Livestock industry in transition: Economic, demographic, and biofuel drivers

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Implications

- Livestock production has experienced a major shift toward intensification in recent years. Livestock production today is using much less land than in the past. That trend is expected to continue in the future.
- Meat production from the most efficient converters of feed, poultry, and pork will grow faster than beef, with poultry being the leader. We expect to see more regional specialization and more international trade in livestock products.
- The biofuels boom and higher feed prices have slowed growth rates in the world’s livestock sector. That effect is expected to diminish as corn ethanol production will not grow significantly in the future.
- For a number of reasons, the prospects for a return to a more stable equilibrium of supply and demand in crop markets appears to be likely. Therefore, with average weather conditions, we expect to see a return to lower animal feed prices (not the historic lows but not the recent extreme highs either) with a movement to increasing growth rates in animal production and consumption.

Key words: animal feed, biofuels and their by-products, crop market, intensification, land use, livestock products

Introduction

The livestock and crop sectors jointly provide food for human life, but they also compete with each other for limited land resources. The global area of agricultural land (including arable land, permanent crops, permanent meadows, and pastures) has increased from 4.56 billion hectares in 1970 to 4.89 billion hectares in 2010. However, per capita agricultural land has decreased from 1.24 ha/person/year to 0.72 ha/person/year during the same time period. This means that each person must be fed with fewer land resources. The crop and livestock sectors have achieved this through major technological progress which has increased output per unit of land. The tight competition between the two sectors has led the livestock sector to move toward intensification of land use (FAO, 2008, 2009; World Bank, 2009).

While livestock is still the largest land-using sector in the world (Steinfeld et al., 2006), its dependency on land has changed during the past decades. Until a few decades ago, the crop sector was allocating a big portion of its cropland to feed crops such as silages, forages, hay, alfalfa,
sorghum, oats, and so on. This pattern has changed significantly in recent decades. In 2010, only 16% of the global harvested area was occupied by these crops. In addition, some pasture lands have been converted to cropland in recent years to meet the increasing demand for plant-based human foods and other uses. The global area of permanent meadows and pastures has decreased by about 69 million hectares (MH) during the time period of 2000 to 2009. Alternatively, production of corn and oilseeds, which can be used for food, feed, and/or energy, have sharply increased with their harvested areas expanding by 30.6 and 82.2 MH, respectively, from 1990 to 2010.

The rapid expansion in biofuel production in the United States, Europe, Brazil, and other countries has changed the mix of feed supplies available for the livestock sector. In 2011, more than 40% of corn produced in the United States, the world largest corn producer, was used to produce about 14 billion gallons of ethanol and by-products. Significant portions of oilseeds produced across the world are also now converted to biodiesel. In the 2011/2012 marketing year, 25% of the U.S. soybean oil production was used as biodiesel, 26% of world palm oil production was devoted to industrial uses, 19% of world soybean oil production, and 31% of world rapeseed production went into industrial uses including biodiesel. The expansion in biofuel production and other economic factors such as the rapid expansion of demand for food across the world, in particular in China due to income growth, has contributed to much higher feed prices, which in general negatively affected the global livestock sector (Abbott et al., 2008, 2009, 2011). While the portion of corn production available for livestock decreased, there were more distiller grains (co-products of ethanol) available for feed use. The increased use of oilseeds for biodiesel also meant an increase in oilseed meals which are joint products with vegetable oil production (Taheripour et al., 2011). While only modest additional expansion is expected in production of ethanol from food based crops like corn and wheat, the production of biodiesel produced from vegetable oils and cellulosic biofuels from crop residues or dedicated energy crops could grow in the future. The growth of dedicated energy crops, such as switchgrass and miscanthus, would increase competition for some lands used today for grazing, and thus would further constrain land use by the livestock sector.

Higher feed prices are negative to the livestock sector because they raise the costs of production. In the short-run, livestock producers must absorb these higher costs in the form of financial losses. Over time, those financial losses result in some liquidation and reduced production. Once a sufficient volume of production is cut, retail prices of livestock products rise, and consumers cut back the volumes they buy. Then higher prices plus additional demand due to income and population growth could encourage livestock producers to expand their supply over time.

The continuing evolution in land use and rapid changes in global economic conditions are shaping the trends in production and consumption...
of livestock products. This paper will analyze these trends and suggest their future directions. In addition, this paper highlights the most recent changes in consumption, production, and trade of livestock products to investigate the potential impacts of the recent events such as the recent boom in global biofuel production and sharp surges in demands for food products due to rapid income growth in China, India, and other developing countries for the global livestock industry and its future expansion.

Intensification and Evolution in Feeding Practices

The livestock and crop sectors are linked together in several ways, and in particular through the land market. On one hand, the livestock sector uses pasture land and crops to feed livestock that provides meat, dairy, and poultry products which are important human foods. On the other hand, croplands are needed to provide fruits, vegetables, nuts, and grain based foods for human nutrition. Hence, while the livestock and crop sectors compete for limited land resources, they jointly provide food for humans. Many factors such as population growth, economic growth, and changes in income, taste and health issues, yield improvement, and technological progress in crop and livestock production affect the allocation of land among the livestock and crop sectors and within alternative crops. These factors have evolved gradually over time, in particular during the past two decades, and will continue to change in the future. Figure 1 summarizes the evolution in agricultural land allocation patterns in recent decades and outlines its likely future direction. To introduce these patterns, we classify crops in three main categories. Crops such as rice, wheat, vegetables, fruits, and nuts, which are mainly produced for human food, are considered as food crops. Crops such as silages, forages, hay, alfalfa, sorghum, oats, and barley, which are mainly used as animal feed, are classified as feed crops. Finally, corn and oilseeds which can be used as food and/or feed are considered as food-feed crops. Since corn and oilseeds are now being used to produce biofuels, we refer to this group as food-feed-energy crops. For a complete list of crops and their classifications, see Taheripour and Tyner (2013).

Panel I of this figure represents a traditional view of agricultural land allocation where croplands are divided mainly among three groups of food, feed, and food-feed crop categories, with a larger share for food crops and relatively smaller shares for feed and food-feed crops. The livestock sector uses pasture land, feed crops, and a portion of food-feed crops to provide livestock food products for human consumption. The livestock sector heavily depends on the primary input of land. This was a dominant land allocation pattern until recent decades. For example, in 1990, global harvested area was about 1358 MH with 57%, 22%, and 21% used to produce food, feed, and food-feed crops (Figure 2).

During the past few decades, in particular during the past two decades, this pattern has changed as presented in panel II of Figure 1. The share of feed crops has contracted but the share of food-feed crops has increased. As shown in Figure 2, the global area of cropland in feed crops has decreased by about 66 MH during the past two decades (from about 295 MH in 1990 to 229 MH in 2010). The share of feed crops in total harvested area has decreased to 16% in 2010 (Figure 2), while the area harvested for food-feed crops (corn and oilseeds) has increased by about 113 MH during the past two decades. The share of these crops has increased from 21% in 1990 to 28% in 2010. During this time period the harvested area for food crops has increased by about 20 MH while their share has remained around 56%. For a detailed discussion on changes in agricultural land by region, see Taheripour and Tyner (2013).

During the past two decades, a major change occurred in livestock feeding methods. The livestock sector has moved toward the use of more corn, oilseed meals, and distiller grains (by-product of ethanol production) in feed rations instead of using traditional feed crops. This is an important change which reduces the dependency of the livestock sector on land and reduces the pressure on the demand for land. Biofuel expansion in recent years has intensified this process by providing more distillers grains and oilseed meals produced as co-products of ethanol and biodiesel, respectively (Taheripour et al., 2011).

In addition to the reduction in harvested areas of feed crops, the livestock sector has lost a portion of its pasture land in recent years as well. According to FAO data, the global area of permanent meadows and pastures has decreased by about 69 MH during the time period of 2000–2009. This reduction has been seen in many countries across the world, in particular in Asia, Europe, and Oceania. This means that the global livestock sector is now less dependent on land inputs. As discussed in the next section, the livestock sector has also shifted away from ruminants to more pigs and poultry during past decades. This also allowed the industry to reduce its land input over time (FAO, 2009).

While intensification of livestock production provides more land resources to expand crop production for food, feed, and energy, the conversion of pastureland to cropland could cause adverse environmental consequences such as loss of biodiversity, soil erosion, reduction in land carbon sequestration capacity, release of carbon stocked in land to atmosphere, and distortion in natural ecosystems (FAO 2008). Several

Figure 2. Evolution in global harvested area, 1990 to 2010 (FAOSTAT/USDA PS&D online database).
economic and demographic factors contribute to the land conversion process. In recent years, expansion in ethanol production has augmented the land conversion process. For example, Taheripour et al. (2011) have projected the U.S. and EU biofuel targets will jointly convert 9.2 MH of pasture land and 2.7 MH of forest to cropland, which eventually will cause negative environmental consequences described above.

Panel III of Figure 1 demonstrates possible future land use given the continued shift to relatively more pork and poultry and less ruminants, the current high returns on cropland used for oilseeds and corn, and the possible expansion in biofuel production from cellulosic materials. The share of feed crops will continue to drop, and a portion of existing pasture land may shift to produce cellulosic biofuel feedstocks. This will provide strong economic incentives to move animal production away from extensive uses toward intensive uses of land.

Transition in Livestock Products

The livestock sector provides a wide variety of food products. This section examines changes in major livestock products during the past four decades for production of meat, milk, and egg products. Meat production has increased continuously during the past four decades, and consequently its production per capita has increased from 27 kg/person/year in 1970 to 42.4 kg/person/year (Figure 3). This means that production of meat has increased at a rate greater than population growth. However, in recent years, in particular during the biofuel boom, the meat production growth rate slowed to the population growth rate, and consequently production of meat per capita has not increased in recent years, as shown in Figure 3.

During the past 42 years, production of milk has increased with an annual growth rate greater than 1.5% but with reductions in the early 1990s. In general, milk production per capita remained around 95 to 105 kg/person/year during the past four decades. Production of eggs has followed a sharp upward trend with a rate expressively greater than population growth and therefore its production per capita has increased from 5.5 kg/person/year in 1970 to 10.2 kg/person/year in 2012 (Figure 3).

While total global meat production was on an increasing growth trend during the past four decades, individual species followed different patterns. The global production of ruminant meat has increased at a rate lower than the population growth rate in many years during the past four decades and therefore its production per capita decreased, in particular in recent years as shown in Figure 3. On the other hand, production of pork and poultry meats has followed strong upward paths. Per capita production of pork has increased rapidly from 9.7 kg/person/year in 1970 to about 15.6 kg/person/year in 2012. Among the meat products, production of poultry meat has increased at the highest rate during the past four decades and therefore its production per capita increased sharply from 4.1 kg/person/year in 1970.

Figure 3. Production per capita of livestock products, 1970 to 2012 (FAOSTAT/USDA PS&D online database).
to 14.8 kg/person/year. Today, production per capita of poultry meat is slightly greater than ruminant meat and slightly less than pork as shown in Figure 3. Thus, a major change has occurred in meat production and consumption in favor of poultry meat Figure 4. Factors such as changes in feed prices, production technology and costs, consumer taste, and health concerns regarding red meats drove these major changes in meat consumption and production.

The geographical distribution of meat production also has changed during the past four decades. The U.S. was the largest world meat producer with about 21.3 million metric tons (MMT) of meat output. The U.S. is now producing 41.8 MMT of meats and is the second largest meat producer. China has become the leading global meat producer with 82.9 MMT of meat output. Brazil has also expanded its meat production rapidly from 3.1 MMT in 1990 to 25.3 MMT in 2012. During this time period, some countries such as Germany, Russia, France, Argentina, Mexico, India, Spain, Canada, and Vietnam maintained or improved their position in meat production with moderate to large increases. Some countries such as the Netherlands and New Zealand lost their global rank with minor increases.

The distribution of the various meat products among the large meat producers is very different, as shown in Figure 5. China is the largest pork producer in the world. Production of pork in China has increased from 6.1 MMT in 1970 to about 52.6 MMT in 2012. The U.S. was producing 10.6 MMT of ruminant meats in 1970 and was not very different in 2012 at 11.8 MMT.

The geographical distribution of milk production has also changed significantly during the past four decades (Figure 5). India is now the largest milk producer in the world with 125.8 MMT in 2012. They were producing only 20.8 MMT of milk in 1970. Milk is considered as a common animal food product which can be used by a large group of Indians regardless of their religion. The second largest milk producer is the U.S. with about 91 MMT of production in 2012, only 71% greater than 42 years ago.

With respect to eggs (Figure 5), China is now the world’s largest egg producer with 29 MMT in 2102. Production in China has increased continuously during the past 42 years, in particular in 1980s and 1990s with a more than 10% annual growth rate. The second largest egg producer is the U.S. which produced 5.4 MMT of eggs in 2012 up from 4.1 MMT in 1970.

Recent Changes and Drivers Including Biofuels

The global annual growth rates of meat production were about 3% in the late 1990s and early 2000s. This was a period when global animal product demand was growing rapidly from population and income growth. In addition, feed was inexpensive globally with corn prices in the U.S. averaging ~US$2 per bushel. In the crop years from 2006 to 2012, U.S. corn prices have averaged ~US$5 per bushel with corresponding high prices for protein meals and forages. Higher feed prices increased production costs of meat, and that caused negative shifts in the supply of meat. Therefore, the global annual meat production growth rates have slowed to less than 1.5% in recent years but remain positive. Growth rate patterns vary by species, however. The long term trends are for chicken and pork to have the greatest growth rates, and that has continued but at a slower rate of growth in the biofuels era. By 2012, the chicken annual growth rate had slowed to 3.1% and pork to 1.6%. In contrast, the beef production annual growth rate has turned negative at -0.6%. While the global annual meat production growth rates have slowed in recent years, we expect that these growth rates will return to historical trends in the future for the reasons mentioned in the next section.

Several supply factors seem to be related to the differences in growth rates among species. First, beef production is the most land extensive of these species. Beef cows and calves tend to be used as grazing animals that require large amounts of land for foraging. The argument is that beef cows are able to convert land that has limited economic value into a positive value. However, in some parts of the world like Argentina and parts of Brazil, high quality land is used for grazing.

In the biofuels era, much higher crop values have also contributed to higher land values for both cropping and animal production. For example, the average values of U.S. cropland and pasture land have increased from US$2060 and US$740 per acre in 2005 to US$3,550 and US$1,150 per acre in 2012, respectively (USDA, 2009, 2012). This tends to be most harmful to species that are the most extensive users of land such as beef cattle.

The expansion in biodiesel production, mainly by the EU, has certainly generated a new demand for oilseeds and has contributed to higher prices for oilseeds. However, the new derived demand for oilseeds for biodiesel production has not changed the global expansion path of oilseed meals production. In the 1990s and 2000s, the global production of oilseed meals grew at an annual rate of 4.1%. Thus, the expansion in biodiesel production has not reduced the supply of meals available.

Figure 4. Evolution in livestock production, 1970 to 2012 (FAOSTAT/USDA PS&D online database).

 Shares in total meat production

| Percent | 1970 | 1980 | 1990 | 2000 | 2010 | 2012 |
|---------|------|------|------|------|------|------|
| 100     | 15   | 19   | 23   | 29   | 34   | 35   |
| 80      | 36   | 39   | 39   | 39   | 37   | 37   |
| 60      | 49   | 42   | 38   | 32   | 29   | 28   |
| 40      | 36   | 39   | 39   | 39   | 37   | 37   |
| 20      | 15   | 19   | 23   | 29   | 34   | 35   |

 Annual per capita growth rates

| Annual Percent Change | 1970-1980 | 1980-1990 | 1990-2000 | 2000-2010 | 2010-2012 |
|-----------------------|-----------|-----------|-----------|-----------|-----------|
| 4.5                   | 3.5       | 3.5       | 3.5       | 3.5       | 3.5       |
| 4.0                   | 3.5       | 3.5       | 3.5       | 3.5       | 3.5       |
| 3.5                   | 3.5       | 3.5       | 3.5       | 3.5       | 3.5       |
| 3.0                   | 3.5       | 3.5       | 3.5       | 3.5       | 3.5       |
| 2.5                   | 3.5       | 3.5       | 3.5       | 3.5       | 3.5       |
The expansion in biodiesel production has modestly altered the composition of meals produced at the global scale. The share of soybean meal relative to total meals produced has remained around 70% during the past two decades. The share of rapeseed meal has fluctuated around 11% to 14% with a tendency toward 14% in recent years as the EU increased rapeseed oil use for biodiesel. The share of sunflower seed meal was around 5% and the share of all other types of oilseed meals was around 11% to 14% with a tendency toward 11% in recent years.

Production of oilseed meals in the EU, the main biodiesel producer, was following a downward trend in early 2000s but has rapidly expanded since 2005 when production of biodiesel expanded rapidly. However, during the past three years, production of oilseed meals turned back to a downward trend in this region again. The composition of oilseed meals produced in the European Union has significantly changed in recent years. Due to expansion in rapeseed production and use of rapeseed oil in biodiesel, the share of rapeseed meal in total meals produced in the EU has increased significantly.

Figure 5. Production of livestock products by major producers, 1970 to 2012 (FAOSTAT/USDA PS&D online database); MMT, million metric tons.
has increased from 27% in 2000 to more than 50% in 2012. The share of soybean meal has decreased in this region. Note that the EU is a large producer of oilseed meals but its share in global production has decreased from 13.7% in 1990 to only 9.6% in 2012. The U.S. production of oilseed meals has decreased in this region. Note that the EU is a large producer of oilseed meals, mainly soybean meal, fluctuated between 35 and 41 MMT since 2000, with a downward trend after 2006. Other regions across the world also produce significant amounts of oilseed meals, especially South America.

Unlike biodiesel production, which has not limited availability of oilseed meals to livestock producers, the expansion in corn ethanol, mainly produced in U.S., has curbed global availability of corn for the livestock sector. Corn production in the U.S. was about 252 MMT in 2000, about 43% of global corn production. In this year, the U.S. converted 6.3% of that to about 1.63 billion gallons of ethanol and by-products. Over that past decade this picture has significantly changed. In 2011, the U.S. produced about 272 MMT of corn and converted more than 40% of that to 13.9 billion gallons of ethanol and by-products. This means that corn availability (unadjusted for by-products) for non-ethanol uses (for domestic food and feed uses and exports) has decreased from 236 MMT in 2000 to about 153 MMT in 2011. This means a reduction in supply of corn (unadjusted for by-products) to non-ethanol uses by 83.4 MMT. The net reduction in the supply of corn after adjustment for ethanol by-products would be about 55.6 MMT. The U.S. livestock sector has suffered significantly from the reduction in supply of corn to non-ethanol uses. However, as explained in the next paragraph, by-products of ethanol production (i.e., mainly DDGS) have filled a portion of the reduction in supply of corn to the livestock industry. Corn exports from the U.S. also have decreased by 20 MMT due to this restriction. Consequently, one can conclude that the expansion in U.S. ethanol production has negatively affected the U.S. and global livestock sectors.

While the expansion in U.S. corn ethanol has reduced the supply of corn for the livestock sector, distillers grains produced by the ethanol industry have compensated a portion of the reduction in supply of corn to the livestock sector. The U.S. production of DDGS has increased from 2 MMT in 2000 to about 34 MMT in 2010 (Hoffman and Baker, 2010). U.S. exports of DDGS have increased by 8 MMT during this time period. Currently, China, Mexico, and Canada are the main buyers of the U.S. DDGS.

The two most recent feed price surges impacting the livestock sector were the 2011 agricultural commodity price run-up, and the drought induced price increases in 2012. The prime drivers of the 2011 price increases were the huge increase in Chinese soybean imports and the increased biofuels demand for corn (Abbott et al., 2011). The changes in demand from these two sources are illustrated in Figure 6. Between 2000 and 2011, U.S. hectares needed to meet these two demands increased by fivefold. Between 2006 and 2011, the hectare requirement doubled. In 2012, of course, the U.S. drought was the major driver. However, the more inelastic corn demand caused by the ethanol mandate accentuated the price hike. The ethanol renewable fuel standard (RFS) creates a relatively fixed (inelastic) demand because it requires blending a fixed minimum quantity of corn ethanol regardless of corn production or price. This inflexibility forces other sectors such as livestock feeding and exports to do more of the adjustment in response to the crop shortage. While there is some flexibility built into the RFS (Tyner et al., 2012), the ethanol demand for corn is still more inelastic (less price responsive) than other demands.

Thoughts on the Future

Animal product consumption and production are influenced by a host of factors that will continue to play out in coming years. Global trends do not reverse quickly but tend to stay in place over long periods of time, but with accelerating and decelerating rates of change. Thus it is important to understand recent trends and the drivers of those trends as has been outlined in previous sections.

One of the major recent drivers for animal sectors has been the sharp upward shift in feed prices. The late 1990s and the first half of the 2000s was a period of surplus world grain and feed supplies. Major producers like the U.S. and Europe were subsidizing crop production and selling these feed supplies at below production costs into international markets. Abundant supplies and low feed prices were stimulative to high animal production growth rates.

During the past decade, we observed substantial increases in food demand mainly due to the rapid growth of incomes and population in developing countries. Combined with the rapid biofuel expansion, these demand expansions were greater than production of crops, and hence storage inventories (stocks) were reduced and prices surged. Once storage stocks are tight, any weather disruptions that reduce yields could increase prices significantly. This means feed prices are not only high from a historical standpoint, but are also more volatile.

So, where is the world at the end of 2012? Weather disruptions in South America, North America, and Europe in 2012 have left corn, soybean, and forage markets with short supplies, and markets are forced to ration usage of those short supplies with record high prices. Wheat and rice production was not as severely impacted, and inventories are more stable and prices are not at records.

Looking forward, the prospects for a return to a more stable equilibrium of supply and demand in crop markets appears to be likely, in the absence of
extreme weather events. Supporting this argument are three important potential drivers. First is that a major world supply response is underway. High crop prices and changes in relative crop prices in recent years have resulted in strong expansions in world harvested area. Crop yields are also following significant upward trends across the world. These trends are expected to continue in the future. The major areas of expansion in order of importance are: Sub Saharan Africa, South America, East Asia (China), and South East Asia. On the other hand, the allocation of land among crops has changed in many regions and in particular in developed countries such as the U.S. and EU, with more land being allocated to more efficient crops with greater yields. Another way crop production expansion is occurring is through intensification of production practices. Those include irrigation, improved drainage, increased input usage (e.g., fertilizer), and enhanced application of high yield technology.

The other two major drivers relate to demand for crops. The surge in the usage of corn, sugarcane, and oilseeds for biofuels has been one of the major demand drivers for these crops. Will that rate of growth continue? There are some reasons to believe that it will not. First among these arguments is that the large growth in the use of corn for ethanol in the U.S. is largely over as the renewable fuels standard (RFS) for conventional ethanol peaks at 15 billion gallons annually. This means that the large growth in the land needed to supply corn for fuel is nearly over. The share of U.S. corn going to ethanol will actually begin to fall after the 2014 crop when the RFS reaches the maximum, and corn yields continue to increase.

The second major demand growth factor has been the rise of incomes in developing countries, with China as the center. That brings the question of whether future world economic growth will continue to be as stimulative to food demand growth as in the last five to seven years. In particular, can China continue to have near double-digit economic growth rates? And, can they continue to have as large of an impact on food demand as in recent years? At some point, economic growth rates will slow, and there is evidence that it may be underway for China.

These arguments suggest that feed prices will moderate as those markets reach a new equilibrium between supply and demand. Moderation means lower feed prices as compared with extreme recent highs, but not returning to the lows experienced in the surplus feed era of the late 1990s and early 2000s.

An upcoming period of moderating feed prices would be positive for animal production and consumption. Lower cost feed would result in some recovery of animal production growth rates. The most favored species for global growth will continue to be chicken and pork. The more land extensive beef industry is expected to have low production growth rates, but at least should turn back to positive, although expansion in world beef production may not begin until 2016.

Chicken and pork production and consumption increases will continue to be driven by their high feed conversion efficiency, and thus their ability to provide the developing world with high quality animal protein at moderate consumer prices. Growth of pork will be somewhat constrained due to cultural and religious reasons in parts of the world.

Increased intensity of land use means that land will tend to be used to intensively produce crops rather than be extensively used for grazing. The trend will be for those intensively produced crops to be used in intensively managed animal production operations. This will tend to favor large-scale animal production operations. Intensive technologically driven production systems are already evident for chicken, pork, dairy, and cattle feeding. These systems, with their tightly-managed, standardized and optimized production protocols, can be extended around the globe. However, local, cultural, environmental, and personal resistance is to be expected in many regions.

Continued increasing trends in global trade of animal products, likely means that greater geographic specialization of production will occur in the future. This means that some regions will become more specialized in animal production, and some regions will reduce animal production in favor of more imports. This trend may be evolutionary, not revolutionary, since the import of animal products often implies added concerns about freshness and disease as well as health and sanitation. For bulky products such as fluid milk, development of these industrial systems would be expected close to the human population base.

The regions that appear to be on a track toward greater concentration of animal production are where feed supplies are in surplus. This includes South America, North America, the Former Soviet Union, and Eastern Europe, and to a smaller extent Oceania. Countries like China and India are increasing crop and animal production, and that is expected to continue. However, there are still many people living in these two countries who suffer from malnutrition. India has prospects to become more than self-sufficient and is striving to increase agricultural exports. China had been largely self-sufficient in food production except for soybeans, but they are unable to keep up with food demand growth and are demonstrating an increasing willingness to import more food in the future. Yield improvement in China’s irrigated agriculture could reduce their demand for land.
Conclusions

The major conclusions of this analysis are straightforward. First, livestock production has experienced a major shift toward intensification in recent years. Livestock production today is using much less land than in the past, and that trend is expected to continue. Second, the most efficient converters of feed, poultry, and pork will grow faster than beef, with poultry being the leader. Third, we expect to see more regional specialization and more international trade in livestock products. Fourth, the biofuels boom and higher feed prices have slowed growth rates in the livestock sector of the world. We expect to see that effect diminish as corn ethanol production will not grow significantly in the future. Fifth, for a number of reasons, we expect in the near future, given average weather, to see a return to lower animal feed prices (not the historic lows but not the recent extreme highs either) with a movement towards increasing growth rates in animal production consumption and production. Most of these changes reflect a continuation of historic trends. However, taken together, they amount to important and significant changes in the global livestock sector.

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