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ABSTRACT

A study analyzed grain production in France, the major grain producer in the European Community and one of the leading producers in the world. France is also a major grain exporter and thus competes with the United States in world markets. The United States is pursuing a policy of lower world prices to regain market share. Large grain surpluses in the European Community have resulted in increased budget expenditures to support grain farmers and pressures to lower prices. The study tried to determine the implications of lower prices on French grain production. The results suggest that the French grain area is price elastic. However, supply response also depends upon yield, which is not sensitive to changes in output prices in the short run. French products receive preferential treatment within European Community markets, and their exports to nonmember countries are subsidized, enabling France to increase exports and market share. French competitiveness has also been enhanced by technological improvements, relatively high and stable prices, and structural change. (Author/KC)

United States Department of Agriculture

Economic Research Service

Agriculture and Trade Analysis Division

# Economic Analysis of Grain Production in France

Peter S. Liapis

**ECONOMIC ANALYSIS OF GRAIN PRODUCTION IN FRANCE.** By Peter S. Liapis. Agriculture and Trade Analysis Division, Economic Research Service, U.S. Department of Agriculture. ERS Staff Report No. AGES880202.


## ABSTRACT

This study analyzes grain production in France. France is the major grain producer in the European Community (EC) and one of the leading producers in the world. France is also a major grain exporter and, thus, competes with the United States in world markets. The United States is pursuing a policy of lower world prices to regain market share. Large grain surpluses in the EC have resulted in increased budget expenditures to support grain farmers and pressures to lower prices. What are the implications of lower prices on French grain production? Our results suggest that French grain area is price elastic. However, supply response also depends upon yield, which is not sensitive to changes in output prices in the short run. French products receive preferential treatment within EC markets, and their exports to nonmember countries are subsidized, enabling France to increase exports and market share. French competitiveness has also been enhanced by technological improvements, relatively high and stable prices, and structural change.



Keywords: France, Common Agricultural Policy, grains, supply response, wheat, corn, barley, cereals, European Community

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## SUMMARY

In an increasingly interdependent world, the well-being of U.S. grain farmers depends upon developments in other parts of the world. In the eighties, the U.S. share in world grain markets decreased, while the European Community's (EC) share increased. France is the major grain producer in the EC and among the leading producers in the world. This paper examines France's institutional framework within which production decisions are made; analyzes trends in grain area, production, and yield; compares these results to the U.S. situation; and presents results for France of estimated wheat, barley, and corn area response equations.

Grain production in France has taken place in a relatively risk-free environment. Before the formation of the Common Agricultural Policy (CAP), French grain producers were isolated from vagaries of market forces through government-guaranteed prices. Since the formation of the CAP, producer prices have been supported through a variety of mechanisms. Throughout the period, producers have not been exposed to direct competition in world markets because government programs discouraged imports, while subsidizing exports.

Competitiveness of French grains in international markets has benefited from membership in the EC. As a member, France receives preferential treatment when trading within the EC. Since the midseventies, third-country exports to the EC decreased considerably, being displaced by trade from France and other member countries. Export subsidies used by the EC have also helped French grains to be competitive in third-country markets.

Additional factors that have contributed to improved French grain competitiveness are technological improvements and structural change. Grain yields have increased at a faster rate than yields in the United States. France is increasing the yield advantage in wheat and barley relative to the United States, while narrowing the gap in corn yields.

Several specifications were used to estimate area response equations. The relationship between intervention and producer prices was also estimated. We found that producer prices are strongly related to intervention prices, but producer prices increased less than intervention prices. The results also indicated that French grain area is responsive to price changes, but yields are not. Production response to lowering intervention prices depends upon several considerations, including assumptions regarding green rate adjustments.

# Economic Analysis of Grain Production in France

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## INTRODUCTION

Real net farm income in the United States increased and was paralleled by a strong increase in exports during the seventies. In the early eighties, however, farm income decreased considerably, and this development was paralleled by a strong decrease in agricultural exports. It is apparent, therefore, that international trade became increasingly important to the well-being of U.S. agriculture.

One commodity group that significantly contributed to increasing U.S. agricultural exports was grains. Between 1972 and 1975, U.S. grain exports averaged 68 million tons, 53 percent of total world trade.1/ U.S. grain exports peaked in 1980/81 at 114 million tons, 57 percent of world trade. Since then, however, U.S. grain exports have decreased somewhat, while total world trade has risen slightly. World grain trade increased to 209 million tons in 1984/85, while U.S. grain exports dropped to 94 million or 45 percent of world trade.

The European Community's (EC) grain trade evolved differently. Between 1972 and 1975, grain exports by the EC averaged 10 million metric tons, 8 percent of world total. EC grain exports during the late seventies and early eighties increased and in 1984/85, the EC became the second largest grain exporter (although considerably behind the United States) with exports of 25 million tons (12 percent of world total). An equally dramatic turnaround occurred in grain imports. The EC was the world's largest importer of grains during 1968-71, averaging 22 million tons a year (22 percent of world total). In 1984/85, however, EC grain imports were reduced to 6 million tons (3 percent of world total).

Many factors have contributed to the turnaround in the grain trade of the United States and the EC, including movements in exchange rates and the use of export subsidies by the EC. This paper does not examine the factors that may have caused the United States to lose market shares in grain trade but information on the causes of and the decline in U.S. exports can be found in Embargoes, Surplus Disposal, and U.S. Agriculture (74).2/ The evolution of the EC from a net importing region to the second largest exporter has exacerbated the situation.

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1/ Grains refer to cereals, excluding rice; tons refer to metric tons.
2/ Underscored numbers in parentheses are cited in the References section at end of this report.

Because the EC now consists of 12 countries with diverse agricultural endowments, farm structures, technologies, and climatic conditions, grain production evolved differently, and producer response may vary for each country. I focus in this paper on grain developments in France, the EC's largest grain producer.

This paper will provide (1) an overview of the policies that influence decision-making in French grain markets before and after the formation of the EC; (2) a summary analysis of trends in grain area, yield, production, and trade; and (3) explanatory factors associated with these trends. Factors affecting the competitiveness of France and the United States will be compared when appropriate. Finally, I present estimated supply response equations for wheat, barley, and corn for France.

## BACKGROUND

The agricultural sector is relatively more important to the overall French economy compared with the agricultural sectors of other EC member countries. Agriculture contributed more to the French gross national product (GNP) in contrast to the sector's contribution in other major industrial EC member countries. In 1984, agriculture's share of gross value added at factor costs was 4 percent in France, and employment in the agricultural sector was 7.7 percent of the labor force. Agriculture provides a large share of foreign exchange to France. In 1984, 17.7 percent of the value from all exports was generated by French agriculture, compared with 8.9 percent for the EC.

France is the EC's largest country with 54.9 million hectares (ha). Most of the land area is classified as utilized agricultural area (UAA), making France the largest agricultural country in the EC. In 1984, 31.5 million ha (58 percent) of France's land, was classified as UAA, 31 percent of the total UAA in the EC. Over half (17.5 million ha) of UAA in France was classified as arable land, 38 percent of the EC total.

The relative abundance of arable land implies that France has the natural resources to grow a wide variety of crops, including cereals It is not surprising, therefore, that France is the largest cereal producer in the EC. France provided 37 percent of the cereal area and produced 40 percent of all cereals in the EC in 1984. France harvested 9.7 million ha of cereals in 1984, more than double that of any other EC country.

During the past 30 years, cereal production increased tremendously in the EC and France. Cereal production in the EC in 1955-57 averaged 63.5 million tons while average production increased to 130.2 million tons by 1982-84, an increase of 105 percent. Cereal production in the EC grew at an annual compound rate of 3 percent during 1955-84. Cereal production in France increased 167 percent (from 19.1 million tons to 51 million tons) or at a compound growth rate of 4 percent. Because production increased faster than in other EC countries, France's share of the EC total also increased. France produced a little over 29 percent of all EC cereals in 1958; by 1984, France produced 40 percent of all EC cereals.

In addition to being an important force in the EC, French cereal production also plays a major role in French agriculture. Cereals were grown on 798,000 farms or 63 percent of all French farms in 1980. Of those farms, 559,000 grew wheat, 554,000 grew barley, 303,000 grew corn, 275,000 grew oats, and 165,000 grew other cereals (51). Cereals also contribute a significant share of agricultural income. Cereal sales generated over 8 billion European currency units (ECU), 20 percent of French final agricultural product in 1984. This figure underestimates the value of cereals to French agriculture because it does not include the value of about one-fifth of cereal production that is used on the farms where they were grown.

France and the EC pursue an interventionist policy in agriculture. Production decisions and prices are influenced by policy decisions. The next two sections briefly describe the policies that regulate the grain markets in the EC, and the policies pursued in France prior to the formation of the EC, in order to portray the environment within which French producers operate and prices are determined.

## THE COMMON AGRICULTURAL POLICY IN CEREALS

Six countries (Belgium, France, Germany, Italy, Luxembourg, and the Netherlands) in 1957 signed the Treaty of Rome in which they agreed to integrate their economies by forming what is now known as the European Community. Three more countries (United Kingdom, Ireland, and Denmark) joined the EC in 1973. The EC was further enlarged in 1981 when Greece became a member, and Spain and Portugal increased the Community to 12 members in 1986.

Grain markets were the first to be organized when the Common Agricultural Policy (CAP) was established in 1962. The six original members that formed the EC agreed to integrate their markets by establishing rules to guide the internal markets of the member countries, along with establishing rules to guide trade among the members and between member and nonmember, or third, countries. The CAP in grains, however, was not fully implemented until 1967 when the internal markets were unified.

The principles that underlie the CAP are:

1) A single market: products are to move freely within the EC.
2) Community preference: member states give preference to Community production and protect themselves from third-country imports through uniform protection.
3) Common financial responsibility.

The instruments chosen by the EC to implement the CAP in grains were: 1) common official prices, 2) protection at the border through variable levies, and 3) common financing.

### Price System

The grain markets in the EC are governed by prices that are fixed by the Council of Agricultural Ministers each year.

1) Intervention price: This is the price at which EC authorities must buy cereals offered by farmers or the trade, provided the commodities meet minimum quality criteria. Intervention stores are established in countries that have persistent surplus production. Intervention price (with modifications) serves as the floor price on grain prices in the Community.

2) Reference price: This price became operational during the 1977/78 marketing year and was used to support the price for wheat of bread making quality. It was eliminated in the 1986/87 marketing year.

3) Target price: This price is intended to reflect the wholesale price of grain and is meant to be the indicative market price for EC producers. It is fixed above the intervention price and reference price for each grain.

4) Threshold price: This price is used to insulate the EC grain markets from world markets. Grain imported from nonmember countries cannot enter the EC below this price.

Relative grain prices in the EC are governed by the **silo** system which was introduced in 1975. The silo system was introduced ostensibly to allow market forces to play a larger role in determining grain prices based upon feeding value. It specified that the intervention price for all grains should be the same. This was accomplished for all grains, except rye, during the eighties. The regulation that established the silo system also established the reference price for bread wheat.

## Intervention System

The EC supports domestic markets through intervention centers where sellers (producers or traders) can sell their grain at the intervention price, provided the grain meets certain quality and quantity standards. Intervention centers operate throughout the Community for wheat and barley, while intervention centers for other grains operate only in surplus areas.

## Trade Policy

Grain trade among the EC and nonmember countries is governed by the threshold price and by the use of variable levies and export refunds (subsidies), which adjust internal EC prices to world prices.

Variable levies are the difference between the lowest price, including cost, insurance, and freight (cif), available at an EC port and the threshold price. Regardless of port of entry, import prices are adjusted to reflect a common price at Rotterdam. To incorporate quality differences, cif prices are also adjusted to represent a standard quality. The levy, which varies with changing world prices, is set daily and applies to all imported grain. The import levy assures that imported grain does not sell below the threshold price.

Export refunds are subsidies used by the EC to export grains, mostly wheat and barley. Because domestic EC grain prices are usually higher than world prices, EC grain exports are subsidized so that they can compete in world markets.

Because the EC desires to insulate its domestic market from world fluctuations in demand and supply, the CAP has provisions whereby the operation of levies and refunds can be reversed. If world prices should increase above the EC level, levies may be imposed on EC exports and subsidies may be provided for imports. These provisions have not been imposed since 1974.

A license is required for all imports and exports between the EC and nonmember countries. The license, which is valid for a specified period of time, permits traders to import or export the stated quantity of a particular grain. For exports from the open market, the license states the quantity awarded and the proposed subsidy. Licenses are transferable and a market for them does exist.

## FRENCH GRAIN POLICY PRIOR TO CAP

France has a long history of protecting its agricultural producers, including cereal growers, from foreign competition. In the early 1900's, cereal producers were protected chiefly by high tariffs or import quotas. During the thirties, when France was still a net importer, additional protective measures were implemented in an attempt to maintain high grain prices. For example, a law was passed in December 1929, which gave the Government the authority to establish the minimum share of domestically grown wheat that must be used in milling. To assure compliance with the new law, another law was passed in 1930 imposing a quota on wheat imports and requiring the use of import licenses. Import quotas were extended to barley, bran, corn, oats, rye, and buckwheat in 1933. Also in 1933, a minimum price for wheat with monthly increments was established in an effort to provide growers with sufficient income. Problems enforcing the minimum price led to its abolishment in 1934 (28).

These policies were not very successful in maintaining high cereal prices. Demand for domestically grown wheat was stagnant, and the Government, in an effort to stimulate demand, provided subsidies to denature wheat so it could be used as feed. Export subsidies were provided to stimulate exports, and growers were given storage premiums to keep wheat off the market.

Continuing problems resulted in the creation of Office National Interprofessionnel du Ble (ONIB) in 1936. Its most important functions were to fix producer prices of wheat and to make marketing arrangements for wheat so that the fixed price would be effective. ONIB had monopoly power to import and export wheat, spelt, meslin, and rye. To cover program costs, several special taxes were imposed, including a milling tax and a production tax. The production tax rate increased with quantity produced. Producers had to sell their wheat to designated trading agencies at the fixed price. Marketing margins were established and retail prices of bread and flour were regulated by local authorities. Wheat imports were allowed only when the domestic crop was judged insufficient for domestic demand (28, 72, 73, 78).

After the Second World War, French agricultural policy was geared toward increasing food supply. To increase farm investment and improve efficiency, credits and subsidies were provided by the French Government and price supports continued. The ONIB became Office National Interprofessionnel des Cereals (ONIC) and its powers were extended to all grains. Prices for wheat and corn were fixed by government decree, and all marketable wheat had to be channeled through ONIC approved trading agencies. Production incentives were successful and wheat surpluses appeared. Disposal of these surpluses became expensive and, in 1953, the French Government introduced the quantum system to reduce wheat. The volume of wheat that would satisfy domestic needs was estimated each season and this estimate was the quantum amount. The guaranteed price was paid to farmers only on the quantum amount. The price received for quantities delivered above the quantum decreased as volume increased (16, 28).

The pricing system for other grains (barley, corn, oats, and rye) was similar to, but less rigid than, the pricing system for wheat. To encourage corn plantings, the guaranteed price for corn was supplemented with an encouragement premium from 1950-58. The price for oats was determined by market forces starting in 1956. The quantum system was applied to corn and barley in 1961. However, the corn and barley system was implemented differently from the wheat scheme. The price received for deliveries did not decrease when the volume delivered exceeded the quantum (16).

ONIC had monopoly power over all imports and exports of grains and grain products. Exports were undertaken at ONIC's request, and traders had to submit bids specifying the amount of export subsidy needed. ONIC selected bids with the lowest subsidy.

During the transition period (1962-67) between national policies and the full implementation of the CAP France had to eliminate the quantum system. France, during the transition, could establish minimum cereal prices between the relatively low prices that prevailed in France and the relatively high prices that prevailed in Germany. Grain prices were no longer fixed at the guaranteed level and could fluctuate above the support price.

Since 1967, ONIC has become the body for administering Community regulations in France, while maintaining its national role. The system of licensed buyers has continued. Grain in excess of onfarm consumption must be marketed through collectors approved and licensed by ONIC. Even with the CAP, ONIC controls the flow of cereals into the market indirectly by controlling the lag between the time farmers sell their cereal to collectors and the time collectors repay, and by funding cereal stocks held by collectors. For example, collectors can delay repayments for up to 3 months at the start of the season, but in March, the maximum delay is 1 month (73).

Grain policies that prevailed in France prior to formation of the CAP were not very different from policies that emerged when the CAP was formed. Both were based on the establishment of relatively high prices and protection from foreign competition. The instruments were also similar. They consisted of support prices above world level with monthly increments and the use of export subsidies. One may argue that the price-support mechanism for cereals in the EC was developed principally in relation to French needs. A noticeable difference between French policy before and after the CAP was the shift away from tariffs and quotas and toward variable levies to protect growers from foreign competition.

French grain growers did not have to make large adjustments after the CAP was formed. On the contrary, they benefited from the relatively higher prices following the CAP. During the 1960/61 marketing year, the producer price for wheat was $29.27 less per ton in France than in West Germany. During the transition period, French wheat prices increased 15 percent, while German wheat prices remained relatively constant, so by 1966/67, French wheat prices were only $18.97 per ton less than German prices. Furthermore, because France was a wheat exporter when the CAP was implemented, French wheat producers benefited from the captive EC market.

## TRENDS IN CEREAL PRODUCTION

Cereal cultivation in France expanded considerably once the CAP was instituted. Cereal area harvested averaged 9 million ha a year during 1955-60. The average increased to 9.7 million ha a year between 1980-84. Prior to the CAP, the cereal area harvested represented less than 50 percent of the arable land. Since the CAP, cereal's share of arable area increased and peaked at 58 percent in the early seventies. More recently, cereal's share decreased somewhat, but it was still 55 percent of arable land in 1984.

Wheat is the major cereal produced in France, followed by barley and corn. From 1955-65, these three crops accounted for 83 percent of all cereal production, but during 1980-84, their share increased to 94 percent. Wheat production in France has increased relatively steadily since 1955 (fig. 1). Barley and corn production also increased; however, their rate of increase has diminished recently. Production of rye and oats and mixed grains declined steadily from 1955-84.

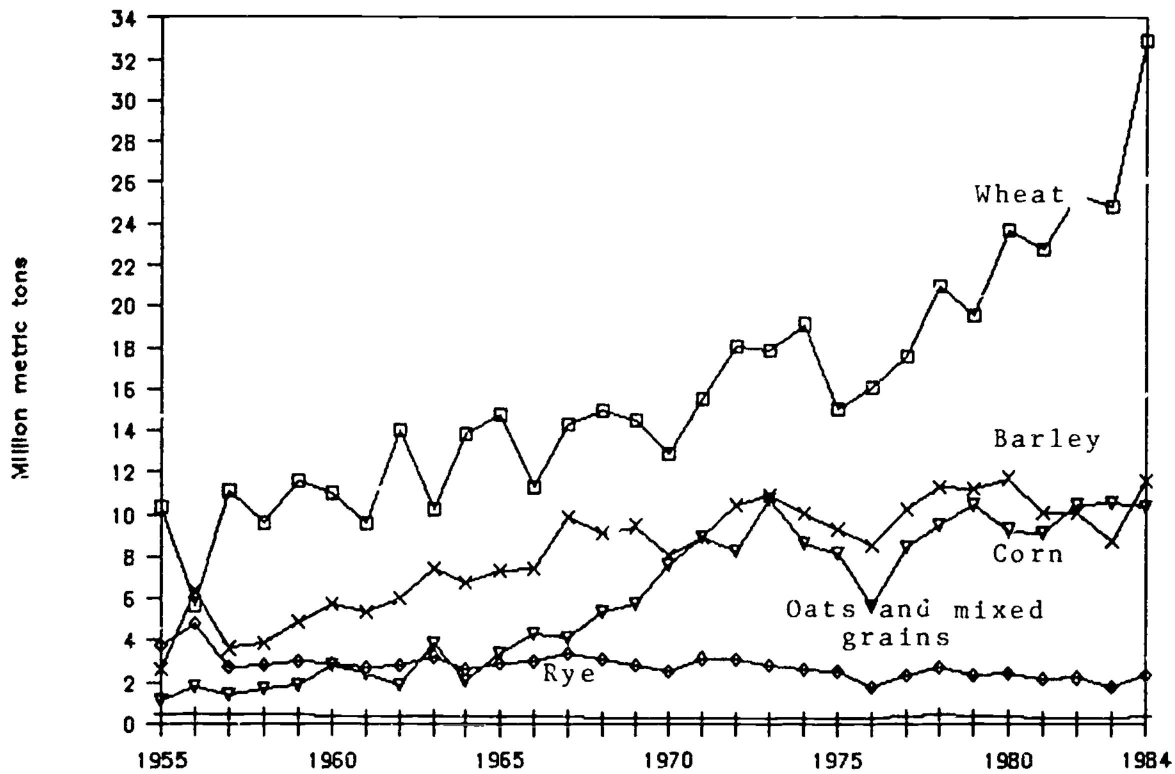
The area of individual cereals harvested between 1955 and 1984 is shown in figure 2. The figure illustrates that there has been some substitution among the various cereals as growers shifted from some cereals (oats and rye) to others. Because the proportion of cereal area to arable land increased for most of this period, it appears that growers opted to shift more of their land base into cereals in lieu of competing crops, such as potatoes or other root crops.

## Wheat

France is the major wheat producer in the EC and one of the leading producers in the world. From 1955-84, France provided 37 percent of the wheat area and 40 percent of production in the EC. The French share of EC wheat production increased from 36 percent from 1955-60 to 44 percent from 1980-84. French wheat production in 1984 ranked fifth in the world, and, among major wheat-exporting countries, France ranked second behind the United States.

Wheat is a leading agricultural commodity in France. Between 1955 and 1984, wheat averaged 45 percent of cereal area and 47 percent of cereal production. During this period, wheat area harvested averaged 4.2 million ha, production

Figure 1 French Grain Production



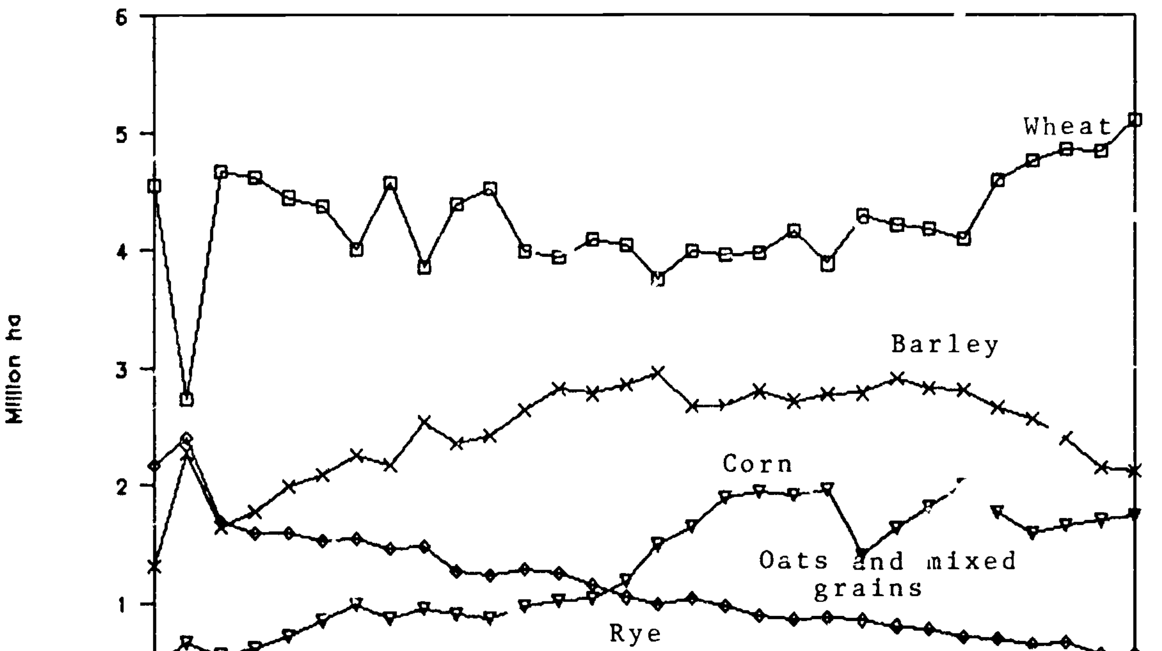
averaged almost 16 million tons, and yield averaged 3.7 tons per ha. In 1984, wheat was responsible for 12.6 percent of the value of final agricultural production, thus ranking third behind milk (17.2 percent) and beef and veal (16 percent).

France produces two c[illegible] of wheat, Durum and common or "soft" wheat. Durum wheat constitutes a relatively small proportion of the wheat grown in France and the EC. It is an ultrahard wheat used in pasta and noodle products. In the EC-10 it is mostly grown in Italy, France, and Greece, with Italy being the dominant producer.

Soft wheat is by far the dominant wheat class grown in France as well as in the EC. It is used in cakes, pastries, cookies, and similar products. In France, soft wheat area harvested averaged 4.7 million ha compared to 118,400 ha for Durum wheat during 1980-84. Production of soft wheat during this period averaged 25.5 million tons, while Durum wheat production averaged 430,600 tons.

Production of soft wheat in France increased considerably during the 30-year period. Except for the eighties wh[illegible] area expanded, production increased, despite falling area, because of substantial yield increases. Wheat yield increased at a compound rate of 3.6 percent per year in 1955-60 and 1980-84. The tremendous yield increases obtained by French wheat farmers during this period are illustrated in figure 3. During 1955-60, wheat yields averaged 2.33 tons per ha, ranging from 2.07 tons to 2.61 tons. During 1961-70, yields averaged 3.19 tons per ha, 44 percent higher than the 1955-60 average. Wheat

Figure 2 Grain Area Harvested in France



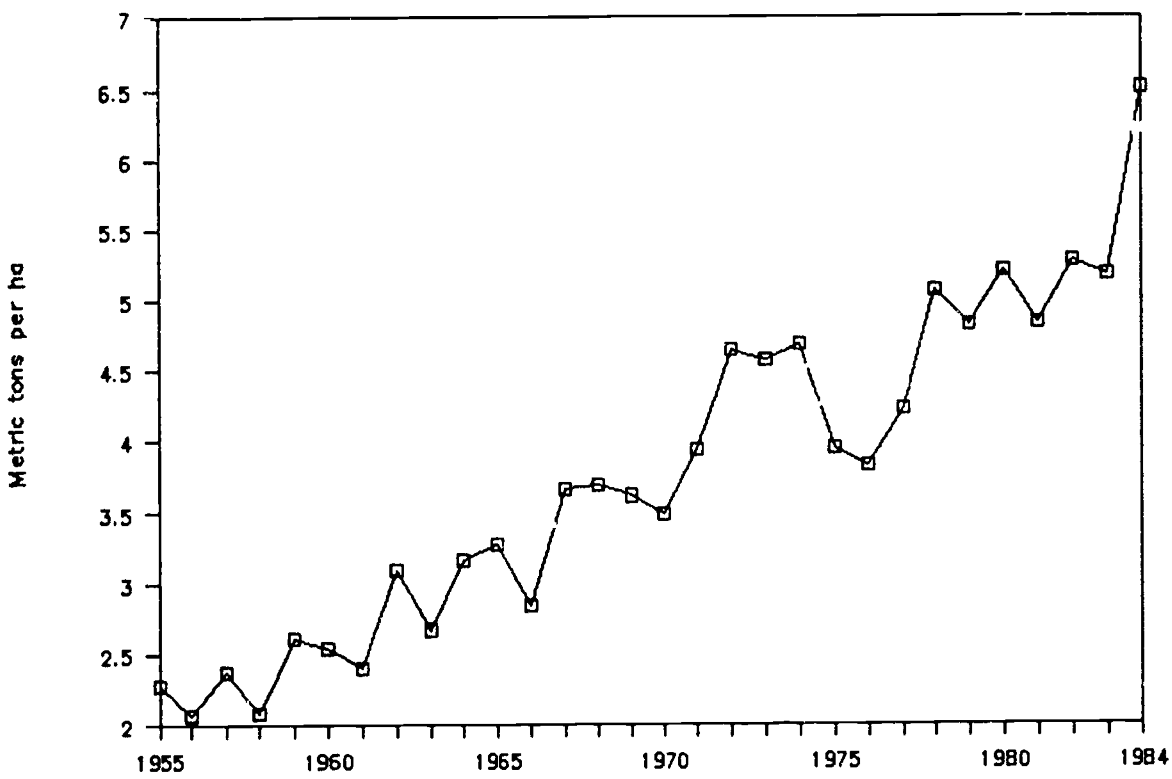
yields continued to increase during the seventies, averaging 41 percent more than the 1961-70 average. During 1980-84, yields averaged 5.4 tons per ha, 20 percent above the average during the seventies. The extent of yield increases is illustrated by the fact that average yields during the seventies were higher than the maximum yields during the sixties. Similarly, average wheat yields in the early eighties were higher than maximum yields during the seventies.

Wheat producers in France plant either in the fall or in the spring. Winter wheat is the preferred crop, and is more prevalent. During 1980-84, winter wheat area averaged 4.6 million ha and production averaged 25.2 million tons. During the same period, spring wheat area averaged 64,400 ha and production averaged 273,000 tons.

Production of winter wheat increased steadily over the past 30 years. Production of spring wheat, however, has decreased over the past 15 years. The divergence between winter and spring wheat production became greater in the eighties.

A major factor behind the divergent time paths of winter and spring wheat production was the difference in yield. The general trend for both has been upward. However, average yields for winter and spring wheat were about the same until 1970. Since then, winter wheat yields increased relatively more than spring wheat yields (fig. 4). From 1980-84, winter wheat yields averaged 5.4 tons per ha, while spring wheat yields averaged 4.3 tons per ha. Increasing winter wheat yields have been accompanied by reduced variability. The

Figure 3 Soft wheat yields in France



coefficient of variation (CV) for winter wheat yield was 0.16 for 1955-60, while it was 0.12 for 1980-84. The CV for spring wheat yields increased from 0.08 to 0.11 during the same period. This indicates that risk-averse growers are better off switching to winter wheat varieties because of higher average yield and lower yield variability.

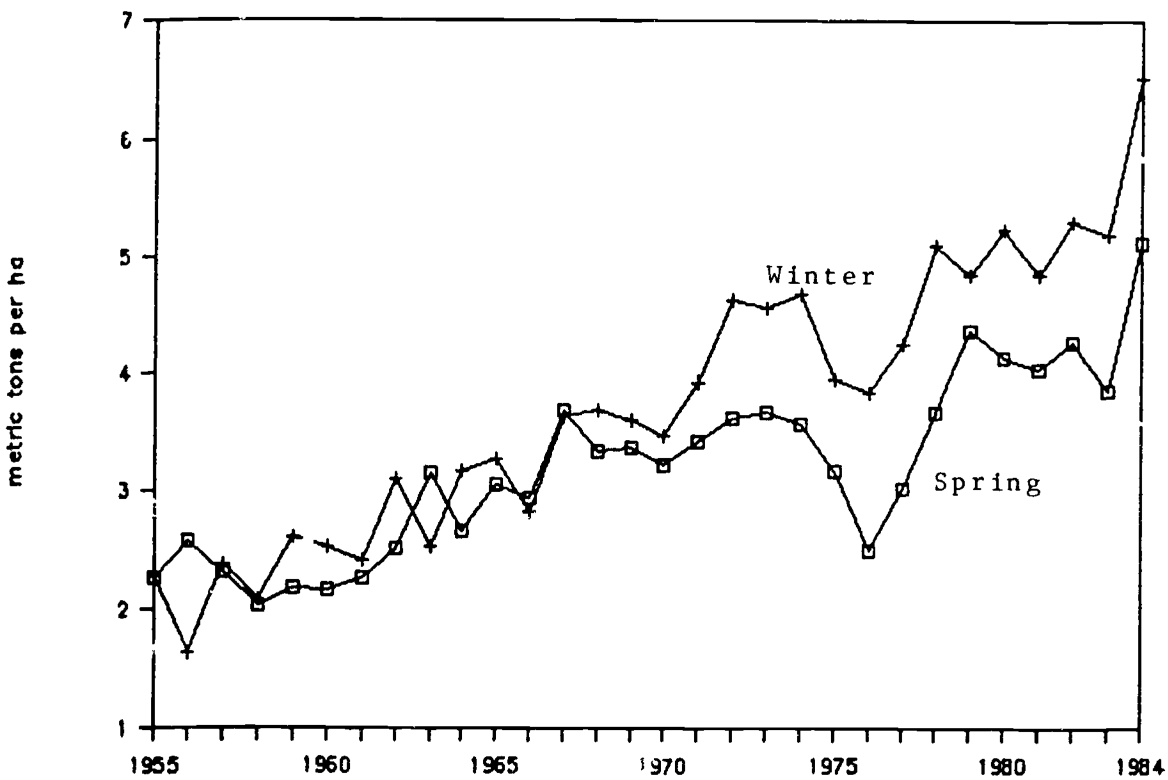
## Barley

Barley is ranked second to wheat in production and area harvested of cereals. France does not dominate the EC barley market as it does the wheat market. France averaged 32 percent of EC barley area and 29 percent of EC production during 1955-84. The French share has decreased, however. France accounted for 31 percent of EC barley production during 1955-60, but its share declined to 26 percent by 1980-84.

Barley is still an important commodity in France. In 1984, barley accounted for 3.2 percent of final agricultural production (third after wheat and corn, among cereals). During 1955-84, barley averaged 26 percent of cereal area and 25 percent of cereal production in France.

Barley area averaged 1.9 million ha, production averaged 4.5 million tons, and yield averaged 2.41 tons per ha during 1955-60. As with wheat, barley area, production, and yield increased over time. From 1980-84, area devoted to barley averaged 2.4 million ha, production averaged 10.4 million tons, and yield averaged 4.4 tons per ha. Contrary to wheat area, barley area increased rather steadily until the midseventies. Since then, French growers began shifting from barley and area declined.

Figure 4 Spring and winter wheat yields

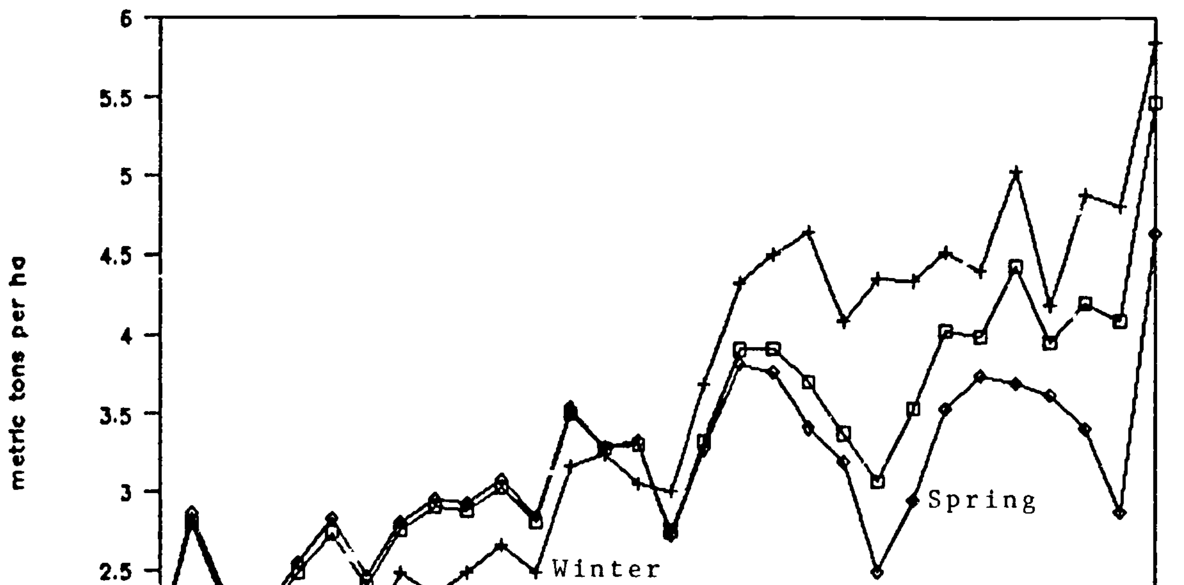


The developments in barley yields are illustrated in figure 5. Barley yields increased at a rate lower than wheat yields. During 1955-60, average barley yield was slightly above average soft wheat yield (2.41 versus 2.33). Since then, wheat yields have outperformed barley yields. The rate of growth in barley yields, 2.5 percent, was 1 percent less than the growth in wheat yields. The different growth rates resulted in average wheat yields that were 1 ton more than average barley yields for 1980-84 (5.4 tons compared with 4.4 tons).

Like wheat, barley is planted in the fall or in the spring in France. Cereal producers preferred planting wheat in the fall and barley in the spring (55, 79). Because of improved winter varieties of both crops, this rotation is followed less rigorously. Until the late seventies, more barley was planted in the spring than was planted in the fall. By the midseventies, however, area planted in the spring began to decrease, while area planted in the fall began to increase sharply. Since 1980, fall sowing of barley has exceeded spring sowing.

Spring barley production was considerably higher than fall production until the midseventies. Barley production from fall plantings averaged almost 7 million tons during 1980-84, while production from spring plantings averaged 3.5 million tons. The shift toward fall plantings coincided with the development of barley varieties that performed better when planted in the fall rather than in the spring (fig. 5). Barley planted in the spring produced higher yields than barley planted in the fall until 1970. Since then, barley yields from fall plantings have been consistently higher than barley yields from spring plantings. Furthermore, the yields from barley planted in the fall are less

Figure 5 Barley yields in France



variable than the yields from spring planted barley. This implies, holding all else constant, that risk-averse growers would prefer to plant barley in the fall.

Based on the data over the last 15 years, there has been a significant shift to fall planting of both barley and wheat. It appears that varietal developments have favored fall planting and French producers have adopted the new varieties obtaining higher yields and increasing production.

## Corn

Corn is the third most important cereal crop in France in terms of area harvested and production volume. In terms of value of agricultural production, however, corn ranked second to wheat with 4.2 percent in 1984.

France is the EC's major corn producer. France accounted for 52 percent of the area and 50 percent of production in the EC during 1955-84. The French share of EC's corn area and production increased in the past 30 years. France accounted for 34 percent of the area and 32 percent of production in the EC during 1955-60, and by 1980-84, its share had increased to 60 percent of the area and 56 percent of production.

Corn is another excellent example of rapid development and adoption of improved seed varieties and other technological advances by French producers. In the fifties, climatic limitations restricted corn production to the southwest of France. In 1955, corn area harvested was slightly more than rye area but much less than wheat, barley, or oats. Hybrid corn varieties and other developments however, expanded the climatic adaptability of corn, and area harvested increased steadily until the seventies (see fig. 2). Corn area expanded from an average of 642,300 ha (7 percent) of cereal area between 1955-60 to 1.7 million ha (17 percent) of cereal area between 1980-84.

Corn production between 1955-84 averaged a little more than 6 million tons a year. As figure 1 illustrates, corn production increased steadily and exceeded barley production in several years. During 1955-60, corn production averaged 1.8 million tons a year. Since 1960, production continued to climb so that by 1980-84 average corn production was 9.9 million tons.

Corn production increased over the past 30 years because harvested area expanded and yields increased from less than 2.5 tons per ha in 1955 to 6 tons in the eighties (fig. 6). Average corn yields between 1955-60 and 1980-84 increased at a compounded rate of 3.3 percent, which was slightly less than the growth rate of soft wheat but more than barley.

Technological and other advances have affected barley, corn, and wheat yields differently as indicated by the different growth rates. Corn yield per ha was 13 percent above barley and 18 percent above wheat during 1955-60. As already discussed, wheat yields increased at a faster rate than either corn or barley yields. Consequently, for the 1980-84 period, average corn yields were only 10 percent above wheat. Because barley yields did not increase as fast, corn yields averaged 34 percent higher than barley yields.

## Other Cereals

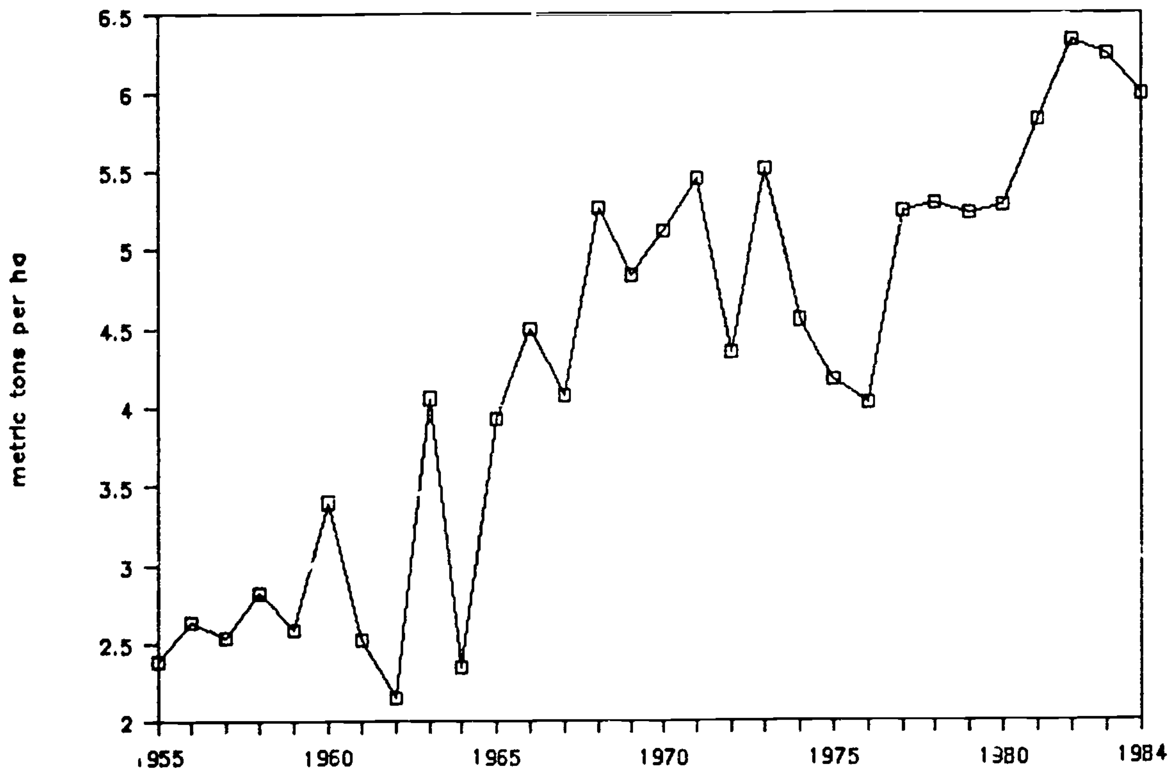
As stated above, wheat, barley, and corn are the major cereal crops grown in France with an average of 85 percent of the area and 89 percent of production during 1955-84. Consequently, other cereals play a minor role. The most important of this "other cereals" group is oats. In 1983, 0.4 percent of final agricultural production was attributed to oats.

Area of oats and mixed grains decreased steadily during the past 30 years. Between 1955-60, area in oats and mixed grains averaged 1.8 million ha; however, area decreased 67 percent to 612,200 ha between 1980-84. Area in rye also decreased from 349,300 ha between 1955-60, to 111,600 ha between 1980-84, a reduction of 68 percent (see fig. 1). Sorghum area on the other hand increased. Sorghum was not a widely known crop in France in the fifties. Between 1955-60, sorghum area averaged 5,000 ha and during 1980-84, it averaged 64,000 ha. Today sorghum is still not widely grown, but area harvested increased, indicating once again the willingness of French growers to experiment and adapt new products and technologies.

Along with area, production decreased substantially for oats and mixed grains, moderately for rye, while sorghum production increased during the past 30 years (see fig. 2). During 1955-60, oats and mixed grains production averaged 3.3 million tons, compared with 2.2 million tons during 1980-84, a reduction of 35 percent. Rye production, which averaged 453,170 tons during 1955-60, decreased to 341,200 tons during 1980-84, a reduction of 25 percent. During the same period, average sorghum production increased from 9,700 tons to 291,600 tons.

Technological and other yield increasing advances were also applied to these "minor" crops as average yields increased steadily over time. Since the midfifties, oats and mixed grain yields almost doubled, rye yields increased 135 percent, and sorghum yields increased 138 percent.

Figure 6 Corn yields in France



## COMPARISONS WITH THE UNITED STATES

Because the United States and France compete in world grain markets, it is interesting to compare developments in grain area, production, and yield between the two countries. The United States dominates France in both area and production. During 1955-60, wheat area harvested in the United States averaged 49.6 million acres, almost five times more than the area harvested in France (10.5 million acres). Barley area in the United States during the same period averaged 14.3 million acres, more than three times the barley area in France (4.6 million acres), while corn area in the United States averaged 67.3 million acres during 1980-84, compared with 1.7 million acres in France. Average wheat area in the United States increased 44 percent to 71.6 million acres while corn area increased only 2 percent to 68.7 million acres. U.S. barley area decreased 36 percent to 9.2 million acres. By comparison, during the same period, wheat area in France increased 13 percent to 11.9 million acres, corn area increased 156 percent to 4.1 million acres, and barley area increased 29 percent to 5.9 million acres.

Average production between 1955-60 and 1980-84 increased in both countries. In the United States, wheat production increased 127 percent from 1,138 million to 2,589 million bushels, corn increased 108 percent from 3,348 million to 6,962 million bushels, and barley, despite a decrease in area, increased 15 percent from 426 million to 491 million bushels. Production in France, however, increased even more. Wheat production increased 162 percent from 363 million to 952 million bushels, barley production increased 129 percent from 209 million to 479 million bushels, and corn production increased 456 percent from 70 million to 391 million bushels.

### Yields

Yields also increased substantially in both countries. France enjoys a yield advantage over the United States in both barley and wheat, while U.S. corn yields are higher than those of France (table 1). It appears that France has been able to increase its yield advantage over time, especially in wheat. Average wheat yields in France were 53 percent above average wheat yields in the United States during 1955-60. During 1980-84, French wheat yields averaged 125 percent above U.S. wheat yields. Developments in barley yields were similar, but not as dramatic. During 1955-60, barley yields in France were 50 percent higher than those in the United States, while during 1980-84, they were 52 percent higher. The United States enjoys a yield advantage over France in corn. However, that advantage has declined over time. Average corn yields in the United States were 15 percent above average yields in France during 1955-60. During 1980-84, U.S. average corn yields were only 7 percent higher than France's yields.

Differences in relative growth rates suggest that technological and other yield increasing improvements were developed and adopted at a much faster rate in France. Based on average yields for 1955-60 and 1980-84, corn yield in France increased at a compounded annual rate of 3.3 percent, while corn yields in the United States increased at a slightly lower rate of 2.8 percent. Barley yields in both countries increased at about the same rate during the period, 2.5 percent per year in France, compared with 2.3 percent in the United States. The crop with the most profound differences in yield growth between the two countries is wheat. Wheat yields increased more rapidly in France with an annual growth rate of 3.6 percent, compared with 1.9 percent growth rate in the United States.

Several factors may be contributing to the divergent growth rates in yield between the two countries. It may be that France has natural advantages over the United States, such as a climate more suited to growing these grains. Factor endowments and input usage (discussed in the next section) may also contribute. Because France is relatively small country, land may be a binding constraint necessitating yield-increasing technology in contrast to abundant land in the United States. Another possibility is that France devotes relatively more resources to expenditures on research and development. Although data are not readily available, information indicates that the fraction of nondefense research spent on agriculture in France exceeds that of the United States (53) and that public expenditures on agricultural research and development have increased faster than expenditures in the United States (14). Such expenditures on research may have been responsible for the development of higher yielding varieties. The CAP provides a relatively predictable, protected environment and price supports. Such an environment may be more suitable to the adoption of new, higher cost and higher yielding technologies, assuming everything else is constant.

## Farm Structure and Input Use

In addition to higher yielding varieties, factors that contribute significantly to increased crop production include farm consolidation and modernization, along with increased and improved input usage. As in other developed nations, the number of farms decreased, while the average farm size increased. In 1960, there were approximately 8 million farms in France with an average size

Table 1--Wheat, barley, and corn yields in the United States and France

| Commodity and year | United States | | France | |
|---|---|---|---|---|
| | Metric tons per hectare | Bushels per acre | Metric tons per hectare | Bushels per acre |
| Wheat: | | | | |
| 1955-60 | 1.5 | 22.83 | 2.3 | 34.52 |
| 1961-70 | 1.8 | 26.85 | 3.2 | 47.16 |
| 1971-80 | 2.1 | 31.62 | 4.5 | 66.03 |
| 1980-84 | 2.4 | 36.34 | 5.4 | 73.70 |
| Barley: | | | | |
| 1955-60 | 1.6 | 29.75 | 2.4 | 44.76 |
| 1961-70 | 2.1 | 39.12 | 3.0 | 55.09 |
| 1971-80 | 2.4 | 45.09 | 3.7 | 69.26 |
| 1980-84 | 2.9 | 53.00 | 4.4 | 82.26 |
| Corn: | | | | |
| 1955-60 | 3.1 | 49.72 | 2.7 | 43.47 |
| 1961-70 | 4.5 | 72.30 | 3.9 | 61.85 |
| 1971-80 | 5.7 | 91.50 | 4.9 | 78.22 |
| 1980-84 | 6.3 | 100.10 | 5.9 | 94.51 |

of 17 ha of UAA. In 1983, the number of French farms had declined to 1.1 million, while average farm size increased 50 percent to 25.5 ha. The average French farm is still considerably smaller than the average U.S. farm (63 acres compared with 432 acres).

The decline in farm numbers occurred predominantly among small- and medium-size holdings. During 1960-84, the largest decrease occurred among farms that were less than 20 ha, a 57-percent decrease. The number of farms between 20-50 ha decreased 7 percent, while the number of farms above 50 ha increased 57 percent. The farmland released by the elimination of smaller farms was used to increase the average farm size of the larger holdings. In 1960, farms greater than 50 ha represented 6 percent of all farms and controlled 28 percent of UAA. In 1983, farms larger than 50 ha represented 15 percent of all farms and controlled nearly half (46 percent) of the UAA.

General trends related to cereal farms are difficult to ascertain because information is not readily available. Available data indicate that cereal farms tend to be larger than the average farm in France (25). In 1984/85, the average size of cereal farms represented in the survey (25) was 66.2 ha (164 acres) which was almost twice the average size for all farms (36.8 ha).

As mentioned previously, cereals are grown on most French farms. In 1980, 63 percent of all farms grew cereals: 559,000 farms grew wheat, 554,000 grew barley, and 303,000 grew corn (52). Cereal production is also becoming more specialized. Based on data for 1982/83, only 20 percent of the cereal producers farmed more than 100 ha; however, they delivered 73 percent of the cereals (55). The increase in average farm size may indicate that French cereal producers are becoming more efficient. Information from the United States indicates that there are economies to scale in the production of cereals up to the 1,000-acre range (74, 76). Chances are good that French producers are also able to obtain economies as size increases, thereby, lowering unit costs as output expands.

Cereal farms in France are also becoming less labor intensive. In 1984/85, the average cereal farm employed 1.34 workers per year, while the average for all farms was 1.65 workers per year (25). Labor engaged in cereal production is more productive than labor engaged in other agricultural activities. Net value added per work year was ECU 11,500 for all farm types, compared with net value added in cereals of ECU 23,900.

Cereal farms in the United States are also becoming larger and more specialized, while their numbers are decreasing. During 1964-78, the number of farms growing corn decreased from 1.5 million to 919,000, while average acreage of corn harvested per farm increased from 39 acres (16 ha) to 76 acres (31 ha) per farm (75). The number of farms growing barley also decreased from 121,700 in 1969 to 97,000 in 1978, while average number of acres harvested per farm increased from 79 acres (32 ha) to 95 acres (38 ha) (74). Wheat was grown on about 383,000 farms in 1978, with each farm harvesting 142 acres (57 ha) (76).

Cereal farms in the United States are also becoming more specialized. Corn was the primary crop grown on all farms that produced corn. Farms with 500 or more acres of cropland accounted for 13 percent of farms that grew corn, but they accounted for 41 percent of production (75). Barley is also primarily grown on large farms; 46 percent of the farms that grew barley had 500 or more acres of farmland. Of these, farms that harvested 250 or more acres of barley accounted for 5 percent of the barley farms and 44 percent of production (74). Wheat also tends to be produced on larger farms; 35 percent of the wheat farms had 500 or more acres of cropland. Wheat tends to be a secondary crop, however. About 17 percent of the wheat farms harvested 250 or more acres, but 65 percent harvested 100 acres or less (76).

Technological progress affected other inputs as well. French agriculture became more mechanized and dependent upon purchased inputs. In 1958, there were 623,000 tractors in France, and by 1983, the number had increased to almost 1.5 million. This equals about 5 tractors per 100 ha of UAA or 1 tractor per farm. The number of combines and harvesters also increased significantly during this period. While there were 42,000 combines and harvesters in 1958, their numbers increased to 152,000 in 1983. In terms of cereal area, there was an average of half a combine per 100 ha in 1958; the ratio increased to 1.5 combines per 100 ha in 1983.

Technological progress also encouraged greater use of intermediate or purchased inputs. More and better use of fertilizers and plant protection inputs, coupled with improved varieties, significantly increased yields. During 1956-60, fertilizer consumption averaged 56 kilograms per hectare (kg/ha) of UAA. In 1983/84, fertilizer consumption increased to 185 kg/ha, an increase of 130 percent. Not only did the volume of fertilizer increase, but application timing also improved. Fertilizer is now applied at planting with several applications during the season.

Use of other intermediate inputs followed a similar, increasing pattern. Volume of all purchased inputs increased at an annual rate of 7.2 percent between 1960-73 and at a rate of 3.5 percent between 1973-80 (11). The agricultural decline of the eighties experienced by the United States and other countries also affected France. The growth rate of purchased inputs decreased considerably. Consumption of all inputs between 1973 and 1985 increased at an annual compounded rate of 1.7 percent (11).

An additional development was the persistent substitution of capital (machinery) and intermediate inputs (fertilizers and pesticides) for labor. Consequently, the number of persons engaged in agriculture decreased substantially. Between 1959-75, labor decreased at an annual rate of 3 percent. The decrease rate moderated to 1.1 percent during 1975-80, mainly because of a slowdown in the use of purchased inputs (11). The decrease in the number of workers engaged in agriculture was accompanied by a large increase in productivity. Labor productivity from 1973 to 1984 increased at a rate of 4.5 percent per year.

Technological change had similar effects on U.S. agriculture; that is, the number of farms decreased while average size increased, and capital and purchased inputs were substituted for labor. Because U.S. farms on average are larger than farms in France, mechanization in the United States evolved differently. During 1970-84, the number of tractors in the United States did not change significantly. Horsepower increased substantially, indicating the shift to larger, more powerful tractors. In 1970, total tractor horsepower was 203 million; by 1984, this had increased 53 percent to 311 million horsepower.

As in France, U.S. fertilizer use increased over time. However, fertilizer use per hectare is less in the United States. Labor requirements in U.S. agriculture decreased considerably faster than labor use in France. Based on the index of labor input (1977=100), labor use in the United States decreased at a compound annual rate of 3 percent during 1970-84. The change in input usage was accompanied by productivity increases. Total productivity (farm output per unit of input) in the United States increased at a compound rate of 2 percent per year during 1970-84.

French and U.S. agriculture have some differences in relative intensity of input use. French agricultural technology is more fertilizer intensive on average, using 68 percent more fertilizer per ha than the United States. Another difference due to different farm size between the two countries is mechanization. The large average farm size in the United States has resulted in farmers opting for larger machines, while the relative small farm size in France has resulted in farmers opting for more, but smaller, machines. Although use of total inputs changed very little in the United States, they continued to increase in France. The U.S. index (1970=100) of total farm inputs stood at 97 in 1970 and 96 in 1984. In France, volume of purchased inputs increased considerably during the seventies, and continued to increase at a slower rate in the eighties.

There are many similarities in the technological developments in French and U.S. agriculture. The result has been increased production and productivity, along with larger, more specialized farms that are capital intensive. In both countries, cereals are grown on a large number of farms, but production is concentrated among the larger producers. It appears that growers tend to focus on crops for which the country seems to have a relative advantage. In the United States, more farmers grow corn than other cereals, while French farmers tend to specialize in wheat.

In France, the increased use of purchased inputs and machinery also facilitated the switch to higher yielding winter varieties and increased the grower's flexibility to choose cropping patterns. Increased mechanization, fertilization, and pesticide use minimized the need to rotate crops and relaxed the relatively inflexible rotation patterns followed in the fifties and sixties, enabling cereal area to expand (54, 57). Increased mechanization also allowed growers to plant more area faster than before, freeing them, somewhat, from the vagaries of weather.

Even though it appears that technological change similarly affected both the United States and France, the rate of change, based on cereal yields, has been faster in France, enabling it to increase its yield advantage over the United States in wheat and barley, while narrowing the gap in corn yields. The relatively higher emphasis by the French on agricultural research and development indicates that technological enhancements may accelerate in the future.

These developments have implications for the competitiveness of these crops in world markets. Competitiveness depends on many factors, including production costs, exchange rates, trade policy, and productivity. It is beyond the scope of this report to examine the competitiveness issues in detail. The information presented indicates that France, under relatively high prices and protection of the CAP, is making a concerted effort to improve farm structure and productivity. The payoffs have been large increases in productivity, especially in cereal yields. Recent studies indicate that French cereal producers are competitive with U.S. producers in world markets (22, 34, 49, 65). Community preference and export subsidies provided by the CAP have also helped France increase cereal exports.

## GRAIN TRADE

Cereal trade is increasingly important to France, not only to generate foreign exchange, but to reduce surpluses in response to sluggish domestic demand. The importance of exports to French cereal producers can be ascertained by calculating the proportion of cereal area devoted to production for export. From 1980 to 1983, France exported production from 57 percent of the wheat area, 45 percent of the barley area, and 42 percent of the corn area harvested. During the same period, the United States exported production from 30 percent of the corn area, 17 percent of the barley area, and 60 percent of the wheat area harvested. France and the United States devote about the same proportion of their wheat land base to exports, while French corn and barley producers are more dependent upon trade than their U.S. counterparts.

French exports of wheat, barley, and corn have increased considerably. Wheat exports more than doubled during 1975/76-1984/85 marketing years, increasing from 8.9 million tons to 19.2 million tons. During the same period, corn exports increased 50 percent, while barley exports increased 44 percent (table 2). Given the increase in exports, one may be tempted to conclude that France is very competitive with other countries, including the United States in world grain trade. An increase in exports does not necessarily indicate that France is competitive because a significant share of French trade is with other EC countries, a market that gives preferential treatment to members, while trade with non-EC countries is facilitated through extensive use of export subsidies.

The advantage to being a member of the EC is evidenced by the proportion of French exports going to other EC members. During 1975/76-1984/85, 42 percent of French wheat exports were shipped to other EC countries, while barley exports to other EC countries averaged 54 percent. French dependence on the EC market is especially evident in corn trade, where over 90 percent of corn exports were shipped to other EC countries. The advantage of EC membership to French exports compared with nonmember countries is evidenced by trends in total EC trade.

Table 2--French cereal exports: Total and intra-EC

| Marketing year | Wheat | | Barley | | Corn | |
|---|---|---|---|---|---|---|
| | Total | Intra-EC | Total | Intra-EC | Total | Intra-EC |
| | 1,000 metric tons | | | | | |
| 1975/76 | 8,944 | 4,241 | 4,092 | 1,795 | 3,218 | 2,992 |
| 1976/77 | 6,996 | 4,518 | 2,764 | 2,035 | 957 | 801 |
| 1977/78 | 8,083 | 5,507 | 4,498 | 2,336 | 2,736 | 2,534 |
| 1978/79 | 9,718 | 4,426 | 4,803 | 2,397 | 3,231 | 3,006 |
| 1979/80 | 10,579 | 3,894 | 4,731 | 2,587 | 4,025 | 3,776 |
| 1980/81 | 13,497 | 4,010 | 5,544 | 2,558 | 3,048 | 2,732 |
| 1981/82 | 13,503 | 4,284 | 4,706 | 2,597 | 3,263 | 2,970 |
| 1982/83 | 13,420 | 3,642 | 4,151 | 2,450 | 4,379 | 4,107 |
| 1983/84 | 14,457 | 4,735 | 3,896 | 2,430 | 5,891 | 5,479 |
| 1984/85 | 19,244 | 6,517 | 5,907 | 2,790 | 4,812 | 4,397 |

The EC imported 7.1 million tons of wheat from third countries in 1975/76, 57 percent of total imports. The proportion of wheat imports supplied by third countries has decreased substantially since then. In 1984/85, third countries supplied 2.7 million tons (20 percent) of total wheat imports. French wheat exports to other EC countries increased from 4.2 million in 1975/76, to 6.5 million tons in 1984/85. Similar developments occurred in barley and corn trade. Third countries supplied 40 percent (2.3 million tons) of EC barley imports in 1975/76, but their share decreased to only 5 percent (0.26 million ton) in 1984/85. The reversal was equally dramatic in corn imports. Third countries supplied 80 percent (14.3 million tons) of total EC corn imports in 1975/76, but only 31 percent (3.4 million tons) in 1984/85. French exports to other EC countries on the other hand increased during this time. Barley exports from France to other EC countries increased from 1.8 to 2.8 million tons, while corn exports increased from 3.0 to 4.4 million tons.

French wheat and barley exports to third countries also increased. In 1975/76, France exported 4.7 million tons of wheat to third countries. Wheat exports almost tripled; equaling 12.7 million tons in 1984/85. Barley exports to third countries increased 36 percent (2.3 to 3.1 million tons) from 1975/76 to 1984/85. The EC subsidizes wheat and barley exports to non-EC countries. Data for France are not available. However, for 1982-84, 66 percent of EC-wheat and 75 percent of EC-barley exports to non-EC countries were subsidized through the open tender system.3/ Because most of the wheat exports and a sizeable portion of barley exports come from France, French exports to third countries undoubtedly benefit.

Based on the trade data, it appears that the CAP is successful in promoting intra-EC trade. As the largest grain producer in the EC, France has benefited by increasing trade with member countries, while variable levies limit the ability of nonmember countries, including the United States, to compete. The ability of French grain exports to compete in third countries is enhanced with the export subsidies provided by the CAP.

## APPROACHES TO ESTIMATING SUPPLY RESPONSE

The previous sections presented information on cereal yields, area, production, and trade. In order to be able to characterize the production technology and ascertain changes in outputs and inputs from changes in prices or other exogenous forces (and thus determine competitiveness on world markets), relationships between inputs and output need to be quantified. Several approaches are available, ranging from deterministic programming models to stochastic models that use econometrics to estimate the relationships. The method chosen depends upon data availability, objectives, and time constraints. Two of the more common methods of estimating supply response using econometrics are presented, and some of their advantages and disadvantages are discussed.

One approach to estimating supply begins with the theory of the firm, assumes producers maximize profit (within a perfectly competitive market), is only constrained by the technology available, and employs first order conditions for profit maximization to derive output supply and/or input demands. This approach provides a link between theory and empirical estimation, and it provides

3/ Open tender system is one of the methods used in the EC to facilitate exports. Exporters submit bids to the Cereal Management Committee stating the volume they want to export and the subsidy that will be granted.

theoretical restrictions on the behavior of supply and demand equations that can be econometrically tested. Information on technology is provided, and issues (such as degree of substitutability among inputs, economies to scale, and other production relationships can be addressed). The unknown parameters are usually estimated with cross sectional data on firms, or highly aggregated (sectoral or industry level) time series data. Explicit or implicit assumptions associated with this method include instantaneous adjustments, continuous substitution among inputs, and, usually, input and output prices are exogenous and known with certainty.

This approach to estimating production or supply is well-founded in neoclassical economic theory. Parameters are estimated conditional on the data once a functional form for the production or profit function is specified. Early applications involved estimating production functions. One problem of estimating a production function (abstracting from problems of defining and measuring inputs, especially capital) is simultaneity bias because inputs and outputs are jointly determined. Secondly, biased estimates will be obtained if there are variables that are observed and employed by the decisionmaker when determining quantities of other explanatory variables, but are left out of the equation (because data was not collected or for other reasons) (80).

More recent approaches to characterize technology and derive input demands or supply functions are based on duality and specify cost or profit functions. The fundamental principle of duality is that all economically relevant aspects of technology are captured by the cost or profit function. Estimating cost or profit functions has become increasingly prevalent because these functions allow greater flexibility when specifying factor demand and output supply response (43).

The cost function represents the minimum cost of producing any specified output level given the technology and is written as a function of input prices and output level. Properties of the cost function are discussed in (80). By using one of those properties, Shephard's Lemma, the conditional demand function for an input is obtained by differentiating the cost function with respect to the input price.

The profit function gives, for each set of prices, maximized profits. It is less rictive then the cost function and is written as a function of input and output prices. Properties of the profit function are discussed in (80). Using one of those properties, Hotelling's Lemma, one obtains the supply function by differentiating the profit function with respect to output price, while input demands are obtained by taking the negative of the derivative of the profit function with respect to input price.

Primal production or transformation functions, and dual cost or profit functions, have been used to estimate agricultural supply functions, assuming single or multiple outputs. The advantage of using the dual rather than the primal approach to derive the estimated factor demand and output supply responses is that one does not have to solve a complex system of first order conditions to undertake comparative statics. The dual approach also has the econometric advantage in that the exogenous variables (input and output prices) are on the right side of the equations, while endogenous variables appear on the left side (43, 58, 63).

Agriculture is considered a competitive industry and, thus, is well suited to these methods for estimating supply and input demand equations. Applications of the dual approach in agriculture have expanded considerably since the early seventies, indicating its usefuln ss. Several cost or profit functional forms have been used to estimate factor demands and output supply, assuming either single or multiple output(s). These functional forms (such as generalized Leontief, translog, and generalized Cobb-Douglas) are flexible because they impose few a priori restrictions on technology. The interested reader is encouraged to examine some of the literature cited that employed these approaches to estimate supply response and other relationships (6, 12, 13, 36, 39, 40, 41, 42, 43, 44, 45, 59, 63, 64, 81). The list is not all inclusive, but does represent the various different approaches taken in applied work. The reader should note the different functional specifications employed, the restrictions imposed, and conclusions reached regarding the production technology and the relationship between inputs and outputs.

The other popular approach to estimating agricultural supply response is more ad hoc in that the theory of the firm does not play a significant role in specification and estimation of the models. Behavioral assumptions (such as profit maximization or cost minimization) are not formally incorporated (18, 37). In its usual application, this method employs time series data (usually at aggregate rather than firm level) to estimate single equation, single output supply, as a function of input and output prices. Generally, the functional specification is linear or log linear.

This approach has been used to estimate both static and dynamic supply relations. Dynamic supply response relationships (generally postulated as distributed lags) are attributed to Nerlove's work in the late fifties (37). Unlike the dual approach, which assumes that prices are known, the Nerlove model assumes that farmers react to expected prices, and there are adjustments and other costs that prevent farmers from adjusting fully to those expectations (7, 8). The simple Nerlove model consists of three equations that explain desired acreage, expected price, and actual area planted (7, 8, 51). The model can be solved in reduced form for actual acreage planted as a function of expected price and other exogenous variables.

In empirical applications, different assumptions have been employed to describe price expectations, including naive expectations which assume that expected price is the previous period's price; adaptive expectations which assume that current expected price differs from past expected price by a constant amount, proportional to previous forecast error; and rational expectations which assume that expected price is a function of the expected values of the exogenous variables (37, 62). The rational expectations approach has not been employed often due to complexities of translating the model into observable variables (62). In addition to different assumptions regarding price expectations, different functional forms such as Koyck or Almon lags have been employed.

Because these models are not formally derived from axioms of individual behavior, estimation usually consists of a researcher using personal judgment and knowledge of the market to decide how price expectations are formed and which price variables to include in the model. Price series most frequently cited in the extensive studies reviewed by Askari and Cummings include: 1) producer price, 2) ratio of producer price to some consumer price index, 3) ratio of producer price to producer prices paid index, and 4) ratio of producer price of the crop in question to the price of most competitive crop(s) (7, 8). The researcher must also specify a yield relationship to estimate production when the dependent variable is area planted.

The popularity of the Nerlovian approach to estimate supply response by either estimating single-product supply for commodity analysis or by building large scale models is evidenced by the large number of studies cited by Askari and Cummings (7, 8).

An obvious advantage to this approach is the availability of data on area planted or harvest and output prices. In addition, these models' dynamic nature makes them more suitable for dated forecasts, and their partial nature allows flexibility in developing appropriate dynamic structures (18, 38).

The ad hoc nature of these models is one of their limitations. Output prices do not capture all the relevant information. For example, supply is a function of relative profitability in the neoclassical model. Changes in market prices do not reflect changes in relative profitability, unless costs and yield of competing crops remain the same. In an effort to correct this limitation, relative prices and expected returns have been used, rather than expected prices. Cost data generally are not available and the researcher has to use gross returns as proxy for relative profitability. Gross returns also do not reflect relative profitability, except under some very strong assumptions. In addition, insufficient attention is often given to the form that prices enter the supply function. Another problem is the use of area, an input in the production process, to represent planned output. There also are statistical problems associated with estimating these models due to serially correlated disturbances (7, 51).

The purpose of the discussion was to briefly present two frequently used methods that utilize econometrics to estimate supply response. It was not meant to be exhaustive nor totally inclusive. The reader undoubtedly noticed that the two approaches utilize similar explanatory variables, notably prices. Models that have utilized the profit or cost function approach have tended to emphasize examination of technological relationships, substitution among inputs, economies of scale, and impact of technological change on input use. However, they have also tended to rely on sectoral rather that commodity specific data. Even multiple output profit functions have been utilized to estimate relationships among aggregate commodity groups, such as crops and livestock, rather than specific commodities.

Models that employed Nerlove's approach were used to estimate crop or commodity-specific supply models. Some models have been used to develop large-scale econometric and simulation models. With respect to cereal supply in the EC and more specifically France, technological improvements played a significant role in cereal production. Consequently, the theoretically consistent, multiple output profit function approach would produce relevant information on the relative competitiveness of French cereal production. However, data to implement this approach for specific crops were not available. Furthermore, price expectations were considered important to output response. Consequently, Nerlove's approach to estimating acreage response for the three major grains produced in France was used. Before presenting the results, I review some of the relevant studies that estimated cereal production either for the EC or France.

## EC AND FRENCH CEREAL PRODUCTION MODELS

Econometric studies of cereal production for the EC and France, written in English, are scarce. Of the few that have been located, the majority have been developed as components of larger models that examine issues such as world wheat trade (10, 30, 61), impacts of alcohol production from corn on selected markets (32), or the effects of EC policies on wheat production (46).

These models were estimated using aggregate EC data and illustrate the variety of variables and approaches used to estimate models based on Nerlove's methodology. Gardiner used naive price expectations to estimate separate EC wheat and corn area equations as functions of own expected returns and area of other cereals (32). Schiff, on the other hand, postulated that producers could forecast wheat prices with certainty because he assumed that producer prices equaled policy prices (61). Thus, Schiff did not specify a price expectation equation. Price expectations were not used in the wheat model developed by Meilke and de Gorter (46) nor in the corn and wheat models developed by Bahrenian and others (9) and Devadoss and others (27).

A consensus among modelers on the appropriate dependent variable is also lacking. Both the Gardiner (32) and the Meilke and de Gorter (46) models used area harvested as the dependent variable, while the Schiff (61) model used expected output (defined as expected yield times last periods area harvested) as the dependent variable. Devadoss and others (27), on the other hand, assumed that wheat area was exogenous and estimated a wheat yield equation. Bahrenian and others (9) used corn yield as the dependent variable in their EC corn equation, while barley area harvested was the dependent variable in their barley equation. Supply in the Schiff (61) model, therefore, was directly obtainable, while the other models needed to specify additional equation(s) or identity(ies) to obtain supply. Gardiner (32) specified a yield equation, while Meilke and de Gorter (46) estimated output as a function of area and a time trend. Bahrenian and others (9) and Devadoss and others (27) used the identity that production equals area times yield with either area or yield exogenous, depending upon the equation. Meilke and de Gorter (46) were able to incorporate the price of wheat and barley (deflated by production cost lagged one period) in their estimation of wheat area. Gardiner (32) and Schiff (61) reported that when prices or expected revenue from competing cereals (such as barley) were included in their model, results were drastically altered. Bahrenian and others (9) and Devadoss and others (27) did not include price of competing crops in their estimations. Cross price effects, therefore, could not be calculated from these models.

Cereal supply models specifically for France are also scarce (especially in English). A recent literature search for cereal supply models by Caspari and others (15) identified two studies, one of which was available in English. The French models that we identified also employed Nerlove's methodology and, as was the case for the EC models, different specifications and variables were used.

One of the first grain production models for France published in English was developed by Oury in the early sixties (54). Oury separated cereal into wheat and feed grains and estimated production directly by using production as dependent variable and indirectly by estimating a yield and an area equation. Oury preferred the indirect approach and presented several estimated equations employing a variety of variables. The yield equations that he preferred contained several environmental variables and prices as explanatory variables. Area was also estimated as a function of environmental variables and prices.

The EC Commission was also interested in understanding and quantifying cereal supply for the EC. Rather than estimating EC production from aggregate EC data, models were estimated for each country. A model of French cereal production was estimated as part of an overall EC cereal model (83, 84). The larger countries, such as France, were further subdivided into regions. The French cereal model consisted of yield and area equations for each cereal in three regions. Yield was specified as a function of time and weather variables. Area equations were estimated using the ratio of individual cereal area to total cereal area as the dependent variable and previous year's own expected returns as independent variables. Cross-price effects were not included because of multicollinearity and other estimation problems. The difficulty of estimating cereal supply relations in France was highlighted by the fact that different specifications were employed to estimate area response in each region. Although the first study (84) reported standard errors, the updated version (83) did not provide information on whether estimated parameters were statistically significant.

Another study that included estimating wheat and barley production in France was conducted by Muriel (49). He developed a wheat and barley model for each of four EC countries, including France. His model consists of a yield and area equation for each crop in each country. His results indicate that for France, wheat area was best explained using prices rather than returns. The independent variables in his equations were wheat and barley prices lagged one period. Yields were estimated as a function of own output and fertilizer price lagged one period.

One of the more detailed examinations of area and yield response equations for wheat, barley, and corn was published by the French Ministry of Agriculture (47). The area of each crop was expressed as a ratio to total cereal area, while explanatory variables included lagged output price ratios or output prices deflated by the GDP deflator. Several specifications for each crop are reported. The results suggest that wheat competes with barley and corn for land, while barley and corn do not compete. Yield was estimated as a function of fertilizer consumption and/or capital per hectare, using cross section or time series data. Yield equation results were not satisfactory; the explanatory power of each equation was low, and most of the estimated coefficients were insignificant.

One of the problems with the ministry's model (47) is that it is difficult to ascertain the influence of the exogenous variables because the estimated coefficients are not reported, nor is it possible to determine how well the equation explains the variation in the dependent variable because the $R^2$ is not reported. Based on the estimated t statistics that are reported, the results indicate that inclusion of all three output prices (wheat, barley, and corn, whether as a ratio or deflated) produced insignificant coefficients in the area equations due to multicollinearity.

An econometric model of French agriculture has been developed (MAGALI) that explains the supply of 27 agricultural products, including cereals (5). Unfortunately, detailed specification and estimation results are not available. It is reported by Albecker and Lefebvre that in estimating area equations, price variables were insignificant and were replaced by variables indicating profitability (the nature of these variables could not be determined) (5). Results of wheat and barley yield estimates were provided in a follow-up study (48). Wheat and barley yields were estimated as a function of time, own output price, input price (both prices deflated with up to a 4-year lag), and several environmental variables. The specification in (48) was the best with respect to statistical significance of the estimated coefficients. However, the $R^2$ is not reported, so the explanatory power is not known, and they obtain some perverse results. For example, a reasonable assumption is that an increase in output price will increase yield while an increase in input price will have the opposite effect. If there are adjustment lags, then the absolute value of the adjustment coefficients should decrease over time; prices in the more distant periods should have a smaller impact upon yields. There are no reasons to expect sign switches over time; that is, output price should not switch from a positive to a negative effect on yield over time. Both wheat and barley yield equations did not fulfill expectations. The estimated parameters indicate that an increase in wheat price in year one increases wheat yields in years two and three, but decreases wheat yield in the fourth year. Based on the magnitude of the estimated coefficients, the longrun effect of a price increase on wheat yields is smaller than the shortrun effect (the absolute value of the most distant coefficient is the largest; hence, the sum of the coefficients is smaller than the one-period coefficient). The impact of a change in input price also changes over time. Similar results were reported for barley.

All the models identified used a variation on Nerlove's methodology by either explicitly incorporating expectations or implicitly assuming naive expectations by employing lags. Explanatory variables were selected mostly on the basis of statistical considerations (whether the variables are statistically significant and have the 'right sign'). Variables have been specified as linear, log linear, ratios, or moving averages, and various deflators have been used, including the Consumer Price Index, wholesale price index, GDP deflator, and cost of production index. The diversity of included variables, specification, and time periods used to estimate the various models, preclude the possibility of deriving and comparing elasticity estimates. A theme often stated by the developers of the models reviewed is the problem with multicollinearity and lack of data. The latter is best captured by Weindlmaier and others in their study for the EC Commission (<u>84</u>). These researchers presumably had access to all available data, including data not available to others. Nevertheless, they state,

> "The following features of the basic data impose constraints on quantification:
>
> * not all the factors we felt to be relevant are covered by the available statistics;
> * often there is no appropriate regional breakdown of the statistics;
> * the statistical series that are available are frequently not long enough for estimating econometric functions;
> * the figures are not always based on direct surveys but may be estimates with varying degrees of accuracy " (<u>84</u>, p. 128).

## ESTIMATION RESULTS

Previous discussion clearly illustrates the technological changes that have affected French cereal production, along with the difficulties encountered by previous researchers obtaining data and reasonable results. The reader should keep this background in mind when reading the results. In this section, area and yield response estimations for wheat, barley, and corn are reported.

### Price Expectations

The price expectation variable used in this study is somewhat different from ones used in other studies. A key component of the CAP in grains is the fixing of intervention, target, and threshold prices each year. Policy prices, which are exogenous, influence producer expectations regarding prices. Because France is a surplus producer, I have assumed that producer prices are closely related to intervention prices. Unlike Schiff, however, I do not assume a perfect relationship between policy prices and producer prices. Because of payment delays, transportation costs, and quality standards, less than perfect correspondence is anticipated. Expected producer price for each cereal was defined as the result from estimating producer price as a function of intervention price. The results are (values in parentheses are t statistics; values in brackets are elasticities):

$$WHNMPR = \underset{(.40)}{1.45} + \underset{\substack{(20.2)\\ [.97]}}{.89}\ WHINTPR \quad adj\ R^2 = .98;\ D.W. = 1.46;\ F = 1106$$

$$CORNMPR = \underset{(4.2)}{5.12} + \underset{\substack{(33.1)\\ [.92]}}{.87}\ CORINTPR \quad adj\ R^2 = .98;\ D.W. = 2.07;\ F = 1098$$

$$BARNMPR = \underset{(4.2)}{5.12} + \underset{\substack{(48.2)\\ [.91]}}{.79}\ BARINTPR \quad adj\ R^2 = .99;\ D.W. = 2.17;\ F = 2320$$

Where,

WHNMPR = producer price for wheat (ff per 100 kg)
WHINTPR = wheat intervention price (ff per 100 kg)
CORNMPR = producer price for corn (ff per 100 kg)
CORINTPR = corn intervention price (ff per 100 kg)
BARNMPR = producer price for barley (ff per 100 kg)
BARINTPR = barley intervention price (ff per 100 kg)

The results clearly indicate the high correlation between producer price and intervention price in France. These results for France are similar to results obtained by Colman (17) for the United Kingdom; that is, the estimated coefficients for the price terms are less than one, indicating the imperfect relationship between intervention and producer prices. The estimated parameters indicate the discounting that occurs between intervention and producer prices, partly due to the factors discussed above.

Elasticities calculated at the mean indicate that producer price of wheat is more responsive to changes in intervention price than producer price of corn or barley. At the mean, a 1-percent change in intervention price results in almost a 1-percent change in producer price of wheat, but less than a 1-percent change in producer price of corn or barley. A surprising result in the relatively low estimated elasticity associated with corn intervention price. Because the EC was a net corn importer during the period, I expected the discount between intervention and producer price to be less for corn than barley or wheat. The discounting between intervention and producer price for corn indicates that French corn may not be considered a close substitute for the imported corn (which in recent years is mostly used by the wet milling industry). Rather, French corn trades at its feed value and, thus, competes with feed wheat and barley.

## Area Response

Theory does not provide clear-cut directions on model specification and choice of explanatory variables, so I estimated several formulations. The dependent variable in each case was area harvested because data on area planted were not available, and the time period of the estimation was 1963-84. The equations were estimated with OLS, except in cases when serial correlation was indicated; in which case Cochrane-Orcutt estimation was used.4/

Results from selected estimations are reported in table 3. Criteria for inclusion in the table included desire to incorporate economic variables when possible, the explanatory power of the equation, and reasonableness of the estimated parameters.

The first three equations in table 3 explain the variation in wheat area. Wheat area in equation 1 is estimated as a function of expected wheat and barley prices. I assumed naive expectations with respect to inflation; therefore, expected price is deflated by GDP deflator lagged one year. Both the expected price of wheat and the expected price of barley are statistically significant and have the expected sign. French farmers increase their wheat area when they expect wheat prices to increase, while expectations that barley prices will increase result in a reduction in wheat area. The results confirm that wheat and barley substitute for each other. Expected corn prices were not included due to multicollinearity.

The second and third equations explain wheat area as a function of expected wheat revenue (expected price times expected yield per ha) and barley or corn area. Expected revenue is used as a proxy for profitability because cost data were not available. Area is used to capture competitiveness among crops due to multicolinearity among expected revenue variables. Note that variation in wheat area is better explained with these equations. The results indicate that barley or corn can be substituted for wheat, and the relatively larger estimated barley area coefficient suggests larger wheat area adjustments when barley area changes, compared with the same change in corn area.

Point elasticities, calculated at the mean, are also reported in table 3. The first equation indicates that wheat area is price elastic; a 1-percent change in the price of wheat or barley results in more than a 1-percent change in wheat area. The second and third equations imply that wheat area is very unresponsive to changes in expected revenue.

Variations in barley area are explained by equations 4 and 5. Equation 4 describes barley area as a function of expected wheat and barley prices and wheat area. The explanatory power of this equation is good, the estimated coefficients are statistically significant, and they have the correct signs. As anticipated, barley area is positively related to expected barley price and negatively related to expected wheat price and wheat area. Estimating barley area as a function of expected revenue from wheat and barley rather than prices also resulted in significant parameters, but the explanatory power of the equation was reduced. Results from the five equations are consistent (that is, wheat and barley are substitute crops). When corn price or area was used as explanatory variable in the barley equations, the estimated parameters were insignificant. The results, although not reported, suggest that barley and corn do not compete. The elasticity values from both equations 4 and 5 imply that barley area is highly responsive to changes in expected wheat and barley price or revenue.

Equations 6 and 7 in table 3 explain variations in corn area. Because serial correlation was indicated, these equations were estimated using Cochrane-Orcutt

4/ Estimations were made on an IBM-XT using SORITEC©

Table 3--Wheat, barley, and corn area regression results in France*

| Item | WHAR | | | BARAR | | CNAR | |
|---|---|---|---|---|---|---|---|
| | Equation 1 | Equation 2 | Equation 3 | Equation 4 | Equation 5 | Equation 6 | Equation 7 |
| Constant | 8,517.80<br>(10.96) | 6,339.1<br>(10.3) | 4,302.0<br>(27.5) | 4,037.60<br>(3.77) | 2,882.30<br>(3.82) | 2,566.80<br>(3.98) | -272.20<br>(-.76) |
| EXPRWHD | 41.7<br>(2.56)<br>[1.17] | | | -25.13<br>(-3.64)<br>[-1.1] | | | |
| EXPRBAD | -91.6<br>(-3.64)<br>[-2.24] | | | 34.59<br>(2.07)<br>[1.32] | | | |
| EXPRCNDF | | | | | | | 49.70<br>(8.01)<br>[1.27] |
| EXWHREV | | .99<br>(3.5)<br>[.07] | 2.44<br>(8.95)<br>[.18] | | | | |
| EXBAREVD | | | | | 10.45<br>(2.21)<br>[1.41] | | |
| EXWHREVD | | | | | -5.00<br>(-1.87)<br>[-.94] | | |
| WHAR | | | | -.48<br>(-4.1) | -0.39<br>(-4.8) | -0.58<br>(-3.5) | -.37<br>(-6.78) |
| BARAR | | -.95<br>(-4.5) | | | | | |
| CNAR | | | -.61<br>(-5.03) | | | 0.53 ^<br>(3.78) | 0.33 ^<br>(4.56) |
| EXPRCN | | | | | | 9.1<br>(3.0)<br>[.39] | |
| T | | | | | | | 73.3<br>(98.64) |
| Adj $R^2$ | .65 | .76 | .79 | .74 | .69 | .84 | .95 |
| F | 20.40 | 34.10 | 40.00 | 21.10 | 16.50 | 36.60 | 98.5 |
| DW | 1.71 | 1.48 | 1.61 | 1.44 | 1.29 | 1.84 | 1.97 |

*Numbers in parentheses are t-ratios; in brackets elasticities calculated at the mean. T = time trend; WHAR = soft wheat area harvested; BARAR = barley area harvested; CNAR = corn area harvested, (^) = lagged; EXPRWHD = expected price of wheat, EXPRBAD = expected price of barley, deflated by GDP deflator lagged 1 year; EXPRNCD = expected price of corn deflated by fertilizer price index lagged 1 year; EXPRCN = expected corn price; EXWHREVD = expected wheat revenue, EXBAREVD = expected barley revenue, both deflated by GDP deflator; EXWHREV = expected wheat revenue.

procedure. Corn area is estimated as a function of expected price of corn, the previous years corn area, and wheat area (equation 6). The results suggest that when expected corn price increases, corn area increases, and farmers who harvest corn tend to harvest more the following year.

In equation 7, expected corn price is deflated by the fertilizer price index and a time trend is added. The explanatory power of this equation is substantially improved over equation 6. The trend variable indicates that corn area has been steadily increasing during the estimation period for reasons other than price. Corn and wheat tend to compete for land, whereas, barley and corn do not. This relationship between wheat and corn is verified in all the estimations. The estimated elasticity indicates that corn area is relatively price elastic with respect to changes in expected corn price. Because of the specification of this equation, we can also calculate a longrun elasticity. As expected, the longrun elasticity of corn area with respect to corn price is higher with a calculated value of 1.9.

The results in table 3 are based on single-equation estimation techniques that assume area allocation decisions of competing crops were exogenous. The same assumption was made by Bahrenian, Devadoss, and Meyers (9), Gardiner (32), and Ministere de l'Agriculture (47) in estimating their models. This may be a reasonable assumption for wheat and corn because wheat is planted in the fall or early spring, while corn is planted later in the season. If area decisions are made simultaneously, ordinary least squares result in biased and inconsistent estimates. Better estimates may be obtained using simultaneous estimation procedures. The three equations with the highest adjusted $R^2$ were estimated using full-information-maximum-likelihood procedure. The results (t statistics are in parentheses; elasticities in brackets) are:

$$WHAR = \underset{(31.2)}{4510.5} + \underset{\substack{(11)\\ [.20]}}{2.82}\ EXWHREV - \underset{(-7.6)}{.82}\ CNAR$$

$$BARAR = \underset{(7)}{4839.7} + \underset{\substack{(3.2)\\ [1.23]}}{30.78}\ EXPRBAD - \underset{\substack{(-4.2)\\ [-1.07]}}{24.55}\ EXPRWHD - \underset{(-6.6)}{.6}\ WHAR$$

$$CNAR = \underset{(5.4)}{1789.1} + \underset{\substack{(3.0)\\ [.39]}}{15.15}\ EXPRCNDF - \underset{(-6.5)}{.46}\ WHAR + \underset{(3.8)}{.22}\ CNAR(-1) + \underset{(7.8)}{58}\ T$$

The two estimation procedures resulted in similar values for the estimated coefficients and elasticities in the wheat and barley equations. However, the estimated parameters in the corn area equation were substantially changed, as was the price elasticity. Corn area is highly inelastic with respect to corn price in this specification. The longrun elasticity (0.49), although slightly higher, is still inelastic. The absolute value of t-statistics in the wheat and barley equations increased with the incorporation of more information, while the absolute value was reduced in the corn area equation.

## Expected Yield

Crop yields were specified as a function of biological and technical progress as reflected in a time trend variable, lagged fertilizer price index deflated by GDP deflator, and area. We also estimated the yield equations, including expected output prices. The estimated parameters were not significant, and the results are not reported. Specifying technological progress as a time trend has the limitation that technological progress is assumed to occur at a constant rate over time. Time trend is often used as a proxy for technological progress, however, because other variables that satisfactorily capture technological progress are lacking. Wheat and barley yields were estimated using OLS, while the corn yield equation was estimated using Cochrane-Orcutt. The regression results based on data from 1963-84 are (numbers in parenthesis are t-ratios; in brackets, elasticities):

$$
\begin{array}{lllll}
WHTYLD = & 3.8 & + .09\ T & - 1.32\ RLFERT & + .0008\ WHAR \\
 & (4.3) & (6.5) & (-4.4) & (3.4) \\
 & & & [-.89] & \\
\end{array}
$$

Adj $R^2$ = .91; D.W. = 2.04; F = 68.3

$$
\begin{array}{lllll}
BARYLD = & 7.66 & + .062\ T & - .78\ RLFERT & - .001\ BARAR \\
 & (4.6) & (4.9) & (-2.3) & (-6.4) \\
 & & & [-.61] & \\
\end{array}
$$

Adj $R^2$ = .73; D.W. = 1.96; F = 20.4

$$
\begin{array}{lllll}
CORNYLD = & 1[illegible].67 & + .19\ T & - 3.27\ RLFERT & - .002\ CNAR \\
 & (9.76) & (10.96) & (-7.5) & (-6.4) \\
 & & & [-1.87] & \\
\end{array}
$$

Adj $R^2$ = .81; D.W. 2.16; F = 28.8

Where,

| | | |
|---|---|---|
| WHTYLD | = | soft wheat yield (metric tons per hectare) |
| BARYLD | = | barley yield (metric tons per hectare) |
| CORNYLD | = | corn yield (metric tons per hectare) |
| T | = | time trend (1963 = 1, ..., 1984 = 22) |
| RLFERT | = | deflated fertilizer price index lagged one year. |

The estimated yield equations (especially wheat and corn) perform very well as reflected in the relatively high $R^2$. The estimated coefficients are significant and have the right sign. As expected, yields increased significantly over time. The results indicate that each year corn yield increased 190 kilograms per ha, while wheat and barley yields increased 90 and 60 kilograms per ha respectively. As anticipated, expected fertilizer price is negatively related to yield. Growers use less fertilizer when expected fertilizer price increases, thereby reducing yield. The calculated elasticities indicate that wheat and barley are not very price responsive to changes in fertilizer price, while corn is relatively responsive. The results further suggest that increasing wheat area has a positive impact on yield, while expansion of corn or barley area has a negative effect. For corn, this result may be due to area expanding to new locations faster than the development of varieties that are better suited to the new locations. For barley, the negative effect may be due to area expansion occurring on marginal land because the better land is allocated to wheat.

It appears that area harvested is dependent upon expected output prices and area harvested of competing cereals, while yields depend upon fertilizer price, technology, and area. Single-equation estimation results indicate that French cereal area is relatively price responsive, while system estimation results indicate that corn area is inelastic with respect to changes in corn price. Wheat and barley yields are not very sensitive to changes in fertilizer prices, while corn yield is.

The relatively high price elasticity is surprising. During the debates on CAP reform, it was suggested that price reductions would not effectively reduce supply because cereal production was assumed to be price unresponsive due to a lack of production alternatives. As stated previously, cereal production was encouraged through the early years of the CAP because the EC had a cereal deficit. Consequently, cereal area in France increased as a proportion of arable land. More recently, protein and oilseed crops have been developed that can compete with cereals in resource allocation decisions. Development of protein and oilseed crops has been very recent, and they could not be incorporated in this analysis (incorporation of producer price for rapeseed in area equations produced insignificant coefficients).

Estimated area response equations are reasonable and consistent with most previous studies of French cereals. The yield response equations also performed well. Despite the data limitation problems, the explanatory power of the estimations compared favorably with previous attempts. The data confirmed the substitution relationship between wheat and barley in France (47, 48). It is suggested in the Agra Metrics Report that wheat area is positively related to barley price, whereas the relationship between barley area and wheat price is uncertain; it can be either positively or negatively related to wheat price (4). The results also confirm the substitution relationship between wheat and corn and the independent relationship between corn and barley alluded to in (48). Previous studies that reported estimated elasticities for France were not found; therefore, the results here could not be compared with previous studies.

The reader is reminded that, due to data limitations, estimated results suffer from biases because of left out variables. The stability of the estimated parameters is questionable because of multicollinearity problems. This last problem is a universal complaint among those who have attempted to estimate cereal production in France (and the EC), using prices as explanatory variables. During the period of the estimation, the CAP resulted in relatively predictable increases in policy prices with very little variance. The silo scheme confounded the problem by dictating relative prices among the cereals. The French and other European researchers with presumably better access to data had difficulties attaining well behaved, robust estimates. In the MAGALI report, it is stated that because of multicollinearity problems the stability of the estimated parameters is not assured (48).

## FUTURE PROSPECTS

The previous section demonstrated that producer prices and harvested area are closely related to policy prices. Consequently, future prospects and developments in French cereal production are intertwined with political decisions in Brussels. The evolution of the EC from one of the world's largest grain importing regions into one of the world's largest grain exporting regions has not been costless, and the Community is facing large surpluses and mounting costs. The Commission has attempted to implement several modifications in the cereal regime to reduce surplus production and budget exposure problems.

The first attempts of the Commission to deal with the budget costs and surplus problems (the "guarantee threshold" linking policy prices to cereal production levels) failed during the 1985/86 marketing year. The Ministers were unable to agree to the minuscule 1.8 percent price reduction proposed by the Commission (under the guarantee threshold concept, prices should have been reduced the full 5 percent). The Commission has made several new proposals to alleviate the budget and surplus disposal problems, starting with the 1986/87 marketing year. Proposals include: reducing the intervention price of feed wheat and barley by 5 percent, freezing intervention price of bread wheat and corn, tightening the quality standards for cereals sold to intervention, imposing a 3-percent coresponsibility levy on all marketed cereals, and reducing the time period in which cereals can be sold to intervention.

The proposals are to restrict price policy and to encourage producers to decrease production. The price reductions are denominated in ECU. Actual price reductions to producers in each member state, expressed in domestic currency, will depend upon: "green rate" adjustments, cereal quality, and the proportion of cereals that can be diverted from marketing or intervention chains.

The impact of the intervention price reductions on French cereal production is not certain. The results partly depend upon changes in green rates and the translation of the intervention price from ECU to French francs. The new quality standards may also affect the level of discounting that occurs between intervention price and producer price. If I assume that the relationship estimated between intervention price and producer price during the period when prices were increasing continues when prices decrease, then a 5-percent reduction in intervention price in francs will result in producer prices decreasing 4.9 percent for wheat and 4.6 percent for barley and corn. If the elasticities based on 1984 values are used, than producer prices will decrease 5.2 percent for wheat, 4.9 percent for corn, and 4.8 percent for barley, given a 5-percent reduction in the intervention price. Based on our results, if everything else is held constant, the 5-percent decrease in the producer price of wheat will result in more than 5-percent decrease in wheat area. However, because of the relationship between wheat and barley, the reduction in barley price actually causes wheat area to increase. Results suggest that barley area will decrease because the own price effect is larger than cross price effect. The proposals do not include a decrease in the price of corn, so there should not be a price effect on corn area. However, the relationship between wheat and corn suggests that corn area should decrease as wheat area increases.

Primary interest is on production and not on area response. The effect of the price proposals on production depends not only on area but on yield. The results indicate that cereal yields in France have increased independent of output prices. To the extent that this continues, it is difficult to predict supply response because of the new price proposals. The results also suggest that yield depends upon harvested area, and based on expected area response, yields should increase.

The production response to lower prices is subject to the caveats mentioned earlier, including the relationship between cereals and other enterprises. Farmer response will depend not only on relative cereal prices but also on the relationship between cereal profitability compared with competing enterprises such as oil or protein crops and on nonfarm income opportunities. Profit-maximizing producers will plant a crop mix that is consistent with their objective(s). French growers do not have many alternative options. Sugar and dairy are produced under quotas, developments in oil and protein crops are relatively new, and policy price adjustments are also being discussed for these crops. In addition, the relative riskiness of competing enterprises will also affect the eventual outcome.

Another factor that will influence cereal supply response is farm structure. Lower cereal prices may accelerate the move out of agriculture by inefficient producers, but, if the land is used to increase average farm size, production may not decrease due to economies of scale. Because of these considerations, it is difficult to quantitatively determine the impact on cereal supply of the new price proposals.

Cereal prices in real terms decreased consistently, while production increased because productivity increased faster than inflation. Currently, inflation has moderated in France, which implies that price declines in real terms will be slowed by the lower inflation rate. The present reduction in oil prices implies that energy prices should decline along with the price of fertilizers, plant protection products, and other inputs derived from petroleum. There is the possibility that production costs may be reduced, which would encourage yield increases that could mitigate the output effect of lower cereal prices. An additional factor that has an impact on future prospects of cereal production is France's ability to export. The freeze of policy prices at current levels means that the EC grain market will continue to be protected. Budget data indicate that French producers are competitive in the Community (22, 29, 47, 55, 65). France may be better able to absorb price declines than other EC countries. If the price reductions result in lower production and reduced self-sufficiency of other EC countries, France may be able to increase exports to these countries. With respect to trade with nonmember countries, the proposed price reductions will have minimal effects. The difference between domestic and world prices are bridged with export refunds. This policy is not expected to change.

Finally, the enlargement of the EC to 12 countries with the addition of Spain and Portugal will also influence developments in France. Spain and Portugal currently import grains. As the CAP is implemented in these two countries, more of their imports will come from the EC, and France may supply a large share. In the short run, therefore, one may expect an increase in the demand for French cereals, which may reduce the pressure on prices. The higher domestic prices implemented by the CAP should stimulate cereal production in the two new member countries. If Spain and Portugal obtain the technology currently used in the EC, their production will eventually increase and may exacerbate the surplus problem.

It is difficult to predict the decrease in producer prices implied by the current Commission price package. It is also difficult to predict the supply response (short or long run) implied by the proposals. Predicting the supply response to the proposals requires knowledge of the resulting relative price ratios of competing and complementary enterprises, input costs, structural and technological developments, and the effect of the proposals on producers' assessment of price risk and uncertainty. Additional considerations that influence the outcome include the following questions:

- Can the productivity growth over the past 20 years continue?
- What are the tradeoffs between higher yielding and higher quality varieties?
- To what extent have current technological developments been adopted, what were the conditions that stimulated such rapid increase in production, and will they continue?
- Are the possible price reductions sufficient to alter production plans?

Preliminary indications suggest that price reductions in the 20-30 percent range are required to significantly decrease production in the EC and alleviate budget problems (19, 65). Our results for France suggest that given the data, cereal area is elastic with respect to output prices. Because price response and technological developments differ among the commodities, proposals should be more commodity specific in order to reduce the likelihood of imposing quotas in the cereal markets as was done for the dairy markets.

The implications for the United States and other exporters are not encouraging. The world market is being reduced with enlargement. The EC grain market continues to be restrictive to foreign imports, while technological and other improvements result in continued expansion of output. The coresponsibility levy may encourage more onfarm feeding, possibly reducing demand for cereal substitutes, while competition in foreign grain markets with the EC will continue. It is not likely that the current proposals will significantly reduce cereal production, and the EC has not given any indication of withdrawing from foreign export markets. The Commission is proposing a program to boost grain exports that goes beyond normal export refunds. The proposed program will include EC financed subsidies to extend credit, maritime freight, and insurance (1).

## CONCLUSION

In this report, the CAP in cereals was reviewed, trends in France's cereal area, yield, and production were examined, and area and yield response equations for wheat, barley, and corn were presented. Since 1955, certain trends become apparent: area in oats decreased and corn area increased considerably. Since the midseventies, there has been a major shift toward winter wheat and barley, and the proportion of cereal area to total arable land increased considerably.

Concomitant with this increase in area has been an increase in average yield and production. Over the past 30 years, cereal production in France increased 144 percent, while average yield increased 127 percent.

Cereal area and production increased due to technological and structural changes in French agriculture. Varieties were developed with higher inherent yield potential, and growers adopted them. Other development facilitated the adoption of higher yielding varieties and insured that the higher yield potential was realized. These developments included larger farm size, increased mechanization, and increased use of purchased inputs, such as fertilizers and plant protection inputs. All of these change are interdependent. Increased farm size allowed specialization and generated more earnings. This relaxed the budget constraint, enabling growers to increase their use of purchased inputs and machinery.

Increased use of purchased inputs and machinery also facilitated the switch to higher yielding winter varieties and increased the growers' flexibility to choose cropping patterns. Increased mechanization and use of fertilizers and pesticides minimized the need for crop rotation and relaxed the relatively inflexible rotation patterns followed in the fifties and sixties, enabling cereal area to expand. Increased mechanization also allowed growers to plant more area in a shorter period of time, freeing them somewhat from the vagaries of weather and the cropping pattern of winter wheat and spring barley. The tremendous increase in corn area and production during 1955-84 is another indication of producer willingness to employ technological improvements. Corn developed from a relatively minor crop grown in the southwest of France to the second largest grain in terms of value.

Technological and structural changes resulted in wheat, barley, and corn yields increasing at a faster rate in France than in the United States. France is increasing its yield advantage in wheat and barley and is catching up to U.S. corn yields. These developments occurred during a period when the EC attempted to increase farm income by granting relatively large price increases through the intervention and threshold price mechanisms. The results from expected price equations indicate that producer prices in France are closely related to intervention prices. That is, producer prices in nominal francs were basically determined by price setting in Brussels and were somewhat independent from demand and supply considerations. Increases in intervention prices coupled with green rate adjustments in France resulted in predictable and consistent price increases in nominal francs. Producers, when making planting decisions, had a good notion of the price they will receive for their output. Consequently, price uncertainty is greatly reduced, if not eliminated, leaving only yield as the uncertain variable. The "silo" mechanism operated to reduce drastic shifts in relative cereal prices.

The CAP helped French cereal producers not only by providing relatively consistent price increases, but also by isolating the EC market and reducing competition from nonmember countries with the variable-levy system. French cereals found a ready market in the EC. For example, France supplied 60 percent of the wheat traded within the EC, 51 percent of the barley, and 66 percent of the corn during 1981/81 and 1984/85. The dependence on the EC market is demonstrated by the fact that more than 50 percent of French barley and corn exports were to other EC countries. Since the late seventies, most of the French wheat exports have been to nonmember countries. The CAP has assisted French trade in these markets by providing export refunds, enabling French wheat producers to compete.

The CAP through market insulation, policy prices, and export subsidies has influenced cereal production in France. It is difficult to quantitatively determine the CAP's influence because many of the same programs existed in France prior to the CAP. The structural and technological developments that occurred in French agriculture were similar to developments in agricultural sectors of other countries, such as the United States. During much of the period, the economies of France and the other EC countries grew at a relatively high rate. It is difficult to ascertain the degree to which the CAP contributed or hindered these developments.

In terms of analyzing effects of changes in policy prices on EC grain production, the reader is reminded that the EC is not a monolithic block. Different grains play varying roles in the agricultural sector of each member country. Each member also has somewhat different farm structures and technology. Although EC policy prices are the same in each country (when denominated in ECU's), they are not the same at the producer level because of monetary adjustments and other factors. If resources are available, analysis based on individual member response, followed by aggregation to obtain EC-level impacts, may be more useful than analysis based on aggregated EC data. Analysis based on the second approach assumes perfect substitutability and factor mobility among EC countries. It also assumes that producers respond to prices denominated in ECU's as if the prices were in national currencies--assumptions that may not always be realistic.

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