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Livestock Feeding and Feed Imports in the European Union—A Decade of Change

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Abstract

The livestock sectors of the European Union (EU) are among the world's largest, and therefore the EU is the world's largest importer of feed ingredients. The decade of the 1990s saw important events and policy changes in the sectors that have affected world trade. Lower grain support prices and a declining euro have closed the gap between EU and world grain prices that was a hallmark of the EU's Common Agricultural Policy and the source of large economic distortions in EU feed use. Prices of non-grain feed ingredients (NGFI) on EU markets followed EU grain prices downward during the 1990s as the value of NGFI as substitutes for grains also was reduced. Also important for the feed sector were shifts in meat consumption partially related to several animal disease epidemics. Beef consumption declined, while pork consumption expanded, and poultry consumption expanded very rapidly. Because EU beef is raised largely on pastures, the shift in production was from animals consuming grass to animals consuming feed concentrates. As a result of these factors, the end of the 1990s saw a surge in the feeding of grain, the import of soybeans and soybean meal, and the displacement of NGFI in rations. The fundamental trends in the sectors were disrupted by animal disease epidemics, making forecasts difficult, but grain and soybean meal feeding appear likely to continue to increase while NGFI use declines.

Keywords: European Union, feed concentrates, trade, non-grain feed ingredients, Common Agricultural Policy.

Introduction

Wealthy, and with 100 million more people than the United States, the European Union (EU)[1] has a prodigious demand for meat and other livestock products. Demand has been met almost entirely from domestic production, while the EU also has been a major net exporter of beef, pork, poultry, and dairy products.

The scale of EU livestock production can be judged in comparison with the United States. In 1998-2000, EU commercial production of fluid milk was over 60 percent greater and pork production was twice that of the United States. EU egg production roughly equaled U.S. production, while EU beef production was 60 percent of U.S. production and EU poultry production was roughly one-half. Overall, EU feeding of grain and other commercially traded feed concentrates (excluding pasture and forages) has been almost 210 million tons in recent years. (box 1 and fig.1)

Box 1: Feed Concentrates

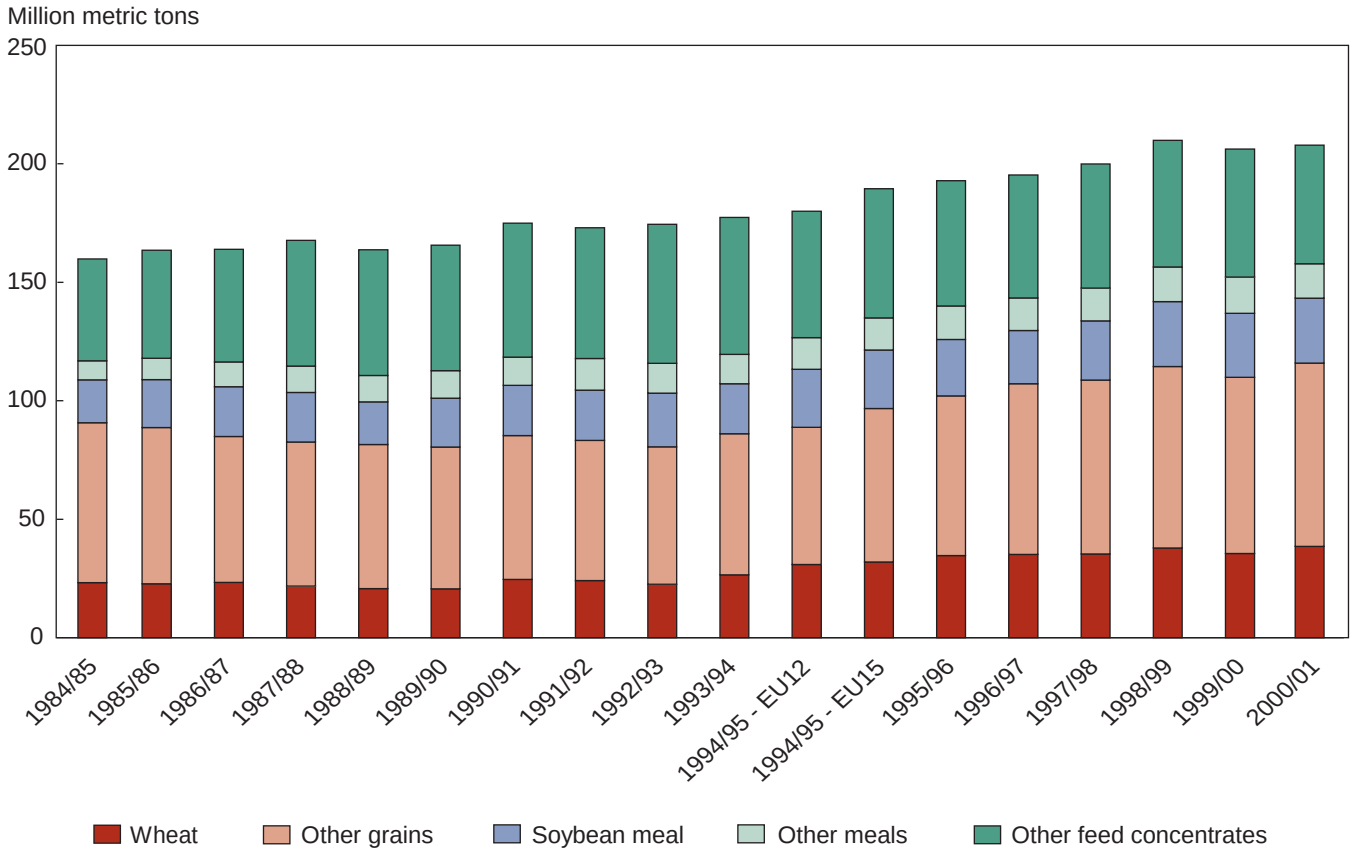
Ruminant animals, including cattle and sheep, can digest the cellulose in grass and other pasture-based feeds. However, the volume of pasture-based feeds that an animal can consume is limited. A certain amount of nutrients are required for maintenance of an animal's weight. Only feed intake greater than maintenance levels allows for the weight gain required for livestock production. In order to provide an animal with a greater quantity of energy and protein nutrients and the potential for more rapid weight gain, other feed ingredients are needed with much greater energy or protein content for any given volume. These feed ingredients are called feed concentrates. Pigs and poultry are fed largely on feed concentrates. The most important feed concentrates are grains and oilseed meals, such as soybean meal. There are, however, many other feed ingredients with relatively large amounts of nutrients compared with their volume. Feed concentrates generally are traded commercially, whereas trading of most hay and other pasture-based feeds is more limited and generally confined to local markets.

All estimates of feed concentrate use in this article are from the Commission of the European Union and may differ from U.S. Department of Agriculture estimates, which include feed and seed use as well as a residual calculation. Feed concentrates include grains, oilseed and other protein meals, field peas and beans, dehydrated fodders, cassava, skimmed-milk powder (SMP), and an array of commercially traded agricultural by-products, including corn gluten feed (CGF), bran, corn germ meal, citrus pulp, sugarbeet pulp, brewer's and distiller's residues, fruit and vegetable wastes, molasses, animal and vegetable fats, fish meal, and meat and bone meal. Feed concentrates, other than grains, also are often referred to as non-grain feed ingredients (NGFI) in Europe because they are thought to displace grain in feed rations. During the 1980s, they often were referred to as "cereal substitutes" in the policy debate, reflecting the principal concern. In this article, NGFI refers to all feed concentrates other than grains and high-protein oilseed meals.

[1]The European Economic Community (EEC) was created in 1957. The original six members were West Germany, France, Italy, the Netherlands, Belgium, and Luxemburg. Evolving arrangements were established by subsequent treaties providing for the European Communities (EC) in 1967 and the European Union (EU) in 1992. The United Kingdom, Ireland, and Denmark joined in 1972. Other countries joined subsequently: Greece (1981), Spain and Portugal (1986), and Sweden, Finland, and Austria (1995).

Figure 1

EU use of feed concentrates



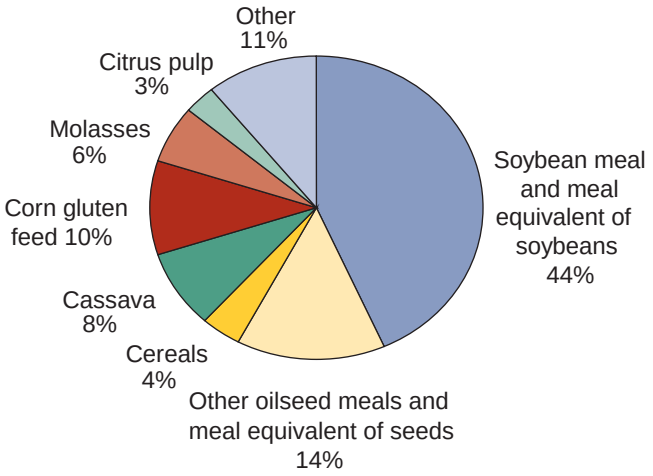
Source: European Commission.

The EU is the World's Largest Importer of Feed Ingredients

To sustain its livestock production, the EU has been the world's largest importer of feed ingredients, importing more than one-fourth of all the concentrates fed within the EU. EU feed imports peaked in 1992/93 at 58 million tons with only 12 member states. In recent years (1998/99-2000/01), imports have been relatively stable, exceeding 55 million tons. Through trade impacts, developments in the EU feed sector are important to world markets (fig. 2).

Over the decade of the 1990s, soybean meal imports (including the meal equivalent content of soybeans) accounted for almost half of EU feed ingredient imports.[2] In recent years the EU has accounted for one-third of world imports of soybeans and 45 percent of world imports of soybean meal (excluding trade within the EU). The United States has been a major supplier of soybeans, providing about 45 percent of EU imports, while Brazil and Argentina also have supplied soybeans and most soybean meal imports, accounting together for three-fourths of all EU imports of soybean meal equivalent.

Figure 2
EU feed concentrate imports 1990-2000



Source: European Commission.

[2] In this article, references to trade in soybean meal and other meals include the meal equivalent of soybeans or other oilseeds.

Protein Feeds

The scale of EU imports of protein feeds is largely the result of natural conditions. Rapeseed, sunflowers, and some soybeans are produced in the EU, but Europe's capacity to produce protein feeds is seriously inadequate to meet its needs. Europe's natural conditions have other important implications for EU agriculture that make for some important differences between EU and U.S. livestock production and feeding practices. Northern Europe has particularly generous pasture resources over extended seasons, allowing very efficient pasture-based production of dairy products, beef, and sheep meat with less reliance on concentrate feeding than in the United States. Corn is produced in the EU in the southern countries, but conditions in the north favor production of small grains, particularly wheat and barley, which are much more important as feed grains in the EU than they are in the United States. Corn has accounted for only 28 percent of all EU grain fed in recent years, while wheat fed in the EU has accounted for 35 percent. The EU imported significant quantities of corn during the 1970s, but high import levies made corn relatively expensive compared with EU barley and feed wheat. After the EU became a surplus producer of coarse grains in the 1980s, EU imports declined.

During the 1990s, EU imports of high protein feed ingredients (greater than 29 percent protein), other than soybean meal, averaged 5 million tons annually. These imports included linseed meal, cottonseed meal, and peanut meal from various origins. Most important, however, were imports of sunflowerseed meal from Argentina, Eastern Europe, and the former Soviet Union and imports of rapeseed meal from Eastern Europe and Australia.

The EU also imported an array of NGFI of medium protein content (17-29 percent). Large imports of copra and palm kernel meal came from Indonesia, Malaysia, and the Philippines. Annual imports of CGF and distillers' dried grains (DDG) averaged 5.5 million tons and 770,000 tons, respectively, and came mostly from the United States. EU imports of leguminous peas and beans averaged 800,000 tons, largely from Canada and Australia. Maize germ cake has been imported from South America.

High-Energy Feeds

EU imports also included a diverse array of energy-rich NGFI, including an average of 4.5 million tons of cassava annually, mostly from Thailand. EU cassava imports peaked in 1992/93 at 6.8 million tons when Indonesia and China also were suppliers. Molasses imports averaged 3.3 million tons and came principally from Pakistan and India, although Egypt and the United States each have supplied as much as 250,000 tons annually. EU imports of citrus pulp and other fruit and vegetable wastes, mostly from Brazil and the United States, averaged 2.8 million tons during the 1990s. Other EU imports included almost 800,000 tons of sugarbeet pulp annually, with significant amounts supplied by the United States.

The diversity and global origins of EU feed ingredient imports are remarkable. While EU imports of high-protein feeds are a consequence of natural conditions, EU imports of medium protein and energy-rich NGFI represent a significant market distortion created by EU agricultural policy, which is discussed in the next section. The EU has viewed NGFI imports as a serious policy problem.

The Common Agricultural Policy

The countries of the EU have operated a strongly interventionist Common Agricultural Policy (CAP) with common agricultural markets since the 1960s. From the beginning, the CAP supported agriculture generally by maintaining high and stabilized internal prices for unlimited quantities of most commodities produced on a significant scale within the EU. Variable import levies set the minimum price, eliminating competition from cheaper imports. Provision for unlimited domestic intervention purchasing (assuming minimum quality standards) guaranteed internal prices, and variable export subsidies or taxes as required helped maintain domestic price objectives.

High prices strongly encouraged EU agricultural production while suppressing EU demand for agricultural products. From a net importer in the 1970s, the EU emerged in the early 1980s as a major net exporter of wheat, feed grains, beef, pork, poultry, and dairy products. Chronic surpluses and skyrocketing agricultural budget costs to cover support programs and export subsidies became the enduring chronic agricultural policy problem for the EU into the 1990s. Numerous CAP "reforms" have lowered some agricultural prices and imposed supply controls and limitations on price supports for some commodities.[3]

High Grain Prices

Central to the CAP have been very high prices for grains. In the late 1980s, EU feed grain prices generally were much more than twice prices on world markets and, at times, were as much as three times as high as world prices (fig. 3). While maintaining very high prices for feed grains, the CAP allowed near duty-free import of NGFI since the Dillon Round (1962) of negotiations of the General Agreement on Tariffs and Trade (GATT). At that time, the EU agreed to low or duty-free bindings on soybeans and products, other oilseeds and products, corn gluten feed, beet pulp, citrus pulp and other fruit wastes, and brewers' and distillers' grains. At the time, these commodities were either of little significance in the EU or, in the case of protein feeds, essential but not strongly in competition with European production. A low duty rate of 6 percent eventually was established for cassava within tariff-rate quotas. These quotas were established in voluntary restraint agreements with Thailand and other major suppliers in the mid-1980s.

Non-Grain Feed Ingredient Imports

Because of low import duties, NGFI could be imported into the EU at relatively low prices and provided relatively cheap substitutes for high-priced EU grains. The incentive for importing and feeding NGFI within the EU proved very strong and, having begun early, NGFI imports expanded rapidly. By the late 1970s, NGFI imports other than oilseeds and meals averaged 15 million tons. As NGFI displaced grain in EU rations, the percentage of total feed accounted for by grain actually declined for much of the 1980s. From 1984 to 1992, grain fed in the EU declined by 11 percent while total feed use increased by 9 percent. EU policymakers saw the substitution of imported NGFI for EU grains as a serious policy-induced distortion that effectively increased EU grain surpluses and the associated costs of export subsidies to provide for surplus disposal.[4]

WTO Export Subsidy Limitations

Options for EU policymakers in the disposal of surplus grains were significantly curtailed in 1994 with adoption of the Uruguay Round Agreement on Agriculture of the GATT, now the agricultural trade rules of the World Trade Organization (WTO). The agreement included limitations on the quantity of subsidized exports and on the total value of export subsidies. From a base period of 1986-90, the volume of subsidized exports was to be reduced by 21 percent and the value of export subsidies by 36 percent over 6 years.

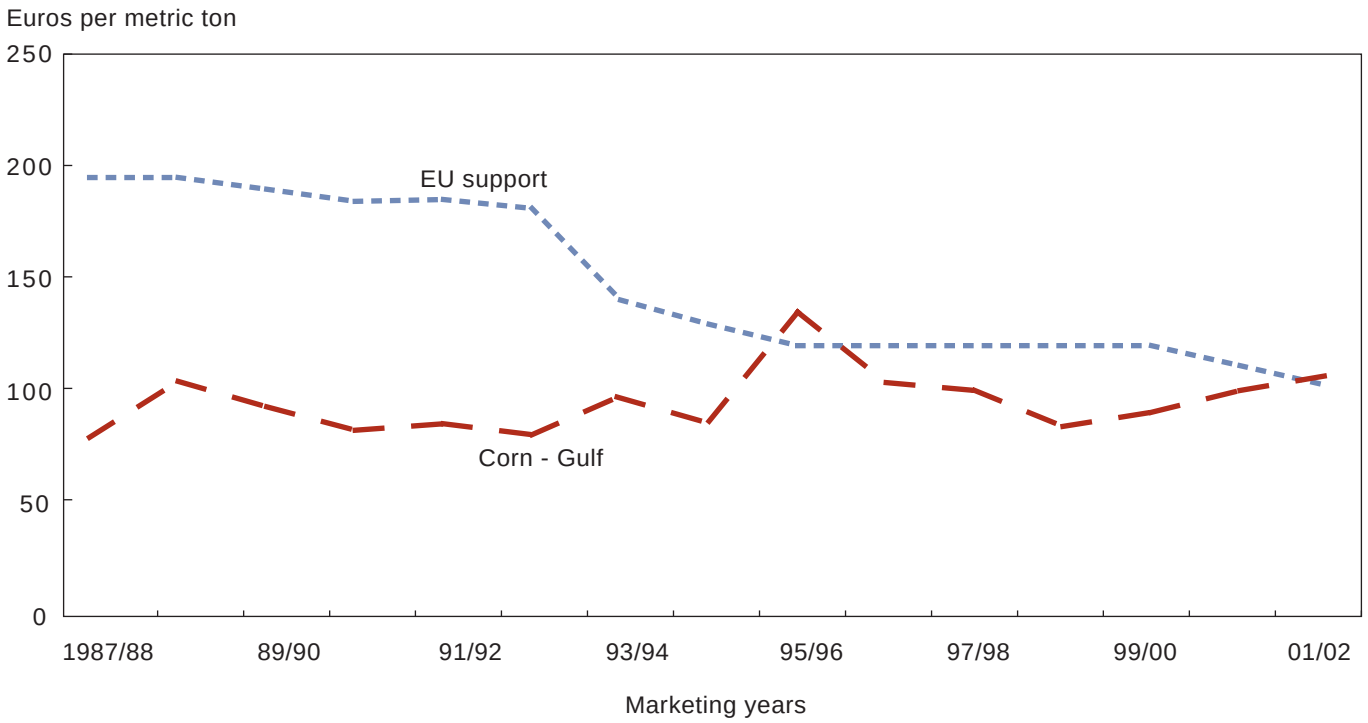
Grain Price Reductions

To prepare for implementation of expected Uruguay Round requirements, the EU adopted in 1992 the MacSharry reforms (named after the Commissioner

[3]See Hasha.

[4]During Uruguay Round GATT negotiations in the 1990s, the EU sought to raise tariffs on NGFIs and oilseeds to close the "loophole" that allowed displacement of EU grain in rations. This proposal, called "rebalancing", was not accepted. The Uruguay Round Agreement also made voluntary restraint agreements illegal, leading to the establishment of tariff-rate quotas, which allow for some quantity of imports at a reduced tariff.

Figure 3
EU grain support and world corn prices



Source: European Commission and Economic Research Service.

for Agriculture). Beginning in July 1993, EU grain prices were reduced by 30 percent over 3 years. The reforms also raised quality standards required for wheat to qualify for intervention support, leaving feed quality wheat without intervention support. Later, Agenda 2000 reforms provided for a further reduction in grain prices of 15 percent by 2001 (fig. 3). Agenda 2000 also reduced compensatory area payments for oilseeds to parity with payments for grains. Payments for field peas and beans were reduced to 112 percent of payments for grains. Reduced production incentives have lowered production somewhat.

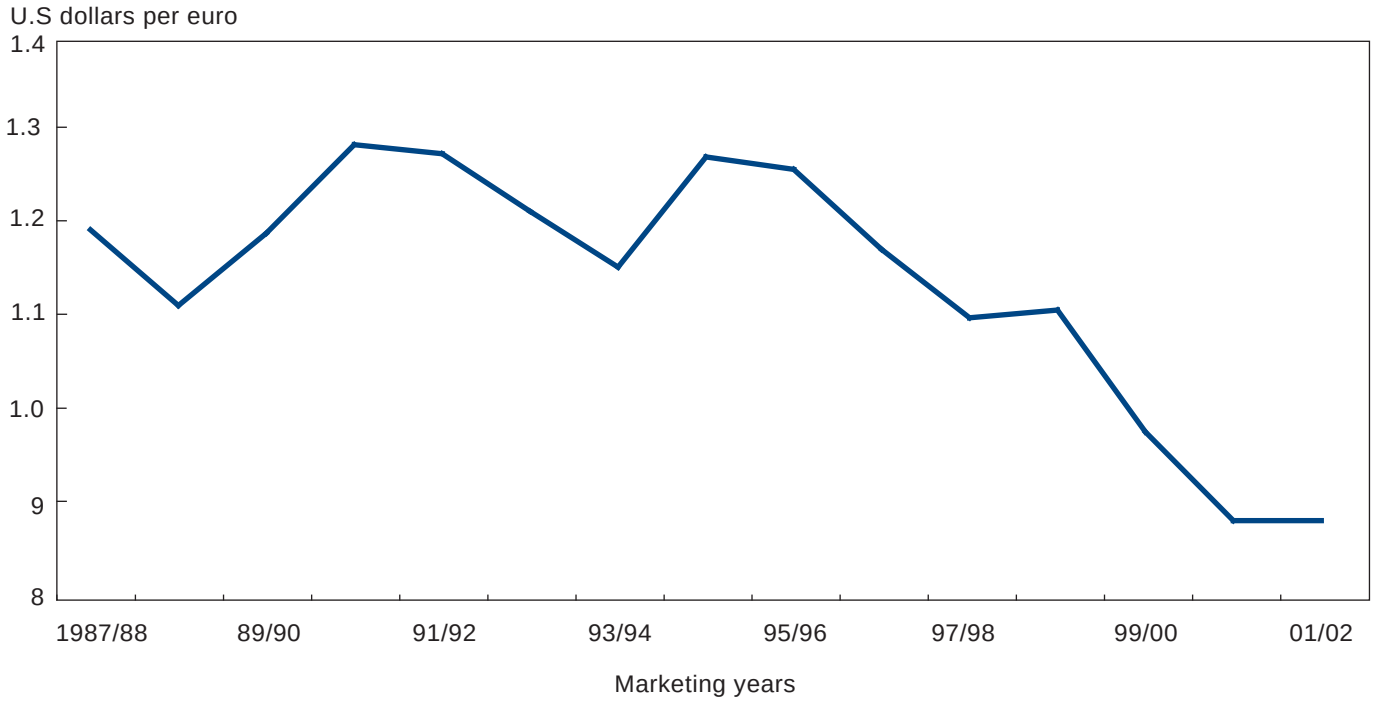
In addition to support price reductions, a 30-percent decline in the value of the euro[5] from 1994 to 2000 also has been critical (fig. 4). Collectively, the result has been a dramatic reduction in the gap between EU grain prices and those on world markets. The gap was temporarily closed in 1995/96 when world prices were unusually high. The most recent price reductions are expected to eliminate the gap except in the event of low world prices or appreciation of the euro (fig. 3).

It also was widely expected that reduction of EU grain prices would lower feeding of NGFI and stimulate feeding of EU grains. With smaller grain surpluses to export, the EU will have less difficulty remaining within WTO limitations for subsidized exports. Of course, if EU prices remain at world price levels, the EU can export without subsidies or concern for WTO limitations.

[5]The euro was adopted by 11 EU countries in 1999. Its value was equivalent to the European Currency Unit (ECU) which preceded it.

Figure 4

Exchange rates



Source: Economic Research Service.

EU Feed Developments During the 1990s

The decade of the 1990s saw important events and policy changes that not only increased total EU feed concentrate use considerably but also significantly changed the composition of EU feeds. Important impacts on trade resulted.

Over the decade of the 1990s, excluding the impact of enlargement, which included Sweden, Finland, and Austria in 1994, total EU use of feed concentrates increased by over 24 million metric tons, almost 14 percent.[6] Excluding EU enlargement, the annual growth rate in EU use of feed concentrates was about 1.7 percent per year, largely in response to the increase in EU demand for pork and poultry. During the previous decade, feed concentrate use increased a little over 1 percent per year.

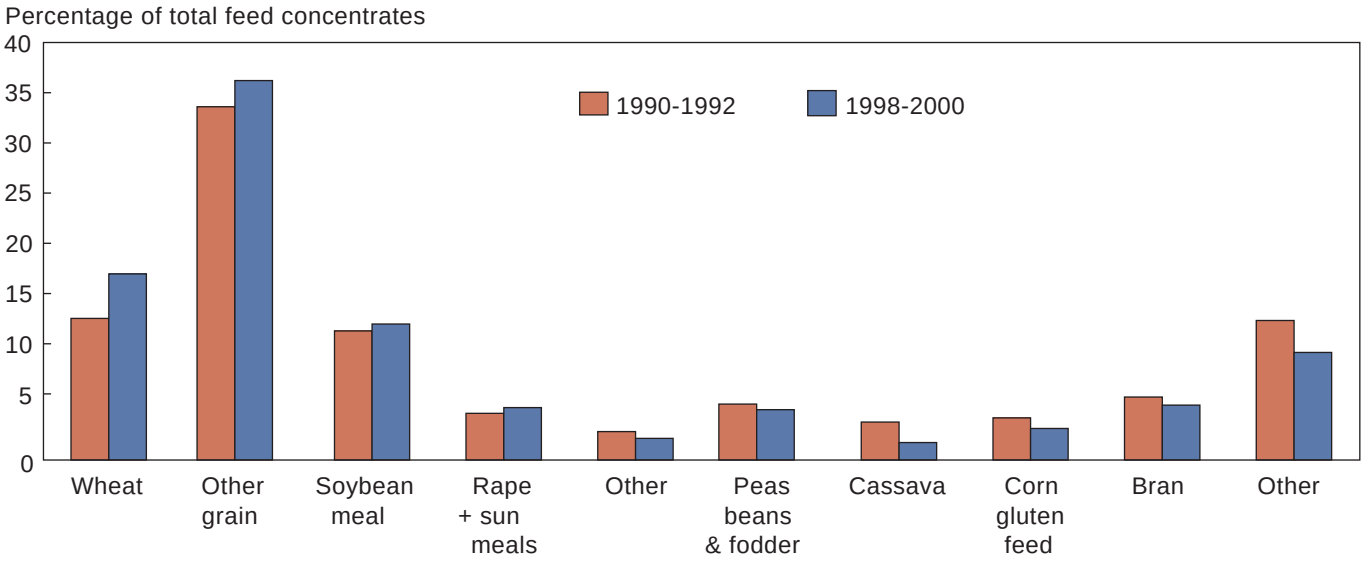
Increased Feeding of Grains and Oilseed Meals

The changes in feed composition that occurred also were as important as the increase in total EU use of feed concentrates. Most important was a large increase in the feeding of grains, up by over 22 million metric tons or 27 percent during the 1990s, dramatically reversing the declining trend in grain feeding of the 1980s. Almost half of the increase in grain feeding was accounted for by wheat. During the 1990s, the share of total EU use of feed concentrates accounted for by grain increased from 47 percent to 55 percent, while wheat's share rose from almost 14 to 18 percent (fig. 5).

The increase in feed concentrate use during the 1990s included a significant increase in the feeding of grains grown on the farm. Output of the feed manufacturing industry also increased by over 8 percent, although the percentage of total concentrate feeds accounted for by manufactured feeds declined marginally. The percentage of cereals in manufactured feeds increased from only 30 percent before the MacSharry reforms to over 40 percent by the end of the decade. Continued expansion of the feed manufacturing industry is consistent with the large increase in poultry production.

[6]Decade of the 1990s refers to the average of 1998/99-2000/01 compared with the average of 1990/91-1992/93, effectively an 8-year period. To facilitate comparisons in percentage terms, numbers have been adjusted for the addition of Sweden, Austria, and Finland in 1994.

Figure 5
EU use of feed ingredients



Source: European Commission.

Utilization of oilseed meals also increased absolutely by almost 7.3 million metric tons, about 21 percent, but the share of oilseed meals in total feed use increased by only ½ of 1 percent. The share of soybean meal, rapeseed meal, and sunflower seed meal increased marginally while the share of other oilseed meals declined marginally. Demand for the main oilseed meals was boosted by reduced utilization of some other protein feeds of minor overall significance, including skim milk powder. Important to the United States were a 700,000-metric-ton reduction in feeding of CGF and a much smaller reduction in feeding of distillers' dried grains.

Decreased Imports and Feeding of Non-Grain Feed Ingredients

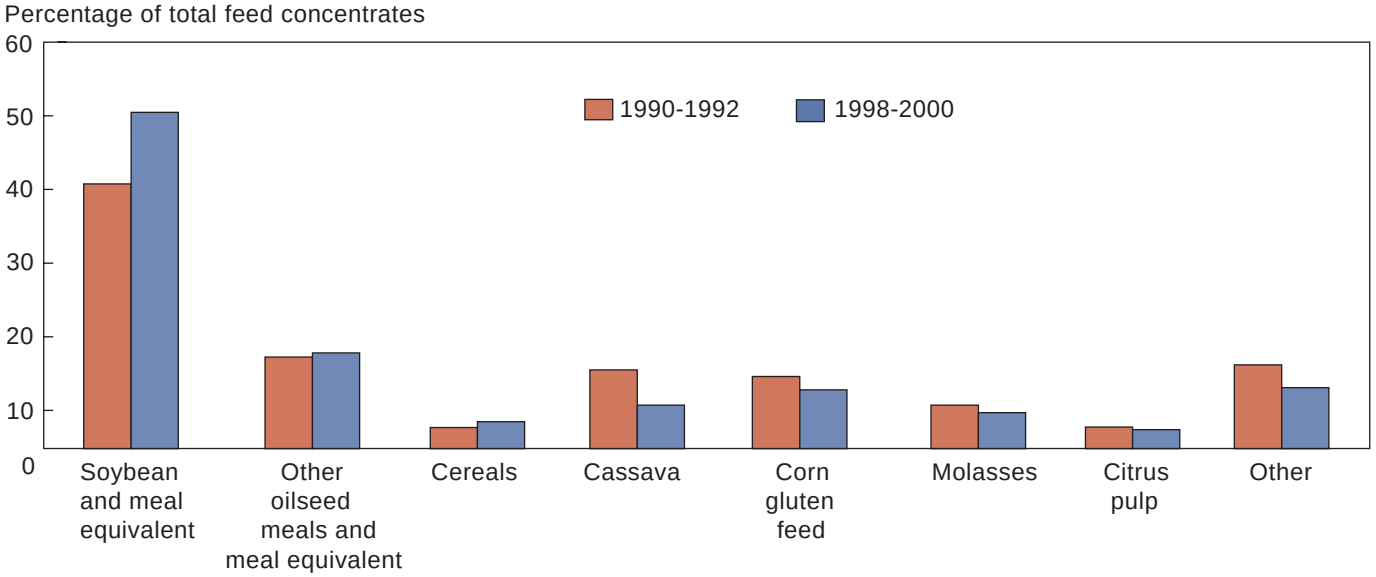
Along with CGF and distillers' dried grains, imports and utilization of most NGFI (not including the major oilseed meals) were reduced absolutely during the 1990s, including reductions of relatively minor individual significance in the utilization of bran, citrus pulp, dehydrated fodders, field peas and beans, molasses, and sugarbeet pulp. Among NGFI, only utilization of fruit and vegetable wastes increased significantly. Collectively, use of NGFI declined by 5.3 million metric tons, or 10 percent, and the share of NGFI in total EU feed concentrates use declined from over 32 percent to only 25 percent. The economics of the decline in NGFI use is discussed below.

Total EU Feed Imports Not Increased

The large increase in total EU feed use during the 1990s was not accompanied by increased EU imports of feed ingredients. Total EU feed ingredients imports hardly changed. Imports of the 15 EU countries in 1998-2000 were only 2 percent greater than the imports of the 12 EU countries in 1990-1992. Increased total feed use did require significantly greater imports of protein feeds, reflecting the EU's limited production potential. Soybean meal imports rose by 6 million tons and increased from 39 percent of total imports to 50 percent (fig. 6). Resistance to the use of genetically-modified soybeans in Europe probably reduced the U.S. share of EU soybean imports below what it otherwise would have been.

Offsetting increased protein feed imports were significant reductions in imports of NGFI. Most important have been reductions in cassava and CGF imports. In 2001, EU imports of these key NGFI were less than half of their record levels in 1992 before implementation of the MacSharry grain price reductions. Reductions in EU grain prices under the MacSharry and Agenda 2000 reforms, together with significant devaluation of the euro, can be seen to have achieved some success towards the EU's policy goal of reversing the substitution of NGFI for EU grain in feed rations.

Figure 6
EU imports of feed concentrates



Source: European Commission.

Growing Consumption of Pork and Poultry Increases Total Demand for Feed Concentrates

The reduction in EU grain support prices has played a role in expanding total EU demand for feed concentrates. Lower grain prices eventually result in lower product prices, which encourage consumption. EU grain support price reductions were complete by mid-2001. Real wholesale pork and poultry prices were down approximately 15-20 percent by the end of the 1990s compared with prices before the MacSharry reforms. The numerous market disruptions during the 1990s that are discussed below make it unclear how completely lower grain prices have been reflected in product prices. Of course, reductions in retail prices would be much smaller.

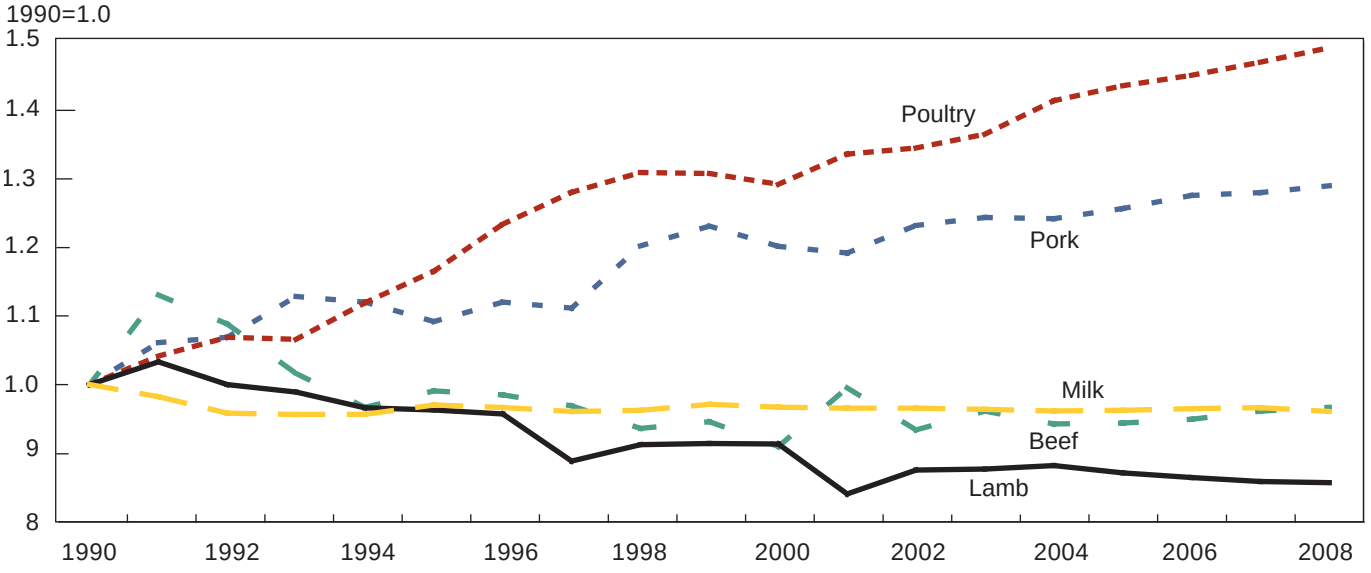
The increase in total EU use of feed concentrates has depended largely on growth in the production of pork and poultry. Changes in beef and sheep meat production have limited impact on total use of feed concentrates. EU beef production still utilizes few feed concentrates, particularly in comparison with U.S. beef production. Poultry and pigs, however, are raised largely on feed concentrates, and higher production translates directly into increased use of feed concentrates.

EU trade in pork and poultry has not accounted for a large portion of EU production; EU net exports have been only roughly 5-7 percent of production. Forecasts of the EU Commission for the coming decade are for the increase in combined net exports of pork and poultry to account for only 3.5 percent of the increase in combined production. For this reason, the increase in EU production of pork and poultry and the associated feed use is closely related to the development of EU demand for pork and poultry (fig. 7).

Consumption of Beef and Sheep Meat Declines

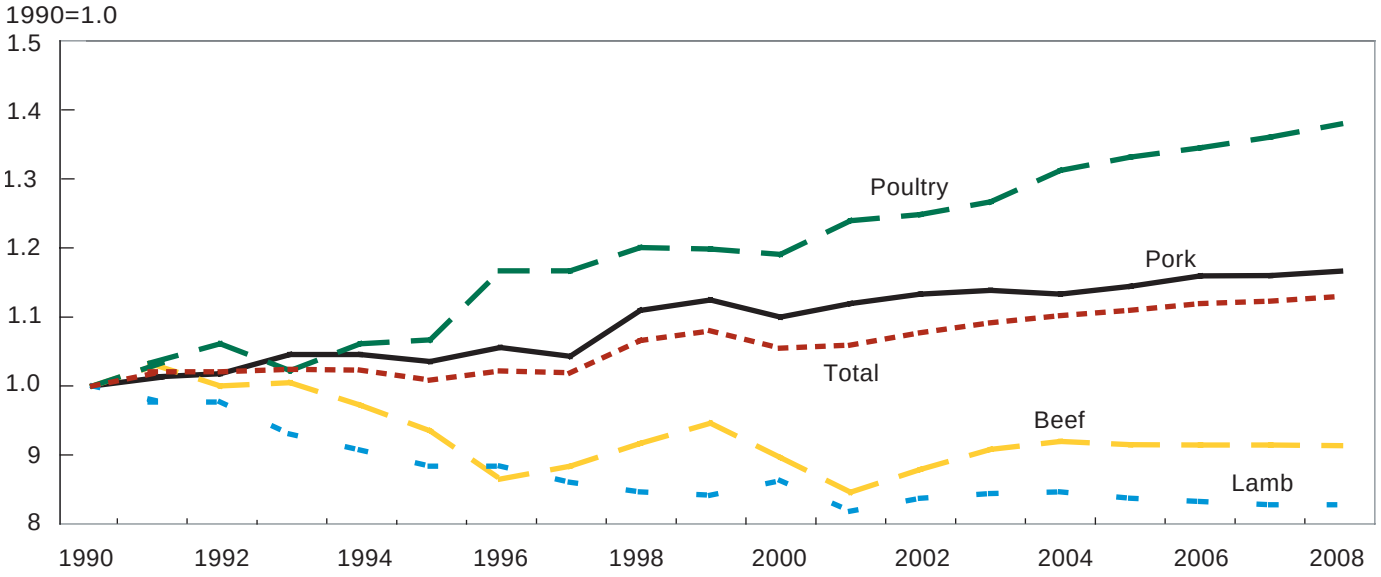
Combined per capita consumption of the major meats—beef, pork, poultry, and sheep and goat meat—has increased at about two-thirds of 1 percent per year (fig. 8). However, per capita consumption of beef and sheep meat declined significantly during the

Figure 7
EU livestock production indices



Source: European Commision.

Figure 8
EU per capita meat consumption indices



Source: European Commission.

1990s. Per capita consumption of sheep meat declined by about 12 percent but is relatively unimportant, having accounted for no more than 5 percent of consumption of the major meats. The decline in beef consumption probably was about 10 percent, although the BSE crisis discussed below complicates any assessment. Although the EU Commission has forecast consumption of beef and sheep meat to stabilize, it is expected to remain well below the levels of the early 1990s.

Among the major meats, pork accounts for roughly half of EU meat consumption, far more than in the United States. Pork consumption also has grown slightly faster than total meat consumption. By far the most rapid growth has been in poultry consumption, with a long-term growth rate of almost 2 percent per year. Growth was very rapid in the mid-1990s, and poultry consumption surpassed beef consumption in 1996, but still is only 40 percent of per capita consumption in the United States.

The shift in consumption from beef and sheep meat to pork and poultry means that total EU use of feed concentrates has increased more rapidly than total meat consumption and production. Production has shifted from animals that eat grass to animals that are fed feed concentrates, and demand has shifted to concentrates with less fiber.

Pork production remains the dominant factor in the development of total EU demand for feed concentrates. Pork production requires about twice as much feed concentrates for each pound of product as does poultry production, and EU pork production is roughly twice as large as poultry production. Even with a growth rate only a little more than half that of poultry production, pork production accounts for four times as much use of feed concentrates. Because of its scale, increased pork production has contributed more to increased feed demand than has increased poultry production, at least so far.

Dairy cows also are fed significant quantities of feed concentrates. And, EU per capita consumption of cheese is on a long-term trend increase of almost 1 percent per year and by weight is equal to 20 percent of per capita consumption of the major meats. However, EU milk production is significantly in excess of EU consumption. Production is largely fixed by quotas and occurs at stable prices. Agenda 2000 reforms provided for an increase in the dairy quota of only 2.4 percent by 2007. Milk yields per dairy cow in the EU are increasing by 1.8 percent per year as each cow is fed ever greater quantities of feed concentrates. The number of dairy cows also is declining continuously, however, offsetting increased yields and resulting in near constant production levels. The overall impact on feed concentrate use in the dairy sector is minimal.

Animal Disease Problems in the 1990s

During the 1990s and early 2000s, several animal disease epidemics seriously disrupted the long-term trends in the EU livestock sectors as well as ongoing adjustments to lower grain prices. In the middle years and again at the end of the decade of the 1990s, three disease episodes, together with the policy responses to them, led to high levels of production and consumption of pork and poultry that were significantly above the long-term trend. High production in these sectors was the cause of the surge in total EU demand for feed concentrates during much of the 1990s.

Public Fear of BSE Underlies Shifting Consumption Patterns

The continuing crisis concerning "mad cow" disease or Bovine Spongioform Encephalapathy (BSE) has been the most severe animal disease problem. First discovered in 1986, the disease causes progressive degeneration of the animal's nervous system. Many in Europe believe that BSE reached epidemic proportions through the feeding to cattle of meat and bone meal produced from animal carcasses. There have been 183,000 cases, mostly within the United Kingdom. The epidemic peaked in 1992, but new cases still are being discovered.

To contain BSE, almost 2 million cattle were slaughtered by the end of 1997. The implications of the BSE crisis for the livestock sectors greatly increased in 1996 with the official acceptance that variant Creutzfeldt-Jacob Disease possibly could be caused by the transmission of BSE to humans. There have been 100 cases, again mostly within the United Kingdom. Enormous uncertainty still surrounds the cause of BSE and its transmission among animals and to humans, and EU consumers have shown great anxiety about the safety of beef.

Long declining, beef consumption had been reduced below trend by the BSE crisis before 1996. In that year, beef consumption plummeted and did not recover until 1999 to levels forecast by the EU Commission before the crisis. The BSE crisis was positive for the pork and poultry sectors, however, as consumers shifted away from beef. Increasing rapidly since 1994, poultry consumption remained significantly above trend until 2000 in spite of a crisis with dioxin-contaminated feed in 1999.

Swine Fever Temporarily Reduces Pork Production

Pork consumption also was rising in 1996 until, in mid-1997, the Netherlands was afflicted with its worst ever epidemic of classical swine fever. The epidemic soon spread to several other countries. More than 10 million pigs raised on farms in 1997, including half of the Dutch pig herd, were withdrawn during the summer from the market. Pork production was reduced by the epidemic just as demand for pork was rising due to BSE concerns. Pork production was reduced in 1997, but the shortage of pork augmented the already surging demand for poultry, and very high prices stimulated high levels of pork production in the following 2 years.

In early 2000, beef consumption had recovered significantly. At that time enhanced testing for BSE revealed that the number of BSE cases was increasing. Consumer confidence in the safety of EU beef soon collapsed again, and by the end of 2000 beef consumption had fallen by one-third in France and by one-half in Germany. By the end of 2001, beef consumption had significantly recovered, with consumption levels only about 5 percent below the levels forecast by the EU Commission before the 2000 crisis. It is likely that many pork and poultry producers expected the positive impact of BSE on demand for pork and poultry to be longer lasting.

Foot and Mouth Disease Strikes Britain

In February 2001, an outbreak of foot and mouth disease (FMD) occurred in southern England and quickly spread throughout the United Kingdom and on a limited basis to other countries. The epidemic peaked in late March, but was not considered under reasonable control until the end of the year. There were at least 2,000 cases. Four million animals were slaughtered; most were sheep. Many of the cattle slaughtered might have been slaughtered under BSE measures in any case. Only 5 percent of cases were among pigs, and the number of pigs slaughtered was minimal. The FMD epidemic in 2001 appears to have had only limit-

ed impact on the pork sector, with production down less than 1 percent.

The various measures adopted to control BSE and FMD had very large impacts on production of beef and sheep meat. The EU Commission has estimated that BSE and FMD measures reduced beef production by at least 200,000 tons every year beginning in 1996. In 2001 alone, beef production was reduced by almost 600,000 tons according to the Commission. FMD measures reduced sheep meat production in 2001 by 8 percent, but production is forecast to recover in 2002.

Because sheep in the EU are raised largely on pastures with limited feed concentrates, changes in production of sheep meat have negligible impacts on use of feed concentrates. In any case, the sheep meat sector is very small. The beef sector is much larger, but the impacts of reduced production also have been relatively limited because beef cattle also are raised largely on pasture with limited feeding of concentrates. Although measures to control BSE included significantly increased culling of dairy cows, milk production and the associated use of feed concentrates were maintained. Many of the cattle and the few pigs destroyed under BSE and FMD measures also were fed at normal rates for some period before decisions were made to destroy them. FMD measures restricting the movement of sheep and cattle to pastures may actually have increased feed concentrate use with animals in confinement.

Increased Production and Lower Grain Prices Change the Composition of EU Feeds

The expansion of pork production and the rapid expansion of poultry production required increased supplies of energy and protein feeds. Larger poultry production was particularly important in the increased feeding of soybean meal and other protein meals because of the high protein requirements for poultry production.

EU grain price reductions under the MacSharry reforms and Agenda 2000 did play an important role in reversing the substitution of some NGFI for EU grain in feed rations. However, the increase in grain fed during the 1990s was at least 4 times the reduction in NGFI use. The EU's increased feed requirements could not be met with NGFI, because most NGFI are by-products of agricultural processing, and their supplies are relatively fixed and have little association with NGFI prices but depend on other markets. Supplies of cassava, the only NGFI in large supply on world markets, have been limited on EU markets by quota restrictions since 1983. It was inevitable that increased EU feed demand would be supplied by the dominant feed ingredients, grains and oilseed meals, reducing the role of NGFI in feed rations and enlarging the role of grain in the composition of EU feeds.

One BSE measure had a direct impact on the composition of EU feed. In an attempt to contain BSE, the EU banned the feeding of meat and bone meal to ruminant animals, and from the beginning of 2001, the ban was extended to all animals. Total feed demand was not affected, but roughly 1.5 million tons of soybean meal was required to replace the protein in the meat and bone meal that had been fed in the EU.

Imports and use of NGFI declined during the 1990s because the reduction in EU grain prices made NGFI less attractive as substitutes for EU grain in feed rations. Nonetheless, significant NGFI imports continue even though the gap between EU and world prices for grains has been eliminated. EU feed ingredient imports in 2001 still included 2.7 million tons of cassava and 3.7 million tons of CGF. The combined energy and protein in those imports could be replaced by roughly 5-¼ million tons of EU wheat and 600,000 tons of soybean meal. Beyond cassava and CGF, the EU still imports about 10 million tons of NGFI. Further reductions in NGFI feeding would allow even more feeding of EU grain. The fate of the remaining NGFI will depend on the fundamental economics of feed pricing on EU markets.

Box 2: Substitution Among Feeds

Feed ingredients in appropriate combinations generally are highly substitutable technically. If their relative prices are appropriate, substitution does occur. It is the general substitutability among feed ingredients that allowed the substitution of NGFI for EU grains from the 1970s and its partial reversal during the 1990s.

Nutrient requirements vary by animal, stage of development, and other conditions. Those requirements include vitamins, minerals, amino acid balance, and other factors. Energy and protein content are the dominant nutrient factors, however, and they are central in determining the relative feed value and prices of large volume feeds. Poultry rations generally have the highest protein content, about 16-18 percent. Dairy rations have about 14-16 percent protein, and pork rations generally are 12-14 percent. Fiber content also is important because it can be utilized for energy by ruminant animals (cattle and sheep), while pigs and chickens cannot digest fiber and may not tolerate high fiber rations.

Many ingredients are used in feeds for livestock production, particularly in the EU. The specific nutrient content of feed ingredients varies greatly (table 1).

Table 1—Nutrient content of some important feed ingredients

Feed ingredient	Energy[1]	Protein[2]	Fiber[3]
Corn	80	7.9	1
Barley	74	11.5	5
Feed wheat	78	10.9	2.8
Soybean meal	78	48	7
Rapeseed meal	64	36	13.2
Cassava	68	2.4	7.6
Corn gluten feed	75	21	10
Citrus pulp	74	6	12.2

[1]Total digestible nutrients (TDN) for ruminant animals, in percent.
[2]Crude protein, in percent.
[3]Crude fiber, in percent.

All feeds contain significant energy and usually some protein. Feed grains, the dominant source of energy in the EU, contain 7-13 percent protein. Soybean meal, the dominant source of protein, contains 44-48 percent protein, almost as much total energy as corn, and more energy than barley. Cassava, on the other hand, is almost entirely energy. Feed grains and other high energy feeds generally are combined with oilseed or other high protein meals as necessary to achieve required protein content and other requirements of particular feeding situations. The wide array of animals in the EU can efficiently utilize large volumes of most available feeds when combined in appropriate mixes, allowing broad opportunities for substitution among feeds.

Some variability in nutrient content is common. Grains may vary in moisture and protein content by several percentage points. Feed manufacturers can test for specific nutrient content. Equivalent nutrient content also does not always produce equivalent results. Probably the most extreme example is corn gluten feed, which provides weight gain in cattle of only 77 percent of that achieved with a ration of corn and soybean meal containing equivalent energy and protein (see Allison and Poore).

Producers' main concern is obtaining weight gain at the lowest possible cost. To achieve this goal, producers and feed manufacturers choose among feeds based on their nutrient contents and their prices. In competitive markets like EU feed markets, the prices of all feeds must reflect their relative feed value, although the CAP has functioned until recently to make all high-energy feed prices artificially high. Substitution among feeds occurs continuously in competitive markets as livestock producers and compound feed manufacturers seek combinations of available concentrate feeds that meet specific nutrient requirements at the lowest possible cost. Substitutions result from perceived cost savings that often are quite small but are important in large volumes.

The result is that the price of most feed ingredients is closely related to their protein and energy content, and prices of feeds with similar nutrient values maintain a close correspondence, particularly in relation to the dominant feeds. High energy feeds find a market value and experience price movements closely related to the price of feed grains. The greater the protein content of a feed, the more its price is influenced by the price of soybean meal.

It can be demonstrated that a mixture of 863 kilograms of cassava and 196 kilograms of soymeal can substitute for one metric ton of barley at a nearly equivalent price (table 2).

Table 2: Substitution of cassava and soybean meal for barley

	Total *kilograms*	*Energy* *kilograms*	*Protein* *kilograms*	*Price*[1] *euros*
Barley	1,000	740	115	119.50
Cassava	863.5	587.2	20.7	83.93
Soybean meal	196.5	153.3	94.3	31.83
Combined	1,060	740.5	115.0	115.77

[1]Price is 1999/2000 for the amount indicated.
Source: European Commission.

Grains

Intervention buying of durum wheat, bread quality wheat and rye, and all barley and corn at a fixed support price is legally obligatory in the EU, subject to certain moisture content and other quality standards, while import levies prevent competition from cheap imports. Since 1993, as support prices were reduced, all of these grains have been supported at the same intervention price. Effective support for EU grain prices has sometimes been provided through the provision of export subsidies adequate to induce commercial traders to remove surpluses from EU markets before grain prices fall to intervention triggers. On EU markets, prices for grains have been somewhat above or below the support price, depending on the EU Commission's decisions to employ export subsidies to support prices or to allow prices to fall, triggering significant intervention purchasing. Although the gap between EU feed grain prices and world prices has been largely closed, CAP mechanisms in place will continue to largely stabilize prices on EU markets.

Except for rye, among the major feed grains, barley generally is the least valuable. Under European conditions, feed wheat and triticale are worth more per ton as feeds than barley because they have more energy with less fiber and roughly equivalent or more protein. Corn generally has been worth more as a feed than wheat or barley on EU markets because of its high energy and low fiber content and because it also is the most suitable feed for poultry. Because prices reflect relative feed values, EU markets have consistently priced wheat above barley and priced corn above both (fig. 9). With EU grain prices near world price levels, the historical premium within the EU for energy content over protein is reversed, and the price advantage of corn compared with wheat on EU markets also may be reduced.

Because all grains have the same support price and barley is the least valuable, and because corn generally is in short supply, corn prices rarely can fall enough to qualify for intervention. Surpluses of feed grains result in intervention purchases or subsidized exports of barley.[7] The prices of feed wheat and corn on EU markets are supported indirectly through support for barley. In practice, support for barley is key to the pricing of EU feed grains.

The quality standards for wheat intervention established by the MacSharry reforms effectively excluded a large volume of lower quality wheat from direct intervention support. Some EU wheat that does not qualify for intervention is, nonetheless, of adequate quality for export as bread wheat to some markets. Such lower quality bread wheat is supported indirectly by EU bread wheat intervention buying or even directly by export subsidies. A large volume of EU wheat, however, has no potential other than for feed use. Some small quantities of feed wheat have been exported with subsidies at times, but most EU feed wheat must find a market commercially within the EU at a price consistent with the price of barley, i.e., reflecting their relative feed values (fig. 9).

Oilseed and Protein Meals

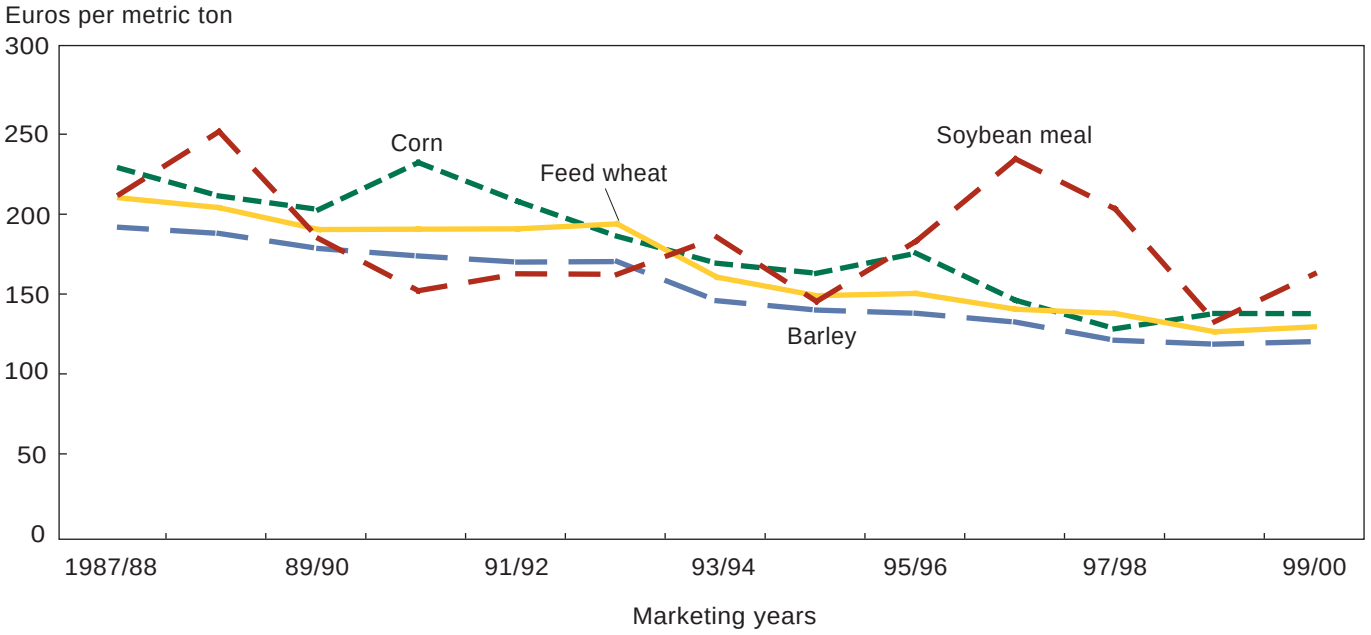
Prices of oilseed and other protein meals on EU markets are the same as prices on world markets and are determined by global supply and demand for protein feeds. The price of soybean meal on EU markets relative to grain prices was transformed by EU grain support price reductions, being generally below grain prices before 1993, and significantly above them since 1995 (fig. 9).

Protein meals do contain significant energy and provide a significant portion of the energy content of any ration. Because EU feed grains prices and the associated value of energy were so high before 1993, soybean meal and some other protein meals provided a relatively cheap source of energy as well as protein (fig. 10). Figure 10 presents indices of the cost of energy supplied by a feed in comparison with the cost of the same amount of energy supplied by barley on EU markets. Wheat and corn have been consistently more expensive sources of energy than barley, an

[7]Rye has presented a special problem because production has exceeded domestic food demand, and most rye production meets intervention quality standards. The support price exceeds rye's value as a feed, resulting in large accumulations of intervention stocks. Rye remains a significant policy problem, but it plays a limited role in EU feed markets, except in Germany.

Figure 9

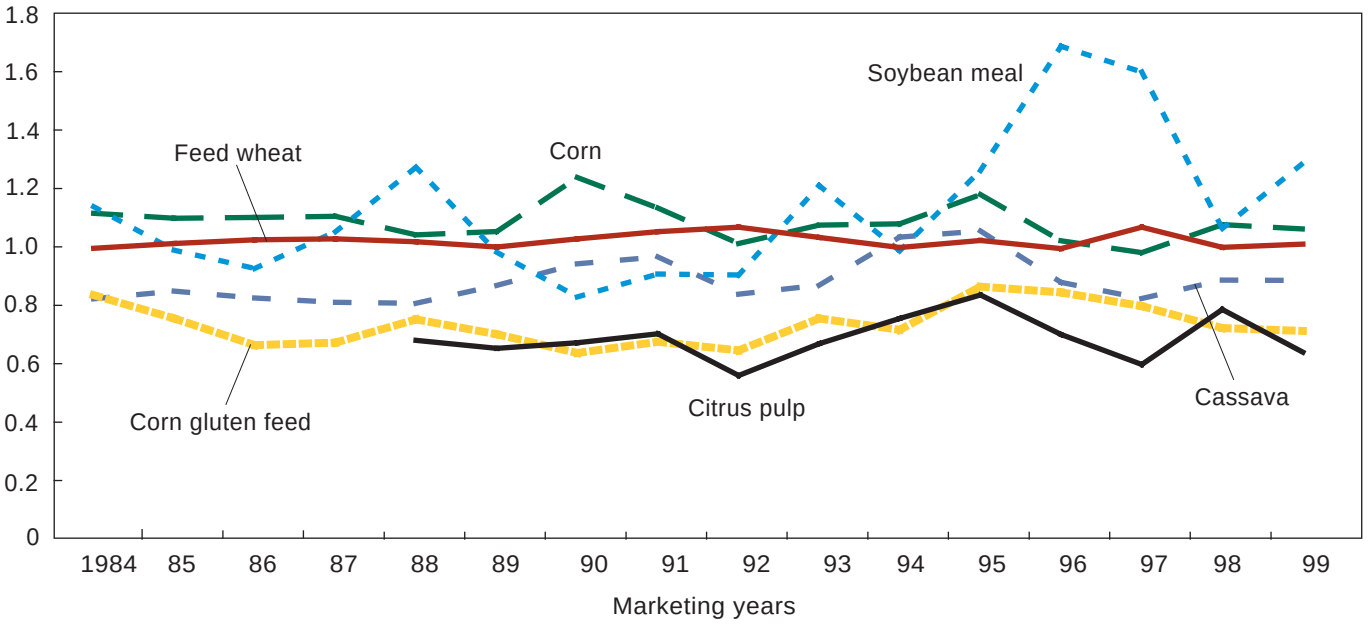
Grain and soybean meal prices on EU markets



Source: European Commission and Economic Research Service.

Figure 10

Relative cost of energy content



Source: European Commission.

expected result given their lower fiber content and expansion in the poultry sector.

World soybean meal prices have been volatile, but soybean meal provided energy at an equal or lower cost than barley in 7 out of 10 years from 1985 to 1994. In those years, soybean meal could have been economically substituted for barley for its energy content alone. The scope for feeding soybean meal for energy content is limited by the ability of animals to tolerate high protein rations, but some substitution has occurred. As a relatively cheap source of energy, soybean meal use in the EU may have been somewhat greater than it otherwise would have been. Reduced EU grain prices eliminate any incentive to feed soybean meal for energy alone. Despite the increase in the relative cost of protein in the EU as grain prices were reduced, the increasing prominence of high-protein poultry rations has maintained the percentage of crude protein in the combination of all EU feed concentrates at a remarkably constant level.

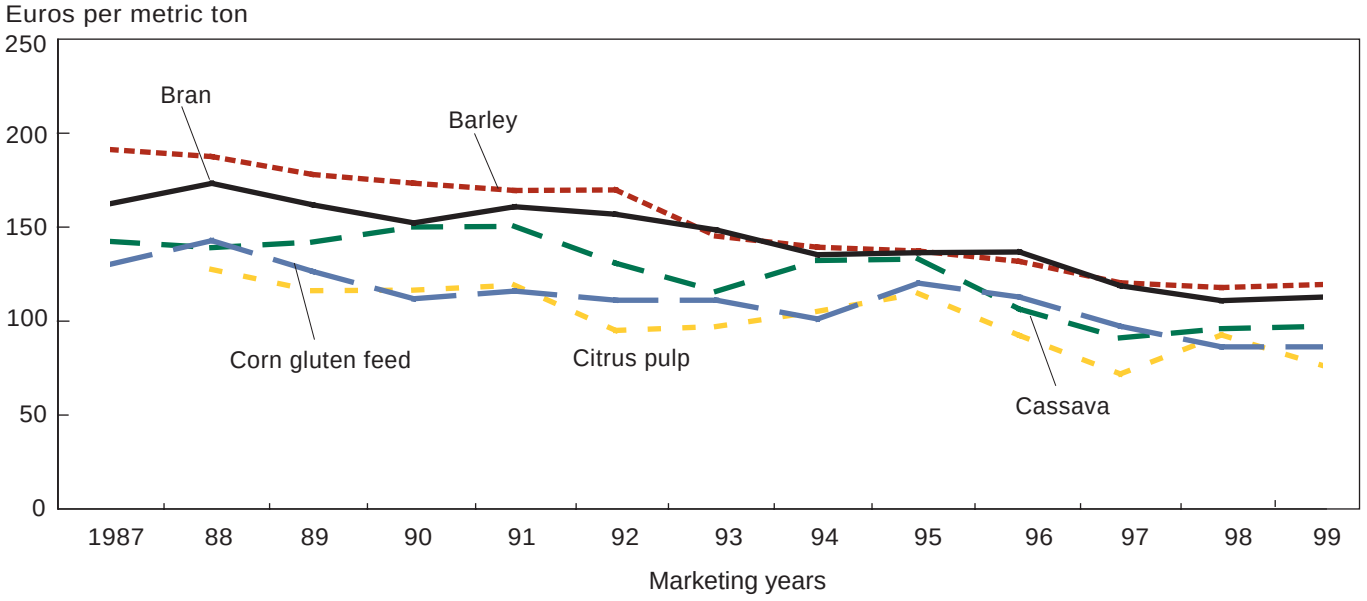
Non-grain Feed Ingredients (NGFI)

A high proportion of EU imports of NGFI have been the unintended result of efficient markets responding to distorting policies. Corn gluten feed (CGF) and distillers' dried grains (DDG) are produced in the American Midwest as by-products in wet and dry milling of corn. These feedstuffs could be utilized in the United States, but instead considerable marketing and transport costs are incurred to export them to Rotterdam. This trade has perplexed many, but the economics are simple--CGF has been worth much more as a feed in Rotterdam than it is worth in Illinois, or anywhere else. Similar economics govern U.S. exports of distillers' dried grains, corn germ meal, sugarbeet pulp, citrus pulp, and fruit and vegetable wastes to the EU.

Europeans have been willing and able to pay more for these NGFI than they are worth to U.S. livestock producers because their value on EU markets has reflected the relatively high prices of EU grains, whereas their value on world markets has been much lower, reflecting the much lower price of corn on world markets. Prices of the important NGFI on EU markets followed EU grain prices downward during the 1990s as lower EU grain support prices reduced the value of NGFI in EU markets as substitutes for grains, and European users lowered the price they were willing to pay for them (fig. 11).

The major NGFI, including cassava, CGF, and citrus pulp, have provided energy at a cost significantly lower than barley, providing a clear economic incentive for their importation (fig. 10). The comparative value of cassava or CGF on EU markets and on world markets can be indicated more generally by calculating the value of the dominant feed ingredients that can be replaced in combinations by a given amount of the NGFI. A simple example is the value of corn gluten

Figure 11
EU market prices for barley and NGFIs



Source: European Commission.

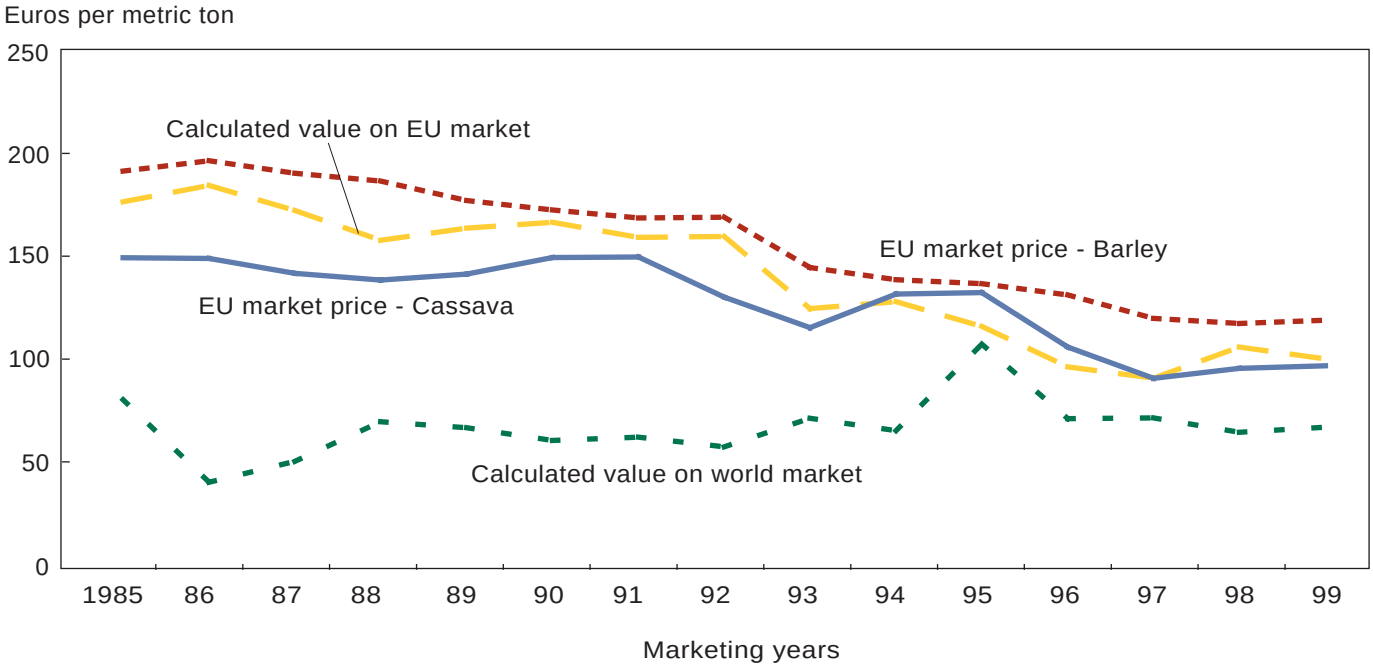
feed calculated as the cost of the combination of soybean meal and corn (on world markets) or soybean meal and barley (on EU markets) that provides exactly equivalent energy and protein content[8] (figs. 12 and 13). Mathematically, the prices, energy content, and protein content of two feeds present a system of two equations with two unknowns, allowing solution for the implicit values of energy and protein (technical appendix).

Actual EU market prices were generally less than the calculated value for the EU just as the U.S. wholesale price for CGF also was less than its calculated value on world markets. Nonetheless, differences in calculated values provide an effective indicator of the discrepancy in the value of these feed ingredients in the two markets.

The calculated value of cassava on EU markets was almost 4 times its value on world markets in 1986, readily allowing Europeans to outbid all others for all available supplies. As the gap between EU and world grain prices closed during the 1990s, the differences in value on EU and world markets also closed for both ingredients. Very high world grain prices in 1995-1997 closed the gaps. Import and feeding of NGFI also was significantly reduced.

Figure 12

Cassava: Market prices and calculated values on EU and world markets

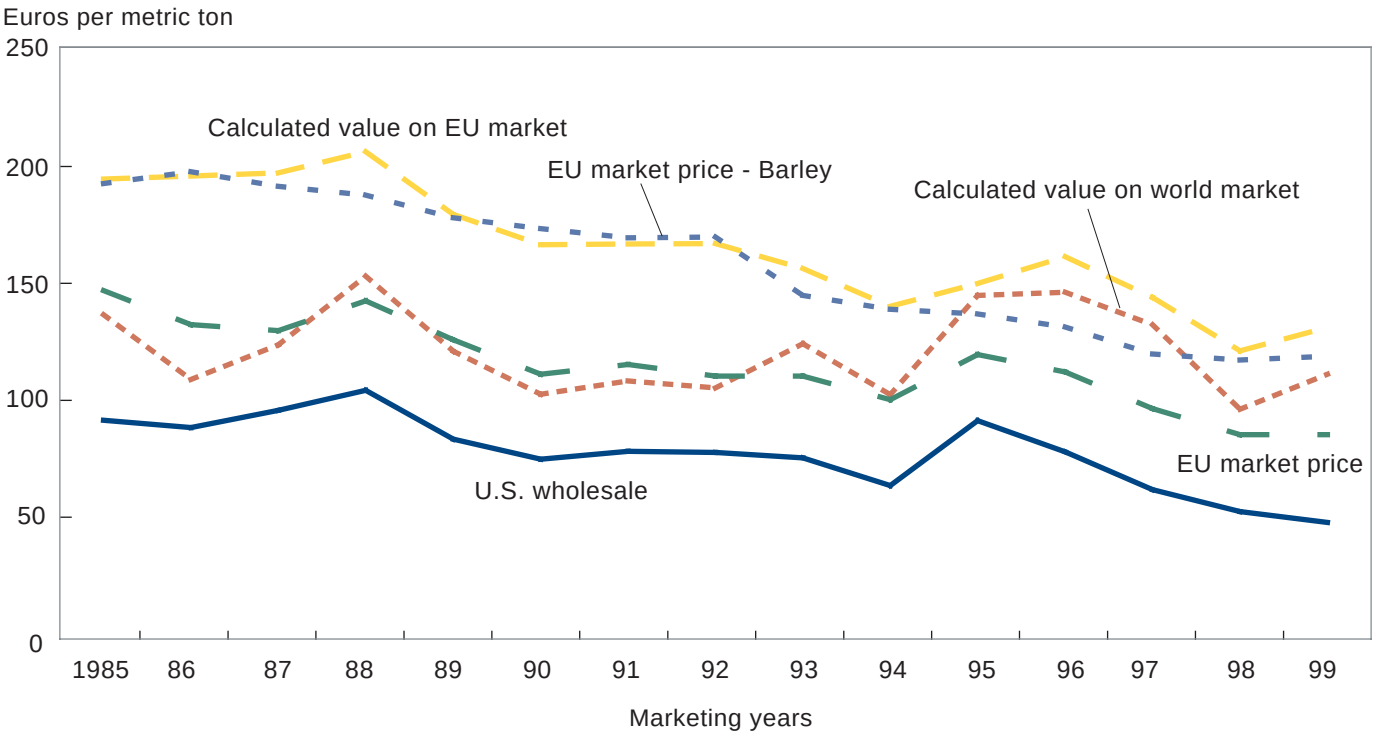


Source: European Commission and Economic Research Service.

[8]For cassava, the replacement is more complicated because it has less protein than grains. To replace cassava in a ration of which it is only a part, one would add grain but remove soybean meal. The value of cassava then is the cost of the replacement grain less the savings from reduced soybean meal.

Figure 13

CGF: Market prices and calculated values on EU and world markets



Source: European Commission and Economic Research Service.

Future Prospects for EU Use of Feed Concentrates

The future development of total EU use of feed concentrates will depend most fundamentally on the expansion of EU consumption of pork and poultry. Of course, disease epidemics may disrupt consumption trends as they did during the 1990s. The EU Commission has forecast that pork and poultry consumption will return to their long-term trends during the next decade, while the decline in beef and sheep meat consumption stabilizes somewhat at levels much below the early 1990s. The disruptions caused by animal disease epidemics during the 1990s make all forecasts less certain, however, and several factors could result in greater growth of total EU use of feed concentrates.

The historical trend in per capita consumption of pork and poultry as well as total per capita consumption of the major meats was associated with considerably higher EU prices for grains than are likely to prevail from 2001 forward. It is reasonable to expect that lower grain prices and lower pork and poultry prices would produce at least a period of accelerated growth in consumption of those meats. Total per capita consumption was relatively stagnant in the late 1980s and early 1990s and accelerated significantly at the end of the 1990s in the context of lower real prices for pork and poultry. That EU total per capita consumption of the major meats is only 70 percent and EU per capita consumption of poultry is only 40 percent of U.S. consumption levels also suggests that expansion of EU consumption is plausible.

EU Commission forecasts for beef consumption by 2004 are for levels only slightly below per capita consumption in 1995, the last year before the BSE crisis. From 1987 to 1995, however, beef per capita consumption had declined by almost 14 percent. The relatively high level of beef consumption for the single year of 1999 was in the context of relatively low real beef prices. If demand for beef continues to decline along the trend before 1996, demand for pork and poultry would be enhanced even if total meat consumption does not increase.

On the other hand, current environmental regulations and numerous proposed regulations governing conditions for the raising of pigs and chickens could have significant impacts on the evolution of production in those sectors. Production could be moved geographically or growth in production could be reduced by higher production costs. Other significant impacts on overall EU livestock production and feed concentrate demand may result from the expansion of the EU to include countries in Eastern Europe. These countries are significant producers of pork and poultry and also are a source of significant supplies of relatively cheap grain as well as rapeseed and sunflower seed.

Low EU Grain Prices May Further Reduce Use of NGFI

The composition of EU feed rations also will continue to evolve. The principal issue is the fate of NGFI in the future. Use of NGFI was reduced absolutely before EU grain price reductions were fully implemented. In any case, it is likely that the expanding need for energy feeds will be met almost entirely by grain, and the expanding need for protein feeds will be met by the major oilseed meals.

As expected, the closing of the gap between EU and world feed grain prices has been associated with a significant decline in imports of cassava and CGF as well as most other NGFI. Use of cassava and CGF in 2001 amounted to less than half their peak use in 1992. Nonetheless, imports and use continue. Several factors may explain continuing NGFI imports and use.

Most NGFI are agricultural by-products, supply of which usually has little association with NGFI prices but depends on other markets. Supplies of most NGFI are relatively fixed, although global expansion of high-frutose corn syrup manufacture or programs for ethanol could significantly increase world supplies of CGF and DDG. In any case, all by-product NGFI will be utilized somewhere. Of course, NGFI produced in the EU will continue to be used domestically because no other feed sector is in a position to bid for those supplies. Other NGFI will find a use closer to their origins or export to the EU remains possible. For some NGFI, demand close to their origins may not be adequate to employ all supplies; an example might be molasses from South Asia.

NGFI imports from the United States, however, including CGF, clearly can be fed in the United States.

Cassava also is produced on a massive scale globally and is a staple food in many parts of the world. Its supply on EU markets was limited only by negotiated quotas. Recent years have also seen the feeding of cassava in Asia and its utilization for starch production. Some plausible institutional factors may explain the apparent lag in full adjustment of cassava, CGF, and other NGFI imports to elimination of the gap between EU and world grain prices. Traders have a vested interest in maintaining established trading relationships, and it is likely that traders did not believe that the high grain prices of 1995-1996 were permanent. There also are fixed costs in equipment and expertise for the handling of cassava and CGF that would allow for continued trade for some period of time.

Whatever the explanation for the apparent lag in adjustment, if world prices do not decline or the euro does not appreciate, eventually most EU imports of cassava, CGF, and many other NGFI should wither away. Elimination of additional NGFI use in EU rations will allow the EU to expand domestic feeding of EU grain and reduce surpluses requiring export. If the EU ceases to import CGF, the United States may gain some part of the additional imports of soybeans or soybean meal that will be required as replacement. The impact on the composition of EU feed rations by elimination of most imported NGFI from EU rations will be an event lasting only some years. Thereafter, the continued expansion of EU pork and particularly poultry consumption will use increasing quantities of EU grains and increase world demand for soybeans and other oilseeds.

Technical Appendix: Calculated Values for Feeds

All feed ingredients include energy and at least some protein, but the variation among feeds is very large (box 2). Conceptually, energy and protein have independent prices, and the prices of various feeds reflect the prices of energy and protein and the energy and protein content of each feed. Mathematically, the prices, energy content, and protein content of two feeds present a system of two equations with two unknowns. The following is a set of equations for corn and soybean meal:

Where:

TDN% = Percentage total digestible nutrients for ruminants

CP% = Percentage crude protein

$$Price_{corn} = (TDN\%_{corn} * Price\ energy) + (CP\%_{corn} * Price\ protein)$$

$$Price_{soymeal} = (TDN\%_{soymeal} * Price\ energy) + CP\%_{soymeal} * Price\ protein$$

Algebraic manipulation allows the derivation of unique prices for protein and energy that are consistent with the prices for corn and soybean meal.

$$Price\ protein = ((TDN\%_{soymeal} * Price_{corn}) - (TDN\%_{corn} * Price_{soymeal})) / ((CP\%_{corn} * TDN\%_{soymeal}) - (TDN\%_{corn} * CP\%_{soymeal}))$$

$$Price\ energy = ((CP\%_{corn} * Price_{soymeal}) - (CP\%_{soymeal} * Price_{corn})) / ((CP\%_{corn} * TDN\%_{soymeal}) - (TDN\%_{corn} * CP\%_{soymeal}))$$

These equations can be employed to calculate the value of a feed relative to the price of corn and soybean meal, based on energy and protein content of corn, soybean meal, and the feed ingredient to be compared. The dominant feeds in the EU are barley and soybean meal, but the process is identical. The calculated value of a feed in relation to the dominant feeds in the market is an indicative value and is unlikely to coincide precisely with the actual price.

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