 compared to the baseline. Beef exports decline in the European Union and Latin America, and imports decline in the remaining developing country regions. The United States shifts from being a net exporter of pork under the baseline to a net importer under Scenario 2. Poultry exports in the United States decline compared to the baseline but are very close the levels under Scenario 1. Poultry exports increase in Latin America and East Asia, and net imports increase slightly in Sub-Saharan Africa, Southeast Asia, and South Asia. Net imports of livestock in the U.S. under Scenario 2 is US$ 0.59 billion, compared to net imports of US$ 0.93 billion under the baseline (Tables 19 and 27).

Scenario 2 indicates meat prices would have been around 1.2 to 2 percent higher than under the baseline. Sheep and goat meat prices increase by the smallest percentage

at 1.2 percent. Beef and poultry prices increase by 1.7 percent and pork prices increase by 1.9 percent compared to the baseline.

CONCLUSIONS

The impact of agricultural research funding levels on agricultural production are obvious, however, it has been shown that the composition of this funding also affects agricultural research productivity (Huffman and Evenson, 2003). Huffman and Evenson (2003) show that an increase in federal competitive grant funding for agriculture at the expense of federal formula funding would lower public agricultural research productivity. Since many researchers in other countries are educated in the United States, it is also possible that these productivity decreases would spill over to other countries as well. Based on these results, we have estimated the effect that such a shift in funding sources would have on agricultural production in the U.S. and internationally.

Overall, the results from these simulations show that these shifts in funding composition would have little affect on harvested area of cereals, particularly when the productivity impacts occur only in the U.S. In Scenario 1, the higher prices would have offset the lower levels of productivity, thus having little overall impact on harvested area (a total increase of 0.09 percent). The greater prices under Scenario 2 would have a larger impact, however, with an increase in total harvested area of 0.5 percent, which could have significant implications for land use and on the environment.

Production effects are larger than those seen for area under both scenarios. Production effects are strongest for Scenario 1, because price increases are higher in Scenario 2, and these partly affect the reduction in productivity growth. Under Scenario

1, total value of cereal production in the U.S. declines by US$ 0.9 billion on an annual basis by 1997, compared to the baseline. Livestock production also declines by US$ 1.2 billion, leading to an overall production loss of US$ 2.1 billion in 1997. The price increases under Scenario 2 offset the decline for cereals, while livestock production value in the U.S. also declines under this scenario, leading to an overall production loss of US$ 0.1 billion in 1997 for both grains and livestock.

The largest impact under both scenarios occurs for trade, with significant negative impacts for U.S. farmers. These effects are again larger for Scenario 1 than for Scenario 2, as Scenario 1 only affects the United States. U.S. producers would experience significant reductions in exports under Scenario 1. The annual value of U.S. net cereal exports under Scenario 1 declines by US$ 0.73 billion. The impact on livestock trade is also quite large. The U.S. shifts from being an annual net exporter of US$ 0.93 billion worth of livestock under the baseline to a net importer of US$ 0.67 billion worth of livestock, an overall loss of US$ 1.6 billion. The total cost to U.S. cereal and livestock exports from the shift of 10 percent of funding from formula funds to competitive grant funds is thus US$ 2.33 billion annually. Developed countries as a group also show this impact, with livestock exports reduced by US$ 1.2 billion. Scenario 2 estimates similar impacts for net livestock trade in the U.S., with an overall loss of US$ 1.53 billion. Scenario 2 shows an even greater impact on developed countries, with a reduction of US$ 2.33 billion in export revenues. These results indicate that a shift in funding sources for public agricultural research would have led to a reduction in revenues, thus having serious implications for producers.

While the results of these two scenarios indicate that a shift in funding composition to include greater levels of competitive grant funding and reduced levels of federal formula funds may not have huge impacts on harvested area or production levels, other effects would be more significant. The estimated productivity shift expected from the change in funding composition would have had a significant impact on world trade, including large reductions in value of net exports for U.S. cereal and livestock producers.

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Table 1. Annual growth in cereal area, production and yield, 1970-1997

	1970-82			1982-97		
	Area	**Production**	**Yield**	**Area**	**Production**	**Yield**
	(percent / year)			*(percent / year)*		
Wheat						
Developed	1.14	2.67	1.51	-0.85	0.64	1.51
USA	4.97	6.15	1.12	-1.43	-0.72	0.72
Developing	1.23	5.54	4.25	0.44	3.15	2.69
World	1.18	3.64	2.43	-0.30	1.69	1.99
Maize						
Developed	1.31	5.26	3.91	-0.10	0.79	0.89
USA	2.00	5.87	3.80	0.00	0.75	0.75
Developing	0.46	3.08	2.61	1.54	3.45	1.89
World	1.18	4.46	3.64	-3.38	1.80	0.87
Rice						
Developed	0.48	0.46	-0.02	-0.58	0.30	0.89
USA	5.01	5.18	0.16	-0.33	1.17	1.51
Developing	0.53	2.59	2.06	0.51	2.24	1.72
World	0.53	2.45	1.91	0.48	2.14	1.65
Other Coarse Grains						
Developed	0.58	1.56	0.97	-2.22	-1.02	1.23
USA	-1.98	0.18	2.20	-3.92	-2.90	1.06
Developing	-1.34	0.45	1.82	0.08	0.09	0.01
World	-0.35	1.22	1.58	-1.09	-0.69	0.41
All cereals						
Developed	0.95	3.07	2.10	-1.18	0.26	1.46
USA	2.12	4.93	2.75	-1.18	0.06	1.26
Developing	0.20	3.01	2.80	0.60	2.52	1.90
World	0.52	3.04	2.51	-0.12	1.36	1.48

SOURCE OF BASIC DATA: FAO 1998.

Table 2. Annual growth in total demand and per capita food and feed demand for cereal crops, by region, 1970 – 1997

	1970-82			1982-1997		
	Total demand	**Per capita food demand**	**Per capita feed demand**	**Total demand**	**Per capita food demand**	**Per capita feed demand**
	(percent / year)					
Wheat						
Developed	0.82	0.05	0.60	0.41	-0.16	-0.82
USA	1.49	0.73	-0.85	1.99	1.39	0.71
Developing	5.25	3.20	4.43	2.81	0.93	1.68
World	2.70	0.86	-0.04	1.70	0.10	-1.33
Maize						
Developed	3.32	1.62	2.23	0.80	1.90	-0.25
USA	2.57	2.05	1.09	1.98	3.51	0.26
Developing	4.31	0.35	4.33	3.89	-0.55	3.33
World	3.69	0.72	1.97	2.14	-0.08	0.39
Rice						
Developed	0.79	-0.05	-6.93	0.52	-0.23	5.24
USA	5.77	5.21	-	3.74	3.66	-
Developing	3.01	0.83	4.74	1.98	0.02	3.97
World	2.87	1.08	4.23	1.91	0.26	4.29
Other Coarse Grains						
Developed	0.74	-2.42	-0.02	-1.68	-1.84	-2.47
USA	-2.47	-0.37	-3.92	-2.15	3.49	-4.15
Developing	0.98	-3.23	3.16	0.74	-1.98	-1.31
World	0.81	-2.97	-0.43	-0.83	-1.89	-2.96
All Cereals						
Developed	1.60	-0.11	1.05	-0.01	-0.13	-1.09
USA	1.44	0.98	-0.08	1.50	1.86	-0.29
Developing	3.55	0.96	4.01	2.54	0.12	2.22
World	2.53	0.72	0.77	1.40	0.11	-0.82

Source of basic data: FAO 1998.

Table 3. Annual growth in livestock number, production, and yield, by region, 1970-1997

	1970-82			1982-97		
	Number	**Production**	**Yield**	**Number**	**Production**	**Yield**
	(percent / year)					
Beef						
Developed	0.38	1.19	0.81	-0.80	-0.19	0.61
USA	-0.06	0.26	0.33	-0.20	0.78	0.98
Developing	2.23	2.27	0.03	2.96	3.67	0.70
World	1.11	1.53	0.42	1.04	1.35	0.31
Pigmeat						
Developed	2.04	2.21	0.17	-0.12	0.33	0.45
USA	-0.41	0.49	0.90	0.70	1.30	0.60
Developing	3.84	5.86	1.95	4.93	6.11	1.12
World	2.75	3.36	0.59	2.45	2.99	0.53
Sheep and Goat						
Developed	-0.25	-0.47	-0.22	-0.81	-0.50	0.31
USA	-3.97	-3.37	0.62	-3.38	-2.23	1.18
Developing	2.64	2.60	-0.04	3.78	4.23	0.43
World	1.31	1.02	-0.28	2.22	2.40	0.18
Poultry						
Developed	4.06	4.57	0.48	1.87	2.93	1.04
USA	2.38	3.38	0.98	4.17	5.29	1.07
Developing	7.07	7.59	0.49	7.33	8.06	0.68
World	5.04	5.43	0.37	4.36	4.99	0.61
All meat						
Developed	3.85	2.13	-1.66	1.76	0.79	-0.95
USA	2.28	1.07	-1.18	4.09	2.49	-1.53
Developing	6.62	4.46	-2.02	7.10	5.70	-1.31
World	4.78	2.88	-1.81	4.23	2.93	-1.25

Note: Number is the number of livestock slaughtered, and yield is the carcass weight per animal slaughtered.
Declining yield in the 'All meat' section reflects the shift in composition from beef and pigmeat to poultry.
Source of basic data: FAO 1998.

Table 4. Annual growth in total utilization and per capita food demand for livestock products, by region, 1970 - 1997

	1970-82		1982-97	
	Total demand	**Per capita food demand**	**Total demand**	**Per capita food demand**
	(percent / year)			
Beef				
Developed	0.91	0.11	-0.31	-0.89
USA	0.20	-0.74	0.32	-0.65
Developing	2.76	0.50	3.89	1.89
World	1.47	-0.36	1.35	-0.25
Pigmeat				
Developed	2.36	0.33	1.55	-0.20
USA	0.58	0.94	-0.44	0.00
Developing	5.87	6.18	3.56	4.18
World	3.47	3.02	1.61	1.44
Sheep and Goat				
Developed	-0.78	-1.56	-0.62	-1.20
USA	-4.05	-4.94	-0.78	-1.74
Developing	3.06	0.81	4.06	2.09
World	1.14	-0.72	2.35	0.87
Poultry				
Developed	4.46	3.62	2.76	2.17
USA	3.24	2.29	4.24	3.23
Developing	7.79	5.38	7.89	5.86
World	5.44	3.52	4.90	3.26
All meat				
Developed	2.03	1.22	0.68	0.13
USA	0.98	0.01	1.74	0.77
Developing	4.77	2.47	5.75	3.74
World	2.91	1.05	2.91	1.31

Note: Total demand for livestock products includes food and feed demand, processing, waste and other uses.
Source of basic data: FAO 1998.

Table 5. Percent difference between historic and model production, area, and yield for all cereals, 1997

	Percent difference between historic and model		
	All Cereals Production	**All Cereals Area**	**All Cereals Yield**
USA	3.4	3.5	-0.1
European Union	0.0	5.5	-5.8
Latin America	7.4	7.8	-0.4
Sub-Saharan Africa	-3.2	2.0	-5.4
East Asia	3.8	4.5	-0.7
Southeast Asia	-4.0	1.7	-5.8
South Asia	2.8	1.9	0.9
West Asia / North Africa	-2.6	-1.0	-1.6
Developed	1.9	4.0	-2.2
Developing	2.2	2.9	-0.7
World	2.1	3.3	-1.3

Table 6. Percent difference between historic and model wheat production, area, and yield, 1997

	Percent difference between historic and model		
	Wheat Production	**Wheat Area**	**Wheat Yield**
USA	7.9	3.9	4.2
European Union	0.1	1.9	-1.8
Latin America	7.8	5.4	2.5
Sub-Saharan Africa	10.4	5.9	4.9
East Asia	12.5	2.3	10.4
Southeast Asia	2.9	1.2	1.7
South Asia	9.4	-1.0	10.3
West Asia / North Africa	-2.1	-5.4	3.2
Developed	4.0	2.9	1.2
Developing	8.8	-0.4	9.2
World	6.3	1.4	4.9

Table 7. Percent difference between historic and model maize production, area, and yield, 1997

	Percent difference between historic and model		
	Maize Production	**Maize Area**	**Maize Yield**
USA	3.8	3.5	0.4
European Union	10.6	5.2	5.7
Latin America	10.9	9.2	1.9
Sub-Saharan Africa	1.8	-3.1	4.7
East Asia	-2.7	6.8	-10.2
Southeast Asia	6.6	5.5	1.2
South Asia	13.0	8.0	5.5
West Asia / North Africa	9.6	8.2	1.5
Developed	7.4	5.9	1.5
Developing	4.0	5.4	-1.4
World	5.9	5.6	0.4

Table 8. Percent difference between historic and model rice production, area, and yield, 1997

	Percent difference between historic and model		
	Rice Production	**Rice Area**	**Rice Yield**
USA	5.5	8.5	-3.3
European Union	6.5	10.4	-4.5
Latin America	4.3	4.8	-0.6
Sub-Saharan Africa	5.4	6.6	-1.3
East Asia	3.4	5.3	-2.0
Southeast Asia	-6.2	1.0	-7.2
South Asia	-0.8	3.1	-4.0
West Asia / North Africa	11.1	10.5	0.6
Developed	4.5	11.0	-7.4
Developing	0.0	3.3	-3.5
World	0.2	3.5	-3.5

Table 9. Percent difference between historic and model other coarse grains production, area, and yield, 1997

	Percent difference between historic and model		
	Other Grains Production	**Other Grains Area**	**Other Grains Yield**
USA	-12.4	1.8	-14.4
European Union	-6.6	9.5	-17.8
Latin America	-9.6	7.9	-19.0
Sub-Saharan Africa	-10.6	3.6	-14.8
East Asia	-21.3	1.5	-23.1
Southeast Asia	-15.2	1.8	-17.6
South Asia	-12.8	1.4	-14.5
West Asia / North Africa	-15.6	5.0	-21.6
Developed	-10.7	4.2	-15.6
Developing	-13.2	3.3	-17.1
World	-11.5	3.7	-15.9

Table 10. Percent difference between historic and model production, and number for all meats, 1997

	Percent difference between historic and model	
	All Meats Production	**All Meats Number**
USA	-3.6	2.3
European Union	-5.6	-0.4
Latin America	-3.5	2.1
Sub-Saharan Africa	-3.6	4.2
East Asia	-1.4	2.2
Southeast Asia	1.3	4.6
South Asia	0.9	6.4
West Asia / North Africa	-4.0	2.4
Developed	-5.7	0.3
Developing	-1.8	2.9
World	-3.6	1.8

Table 11. Percent difference between historic and model beef production, number, and yield, 1997

	Percent difference between historic and model		
	Beef Production	**Beef Number**	**Beef Yield**
USA	-3.7	-2.8	-0.9
European Union	-4.0	-2.6	-1.5
Latin America	-3.6	-3.7	0.0
Sub-Saharan Africa	-2.9	-3.3	0.3
East Asia	0.3	0.1	0.1
Southeast Asia	-3.0	-2.9	-0.1
South Asia	-1.8	-1.7	-0.4
West Asia / North Africa	3.8	3.8	-0.2
Developed	-3.2	-2.6	-0.5
Developing	-2.2	-2.0	0.0
World	-2.7	-2.3	-0.4

Table 12. Percent difference between historic and model pork production, number, and yield, 1997

	Percent difference between historic and model		
	Pork Production	**Pork Number**	**Pork Yield**
USA	-8.5	0.3	-9.2
European Union	-7.4	1.7	-8.7
Latin America	0.0	8.1	-9.1
Sub-Saharan Africa	-1.8	6.5	-10.0
East Asia	-0.9	7.2	-8.2
Southeast Asia	3.7	11.4	-7.9
South Asia	1.6	9.9	-8.4
West Asia / North Africa	-11.3	-2.0	-9.7
Developed	-7.7	1.0	-9.2
Developing	-0.4	7.7	-8.3
World	-3.6	5.0	-8.5

Table 13. Percent difference between historic and model sheep and goat meat production, number, and yield, 1997

	Percent difference between historic and model		
	Sheep & Goat Production	**Sheep & Goat Number**	**Sheep & Goat Yield**
USA	-15.3	-6.5	-7.6
European Union	-17.9	-8.1	-5.7
Latin America	-26.0	-20.9	-7.0
Sub-Saharan Africa	-5.8	2.3	-8.3
East Asia	-4.6	4.0	-11.7
Southeast Asia	18.0	16.4	-0.3
South Asia	9.4	16.5	-9.3
West Asia / North Africa	-11.4	-1.5	-11.6
Developed	-39.4	-31.7	-6.6
Developing	-3.8	4.5	-5.6
World	-14.5	-5.1	-7.4

Table 14. Percent difference between historic and model poultry meat production, number, and yield, 1997

	Percent difference between historic and model		
	Poultry Production	**Poultry Number**	**Poultry Yield**
USA	-1.0	2.4	-3.4
European Union	-1.8	-0.3	-1.5
Latin America	-3.7	2.2	-6.0
Sub-Saharan Africa	-4.1	4.4	-8.9
East Asia	-3.3	1.9	-5.2
Southeast Asia	-0.5	4.5	-5.3
South Asia	-3.0	5.4	-8.8
West Asia / North Africa	-3.3	2.5	-6.0
Developed	-2.0	0.7	-2.7
Developing	-3.1	2.8	-6.0
World	-2.5	1.8	-4.4

Table 15. Crop TFP Reduction Factors: Percent per Year 1970-1997

	Rice	Wheat	Maize	Sorghum	Millet	Other Cereals	Beans	Cassava	Potatoes	Roots and Tubers
China	1.20	1.10	1.10	1.10	1.10	1.10	0.40	0.30	0.80	0.75
S. Korea	1.20	1.10	1.10	1.10	1.10	1.10	0.40	0.30	0.80	0.75
OEA	1.00	1.10	1.10	1.10	1.10	1.10	0.40	0.30	0.80	0.75
Mexico	0.30	1.22	0.50	0.60	0.60	0.60	0.30	0.20	0.80	0.75
Brazil	1.00	1.00	0.70	0.60	0.70	0.65	0.30	0.20	0.80	0.75
Argentina	1.00	1.22	0.80	0.60	0.70	0.65	0.30	0.20	0.80	0.75
Columbia	1.00	0.75	0.50	0.60	0.40	0.60	0.30	0.20	0.80	0.75
OLA	1.00	1.22	0.63	0.60	0.60	0.60	0.30	0.12	0.83	0.75
Nigeria	0.50	1.23	0.30	0.40	0.30	0.35	0.21	0.30	0.80	0.40
North SSA	0.50	1.23	0.30	0.40	0.30	0.35	0.21	0.30	0.80	0.40
C-W SSA	0.50	1.23	0.30	0.40	0.30	0.35	0.21	0.30	0.90	0.40
Southern SSA	0.50	1.23	0.30	0.40	0.30	0.35	0.21	0.30	0.90	0.40
Eastern SSA	0.60	1.23	0.30	0.40	0.30	0.35	0.21	0.27	0.80	0.40
Egypt	1.00	1.00	0.70	0.70	0.70	0.70	0.20	0.30	0.80	0.60
Turkey	1.00	0.80	0.70	0.70	0.70	0.70	0.20	0.30	0.80	0.60
O WANA	1.00	0.93	0.70	0.70	0.70	0.70	0.20	0.30	0.80	0.60
India	1.20	1.10	1.10	1.10	1.20	1.15	0.20	0.20	0.80	0.70
Pakistan	0.80	1.10	0.90	1.00	1.00	1.00	0.20	0.20	0.80	0.70
Bangladesh	0.90	1.00	0.90	1.00	1.00	1.00	0.20	0.20	0.80	0.70
OSA	1.00	1.06	1.30	1.03	1.10	1.10	0.20	0.20	0.76	0.70
Indonesia	0.90	1.00	1.00	1.00	1.10	1.10	0.20	0.20	0.77	0.70
Thailand	0.80	1.00	1.00	1.00	1.10	1.10	0.20	0.60	0.77	0.80
Mongolia	1.00	1.00	1.00	1.00	1.00	1.00	0.20	0.20	0.77	0.70
Philippines	1.00	1.00	1.03	1.00	1.00	1.00	0.20	0.20	0.77	0.70
Malaysia	1.00	1.00	1.00	1.00	1.10	1.10	0.20	0.20	0.77	0.70
Vietnam	1.00	1.00	1.00	1.00	1.10	1.10	0.20	0.20	0.77	0.70
Myanmar	0.40	0.50	0.70	0.70	0.70	0.70	0.20	0.20	0.77	0.70
OSEA	1.00	1.06	1.03	1.03	1.10	1.10	0.20	0.20	0.77	0.70

Table 16. Projected value of cereal production in 1997, Baseline

	Baseline Production in 1997				
	Wheat	**Rice**	**Maize**	**Other Grains**	**All Cereals**
	(Value in Billion $ US)				
USA	7.8	1.4	26.5	3.9	39.7
European Union	11.9	0.5	4.2	9.1	25.6
Latin America	2.8	3.5	8.1	1.9	16.3
Sub-Saharan Africa	0.3	1.9	2.9	4.5	9.7
East Asia	13.6	36.4	12.8	2.0	64.8
Southeast Asia	0.0	25.8	2.1	0.0	28.0
South Asia	10.4	29.9	1.4	3.2	44.9
West Asia / North Africa	5.7	1.3	1.0	2.5	10.6
Developed	39.5	4.4	36.7	29.1	109.7
Developing	32.9	98.9	28.4	14.2	174.3
World	72.4	103.3	65.1	43.2	284.1

Table 17. Projected value of cereal net trade in 1997, Baseline

	Baseline Net Trade in 1997				
	Wheat	**Rice**	**Maize**	**Other Grains**	**All Cereals**
	(Value in Billion $ US)				
USA	3.41	0.53	5.78	0.76	10.48
European Union	1.68	-0.20	0.06	0.88	2.41
Latin America	-0.99	-0.73	-0.86	-0.56	-3.14
Sub-Saharan Africa	-0.90	-1.31	-0.65	-1.30	-4.16
East Asia	-1.37	-0.51	-0.55	-0.17	-2.60
Southeast Asia	-0.95	2.78	-0.82	-0.01	0.99
South Asia	-0.65	0.73	-0.29	-0.29	-0.50
West Asia / North Africa	-3.70	-0.85	-0.84	-1.36	-6.75
Developed	8.62	-0.07	4.03	3.70	16.28
Developing	-8.62	0.07	-4.03	-3.70	-16.28
World	0.00	0.00	0.00	0.00	0.00

Table 18. Projected value of livestock production in 1997, Baseline

	Baseline Production in 1997				
	Beef	**Pork**	**Sheep & Goat**	**Poultry**	**All Meats**
	(Value in Billion $ US)				
USA	45.3	18.3	0.5	10.9	75.0
European Union	30.6	37.7	5.2	6.1	79.7
Latin America	50.4	8.0	2.2	7.0	67.6
Sub-Saharan Africa	9.5	1.8	5.1	0.7	17.1
East Asia	18.1	82.6	9.4	8.0	118.2
Southeast Asia	4.9	8.0	0.7	2.6	16.2
South Asia	15.7	1.2	6.4	0.8	24.1
West Asia / North Africa	5.3	0.1	7.9	2.4	15.7
Developed	117.8	81.9	18.3	21.6	239.6
Developing	104.0	101.8	31.6	21.6	259.1
World	221.7	183.7	49.9	43.3	498.7

Table 19. Projected value of livestock net trade in 1997, Baseline

	Baseline Net Trade in 1997				
	Beef	**Pork**	**Sheep & Goat**	**Poultry**	**All Meats**
	(Value in Billion $ US)				
USA	-0.59	0.23	-0.01	1.30	0.93
European Union	1.97	3.21	0.04	0.09	5.31
Latin America	4.79	-1.74	-1.18	0.73	2.61
Sub-Saharan Africa	-1.52	0.22	0.33	-0.48	-1.46
East Asia	-1.82	-0.05	0.32	0.49	-1.06
Southeast Asia	-1.00	-0.36	0.11	-0.12	-1.37
South Asia	0.08	-0.08	-0.18	-0.03	-0.21
West Asia / North Africa	-2.02	0.01	-0.62	0.24	-2.39
Developed	1.75	2.03	1.27	-0.81	4.24
Developing	-1.75	-2.03	-1.27	0.81	-4.24
World	0.00	0.00	0.00	0.00	0.00

Table 20. Projected value of cereal production in 1997, Scenario 1

	Scenario 1 Production in 1997				
	Wheat	**Rice**	**Maize**	**Other Grains**	**All Cereals**
	(Value in Billion $ US)				
USA	7.7	1.4	26.0	3.7	38.8
European Union	12.0	0.5	4.3	9.2	26.0
Latin America	2.8	3.5	8.4	2.0	16.6
Sub-Saharan Africa	0.3	1.9	3.0	4.6	9.9
East Asia	13.8	36.7	13.2	2.0	65.7
Southeast Asia	0.0	26.0	2.2	0.0	28.3
South Asia	10.5	30.1	1.5	3.3	45.4
West Asia / North Africa	5.8	1.4	1.1	2.6	10.8
Developed	39.7	4.4	36.5	29.4	110.0
Developing	33.2	99.7	29.3	14.4	176.6
World	72.9	104.1	65.8	43.8	286.6

Table 21. Projected value of cereal net trade in 1997, Scenario 1

	Scenario 1 Net Trade in 1997				
	Wheat	**Rice**	**Maize**	**Other Grains**	**All Cereals**
	(Value in Billion $ US)				
USA	3.29	0.48	5.32	0.66	9.75
European Union	1.71	-0.20	0.12	0.90	2.53
Latin America	-1.00	-0.73	-0.78	-0.57	-3.07
Sub-Saharan Africa	-0.90	-1.31	-0.58	-1.28	-4.08
East Asia	-1.36	-0.50	-0.38	-0.17	-2.41
Southeast Asia	-0.95	2.80	-0.81	-0.01	1.03
South Asia	-0.61	0.76	-0.28	-0.28	-0.40
West Asia / North Africa	-3.71	-0.85	-0.85	-1.37	-6.79
Developed	8.58	-0.11	3.68	3.70	15.85
Developing	-8.58	0.11	-3.68	-3.70	-15.85
World	0.00	0.00	0.00	0.00	0.00

Table 22. Projected value of livestock production in 1997, Scenario 1

	Scenario 1 Production in 1997				
	Beef	**Pork**	**Sheep & Goat**	**Poultry**	**All Meats**
	(Value in Billion $ US)				
USA	44.8	17.9	0.5	10.6	73.8
European Union	30.9	38.0	5.2	6.2	80.4
Latin America	50.8	8.1	2.2	7.1	68.2
Sub-Saharan Africa	9.6	1.8	5.1	0.7	17.2
East Asia	18.3	83.3	9.5	8.1	119.2
Southeast Asia	5.0	8.1	0.7	2.6	16.3
South Asia	15.9	1.2	6.4	0.8	24.3
West Asia / North Africa	5.3	0.1	7.9	2.4	15.9
Developed	117.9	82.1	18.4	21.5	239.8
Developing	105.0	102.7	31.8	21.8	261.3
World	222.8	184.8	50.2	43.4	501.1

Table 23. Projected value of livestock net trade in 1997, Scenario 1

	Scenario 1 Net Trade in 1997				
	Beef	**Pork**	**Sheep & Goat**	**Poultry**	**All Meats**
	(Value in Billion $ US)				
USA	-1.39	-0.29	-0.03	1.04	-0.67
European Union	2.07	3.29	0.03	0.14	5.54
Latin America	5.03	-1.68	-1.18	0.80	2.96
Sub-Saharan Africa	-1.44	0.23	0.33	-0.47	-1.35
East Asia	-1.69	0.24	0.33	0.55	-0.58
Southeast Asia	-0.96	-0.31	0.11	-0.10	-1.26
South Asia	0.17	-0.07	-0.18	-0.02	-0.10
West Asia / North Africa	-2.00	0.01	-0.62	0.26	-2.36
Developed	1.16	1.61	1.25	-0.99	3.03
Developing	-1.16	-1.61	-1.25	0.99	-3.03
World	0.00	0.00	0.00	0.00	0.00

Table 24. Projected value of cereal production in 1997, Scenario 2

	Scenario 2 Production in 1997				
	Wheat	**Rice**	**Maize**	**Other Grains**	**All Cereals**
	(Value in Billion $ US)				
USA	8.2	1.4	27.0	3.9	40.5
European Union	12.2	0.5	4.3	9.4	26.4
Latin America	2.9	3.6	8.6	2.0	17.1
Sub-Saharan Africa	0.3	2.0	3.1	4.7	10.2
East Asia	14.2	37.8	13.6	2.0	67.6
Southeast Asia	0.0	26.8	2.2	0.0	29.1
South Asia	10.8	31.0	1.5	3.3	46.7
West Asia / North Africa	6.0	1.4	1.1	2.6	11.1
Developed	41.2	4.5	37.6	30.1	113.5
Developing	34.2	102.7	30.1	14.8	181.8
World	75.4	107.3	67.7	45.0	295.4

Table 25. Projected value of cereal net trade in 1997, Scenario 2

	Scenario 2 Net Trade in 1997				
	Wheat	**Rice**	**Maize**	**Other Grains**	**All Cereals**
	(Value in Billion $ US)				
USA	3.61	0.52	5.74	0.76	10.63
European Union	1.67	-0.21	0.02	0.90	2.39
Latin America	-1.06	-0.72	-0.83	-0.58	-3.20
Sub-Saharan Africa	-0.92	-1.32	-0.59	-1.24	-4.06
East Asia	-1.62	-0.59	-0.49	-0.22	-2.92
Southeast Asia	-0.97	2.89	-0.83	-0.01	1.07
South Asia	-0.68	0.78	-0.30	-0.35	-0.55
West Asia / North Africa	-3.87	-0.86	-0.88	-1.42	-7.04
Developed	9.17	-0.12	3.93	3.84	16.82
Developing	-9.17	0.12	-3.93	-3.84	-16.82
World	0.00	0.00	0.00	0.00	0.00

Table 26. Projected value of livestock production in 1997, Scenario 2

	Scenario 2 Production in 1997				
	Beef	**Pork**	**Sheep & Goat**	**Poultry**	**All Meats**
	(Value in Billion $ US)				
USA	45.1	18.0	0.5	10.7	74.3
European Union	30.8	38.0	5.2	6.1	80.1
Latin America	51.3	8.2	2.2	7.1	68.8
Sub-Saharan Africa	9.7	1.8	5.1	0.7	17.4
East Asia	18.5	84.1	9.6	8.1	120.2
Southeast Asia	5.0	8.2	0.7	2.7	16.5
South Asia	16.0	1.2	6.4	0.8	24.5
West Asia / North Africa	5.4	0.1	8.0	2.4	16.0
Developed	118.1	82.2	18.4	21.5	240.2
Developing	105.9	103.7	32.0	21.9	263.6
World	224.0	185.9	50.4	43.4	503.8

Table 27. Projected value of livestock net trade in 1997, Scenario 2

	Scenario 2 Net Trade in 1997				
	Beef	**Pork**	**Sheep & Goat**	**Poultry**	**All Meats**
	(Value in Billion $ US)				
USA	-1.31	-0.31	-0.03	1.06	-0.60
European Union	1.69	3.03	0.00	0.09	4.80
Latin America	5.22	-1.62	-1.18	0.82	3.24
Sub-Saharan Africa	-1.36	0.24	0.35	-0.47	-1.24
East Asia	-1.57	0.56	0.36	0.57	-0.08
Southeast Asia	-0.93	-0.25	0.11	-0.09	-1.15
South Asia	0.25	-0.06	-0.16	-0.02	0.01
West Asia / North Africa	-1.99	0.01	-0.62	0.26	-2.34
Developed	0.65	1.15	1.17	-1.05	1.91
Developing	-0.65	-1.15	-1.17	1.05	-1.91
World	0.00	0.00	0.00	0.00	0.00