

THE SPANISH HOG MARKET:  
THE EFFECTS OF THE  
EC ENLARGEMENT

BY

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## Abstract

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OF THE EC ENLARGEMENT

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The hog industry is the largest component of the Spanish livestock sector and developments in this industry affect the entire Spanish agricultural sector. Spain's recent entry into the European Community which was accompanied by falling producer prices generated considerable concern over the effect of accession on the hog market. This study analyzes the impact of accession into the Community on the Spanish hog market.

The analysis is performed using a quarterly econometric model which captures the constancies and operation of the Spanish hog market. The model includes causal economic relationships, factors to identify technological change and is specified consistent with biological hog production processes. After examining the relevancy of several price expectations mechanisms (e.g. naive, adaptive and rational expectations), hog supply is specified by a polynomial distributed lag which assumes that expectations about prices are formed as a function of weighted past prices. Demand is modeled within a price dependent, single equation framework. Structural change is detected in demand after entry into the Community.

The econometric model is used to derive the welfare consequences of accession by simulating the evolution of the hog market

under a non-entry scenario. The effects of entry are assessed by comparing the actual and the non-entry evolution of the prices and quantities. Economic surplus measures are used to compute gains and losses to market participants.

Welfare measures indicate that in the hog market, direct gains from the entry into the European Community exceed the direct losses. Consumers gained considerably through increased imports from the Community at lower prices. However, losses to hog producers were quite large and government compensation to them has been limited. More indirect effects of the entry to the agricultural sector included obtaining development assistance for poor or declining regions and the fostering of a more competitive environment which will likely increase technological adoption and lower costs leading to a more efficient hog industry. Government programs designed to induce further productivity advances and to facilitate Spanish pork product exports into the Community would be particularly useful to ameliorate the negative effects of entry on the hog market.

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## CHAPTER I INTRODUCTION

### 1.1 Importance of the study

The livestock sector is a growing and important component of Spanish agriculture. Currently, it accounts for 40 percent of the value of final agricultural output, an increase of 10 percent over the last 25 years. Its importance is magnified by the close linkages that exist with the grain sector which generates feed grains, vital inputs in livestock production. The growth in the livestock sector has been influenced by technological advances which have driven the large increase in production and consumption through favorable price relationships.

Spain entered the European Community (EC) in 1986. A transition period of seven years was established in the accession treaty, but most of the agricultural sectors are already fully integrated (the exception being fruits and vegetables). The entry of Spain into the EC is likely to have a major impact in the Spanish livestock sector, the effects varying for different groups of producers.

Spanish beef and milk producers have deficient production facilities lacking size and upgraded technologies. The existing production quota arrangements by countries in the EC have protected these industries from competition. Hog and poultry producers have

experienced increasing competition since accession and while poultry producers are faring well, hog producers claim that they have suffered large losses derived from accession into the EC. Due to falling prices during 1987 and 1988, producers' organizations complained to the government and lobbied for protective measures. Finally, in mid-1988, and after intense pressures from the sector, the EC enacted provisions to assist these producers through intervention in the Spanish hog market. This study analyzes how the Spanish hog market was affected by accession trying to identify gains and losses to market participants.

To analyze the policies related to the hog sector an understanding of the Common Agricultural Policy (CAP) is needed. As a result of Spain's entry into the European Community, its agricultural policies have moved towards the implementation of the CAP. In CAP, livestock markets have two levels of intervention depending on the product. Intervention in milk and beef markets has been pervasive whereas limited intervention in pork and poultry markets exists. The price intervention mechanism in milk and beef is similar to cereals. Target, threshold and intervention prices are established and support buying is automatic once the market price hits the support level.<sup>1</sup> The system has encouraged large surpluses of milk and beef which have led to production quotas in

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<sup>1</sup> The target price is the market price farmers should receive. The intervention price is the floor price enforced by the buying government agencies. The threshold price prevents imports at world prices and is equal to the target price less transport costs from port of entry, so that the "world market" price plus the custom duties is equal to the threshold price.

milk and to maximum quantities of public buying in beef.

The poultry sector has no intervention mechanism and only a threshold price (i.e. the sluice-price) protects internal production from poultry raised outside the community. The hog sector is regulated through the implementation of base, buying and sluice prices.<sup>2</sup> The base price is the minimum market price which is deemed desirable. The buying price is a somewhat lower price at which market intervention would occur. Government market regulation may occur through buying and financing of private storage. However, the implementation of these regulatory measures is not mandatory as in the case of beef and milk. In recent years, hog market intervention activities have been limited to export subsidies and financing of private storage. In the eighties, the CAP support expenses in milk and beef markets have been around 9,000 million ECUS yearly ( $1.2 \cdot 10^{12}$  pta), compared with expenses around 200 million ECUS ( $26.7 \cdot 10^9$  pta) in the pork market (Comisión de las Comunidades Europeas, 1988).<sup>3</sup>

With the accession into the EC, the implementation of the CAP is likely to change substantially the Spanish livestock sector. Aside from the modest change in the pricing mechanism, the change in the relative levels of input (feed grains) and output (meat) prices may modify price and production cycles.<sup>4</sup> Important changes

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<sup>2</sup> In 1990 base and sluice prices were 2,033.3 ECU/MT (271.64 pta/kg) and 1,122.20 ECU/MT (149.93 pta/kg), respectively. Appendix I gives the exchange rates between ECU's, dollars and pesetas.

<sup>3</sup> In 1989, 1 ECU = 1.1 dollars.

<sup>4</sup> See figure 5 in page 24.

in production and consumption of livestock products also are likely to take place as a result of the opening of trade, changes in production and distribution technologies and organization, and the modification of consumer tastes and habits.

The final effect of these changes is unclear. Depending upon the relative prices, production could change appreciably in the hog and poultry sectors where production quotas do not exist. As a consequence of the entry into the EC downward pressure on hog prices may force the government, if it desires to maintain hog prices within certain price ranges, to purchase excess quantities, provide subsidies for export or financing of private storage, or enforce import quotas.

## 1.2 Objectives of the research

The analysis here focuses on the effect of the CAP on the largest component of the Spanish livestock sector, the hog industry. The industry represents more than 30 percent of the value of meat production. During the last 25 years, it has been one of the most dynamic components of Spanish agriculture, adopting confined production techniques and the extensive use of compound feeds. Its selection for analysis reflects its importance to the livestock sector and close linkages that exist to the grain sector and meat processing industries. The share of cereals in compound feeds is larger than any other country in the EC. Barley is the main cereal used in hog's compound feed.

The primary objective of the research is to increase the understanding of the effects of the entry into the EC on the Spanish hog industry. Specific objectives include: 1) development of a representative econometric model of the hog industry; 2) identification of the likely effects on hog production and consumption of changing production technologies, and input (feed grains) and output (hog) prices; and 3) quantification of the gains and losses derived from these changes for producers and consumers.

From a policy perspective, it is important to identify the likely effects on pork output and prices of entry into the EC. The slump in prices in 1987-88 induced farmers to ask for import quotas and support measures, and they backed these petitions with large demonstrations in many parts of the country. This study tries to determine what is the role played by the enlargement in this slump in hog prices, analyzing the effects of the entry on the hog market.

The effects of the entry are assessed by comparing the hog market with and without integration for the period 1986 to 1990. The analysis is performed using a quarterly econometric model which captures the constancies and operation of the hog market including technological change. The model includes the causal relationships and other information about this complex system. Several expectation mechanisms are examined to ascertain their relevancy for the Spanish hog market.<sup>5</sup> Possible structural change

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<sup>5</sup> Naive, polynomial distributed lags, adaptive and rational expectations.

in the hog market is analyzed examining the constancy of coefficients in the hog model.

The model is used to analyze the welfare consequences of accession. Simulation is carried out to determine hog quantities and prices. For each set of values of the exogenous variables the simulation analysis generates the corresponding output and prices, deriving from that the effects on farmers' income and consumers.

The analysis provides information useful to public and private decision makers. Information on the structure of the industry can provide the Spanish government with insights into the dynamics of the industry. Also the analysis provides the Spanish government with information about the welfare changes taking place as a result of accession. Given the importance of this sector in the Spanish agriculture and the fact that Spain has the second largest herd size among the EC countries, calculation of the distributional effects of the enlargement is a very important question. The work also provides private decision makers in the sector (farmers' organizations and private companies) with information about the sectors response to the changing economic environment. Because analysis of the Spanish hog industry is very limited, the present work also contributes to a better understanding and a sharper insight into the market dynamics of this important sector.

### 1.5 Overview of the thesis

The remainder of the study is organized as follows: Chapter 2

discusses the Spanish and European Community hog industries and characterizes the Spanish hog market. This information is then used to develop an econometric model of this market. Chapter 3 presents a survey of previous studies on the Spanish hog sector and a review of supply response and demand analysis. Then a description of the hog market model with different alternative specifications, along with data sources, is presented. The last sections of Chapter 3 provide the results of estimation for the alternative specifications and an evaluation of these alternatives. The policy analysis is carried out based on the representative econometric model; its results are discussed in Chapter 4. Chapter 5 includes a summary of the important findings of the work, a discussion of the implications of the research for policy makers, and a discussion of further research directions related to the Spanish hog market.

## CHAPTER II THE HOG INDUSTRY IN SPAIN AND IN THE EUROPEAN COMMUNITY

The present study focuses on the Spanish hog industry. An understanding of this industry provides the framework to generate the econometric model of the hog market. Because developments in the Spanish domestic industry are likely to be closely related to the community's industry in the future, information about the hog industry in the European Community also is included.

### 2.1 The Hog Industry in Spain

The livestock sector in Spain is less developed than in other EC countries. Livestock represents 55 percent of final agricultural production in the EC but only 40 percent in Spain. Table 1 demonstrates that Spain is specialized in sheep production, an activity with low capital and technology requirements and high labor requirements. Spain is at competitive disadvantage in cattle, which has high capital and technology requirements. In hogs, the average number of hogs per farm is smaller than in the EC-10, although in most farms the technological level is similar. However, it should be noted that without traditional (or "family") hog producers, the number of hogs per farm is 90 (1989) instead of 48, surpassing the EC average figure of 77 per farm.

Table 1 Livestock numbers by species and number of farms in Spain and in the EC-10, 1000 units, 1987

	Spain				EC-10		
	Number of animals	Percent of EC-10 herd	Number of farms	Animals per farm	Number of animals	Number of farms	Animals per farm
Total cattle	5076	6.9	370	14	73037	1952	38
Dairy cattle	1783	7.8	251	7	22952	1245	18
Hogs	17228	20.4	362	48	84302	1110	77
Sheep	20297	30.5	116	175	66549	721 <sup>a</sup>	92

<sup>a</sup> Data refer to 1986.

Source: La Situación de la Agricultura en la Comunidad. Comisión de las Comunidades Europeas.

### 2.1.1 Production.

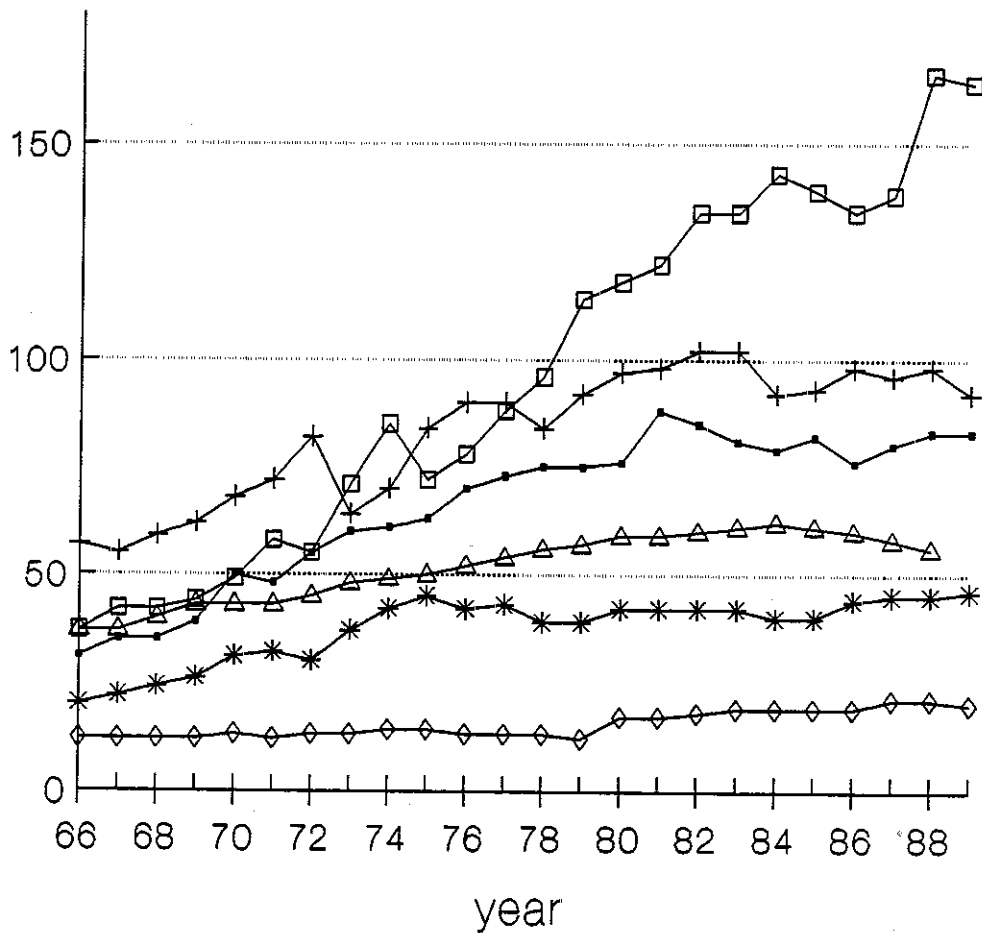
The hog sector has expanded rapidly in recent years, adopting advanced production and management techniques. Swine is the main livestock species raised in Spain and pork represents half the total dressed meat output (figure 1). The hog sector is the main meat supplier of the meat processing industry. More than half of pork produced goes to the processing industry which is important in the Spanish agro-industry system. The stock of animals has changed dramatically since 1955; the indigenous stock, "raza Iberica", represented 40 percent of animal numbers in 1955 but presently is only 3 percent. Landrace, Large-White and crossing stocks represent more than 90 percent of national herd.

The growth in pork production compared with other meats has been prominent; from 266 thousand metric tons in 1965 to 1703 thousands in 1989 a 7.3 percent yearly average increase (figure 1). There is a strong seasonality in supply as figure 2 shows, with an expansion during fall and winter and a reduction during spring and summer. This supply seasonality coincides with the drop in pork consumption during late spring and summer.

Pork production in 1989 was 1703 thousand metric tons corresponding to a herd of 16.1 million heads (April, 1989). However the relationship between production and herd size is relatively low, indicating modest productivity. Generally, Spanish productivity lags behind Dutch and German productivity as well as French productivity level (Servicio de Extension Agraria, DGA.

# Livestock and Poultry Production

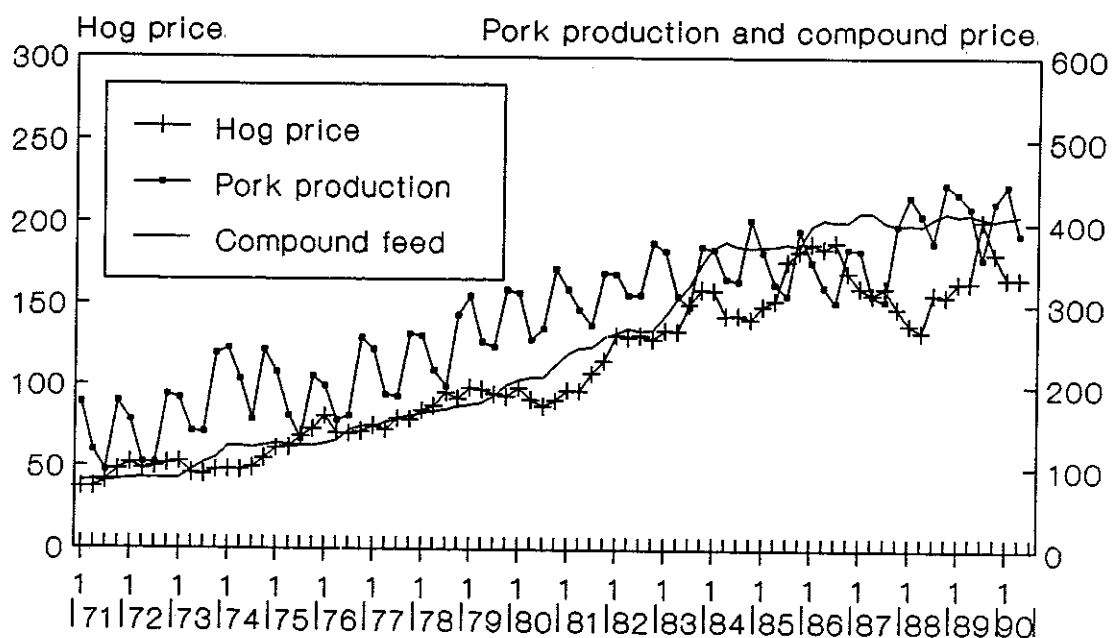
Carcass meat in 10,000 metric tons. Eggs  
10 mill.doz. Milk in 100 mill.liters.



1 metric ton = 2,200 pounds  
1 liter = 0.28 US gallons

Figure 1 Spanish livestock and poultry production, 1966-1989

## Hog and Compound Feed Prices and Pork Production



Hog price in pta/kg, compound price in pta/10kg, pork in 1000 MT

Figure 2 Hog and compound feed prices and pork production in Spain, 1971-1990

Internal documents).

Tables 2 and 3 provide a break down of hog farms by type and size in 1989. The number of "family" farms is not given but it can be estimated at about 150 thousand; these farms lack modern hog production technologies and are very small. "Family" production units represent half the number of hog producers but only 10 percent of the national herd. There are 163 thousand hog farms excluding "family" type farms. However, note (table 3) that many of these operators also are small. The number of hog farms with less

Table 2 Distribution of Spanish hog farms  
by type in thousands, 1989

	Number of farms	Herd	Sows	Feeding animals >50 kg
Farrowing and farrow to fi- nish farms	100	9,783	1,557	2,469
Feeding farms	63	4,757	68	2,367
"Family" farms	-	1,556	224	281
Total	163 <sup>a</sup>	16,096	1,849	5,117

<sup>a</sup> Without "family" farms.

Source: Boletín Mensual de Estadística. MAPA.

Table 3 Distribution of Spanish hog farms by  
number of placements, 1989

Placements	Farrowing and farrow to finish farms		Feeding farms	
	Number of farms	Placements (1,000)	Number of farms	Placements (1,000)
- 10	55,183	197	41,724	103
10 - 50	34,383	670	4,800	111
50 - 200	8,650	686	5,858	582
200 -1000	1,478	509	8,758	3,528
1000-	59	175	1,435	2,497
Total	99,753	2,237	62,575	6,821

Source: Boletín Mensual de Estadística. MAPA.

than 10 placements is still 60 percent of farms.<sup>6</sup>

Vertical integration in the last decades has increased in the Spanish Hog Industry. Table 3 shows that in the farrowing and farrow to finish farms, the class with 50 to 200 placements has the largest number of placements (686,000) and in feeding farms the class 200 to 1,000 placements has the largest number of placements (3,528,000). This is consistent with the observation (Murua, 1989) that integration by feeding farms is far more common, resulting in larger operations and improved production technologies. The unquestionable fact is that vertical integration has increased over time, spreading through the main producing regions which are Cataluña, Castilla-León and Aragón (table 4). Collecting information from primary and secondary sources, Murua states that the percentage of integrated feeding farms in Cataluña and Aragón may reach 80 percent. Castilla-León, Andalucía and Galicia are regions which export feeder pigs to other Spanish producing areas, and Cataluña and Aragón are feeding areas which import feeder pigs.

It is difficult to determine the exact extent of vertical integration for the whole country but large compound feed and slaughtering companies market much of their feed to integrated operations. It is estimated that 60 percent of the compound feed production for hogs is marketed to integrated hog production facilities (Alimarket, 1990). Figure 3 presents the structure in the production process. Selection centers improve breeds and

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<sup>6</sup> Hog farms are arranged in three classes in the data provided by the Ministry of Agriculture (MAPA); farrowing and farrow to finish farms, feeding farms, and "family" type farms.

Table 4 Geographical distribution of Spanish  
hog herd in thousand animals, 1989

Region	Sows	Feeding animals > 50 kg.	Total animals	Production (1,000 tons)
Cataluña	403	1,595	4,477	
Castilla-León	376	741	2,555	
Aragón	207	760	2,042	
Andalucía	175	435	1,461	
Total Spain	1,849	5,117	16,096	

Source: Boletín Mensual de Estadística. MAPA.

breeding centers work on selected breeds to provide better sows. Integrated companies have in most cases selection and breeding operations, as well as farrowing and feeding facilities. Integration by some companies does not include all stages of the production process with some firms lacking the selection and breeding stages.

Integration in Spain has been facilitated by two modes of organization: integration by contract in a private company and integration by membership in a cooperative.<sup>7</sup> Low prices in recent years have pushed hog farmers toward integration; small and medium hog farms participated because they could not finance compound feeds.

Integration contracts prescribe the handling, care and sanitary conditions, and payments to farmers. Integrated companies provide feeder pigs, compound feed and veterinary and pharmacological services, and remove the fed animals. Hog farmers provide their work and facilities in production cycles lasting 5 months and receive a fixed payment between 800 and 1,100 pta per hog.<sup>8</sup>

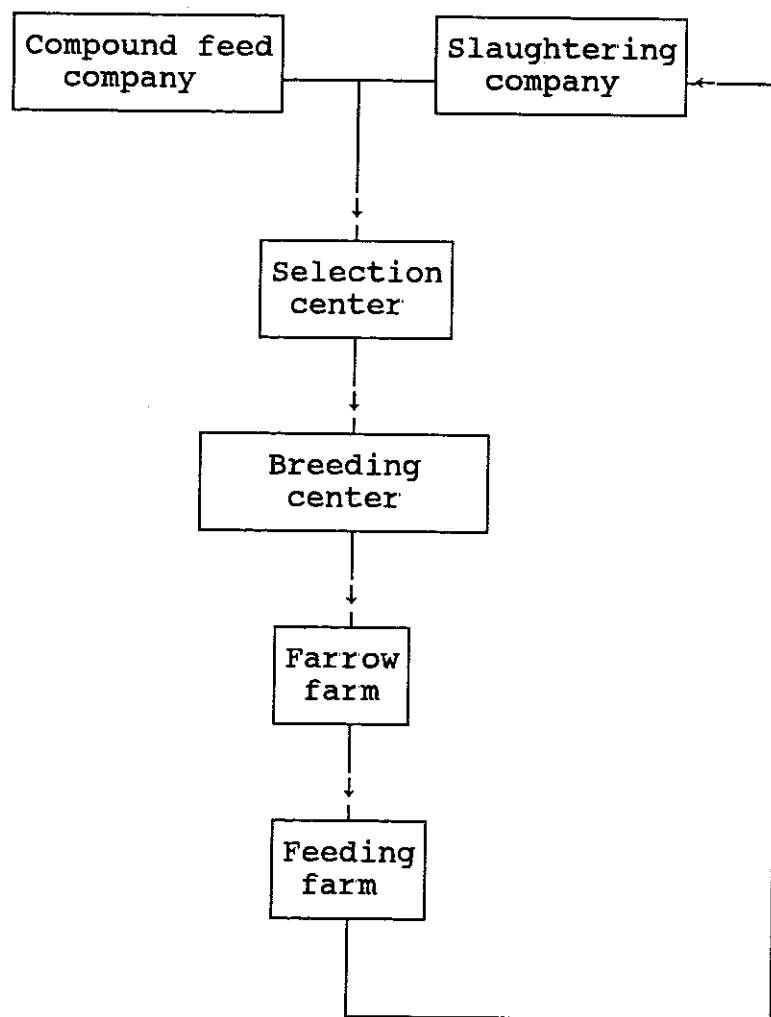
The likely implications of integration in the hog sector are a high degree of sensitivity of production and input usage to price changes and to changes in technology (figure 2). A case could be

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<sup>7</sup> The main integrated companies are Hubbard-Tecna, Vall Companys, Nanta (British Petroleum), Agropecuaria Guissona, Coren, Doux, Copaga, Biona (Conagra), Hens (Cargill) y Gallina Blanca Purina. Most of these companies are present in the main Spanish market located in Lérida (Cataluña). All these integrated companies are private companies except three large cooperatives: Agropecuaria Guissona, Coren and Copaga.

<sup>8</sup> El País, June 1989.

Figure 3 Integration in the Spanish hog sector



Source: MAPA (1985) pg. 22.

made that increased vertical integration, which is usually associated with higher levels of capital investment, has resulted in less sensitivity to price changes. However, the contracts which may be rather short term in nature do permit the companies to expand and reduce their hog operations rather quickly.

The improvement in production technologies has been noticeable, specially during the 1970's and 1980's as integration was spreading. The feed consumption index (relating gains in weight and feed consumed) and sow productivity are approaching the level of other EC countries. This improvement in production technologies has resulted in a decreasing hog-compound feed price ratio (table 5 and figure 2).

The hog sector is the main user of compound feeds (table 6) and as a consequence, the evolution of the hog market has had a large effect in the cereal and oilseed domestic sectors. With the entry into the EC, the compound feed industry has begun to replace cereals by imports of the so-called cereal substitutes.<sup>9</sup> The share of cereals in compound feeds has decreased. In 1986 the share of cereals in compound feeds was 66 percent and it has dropped in 1990 to 54 percent (El País, January 1991), and it may reach the EC average level which is near 30 percent (Koester et al., 1987). Compound feed for hogs, uses mainly barley so that changes in the

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<sup>9</sup> The cereal substitutes are brans, manioc, corn gluten, molasses and citrus pulp. Vidal Maté reports in El País (January, 1991) that imports of cereal substitutes are expanding, attaining more than 1 million MT in 1990, and hog compound feed prices are at about the same than in other EC countries except for Netherlands which has a 5 pta/kg cost advantage.

Table 5 Spanish prices of live hogs, compound feed for hogs and barley, pta/kg, selected years

	<u>1970</u>	<u>1975</u>	<u>1980</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>
Price of hogs	38.8	67.3	92.7	164.7	181.5	155.6
Price of compound feed for hogs	7.5	11.8	19.6	36.1	37.5	37.9
Price of barley	5.3	7.8	12.6	22.0	24.5	22.9
Ratio of hog/compound feed prices	5.2	5.7	4.7	4.6	4.8	4.1

Source: Anuario de Estadística Agraria, MAPA.

Table 6 Spanish industrial production of compound feeds by species, 1,000 M.T., selected years

	<u>1975</u>	<u>1980</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>
Cattle	821	1845	2424	2356	2090
Hogs	1833	4484	4188	4130	4190
Poultry/Eggs	2360	3864	3992	3860	3990
Total	5405	11232	11690	11411	11100

Source: Anuario de Estadística Agraria, MAPA.

hog and compound feed sectors could have important repercussions for barley producers.<sup>10</sup>

The future of the hog sector depends on its ability to increase its competitive level within the EC. The hog sector has adopted advanced production and management techniques. The two modes of organization, integration by contract in a large private company or integration by membership in a cooperative, have facilitated the process. Integration by contract in a large private company is the dominant type of organization. There is room for productivity improvements since the Spanish levels are relatively low; these improvements can be achieved by increasing the size of farms and the level of integration of producers. The government has currently several programs to achieve EC trade requirements, improving the technological level in slaughter, storage and transport facilities. Other programs are aimed at controlling the environment effects of hog production activities and improving facilities processing offals.

In addition, to be able to compete in the EC markets, it will be important to develop distribution networks capable of marketing pork products adapted to the different national tastes and habits.

#### 2.1.2 Consumption.

In recent years, food consumption patterns have been changing

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<sup>10</sup> In 1986, the hog sector consumed compound feeds incorporating 80 percent of total barley production (Buxadé, 1988).

in Spain approaching North European patterns. In general, consumers spend more but eat less quantity. Demand for processed and ready to eat products is growing while expenditure on unprocessed products stagnate. Consumers demand more expensive and sophisticated products which need less time to prepare.

Expenditures in meats and by-products rank first in the consumer food budget. These expenditures were 1.6 thousand billion pesetas in 1988, corresponding to 2.6 billion kilograms of meat. In 1986, from the 1.4 million tons of pork disappearance, slightly more than half was demanded by the meat processing industry. This fact

shows that this sector is adapting to the increasing and profitable consumer requests for sophisticated and carefully presented products (table 7).

Pork consumption per capita in Spain is near the EC average but meat consumption habits for other meats differ in Spain and the EC (table 8 and figure 4). Per capita beef consumption is half the EC average and per capita poultry consumption exceeds EC levels. These differences are

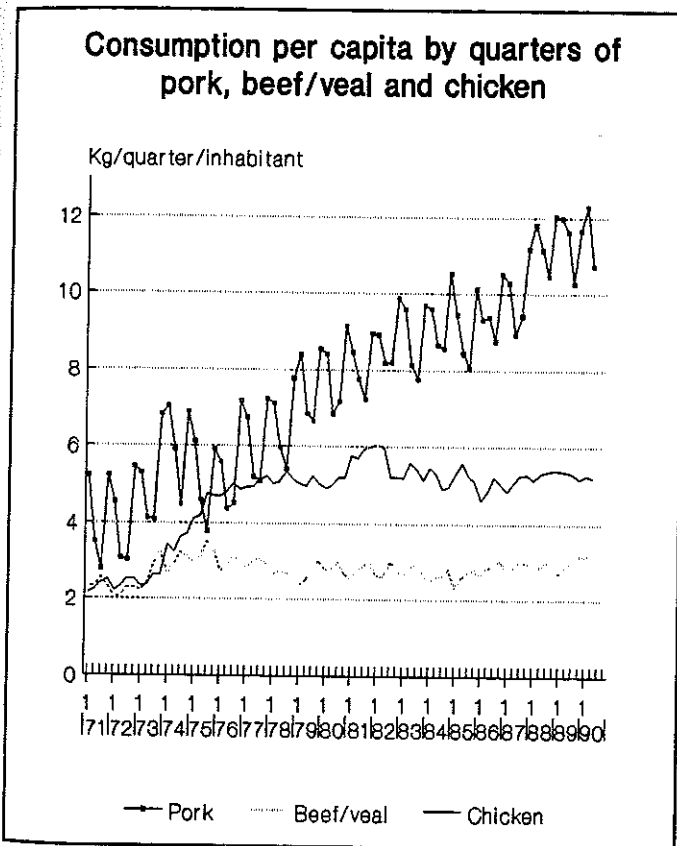


Figure 4 Spanish consumption per capita by quarters of pork, beef/veal and chicken. 1971-1990



Table 7 Spanish pork output by type of product, 1,000 tons, 1986

Pork in carcass	459.7
Carved, fresh, refrigerated and frozen pork	357.8
Ham	92.3
Hard and long pork sausage <sup>a</sup>	85.0
Salami-type sausage <sup>b</sup>	26.8
Shoulder blade <sup>c</sup>	12.6
Bacon	9.3
Pork pie	6.3
Cured loin	5.2
Total direct consumption	670.0
Total industrial consumption	708.7

<sup>a</sup> "Chorizo" and "longaniza".

<sup>b</sup> "Salchichón".

<sup>c</sup> "Paleta".

Source: Anuario de Estadística Agraria, MAPA.

Table 8 Consumption of selected livestock products in selected EC countries, kg/capita/year, 1987

	Spain	Germany	Netherlands	France	EC-12
Total meat	80	98	82	98	86
Beef	8	22	18	25	21
Veal	3	2	2	7	3
Pork	39	62	44	37	39
Poultry	21	11	16	19	17
Mutton/lamb	6	1	1	5	4
Other	3	-	1	5	2

Source: La Situación de la Agricultura en la Comunidad. Comisión de las Comunidades Europeas.

explained by the high consumption of fish and by the relatively low personal income in Spain which has hampered the increase of beef consumption.<sup>11</sup> At the same time, expansion in pork consumption was facilitated by the moderate pork price. Pork consumption per capita has expanded vastly in recent decades and furthermore, the drop in hog prices after the entry into the EC (1986) caused an additional expansion in pork consumption (figure 4).

### 2.1.3 Prices.

Until 1986 pork prices in Spain were, at market exchange rates, below pork prices in the principal EC pork producer countries (figure 5 and table 9).<sup>12</sup> At green ECU rates, pork prices in Spain would have been similar to German and Dutch prices up to 1986, because pork prices converted in pesetas at green ECU rates are lower in these two countries.<sup>13</sup> Green ECU exchange rates have made German and Netherlands pork prices lower in EC markets and any exports (imports) by these two countries have been subsidized (ta-

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<sup>11</sup> In 1989, consumption of fish was 30 kg/year per capita (MAPA).

<sup>12</sup> Note in figure 5 that prices of live hogs in Spain are given in pta/kg and not in ECU and these prices can not be compared directly to the rest of the series because of the different inflation rates of the peseta and ECU, specially prior to the entry. Appendix I gives the conversion rates between ECU's, Green ECU's, dollars and pesetas.

<sup>13</sup> Green ECU rates are different from ECU exchange rates; they were used to achieve policy goals by each EC member country.

**Pork prices in the Netherlands and Spain**  
 ECU/100kg carcass weight, except the se-  
 cond Spanish series given in pta/kg live

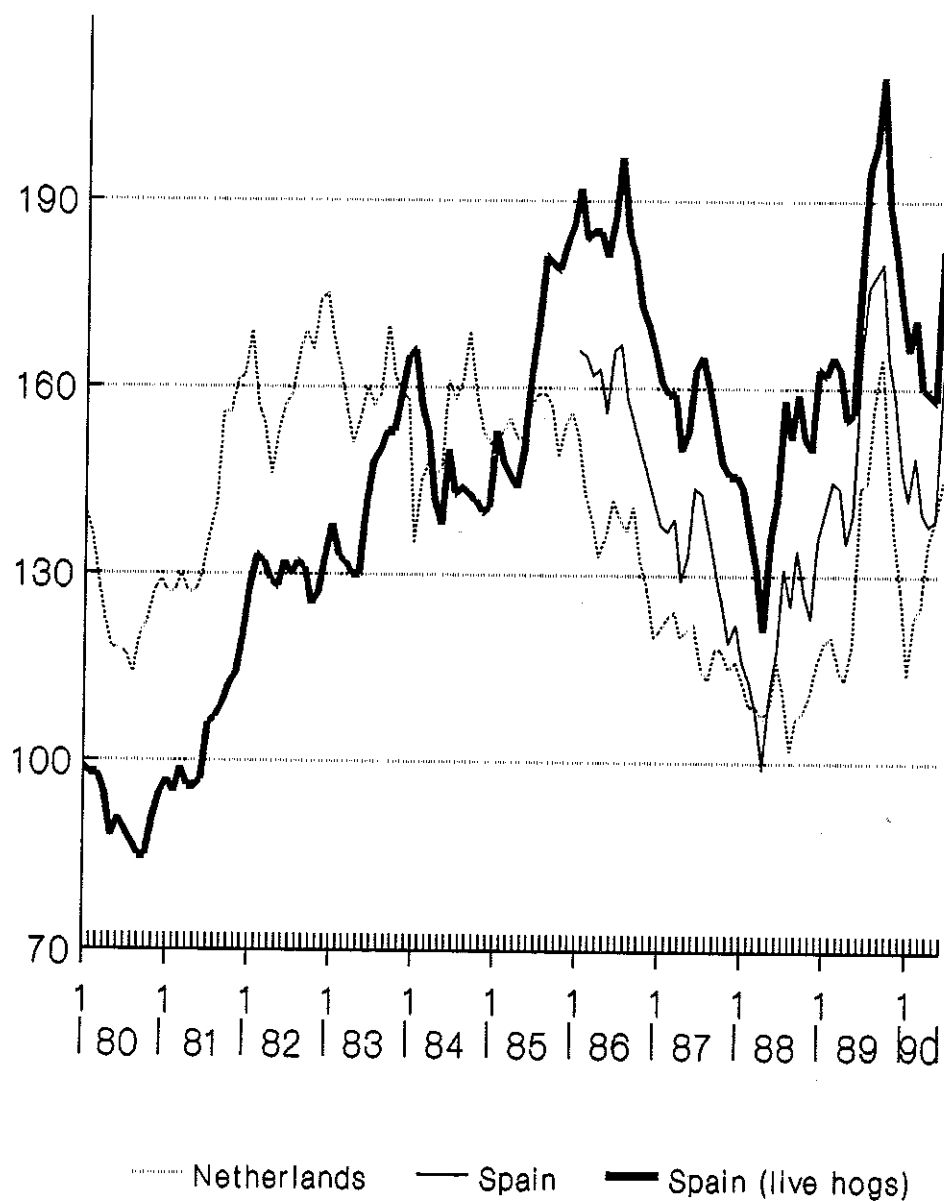


Figure 5 Producer hog prices in the Netherlands and Spain, 1980-1990

Table 9 Pork market prices in the principal EC pork producer countries and in Spain, 1977-1989

Prices in Green ECU per 100 kg. carcass weight.<sup>a</sup>

	77	78	79	80	81	82	83	84	85	86	87	88	89
Germany	136	122	123	125	141	156	142	145	147	136	115	109	140
France	153	140	137	138	152	175	163	166	165	150	129	121	147
Netherlands	131	122	123	123	138	151	148	153	155	139	119	110	134
Italy	151	142	152	159	158	182	170	180	185	173	148	146	164
Spain	118	122	137	118	133	156	147	147	157	159	133	120	156

Prices in Pta per kg. carcass weight at Green ECU rates.<sup>a</sup>

	77	78	79	80	81	82	83	84	85	86	87	88	89
Germany	97	98	113	124	145	167	180	184	190	200	172	170	206
France	109	113	126	137	156	188	208	210	214	220	192	188	216
Netherlands	94	98	113	122	142	162	188	193	200	204	177	171	198
Italy	108	114	140	158	162	195	217	228	238	255	221	227	242
Spain	102	119	126	118	136	168	188	186	203	235	199	187	230

Prices in Pta per kg. carcass weight at market exchange rates.<sup>a,b</sup>

	77	78	79	80	81	82	83	84	85	86	87	88	89
Germany	126	131	127	137	159	187	205	207	204	210	189	173	
France	112	123	123	137	155	181	204	207	222	217	202	183	
Netherlands	113	121	116	124	144	175	205	208	214	213	194	172	
Italy	107	119	129	146	157	186	216	221	239	247	222	218	
Spain	102	119	126	118	136	168	188	186	203	235	199	187	230

<sup>a</sup> Pigs class II from 1977 to 1985, and pigs class I from 1986 to 1989.

<sup>b</sup> These prices are domestic market prices in each country converted in pta at the market exchange rates (green rates are not used). See appendix I for exchange rates.

Sources: Anuario de Estadística Agraria, MAPA. El Sector de la Carne Porcina en España y en la C.E.E. Informes y Estudios del F.O.R.P.P.A. MAPA. 1985. La Situación de la Agricultura en la Comunidad. Comisión de las Comunidades Europeas. Agricultural Markets. Commission of the European Communities.

xed) by the monetary compensatory amounts' mechanism (table 9).<sup>14</sup>

After accession, a slump in hog prices in the EC derived from a peak in production had a depressing impact on the Spanish market. Imports were entering into the country, while exports to the EC were forbidden because of the swine fever. Prices in Spain went from a peak of 200 pta/kg per live animal in 1986 to a low of 120 pta/kg in 1988 (figure 4). A quota on piglets imports reaching 55,000 piglets per month was set in 1987 (but not enforced) to slow down the fall in domestic prices but prices in Spain did not recover until the approval by the EC in April 1988 of strict enforcement of the import quota and financing of private storage in Spain.<sup>15</sup>

The regulations governing hog prices in the EC are similar to Spanish provisions of market intervention before the entry of Spain in the EC: set floor and ceiling prices and subsidized financing of private storage. However, there are no substantial intervention activities when market prices are outside the floor and ceiling boundaries (as was the case in Spain prior to the entry into the EC).

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<sup>14</sup> Monetary compensatory amounts were set in place to reduce the impact of exchange rate movements on agricultural prices. A country with a strong (weak) currency would have decreasing (increasing) agricultural prices as the local currency appreciates (depreciates) because agricultural prices are fixed by the CAP in ECU terms. Monetary compensatory amounts are being eliminated driving green ECU rates toward market ECU rates.

<sup>15</sup> Actualidad Agraria, March-April 1988. Agricultura, March-April 1988. El País, March-April 1988.

#### 2.1.4 Trade.

Table 10 shows hog imports and exports of live animals and meat. Prior to 1986, imports and exports were made by the government exclusively and trade was less than 10,000 tons a year. Hog trade after accession is done almost entirely within the EC with imports of live animals and meat coming almost entirely from EC countries. Netherlands is the main supplier providing more than 60 percent of feeders and near 50 percent of fed pigs and pigmeat. Exports are low because Spanish hog exports to the rest of the EC were forbidden until May 1989. Exports were prevented because of the swine African disease, but improvements in sanitary conditions in recent years have opened the way to hog exports to the EC. Total Spanish hog imports have been around 70,000-120,000 tons per year since the entry in the EC in 1986, which is between 5-7 percent of domestic production.<sup>16</sup> Meat imports represent 50,000-80,000 tons and the rest is imported as live animals (feeders and fed pigs, approximately 40,000 MT).<sup>17</sup>

Hog imports are explained by three factors: hog price differences in "real" terms (at ECU's market exchange rates), the good marketing networks of foreign firms and the monetary compensatory

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<sup>16</sup> This percentage is above 10 percent if production resulting from imported piglets is taken into account (approximately 100,000 MT)

<sup>17</sup> The accession treaty established quantitative restrictions up to 1989 that were implemented several months in 1987 and 1988 (but only enforced during April 1988). According to the accession treaty, Spain may impose quantitative restrictions toward third party countries until 1996.

Table 10 Spanish hog imports and exports, 1985-1989

	Live animals (1000 MT)				Meat (1000 MT)			
	Reproducti- ve Gilts and Boars	Piglets	Fed animals	Total	Refrige- rated	Frozen	Offals	Total
<u>IMPORTS</u>								
1985	0.1	-	-	0.1	0.3	7.3	0.7	8.3
1986	0.5	19.8	36.0	56.3	33.5	27.4	7.6	68.5
1987	0.6	18.0	24.4	43.0	16.4	28.1	10.0	54.5
1988	0.4	9.6	5.1	15.1	5.8	33.0	9.8	48.6
1989	0.3	15.8	22.8	38.9	17.5	49.7	11.1	78.3
<u>EXPORTS</u>								
1985	-	-	-	-	1.8	-	1.2	3.0
1986	-	-	-	-	1.2	0.7	1.9	3.8
1987	0.1	-	-	0.1	1.1	0.5	0.5	2.1
1988	-	-	0.1	0.1	3.4	3.6	1.4	8.4
1989	-	-	0.4	0.4	2.4	1.5	2.3	6.2

Sources: Dirección General de Aduanas. Secretaría de Estado de Comercio. Ministerio de Economía y Hacienda.

amounts (price differential between green and market ECU's). Hog prices in green ECU terms in Spain after the entry into the EC in 1986 have been above prices in the main producer countries such as Netherlands, Germany or France (table 9).<sup>18</sup> Foreign firms take advantage of their distribution networks supplying products with appropriate characteristics in terms of size, weight and quality. Finally monetary compensatory amounts which now are being dismantled provided an export subsidy between 1986 and 1989 to imports from Netherlands and Germany.

There are 2,500 companies in the pork meat business employing 23,000 workers but only 150, with more than 30 percent of output, fulfill the sanitary and technical requirements needed for exporting to the EC. These companies are distributed as follows: 50 slaughtering houses, 40 packing houses and 60 refrigerated warehouses.

## 2.2 The Hog Industry in the European Community.

Hog production in the EC-12 was 13.3 million tons in 1989, almost half the total volume of meat produced. Ranked by herd size, the countries with the largest herds are Germany, Spain, Netherlands, France, Italy and Denmark (table 11). Spain ranks fourth in pork production reflecting the relatively low Spanish productivity.

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<sup>18</sup> Green ECU prices are the prices at which hog imports and exports take place.

Table 11 Hog herd and pork production  
in selected countries, 1988

	Herd size (10 <sup>6</sup> heads)	Pork production (1,000 tons)
Germany	23.7	3,250
Spain	17.2	1,703
Netherlands	14.2	1,908
France	11.9	1,780
Italy	9.4	1,168
Denmark	9.0	1,154
EC-12	104.0	13,289

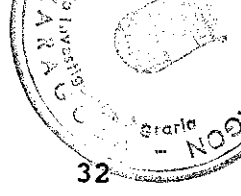
Source: La Situación de la Agricultura en la Comunidad.  
Comisión de las Comunidades Europeas. Eurostat.

Consumption and production are expanding although consumption has been traditionally high in the EC northern countries. Recently there has been an increase in consumption in the EC southern countries, particularly in Spain and Italy. Production takes place in a very competitive environment and large differences between the growth of output and input prices indicate productivity gains. Colson (1988) indicates that the hog price between 1970 and 1981 has decreased in France at a yearly rate of 3.4 percent in constant francs because of reduced compound feed costs and improved production techniques. Two technical ratios indicate these productivity gains, the feed consumption index and the numerical productivity of sows. In France between 1976 and 1986 the feed consumption index has moved from 3.62 to 3.44 kg/kg. and sow productivity has changed from 15.1 to 16.9 hogs/sow/year. These productivity gains have occurred because of large reductions in the number of farms, the increase in the average herd size and regional specialization at the EC level (Colson, 1988).

Trade is developing because of this regional specialization, and production organization and location are changing. Throughout the community the number of hog farms has diminished by more than 50 percent in a decade and the average herd size has doubled to almost 80 animals per farm. But large differences exist in herd size by country: Netherlands (406), United Kingdom (383) and Denmark (246) versus Greece (32), Italy (19) and Portugal (9).<sup>19</sup>

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<sup>19</sup> La Situación de la Agricultura en la Comunidad. Comisión de las Comunidades Europeas. Various issues.



The price support policy in the hog market reflects the CAP framework. Its structure revolves around base and a buying prices. The most important element is determined by production costs, and policy measures intend to ensure this price to farmers. From 1985 to 1990 this base price has been 2,033.3 ECU/MT (299.1 pta/kg.). Intervention measures may occur when market price falls below the 103 percent of basic price but these measures are optional. As indicated previously, intervention measures consist in buying, financing of private storage, and export subsidies but no buying intervention activities have been pursued in recent years. Furthermore, the Commission of the European Communities has proposed a reduction in the base price and in hog export subsidies. Barriers to hog imports from third party countries also may be eased to make possible imports from Eastern Europe.

The relatively low intervention level in the hog market has induced technical and organizational innovations to manage risk (Colson, 1988). These innovations include farrow to finish operations to control the whole production process, and contracts between farmers and producers' associations. By using these contracts farmers obtain technical support and more stable prices.

Among the principal producers in the EC, Netherlands, Germany and Denmark hold a comparative advantage in hog production over France, Spain and Italy. Daumas et al.(1988) have compared the gross margins over feed costs in hog production for several EC-10 countries. They observe that the economic returns for producers in Germany, Denmark and Netherlands are superior to French producers.

Furthermore, they believe that the added value tax and the feeding costs are advantageous factors to German, Danish and Dutch producers.

Netherlands is a country with a very competitive hog sector exporting large quantities of pork to other EC countries. According to Buxadé (1988), the reasons for this dynamic export behavior are: a favorable geographical location, availability of inexpensive feed supplies (Rotterdam), large compound feed facilities taking advantage of economies of scale, farms with a high productivity level, efficient marketing organizations based on cooperatives, and favorable monetary compensatory amounts which encourage exports.

Intra-Community trade was 2.1 million tons in 1985. Netherlands, Denmark and Belgium are the main exporters while Germany, France, United Kingdom and Italy are the main importers (table 12). Netherlands exports to Germany, Italy and France. Denmark supplies the United Kingdom and Germany, and exports from Belgium and Germany go to France and Italy respectively.

External trade is smaller than intra-Community trade. The United States and Japan are important markets for exports and Hungary is an important supplier.<sup>20</sup> Developments in Central Europe may expand hog exports from Hungary and Poland.

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<sup>20</sup> Before reunification, East Germany was also an important supplier.

Table 12 Hog trade in selected EC-10 countries, 1,000 M.T.,<sup>a</sup> 1985

Intra-Community trade			
Imports		Exports	
Germany	576	Netherlands	1,029
France	450	Denmark	450
United Kingdom	422	Belgium	324
Italy	418	Germany	139
Total	2,138	Total	2,138

External trade

Total Imports                      218

Total Exports                      440

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<sup>a</sup> Live animals and meat, given in equivalent carcass meat.

Source: La Situación de la Agricultura en la Comunidad. Comisión de las Comunidades Europeas. Eurostat.

### 2.3 Overview of the Spanish Hog Industry.

Spain has a large hog industry, the second in terms of herd size in the EC. In recent years, there have been important improvements in production and management techniques driven by the integration process in private companies and cooperatives. Nevertheless, a sizable part of the sector still consists of small farms which have a fairly low technological level.

Hog production has increased at a rate of more than 7 percent a year since 1965, and technology has played an important role in this expansion, specially in the 1970's and 1980's, a development driven by integration in private companies and cooperatives. The decline in relative prices (hog/compound feed) and parallel expansion in hog supply can be only understood if technological change is taken into account. Two additional factors are important to consider: the strong seasonality in supply and the existence of cycles in quantities and prices. With accession, the Spanish hog market will likely be more affected by developments on the EC hog market.

The analysis that follows tries to encompass the most salient characteristics of the Spanish hog market and the behavior of producers and consumers, in order to provide information to the different agents (e.g. government, private companies and cooperatives, and farmers) involved in this market.

To perform the analysis, an econometric model is developed

which includes pork and compound feed prices and pork quantities, technology, income level, and behavior of related meat markets. Net imports are taken as an exogenous factor affecting the Spanish market. The modelling process is explained in the following chapter. In Chapter 4 the policy analysis results are presented.

## CHAPTER III MODELLING THE SPANISH HOG SECTOR

### 3.1 Overview of the Spanish Hog Model

The hog market is represented by an econometric model including a supply and a demand equation which are specified as linear. The variables output price and output quantity are endogenous and the remaining variables are predetermined (lagged endogenous or exogenous).

Inventories or external trade are not included; inventories are very small and do not influence price determination. External trade has been historically insignificant but with the entry into the EC a development of external trade is taking place. However, the model is domestic because the lack of trade prior to the entry into the EC prevents the estimation of a trade behavioral equation. Use of the model for policy analysis is performed considering trade exogenous.

Appraising the relevancy of the model requires a discussion of possible structural change induced by the accession, the use of a partial equilibrium as opposed to a general equilibrium framework and the domestic scope of the analysis. Structural change occurs when the parameters or the functional form of the model change. In the presence of a change in the economic environment, such as integration into the EC, structural change may pose a problem with

econometric techniques. Parameters are estimated based on the past relationships among variables and as Labys (1984) points out, the quantitative and qualitative nature of these relationships may change and other variables which are not in the model may become relevant. In order to analyze the structural change in the hog market induced by the entry into the EC, the constancy of model coefficients is assessed.

With respect to the second question, the use of general equilibrium models in agriculture is becoming more common. A general equilibrium model incorporates the linkages between sectors and markets and the model represents the whole economy. These linkages in an agricultural sector model are feedbacks through income on the food demand and feedbacks through input markets on food supply. Another feature of general equilibrium models is the formulation of the model based on the behavioral patterns assigned to the actors in the economy.

A partial equilibrium model describes exclusively a market for particular commodities. Partial equilibrium agricultural models can explain a particular market in considerable detail including the substitution effects between commodities. However, they do not represent non-agricultural prices, household and government income and expenditure. As Keyzer (1988) indicates, this fact limits the use of partial equilibrium models in welfare analysis.

This study uses a partial equilibrium framework because the primary interest of the research is the hog market. This framework makes possible a more careful and detailed representation of the

hog market and permits the inclusion of specific factors influencing hog production and consumption such as technology, input and output prices and government programs. Consideration of the entire agricultural sector and the inclusion of non-agricultural commodities would reduce the precision of the model for analysis of the hog market. It also would increase unnecessarily the complexity of the model in terms of methodology, data requirements and formulation.

The third question is the domestic scope of the model. The model covers only the Spanish market which after the complete entry of Spain into the EC will change. The effective integration of the Spanish hog market has been limited by the existence of the African swine disease. Because of the disease Spain can be considered as a separate market. That is, that while Spain was importing some feeder pigs, fat pigs and meat, hog exports were impossible until May, 1989. Opening the borders has resulted in small exports. The yearly domestic production is around 1,700 thousand tons and exports in 1989 were merely 6.2 thousand tons of meat and 0.4 thousand tons of live animals. Spanish imports from the rest of the EC are increasing and there is a convergence in hog prices as can be observed examining the hog prices in the EC member countries (Figure 4, pg.23).

The effects of entry into the EC on the hog sector are analyzed within a domestic model framework. Some other closed models have been used to analyze agricultural sectors in EC countries (Oskam et al., 1988; Mahé et al., 1978). Oskam presents

a closed model divided in four subsectors and one subsector is intensive livestock farming. The authors acknowledge the influence of developments in other countries on the domestic price formation but their model is closed and the only external influence included is the price of imported feeds. The approach taken here to analyze the trade outlook is similar to that of Mahé et al. (1978). In the present analysis, as in theirs, the model explains domestic demand and supply and trade is basically exogenous. The effect of Spanish entry into the EC is examined by a simulation analysis which takes net imports as exogenous, and permits trade to influence price determination.

### 3.2 Previous studies on the Spanish Hog Sector

This section reviews the quantitative studies on the Spanish hog and related livestock sectors. Early quantitative studies on the hog sector in Spain concentrated on the analysis of the cycle of prices and output. Weinberg and Sobrino (1958) observed a cycle fluctuating from 4 to 5 years. Caldentey (1968, 1980, 1981) used various procedures to analyze prices: covariance with other prices and analysis of pork cycle, distinguishing among seasonal, trend, cyclical and stochastic components. Caldentey observed a cycle of 3 and a half years for the period 1959-77.

Recent studies have used econometric and univariate (ARIMA)

techniques to analyze the hog sector or other livestock sectors.<sup>21</sup> Econometric techniques are used by Caldentey and Titos (1979) and Albiac (1988) to analyze the hog sector and by Soria et al. (1976) to analyze meat demand.

Soria et al. estimate "per capita" meat demand functions using yearly data for the period 1953-1973. They specify the demand for pork as a function of own and substitute meats' prices and income. Estimating a fairly simple demand system with ordinary least squares, a price elasticity of 2.39 is found for pork. Cross elasticities are 2.77 for beef and 1.60 for chicken. The income elasticity they find is 3.86.

Albiac uses a recursive model of the hog market, estimated with monthly data, to forecast hog prices, comparing its accuracy with an ARIMA specification. A naive supply equation is specified with the ratio of hog to feed prices capturing production decisions at lags  $t-6$  and  $t-12$ ; the short-term quantity response to own price also is included. The supply equation is substituted in a price dependent demand equation and this final equation is estimated. Variables are not very significant except for lagged hog price (short-term response).

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<sup>21</sup> A group of researchers has used univariate analysis to predict meat prices: Alvarez and Martínez (1984) predicted lamb prices with an ARIMA model, and San Juan (1984, 1985) used ARIMA and transfer function specifications to analyze price indexes of agricultural products. Sanso et al. (1989) used ARIMA models to predict lamb prices and quantities, analyzing how predictions behave during the first years of Spanish accession into the European Community. Cancelo (1989) has done short-term forecasting of agricultural prices analyzing livestock and other agricultural prices with ARIMA specifications.

Caldentey and Titos analyze the supply response for hogs in Spain, specifying a supply equation with two approaches: partial adjustment and Almon lags. Using quarterly data from 1969 to 1977, hog price and the ratio hog price to barley price as well as a time trend for technology are used to explain hog response. Both formulations, partial adjustment and Almon lags, fit the data well. The partial adjustment frame is specified on a six-quarter lag. The polynomial distributed lag is specified for periods  $t-1$  to  $t-11$  and  $t-12$ , with a second degree polynomial. Price is specified successively as hog price and as an output to input price ratio. The partial adjustment supply elasticities are, short-run: 0.4 (price ratio) to 0.7, and long-run: 0.6 (price ratio) to 1.0. The polynomial lag supply elasticities range from 1.4 (price ratio) to 2.5.

From the perspective of this research, the article by Caldentey and Titos on hog supply is the most interesting work. The results obtained can be used as a reference for the structure of hog supply. A drawback in their work is that they used a limited number of observations (1/69-1/77) and only introduce input price as a ratio with hog prices. Perhaps a reason for not including input price as a separate variable is the possible appearance of wrong signs in the hog supply equations because of the sharp drop in real hog prices induced by technological change.

The information gained from previous research is scarce except for the article by Caldentey on hog supply. Few articles focus on the hog market and some of them use questionable procedures.

### 3.3 Review of supply response and demand analysis

The present study analyzes the hog sector using a market model of supply and demand. An econometric representation of the Spanish hog sector is generated which incorporates the dynamics and production characteristics of the sector. Output and input prices as well as technology are included. Some special factors influencing agricultural supply such as price expectations of farmers are incorporated. The demand component of the model is formulated within a single equation price dependent framework. In this case, price is influenced by quantity and substitutes' quantities, income, population and preferences.

Alternative price expectation mechanisms are used to specify supply: naive, polynomial lags, and adaptive and rational expectations. The expectations mechanism most consistent with the Spanish market will be selected. The hog market model also is examined for structural change.

#### 3.3.1 Supply response formulations

The empirical supply response formulation can be derived from producers' utility functions. A class of these utility functions is defined by:

$$[1] \quad EU = E\Pi = E[py - c(y)]$$

where  $U$  is utility,  $\Pi$  is profit,  $y$  is output,  $p$  is output price and  $c(y)$  is cost. It can be shown<sup>22</sup> that the utility function [1] implies a supply response formulation specified as:

$$[2] \quad y = a_0 + a_1 E(p) + a_2 x$$

where  $x$  is input price.

It is a common practice in many studies to specify directly the supply response function without deriving it from a problem involving the optimization of the producers' utility function. Some authors argue about the advantages of direct specification of the supply function. Hendry et al. (1984) point out that "economic theory provides relatively little prior information about lag structures" and consider that "economic-theory based models require strong *ceteris paribus* assumptions..., and [some assumptions] take the form of inclusion information" which may be wrong (assumptions about exogeneity versus endogeneity, and assumptions about irrelevant variables versus variables assumed constant)<sup>23</sup>.

It is clear that actual supply of a commodity is influenced by numerous factors. The discussion here focuses on price expectations which have long been recognized as important in affecting the supply of agricultural commodities. Later, more discussion is presented on the other factors which influence Spanish hog supply.

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<sup>22</sup> Roe et al., 1985, pp. 385-87.

<sup>23</sup> Hendry et al., 1984, pg. 1025.

### 3.3.1.1 Price expectations

Several formulations exist for modeling price expectations which are discussed here. The early use of expectations includes the cobweb model and work by Fisher (1925) with distributed lags. The cobweb model assumes that the producers' expected price at time  $t$  is the price at current time  $t-1$ , often called naive expectations. An alternative to naive expectations which takes into account the most recent change in prices was proposed by Metzler in the 1940's. Metzler defined extrapolative expectations as:

$$[3] \quad Y_t^* = Y_{t-1} + \beta(Y_{t-1} - Y_{t-2})$$

where  $y_t^*$  is the expected price at time  $t$  viewed from period  $t-1$ ,  $Y_{t-1}$  and  $Y_{t-2}$  are actual prices at time  $t-1$  and  $t-2$ , and  $\beta \geq 0$  is Metzler's coefficient of expectation. Extrapolative expectations modifies the cobweb model adjusting the price  $y_{t-1}$  by a proportion  $\beta$  of the direction of change in prices, where  $\beta$  specifies the weight of the price change in forming the price expectation  $y_t^*$ .

Distributed lags, which were not used until the 1950's to model expectations, were popularized by Koyck's work on investment. Cagan (1956) and Nerlove (1956) used distributed lags to explain expectation formation and conceived the adaptive expectations and partial adjustment models.

The adaptive expectation hypothesis states that the change in expectations from period  $t-1$  to period  $t$  is a fraction of the

difference between the actual and the expected value in period  $t-1$ . That is, the expectations are formed on the basis of the error between lagged expected and actual prices. More formally,

$$[4] \quad Y_t^* - Y_{t-1}^* = \beta (Y_{t-1} - Y_{t-1}^*) \quad 0 < \beta < 1$$

where  $Y_t^*$  and  $Y_t$  are, respectively, the expected and actual value of variable  $y$  at time  $t$ , and  $\beta$  is the coefficient of expectation. Recurrent substitution of  $Y_{t-k}^*$  using [4] results in a geometric lag structure:

$$[5] \quad Y_t^* = \beta Y_{t-1} + (1-\beta)\beta Y_{t-2} + (1-\beta)^2\beta Y_{t-3} + \dots$$

Use of the Koyck transformation, results in expressing supply in terms of lagged supply and last period price, an outcome similar to partial adjustment.<sup>24</sup> However, note that the error terms are

<sup>24</sup> Given the supply equation  $Q_t = \alpha P_t^* + u_t$ , where  $Q_t$  is quantity supplied,  $P_t^*$  is expected price, and  $u_t$  is the random disturbance, if  $P_t^*$  are formed adaptively, by using [5], the supply equation may be written as a transfer function:

$$(1) \quad Q_t = \alpha \beta \sum_{i=0}^{\infty} (1-\beta)^i P_{t-i-1} + u_t$$

Multiplying this equation by  $(1-\beta)$  at time  $t-1$  and subtracting, results in:

$$(2) \quad Q_t = (1-\beta) Q_{t-1} + \alpha \beta P_{t-1} + v_t \quad \text{where } v_t = u_t - (1-\beta)u_{t-1}$$

A similar outcome is obtained from the supply equation  $Q_t^* = \gamma P_t + u_t$  where  $Q_t^*$  follows a partial adjustment mechanism given by:

$$(3) \quad Q_t^* - Q_{t-1}^* = \lambda (Q_t^* - Q_{t-1}^*) \quad \text{where } 0 < \lambda \leq 1$$

Substituting this expression in the supply equation a stochastic difference equation is obtained:

$$(4) \quad Q_t^* = (1-\lambda) Q_{t-1}^* + \lambda \gamma P_t + \lambda u_t$$

As Harvey states it, "the transfer function specification (1) can be derived from a theory of adaptive expectations while the stochastic difference equation (4) arises as a consequence of a

different between the adaptive expectations and the partial adjustment specifications.

The adaptive expectations framework can be viewed as coming from a model generating  $y_t$  as a linear combination of random disturbances:

$$[6] \quad y_t = \epsilon_t + \beta \sum_{i=1}^{\infty} \epsilon_{t-i}$$

which implies that equation [4] gives optimal forecasts. As Chow (1983) points out, Muth stated the underlying model generating  $y_t$  in such a way that equation [4] gives optimal forecasts. The model is given by equation [6], where  $\epsilon_t$  is white noise. Subtracting  $y_{t-1}$  from both sides of the equation and rearranging yields:

$$[7] \quad y_t = y_{t-1} + \epsilon_t - (1-\beta) \epsilon_{t-1}$$

Given the information set  $I_{t-1}$  up to  $t-1$ , defining  $y_t^* = E(y_t | I_{t-1}) = {}_{t-1}y_t$ , and taking expectations on both sides of the last equation, yields:

$$[8] \quad \begin{aligned} {}_{t-1}y_t &= y_{t-1} - (1-\beta) \epsilon_{t-1} \\ &= \beta y_{t-1} + (1-\beta) (y_{t-1} - \epsilon_{t-1}) \\ &= \beta y_{t-1} + (1-\beta) {}_{t-2}y_{t-1} \end{aligned}$$

or noting that  ${}_{t-1}y_t = y_t^*$  and  ${}_{t-2}y_{t-1} = y_{t-1}^*$ ,



process of partial adjustment" (Harvey, 1989; pg.229).

$$[9] \quad Y_t^* = \beta Y_{t-1} + (1-\beta) Y_{t-1}^*$$

which reduces to expression [4]. The model in equation [6] generates the adaptive expectations formula given by equation [4] under the rational expectations hypothesis  $Y_t^* = E(Y_t | I_{t-1})$  which means that "the expectation assessed by the market ( $Y_t^*$ ) equals the true conditional expectation using all available past information ( $E[Y_t | I_{t-1}]$ )" (Mishkin, 1983, pg.9).

An alternative to the geometric lag structure imposed by the adaptive expectations mechanism is the polynomial distributed lag. In this framework, expectations about prices are formed as a function of weighted past prices (Traill, 1978; Hurt and Garcia, 1982). This expectation formation mechanism is similar to the naive formulation with weights spreading over several periods. Meilke et al. (1974) indicate that this mechanism is more realistic than adaptive expectations in modeling livestock production because it may capture more smoothly changes in weights, culling rates and herd expansion decisions. In particular, supply can be specified as:

$$[10] \quad Y_t = \alpha + \beta(w_0 X_t + w_1 X_{t-1} + \dots + w_m X_{t-m}) + \epsilon_t$$

where the weights  $w_i$  are given by a polynomial of degree  $q$ ,

$$[11] \quad w_i = \alpha_0 + \alpha_1 i + \dots + \alpha_q i^q \quad (i=0, 1, 2, \dots, m)$$

As Judge et al. (1985) note, polynomial distributed lags have been used extensively in applied work because of their flexibility, the

reduction in the number of parameters and the simple estimation procedure provided by the method.

Most studies dealing with agricultural supply response generally have specified supply using some form of these expectation mechanisms. At times they are combined with a partial adjustment formulation. Fisher (1982) points out that the restrictions on the distributed lag parameters in these expectations mechanisms are "ad hoc" when the proper procedure is to obtain these restrictions from an optimization process. An alternative expectation formation mechanism which has a more complete theoretical foundation is the Rational Expectations Hypothesis (REH). In this framework, expectations are formed conditional on the structure of the model describing the market and the information from exogenous variables. Rational expectations postulates that the expectations of economic agents are the conditional expectations of the economic variables based on all available information up to the time of the forecast including the structure of the econometric model that generates the forecasts. Rational expectations formulation implies that the expectations of economic agents are distributed around the prediction of the theory.

Sheffrin (1983) and Fisher (1982) indicate several weaknesses within the REH. Two critiques are aimed at two simplifying assumptions of the REH. The assumption that agents know with certainty the process generating the exogenous variables is unlikely and inconsistent with subjectivist probability, learning and adaptive behavior. The subjectivist probability criticism is that subjective probabilities in rational expectations models are equated to the

probability generated by structural models which is inappropriate because the conditions for frequency and subjective interpretations of probability to be valid are not equivalent (Swamy et al., 1982; Swamy et al., 1985). The second simplifying assumption is that all information available is used by agents, which contradicts the fact that information acquisition is costly.

Another objection is the supposition that the use of information by agents is efficient, although this efficiency is congruent with the generally accepted principle that agents are optimizers. The criticism that economic cycles are incompatible with rational expectations has been refuted by Sargent (1987).<sup>25</sup>

An empirical difficulty with the REH is that estimation is more complicated than with other expectations mechanisms because the observable reduced form, which is obtained substituting the expected endogenous variables by their expressions in terms of the model parameters and exogenous variables, is non-linear in the parameters. In testing the REH a projection of the predetermined variables is used which makes tests of the REH frail because these tests are conditioned by the structure used in projecting the predetermined variables. Fomby et al. (1984) recommend the use of parsimonious models on the grounds that economic agents may well use simplified structures to make easier the projection of the predetermined variables.

Chow (1989) raises the question of the empirical validity of

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<sup>25</sup> Sargent shows that technology and cost of adjustment introduce lags in expectations models and the stochastic linear difference equations derived from these models can generate cycles.

the REH compared with alternative expectations hypothesis. He cautions about the use of rational expectations, showing that adaptive expectations combined with models for stocks explain better the data than rational expectations.

Nerlove (1979) considers quasi-rational expectations as an alternative to rational expectations. Quasi-rational expectations are obtained substituting the anticipated values of both endogenous and exogenous variables by their minimum mean squared error predictions from ARIMA specifications. Quasi-rational expectations are easier to estimate but the drawback of this approach is that such a predictor would have a larger forecast error variance than that of the REH provided the REH is correct (Wallis; 1980, pp. 54-55).

### 3.3.1.2 Expectations mechanisms used in this study to specify hog supply

The Spanish hog market is modeled under the naive, polynomial lags, and adaptive and rational expectations mechanisms. These alternative specifications will be examined through parametric and non-parametric validation techniques using non-nested hypothesis testing and performance measures based on out-of-sample forecasts.

The first specification of supply is the recursive model in which quantity supplied depends on lagged price, the lag capturing the effect of the production delay and the assumption that producers expect in the future the price prevailing in the current period. The second expectations mechanism is a polynomial distributed

lag in which the weights of prices in production decisions follow an inverted V.

The third mechanism of expectations used is adaptive expectations under which the expected price can be viewed as a geometric lag structure of past prices, and using the Koyck transformation, quantity supplied depends on lagged quantities and lagged prices. Adaptive expectations have been used thoroughly in empirical work with excellent results, although they have been used, in general, without imposing the restrictions derived from the hypothesis.<sup>26</sup> In the model proposed, the hypothesis that output price follows the adaptive expectations mechanism is given by (Kmenta, 1986):

$$[12] \quad PH_t^* - PH_{t-r}^* = (1-\alpha) (PH_{t-r} - PH_{t-r}^*)$$

where  $PH_t$  is hog price in period  $t$  and  $PH_t^*$  is the expected hog price in period  $t$ . Equation [8] can be written as:

$$[13] \quad PH_t^* = (1-\alpha) PH_{t-r} - \alpha PH_{t-r}^*$$

or

$$[14] \quad PH_t^* = (1-\alpha) [PH_{t-r} + \alpha PH_{t-2r} + \alpha^2 PH_{t-3r} + \dots ]$$

A fourth alternative is to specify a rational expectations model. Following Wallis (1980), a general rational expectations

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<sup>26</sup> These restrictions are derived later in page 64.

model with  $g$  equations and  $g$  endogenous variables can be stated as:

$$[15] \quad BY_t + AY_t^* + \Gamma X_t = u_t$$

where the parameter matrices  $B$ ,  $A$  are of dimension  $g \times g$  and the parameter matrix  $\Gamma$  is of dimension  $g \times k$ . The variables  $Y_t$ ,  $Y_t^*$ ,  $u_t$  are of dimension  $g \times 1$  and variable  $X_t$  has dimension  $k \times 1$ .  $Y_t$  is a vector of endogenous variables,  $Y_t^*$  is a vector of unobservable expected values of  $Y_t$ , and  $X_t$  is a vector of exogenous variables. The rational expectations hypothesis implies that:

$$[16] \quad Y_t^* = E_{t-h}(Y_t | \Omega_{t-h})$$

The reduced form of model [15] is:

$$[17] \quad Y_t = -B^{-1}AY_t^* - B^{-1}\Gamma X_t + B^{-1}u_t$$

taking expectations conditional to  $\Omega_{t-h}$  and assuming that the disturbances are not correlated yields,

$$[18] \quad Y_t^* = -B^{-1}AY_t^* - B^{-1}\Gamma X_t^*$$

or

$$[19] \quad Y_t^* = -(B+A)^{-1}\Gamma X_t^*$$

In this equation,  $Y_t^*$  is expressed in terms of the model parameters and  $X_t^*$ . This permits substituting  $Y_t^*$  into [17] obtaining the "observable" reduced form. The "observable" reduced form is given by:

$$[20] \quad Y_t = B^{-1}A(B+A)^{-1}\Gamma X_t^* - B^{-1}\Gamma X_t + B^{-1}u_t$$

The reduced form shows that  $Y_t$  is a function of the model parameters and the expected and actual values of the exogenous variables.

Under naive, polynomial and adaptive expectations mechanisms,<sup>27</sup> predictable price patterns arise and producers or speculators may profit from them. These expectations mechanisms give rise to dynamic supply equations which, coupled with demand components, may have cyclical behavior to exogenous shocks.

Hayes and Schmitz (1987) discuss the changing patterns of hog cycles and counter-cyclical behavior. They point out the two main opposed arguments involving cycles. One argument states that cycles are the result of irrational producers ignoring information. The second argument affirms that efficient markets prevent the emergence of predictable patterns. The authors state that cycles in pork prices have been dampened by countercyclical producers (producers who behave in a countercyclical manner) and they present evidence supporting the development of countercyclical behavior in recent

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<sup>27</sup> Except in the special case that the adaptive expectations formula is generated by rational expectations. See page 48 above.

decades. They draw the conclusion that efficient markets can exist in the presence of hog price cycles but producers can not profit from this information.

Leuthold et al.(1989) present results which contradict this efficiency showing how to make profits from public available information. They use both an econometric model under naive expectations supply and ARIMA specifications to predict hog prices.

Under rational expectations, hog prices fully reflect all available information and every agent knows the expected price and quantity and acts in consequence.

### 3.3.2 Demand functions

Consumption theory provides the guidelines to specify demand equations. Some important issues to consider in empirical analysis of demand are: demand models available, separability assumptions, and the aggregation problem. The aggregation problem refers to the conditions under which the results of the theory of consumer behavior are applicable to the analysis of market demand. Exact linear aggregation requires average consumption to be a function of average income and prices. This implies that income distribution does not affect consumption, or in different terms, the marginal propensities to consume are identical for all consumers and individual demands are linear in income. Exact nonlinear aggregation requires average budget share to be a function of prices and a "representative" income which can depend on income distribution. In the pork

demand equation presented below, exact linear aggregation is assumed.

Early work in demand analysis focused on individual commodities. Later developments in consumer theory have led empirical demand analysis toward the consideration of demand systems. The more important demand system models are the linear expenditure system, the Rotterdam model, the indirect translog model, and the almost ideal demand system. In these models the specification of demand systems is consistent with a particular utility function.

Discussion of these demand systems is beyond the scope of this study because the present analysis focuses solely on pork demand. For such demand to be independent of other commodities, separability assumptions are needed. Separability is defined by Deaton et al. (1980) as the property that "commodities can be partitioned into groups so that preferences within groups can be described independently of the quantities in other groups". In the model presented here it is assumed not only that pork demand is related exclusively to other meats but also that a single equation is a suitable representation of pork demand. Deaton notes that a single equation approach simplifies the explanation of demand to a small number of variables and facilitates estimation.

Demand systems explain expenditure shares. In the present analysis, instead of explaining expenditures shares, the model of pork demand links directly prices and quantities. Such a model is more appropriate for simulation purposes. Moreover, Deaton et al.

(1980) recommend modelling detailed commodity demand within a single equation context. They indicate that the method is more flexible and it is the best approach in explaining a specific commodity; it permits to modify the functional form freely and select the appropriate explaining variables.

### 3.3.3 Estimation procedures

A supply function specified with naive or adaptive expectations can be estimated by OLS provided that the disturbance term is white noise. An additional condition for using OLS with adaptive expectations is a large sample size. Adaptive expectations in presence of serial correlation require IV or ML estimators because the random term and the lagged dependent variable are correlated (Harvey; 1981, pg. 266). If the structural rather than the reduced form adaptive supply coefficients need to be calculated, then a non-linear procedure is required. An equation with polynomial distributed lags is estimated by a restricted least squares estimator when the polynomial structure on the lag weights is introduced as constraints to the initial model.

A rational expectations model is estimated by non-linear procedures, either LIML or FIML (Wallis; 1980), although single coefficients for the reduced observable form [16] can be estimated by standard multivariate regression procedures (Wallis, 1980). Pagan (1984) warned about the use of predictor and residual generated regressors to anticipate expected prices which may cause

estimation and inference problems, namely efficiency loss and inconsistency of the covariance matrix estimator. He indicates that it is necessary to estimate the model in an error in variables framework. Antonovitz et al. (1989) argue that these constructed regressors can be viewed as being generated by stochastic processes; in such a case the SURE estimator will be also the MLE provided that the regressors are independent of the disturbances. If they are not independent or if the disturbance vector is not white noise an estimator with the MLE properties is required. Only in the case of a true rational expectations model, where producers are aware of the structure of the model and base their decisions on the true unobservable mean, is the error-in-variables model the preferred alternative (Antonovitz et al., 1989).

Auxiliary ARIMA specifications will be used to predict the expected mean of the exogenous variables. These auxiliary models would have to be estimated jointly with the hog model but in order to simplify estimation they are considered separately. Wallis (1980) and Pagan (1984) acknowledge the procedure results in loss of efficiency.

### 3.4 An econometric model for the Hog Market

The hog market is represented with an econometric model including a supply and a demand equation which are specified as linear in the variables. Stocks are not considered since pork inventories are very small; in recent years average pork stocks

were less than 1 percent of annual production (MAPA, 1985). In the supply side, lack of data precludes disaggregating production into the feeding and breeding components.

The hog price and the price of compound feed for hogs are included in the model. The hog market has two policy set prices, base and buying prices as explained above. Because intervention activity in the hog market has been limited, no attempt is made to incorporate in the model bounded price variation. The orientation of the CAP at present is towards less intervention in agricultural markets and the hog market will likely remain a market with a low profile of government interference.

Two important issues need to be considered in examining the hog production process. One is the biological lags involved in production, which arise because of gestation and rearing lengths. The other issue is concerned with identification of the time frame of production decisions and factors affecting these decisions. In hog production, resources are incorporated in the production process for a certain length of time, and the decisions to commit resources are taken based on expectations of relative profitability (Stillman, 1985). Production decisions are further complicated by the fact that in hog production, animals are both consumption and capital goods at the same time.

The short- and long-run hog supply responses to changes in prices are distinct. In the short run, variation in supply is small. Full adjustment in hog supply to changes in prices takes place in the long run where the number of feeding animals and

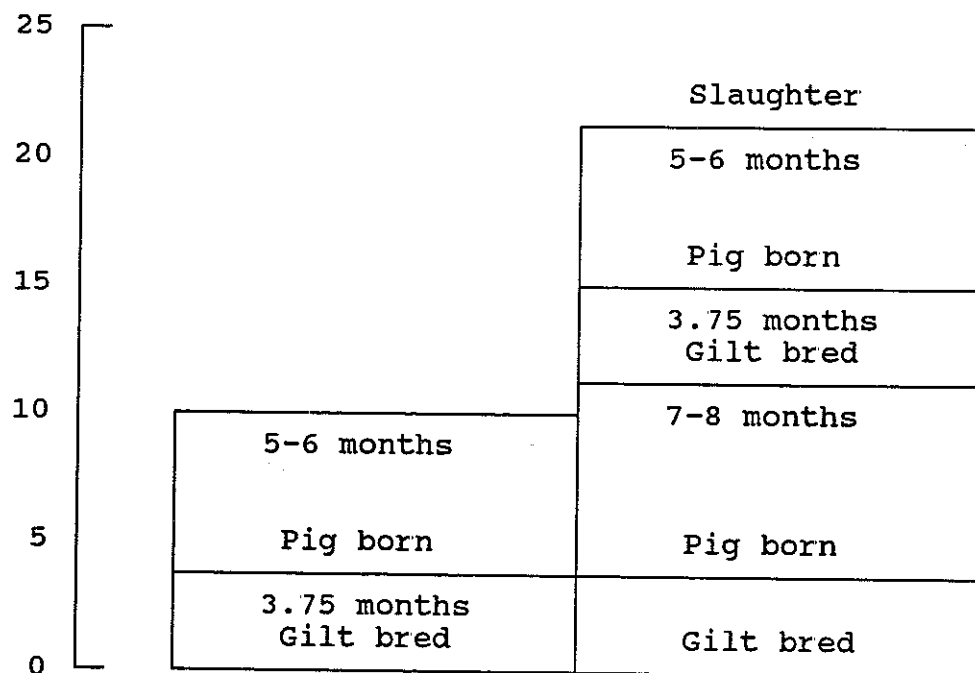
breeding stock can be altered. This short- and long-run livestock supply response has been analyzed by Jarvis (1974) using microeconomic models in which animals are treated as capital goods. In the short run, pork supply and output price can move in opposite directions. When price is high, female animals are kept in the breeding stock to expand production and fed animals are slaughtered earlier at lighter weights; both phenomena decrease supply. The opposite happens when prices are low, increasing output. Generally, this short-run production response is small because pork is a perishable commodity and storage is costly.

Production decisions are based on expected prices, here the hog supply equation has expected price variables which reflect the decisions made in previous periods. Biological lags in hog production are outlined in figure 6.<sup>28</sup> It takes about 11 months to expand the breeding herd, and after new gilts are bred, an additional period of 10 months is required to have fed pigs ready for slaughter. The decision to bred gilts is taken about 10 months before the grown animals are marketed. The breeding decision and the decision to expand the herd are captured by the expected hog price and compound feed price variables at quarters  $t-4$  and  $t-8$ , respectively. Short-run response is not included in the supply function because the data are quarterly and it is presumed that the short-run response is not detectable.

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<sup>28</sup> Because of the swift technological change that has occurred in recent decades in Spain, the gestation and rearing lengths given by Stillman are in line with lengths at most of the Spanish production facilities.

Figure 6 Biological lags in pork production



Source: Stillman, 1985.

The specification of the quarterly pork supply equation follows from equation [2]:

$$\begin{aligned}
 [21] \quad QH_t = & a_0 + a_1 {}_{t-4}PH_t^* + a_2 PCF_{t-4} + a_3 {}_{t-8}PH_t^* \\
 & + a_4 PCF_{t-8} + a_5 T_t + a_6 D_{1t} + a_7 D_{2t} \\
 & + a_8 D_{3t} + u_{1t}
 \end{aligned}$$

where  $QH_t$  is total carcass-weight domestic hog production in thousand metric tons,  ${}_{t-4}PH_t^*$  and  ${}_{t-8}PH_t^*$  are expected price of live hogs in quarter  $t$  as viewed in quarter  $t-4$  and  $t-8$  in pta/kg.,  $PCF_t$  is price of compound feed for hogs in pta/kg.,<sup>29</sup>  $T_t$  is a trend variable representing technological change, and  $D_{1t}$ ,  $D_{2t}$  and  $D_{3t}$  are dummy variables capturing seasonality in supply. Price variables are expressed in real terms. Values are expressed in 1989 pesetas by using the consumer price index (1983=1.00) to transform the price series. The signs of  ${}_{t-4}PH_t^*$  and  ${}_{t-8}PH_t^*$  are expected to be positive, and the signs of  $PCF_{t-4}$  and  $PCF_{t-8}$  are expected to be negative. The model deals with wholesale prices and quantities. Margins are not explained because there is no information available at retail level.

The pork demand equation is specified as price dependent because market equilibrium is attained by adjustment of price until all pork produced is sold. This specification reflects the supply

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<sup>29</sup> While compound feed is an important input in hog production,  $PCF_{t-4}$  and  $PCF_{t-8}$  are not formally expressed in terms of expectations. This specification permits a tractable model under the rational and adaptive expectations mechanisms. Lagged compound feed prices may be viewed as expected prices under the alternative mechanisms and procedures previously discussed.

process where the quantity of pork meat available in a given period of observation is almost completely predetermined by past decisions and stocks are small, which primary determines the flow of product through the marketing system. From a theoretical point of view, price dependent demand equations are derived from the distance function.<sup>30</sup> In the pork demand equation, price is dependent on own consumption, consumption of substitute commodities,<sup>31</sup> and income.

The demand equation is specified as:

$$[22] \quad PH_t = b_0 + b_1 QHCA_t + b_2 QBCA_t + b_3 QCCA_t + b_4 ICA_t + b_5 D_{1t} \\ + b_6 D_{2t} + b_7 D_{3t} + u_{2t}$$

where  $PH_t$  is price of live hogs in pta/kg.  $QHCA_t$  is pork consumption per capita, obtained dividing total hog availability (domestic supply plus net imports) by population,  $QBCA_t$  is beef consumption per capita and  $QCCA_t$  is chicken consumption per capita; they are given in kg./capita/quarter.  $ICA_t$  is real income in  $10^5$  pta/capita/year and  $D_{1t}$ ,  $D_{2t}$  and  $D_{3t}$  are dummy variables capturing seasonality in consumption. Price variables are expressed in real terms. The coe-

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<sup>30</sup> The distance function  $d(u,q)$  is the inverse of the direct utility function, where  $u$  is utility and  $q$  the consumption bundle.  $d(u,q)$  is the quantity by which  $q$  should be divided in order to reach utility  $u$ . The derivative of the distance function with respect to  $q$  is the compensated inverse demand function which is price dependent. From this function, the uncompensated inverse demand function can be obtained substituting  $u$  by  $q$  using the direct utility function  $u=v(q)$ . (Deaton et al., pp. 53-7).

<sup>31</sup> Fish consumption is important in the diet of Spanish consumers and fish provides as a source of protein. However, lack of data prevents the inclusion of fish in the pork demand equation.

efficient  $b_1$  is expected to be negative. The coefficients of substitute commodities' quantities are expected to be negative, and the income coefficient is expected to be positive as pork is presumed to be a normal good.

The information to estimate the model is taken from various Spanish sources. Quarterly data are used to estimate and simulate the model covering the period 1/1971 to 2/1990, a total of 78 observations. The series are obtained from the Boletín Mensual de Estadística Agraria published by the Spanish Ministry of Agriculture (MAPA).<sup>32</sup> Income data series are obtained from the Boletín Estadístico del Banco de España published by the Central Bank and monthly indexes of economic activity used to interpolate the yearly income series are from Banco de Bilbao sources.<sup>33</sup> Data on hog imports and origins are available from the Anuario de Comercio Exterior published by the Spanish Ministry of Economy and from the Instituto de Comercio Exterior (ICEX).

Alternative expectations mechanisms, naive, polynomial distributed lags, and adaptive and rational expectations, are examined to ascertain their relevance in modelling hog supply. In equation [17], under naive expectations, the expected prices  ${}_{t-4}PH^*_t$  and  ${}_{t-8}PH^*_t$  are the prices prevailing in the previous fourth and eighth quar-

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<sup>32</sup> In 1986, MAPA increased 1980 to 1985 production estimates by 20 percent to correct previously published hog output figures. Here, hog production estimates from 1971 to 1979 also are increased by 20 percent to achieve a more homogeneous data series.

<sup>33</sup> The index of economic activity given by the Banco de Bilbao was used to calculate income quarterly from the income per year variable using the activity index to adjust yearly income by quarters.

ters. A more parsimonious naive specification with the ratio output to input prices also is estimated.

Several specifications of the polynomial lag, which specifies expectations as a function of weighted past prices, are considered in the analysis. Based on previous research considerations of the production process (i.e. Caldentey and Titos), second and third degree polynomial distributed lags are specified for hog and compound feed prices with maximum lag  $t-13$  and minimum lag  $t-2$  in both cases. However, other forms of the lag and lag lengths also were examined (e.g. fourth degree polynomials and lags beginning at  $t-1$  and ending at  $t-13$ ,  $t-1$  to  $t-14$ , and  $t-2$  to  $t-14$ ). Supply under polynomial lags is given by:

$$\begin{aligned}
 [23] \quad QH_t = & a_0 + a_1 (w_2 PH_{t-2} + w_3 PH_{t-3} + \dots + w_{13} PH_{t-13}) \\
 & + a_2 (v_2 PCF_{t-2} + v_3 PCF_{t-3} + \dots + v_{13} PCF_{t-13}) \\
 & + a_3 T_t + a_4 D_{1t} + a_5 D_{2t} + a_6 D_{3t} + u_{1t}
 \end{aligned}$$

with weights  $w_i$  and  $v_i$  following a polynomial of third degree,

$$[24] \quad w_{i+2} = \alpha_{01} + \alpha_{11}i + \alpha_{21}i^2 + \alpha_{31}i^3 \quad (i=0,1,2,\dots,11)^{34}$$

$$[25] \quad v_{i+2} = \alpha_{02} + \alpha_{12}i + \alpha_{22}i^2 + \alpha_{32}i^3 \quad (i=0,1,2,\dots,11)^{34}$$

As in the case of naive expectations, the polynomial distributed lags supply is re-specified in terms of the ratio output to in-

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<sup>34</sup>  $i$  is defined from 0 to 11 because the lags considered are from 2 to 13.

put prices to reduce the complexity of the equation.

Adaptive expectations supply is obtained substituting,

$$[26] \quad {}_{t-4}PH_t^* = (1-\alpha_1) [PH_{t-4} + \alpha_1 PH_{t-8} + \alpha_1^2 PH_{t-12} + \dots ]$$

$$[27] \quad {}_{t-8}PH_t^* = (1-\alpha_2) [PH_{t-8} + \alpha_2 PH_{t-16} + \alpha_2^2 PH_{t-24} + \dots ]$$

in [21] and applying the Koyck transformation twice in succession (Kmenta, 1986, pg.531), which gives:

$$[28] \quad QH_t = c_0 + c_1 QH_{t-4} + c_2 QH_{t-8} + c_3 QH_{t-12} + c_4 PH_{t-4} + c_5 PH_{t-8} \\ + c_6 PH_{t-12} + c_7 PCF_{t-4} + c_8 PCF_{t-8} + c_9 PCF_{t-12} + c_{10} PCF_{t-16} \\ + c_{11} PCF_{t-20} + c_{12} T_t + c_{13} D_{1t} + c_{14} D_{2t} + c_{15} D_{3t} + v_{1t}$$

where:

$$c_0 = a_0(1-\alpha_1)(1-\alpha_2) = a_0^*$$

$$c_1 = \alpha_1$$

$$c_2 = \alpha_2$$

$$c_3 = -\alpha_1\alpha_2$$

$$c_4 = a_1(1-\alpha_1)$$

$$c_5 = a_3(1-\alpha_2)$$

$$c_6 = -a_1(1-\alpha_1)\alpha_2 - a_3(1-\alpha_2)\alpha_1$$

$$c_7 = a_2$$

$$c_8 = a_4 - a_2\alpha_1$$

$$c_9 = -a_2\alpha_2 - a_4\alpha_1$$

$$c_{10} = a_2\alpha_1\alpha_2 - a_4\alpha_2$$

$$c_{11} = a_4\alpha_1\alpha_2 \rightarrow 0$$

$$c_{12} = a_5^*$$

$$c_{13} = a_6^*$$

$$c_{14} = a_7^*$$

$$c_{15} = a_8^*$$

$$v_t = u_t - \alpha_1 u_{t-4} - \alpha_2 u_{t-8} + \alpha_1\alpha_2 u_{t-12}$$

$T_t$  is a trend variable capturing technological change. No

constraints are imposed on the coefficients of the constant term, trend and dummy variables, indicated by a star in the coefficients of these variables:  $a_0^*$ ,  $a_5^*$ ,  $a_6^*$ ,  $a_7^*$ ,  $a_8^*$ . Potential difficulties may appear in estimating equation [28]. While the identified constraints will be used in estimating [28], collinearity among variables (output quantities and prices  $QH_{t-r}$  and  $PH_{t-r}$ , or output and input prices  $PH_{t-r}$  and  $PCF_{t-r}$ ) is likely, autocorrelation which frequently appears in quarterly data may also make the results difficult to interpret. To alleviate this problem, a more parsimonious adaptive model with the ratio output to input prices also is estimated.

The model under the rational expectations assumption is somewhat different than the model given by equation [20] because the hog model has two price expectations ( ${}_{t-4}PH_t^*$ ,  ${}_{t-8}PH_t^*$ ) generated at times  $t-4$  and  $t-8$ . Also, the demand equation is not specified in "per capita" terms to avoid further complexity with non-linearities in equations [30] and [31]. That is, the demand equation is specified as:

$$[22'] \quad PH_t = b_0 + b_1 QH_t + b_2 QB_t + b_3 QC_t + b_4 I_t + b_5 D_{1t} \\ + b_6 D_{2t} + b_7 D_{3t} + u_{2t}$$

where  $QH_t$ ,  $QB_t$ ,  $QC_t$ , and  $I_t$  are not given in "per capita" terms as is the case in equation [22].

Hog price is obtained in terms of the other variables by eliminating  $QH_t$  in the hog supply and demand equations [21] and [22']:

$$\begin{aligned}
 [29] \quad PH_t = & b_0 + b_1 [a_0 + a_1 {}_{t-4}PH_t^* + a_2 PCF_{t-4} + a_3 {}_{t-8}PH_t^* \\
 & + a_4 PCF_{t-8} + a_5 T_t + a_6 D_{1t} + a_7 D_{2t} + a_8 D_{3t} + u_{1t}] \\
 & + b_2 Q B_t + b_3 QC_t + b_4 I_t + b_5 D_{1t} + b_6 D_{2t} + b_7 D_{3t} + u_{2t}
 \end{aligned}$$

From this equation, expressions for  ${}_{t-4}PH_t^*$  and  ${}_{t-8}PH_t^*$  can be obtained in terms of the model parameters and the exogenous variables. Substituting the expressions for  ${}_{t-4}PH_t^*$  and  ${}_{t-8}PH_t^*$  in [21] and [22], the reduced observable forms for the endogenous variables  $QH_t$  and  $PH_t$  are:

$$\begin{aligned}
 [30] \quad QH_t = & d_0 + d_1 PCF_{t-4} + d_2 PCF_{t-8} + d_3 T_t + d_4 {}_{t-4}QB_t^* \\
 & + d_5 {}_{t-4}QC_t^* + d_6 {}_{t-4}I_t^* + d_7 {}_{t-8}PCF_{t-4}^* + d_8 {}_{t-8}QB_t^* \\
 & + d_9 {}_{t-8}QC_t^* + d_{10} {}_{t-8}I_t^* + d_{11} D_{1t} + d_{12} D_{2t} \\
 & + d_{13} D_{3t} + u_{1t}
 \end{aligned}$$

where:

$$\begin{aligned}
 d_0 = [a_0 + (a_1 + a_3)b_0] / (1 - a_1b_1 - a_3b_1) = a_0^* & \quad d_1 = a_2(1 - a_3b_1) / (1 - a_1b_1 - a_3b_1) \\
 d_2 = a_4 / (1 - a_1b_1 - a_3b_1) & \quad d_3 = a_5 / (1 - a_1b_1 - a_3b_1) \\
 d_4 = a_1b_2 / (1 - a_1b_1 - a_3b_1) & \quad d_5 = a_1b_3 / (1 - a_1b_1 - a_3b_1) \\
 d_6 = a_1b_4 / (1 - a_1b_1 - a_3b_1) & \quad d_7 = a_2a_3b_1 / (1 - a_1b_1 - a_3b_1) \\
 d_8 = a_3b_2 / (1 - a_1b_1 - a_3b_1) & \quad d_9 = a_3b_3 / (1 - a_1b_1 - a_3b_1) \\
 d_{10} = a_3b_4 / (1 - a_1b_1 - a_3b_1) & \quad d_{11} = [a_6 + (a_1 + a_3)b_5] / (1 - a_1b_1 - a_3b_1) = a_6^* \\
 d_{12} = [a_7 + (a_1 + a_3)b_6] / (1 - a_1b_1 - a_3b_1) = a_7^* & \\
 d_{13} = [a_8 + (a_1 + a_3)b_7] / (1 - a_1b_1 - a_3b_1) = a_8^* &
 \end{aligned}$$

$$\begin{aligned}
[31] \quad PH_t = & e_0 + e_1 PCF_{t-4} + e_2 PCF_{t-8} + e_3 T_t + e_4 QB_t + e_5 QC_t \\
& + e_6 I_t + e_7 {}_{t-4}QB^*_t + e_8 {}_{t-4}QC^*_t + e_9 {}_{t-4}I^*_t + e_{10} {}_{t-8}PCF^*_{t-4} \\
& + e_{11} {}_{t-8}QB^*_t + e_{12} {}_{t-8}QC^*_t + e_{13} {}_{t-8}I^*_t + e_{14} D_{1t} + e_{15} D_{2t} \\
& + e_{16} D_{3t} + e_{17} u_{1t} + u_{2t}
\end{aligned}$$

where:

$$\begin{array}{lll}
e_0 = b_0 + b_1 d_0 = b_0^* & e_1 = b_1 d_1 & e_2 = b_1 d_2 \\
e_3 = b_1 d_3 & e_4 = b_2 & e_5 = b_3 \\
e_6 = b_4 & e_7 = b_1 d_4 & e_8 = b_1 d_5 \\
e_9 = b_1 d_6 & e_{10} = b_1 d_7 & e_{11} = b_1 d_8 \\
e_{12} = b_1 d_9 & e_{13} = b_1 d_{10} & e_{14} = b_5 + b_1 d_{11} = b_5^* \\
e_{15} = b_6 + b_1 d_{12} = b_6^* & e_{16} = b_7 + b_1 d_{13} = b_7^* & e_{17} = b_1
\end{array}$$

No constraints are imposed on the coefficients of the constant term and dummy variables in equations [30] and [31] and that is indicated with a star in the corresponding coefficient ( $a_0^*$   $a_6^*$   $a_7^*$   $a_8^*$  in equation [30] and  $b_0^*$   $b_5^*$   $b_6^*$   $b_7^*$  in equation [31])

Expected values for the exogenous variables appear in the reduced observable forms [30] and [31], as shown in section 3.3.1.2; expected exogenous variables are denoted by a star in equations [30] and [31]. As noted in the discussion of estimation procedures, auxiliary ARIMA specifications are needed to calculate the expected values of exogenous variables. ARIMA specifications for these variables are given in appendix II.

From a general perspective, the plausibility of rational

expectations in explaining the hog market depends in part on the make up of the industry. The rational expectations hypothesis may be appropriate when a small number of firms produce a large proportion of output, are vertically integrated, use sophisticated technologies and pay close attention to information from related markets. However, the number of small producers in Spain makes the underlying assumptions of the rational hypothesis somewhat tenuous. Furthermore, the model's complexity and its heavy reliance on ancillary forecasts may make its usefulness questionable and results may be difficult to assess. An additional drawback of this approach is the potential estimation difficulties derived from collinearity among variables and autocorrelation problems. If the ancillary forecast are highly accurate, then  ${}_{t-8}PCF^*_{t-4}$  and  $PCF_{t-4}$  should be highly related making estimation and interpretation difficult. As in the case of adaptive expectations supply, estimation results may be questionable.

Estimation of the adaptive and rational specifications is made including the non-linear constraints in the estimated equations. A non-linear maximum likelihood procedure which permits correction for autocorrelation is used. In the case of the rational structure, the observable quantity and price equations [30] and [31] are estimated as a system.

The following section suggests several approaches for determining the relevancy of the alternative expectations in representing the Spanish hog industry. Based on these findings, a representative model is selected for policy analysis.

### 3.5 Model estimation and validation

The relevancy of the different specifications is examined performing statistical tests on the estimated parameters and assessing the accuracy of forecasts. The model is then used to assess the effects on the hog market of the entry into the EC by simulation. This section explains the validation procedures used and presents results of estimation and final specification. Policy analysis based on simulation of the model follows in Chapter 4.

The selection of the expectation formation mechanism that "best" explains the behavior of producers in the Spanish hog market is the key specification issue. The usual parametric procedures to check the significance of variables and the behavior of residuals are used.

As Sheffrin (1983) suggests, the test for the rational expectations hypothesis can be performed using the overidentifying restrictions on the parameters estimates. This overidentifying restrictions arise from the difference between the number of variables in the equations and the number of parameters to estimate (excluding the constant term parameters). The test is based on the estimation of the parameters with and without the constraints which will indicate if the rational hypothesis is valid, although the test includes the maintained hypothesis that the model specification is correct. A Wald test is computationally advantageous since it only requires the unrestricted maximum likelihood estimates avoiding the need of estimating the parameters

under the non-linear restrictions. However, in the case of non-linear restrictions the Wald statistic is not invariant to equivalent null hypotheses and the use of the likelihood ratio or Lagrange multiplier tests is more appropriate. The rational expectations hypothesis is tested here with a likelihood ratio test.

Two additional procedures are used: non-nested and post-sample predictive procedures. Non-nested tests are required because the alternative specifications are not nested. Following Harvey (1989), non-nested hypotheses testing can be based on a given criterion, and that is called "discrimination", or it can be based on embedding the alternative specifications in a general model. "Discrimination" consists of choosing between various competing models based on some appropriate performance measure such as the  $R^2$  or the value of the likelihood function corrected by a factor that accounts for parsimony such as the Akaike Information Criterion (AIC) or the Schwartz Criterion (SC).

An "embedding" procedure works embedding two or various alternative hypotheses in a general model and then testing each hypothesis as a restriction to the general model. Both "discrimination" and "embedding" procedures are used here. The discrimination criteria are  $R^2$ , AIC and SC. The AIC is defined by:

$$\text{AIC} = -2 \log(\hat{\psi}) + 2 k$$

and the SC is defined by:

$$SC = -2 \log(\hat{\psi}) + k \log(n)$$

where  $k$  is the number of parameters and  $n$  the number of observations. AIC is based on the minimization of the Kullback-Leibler mean information (a generalization of the maximum likelihood principle) and SC is based on Bayesian arguments. The criteria are not asymptotically equivalent. Judge (1985) states that the SC is a consistent estimation rule and the AIC is not, however he indicates that the AIC is not useless because it has in some cases optimality properties.

Two embedding procedures, the J-test and C-test also are examined. The J-test measures the explanation added to a given model augmented by a variable whose values are the predictions from a competing model. Specifically the J-test examines the null hypothesis  $H_0: y_i = x_i \beta + \epsilon_{0i}$  against the alternative  $H_1: y_i = z_i \gamma + \epsilon_{1i}$  where  $y_i$  is the endogenous variable and  $x_i, z_i$  are the exogenous variables. The regression  $y_i = (1-\alpha)x_i \beta + \alpha z_i \hat{\gamma} + \epsilon_i$ , where  $\hat{\gamma}$  is the maximum likelihood estimate of  $\gamma$ , is used to test if  $\alpha$  is zero, because if  $H_0$  is true then the true value of  $\alpha$  is zero (Davidson and MacKinnon, 1981). Several alternatives can be tested at once provided that the regression includes several terms of the form  $\alpha_1 z_{1i} \hat{\gamma}_1 + \alpha_2 z_{2i} \hat{\gamma}_2 + \dots$ , instead of the term  $\alpha z_i \hat{\gamma}$  (But in this case collinearity may make the results irrelevant). The C-test is a variation of the J-test when  $H_0$  is non-linear. The C-test checks the truth of  $H_0$  estimating the regression  $y_i = (1-\alpha)x_i \hat{\beta} + \alpha z_i \hat{\gamma} + \epsilon_i$ . Because of the resulting t-statistic for  $\alpha$  has a smaller asymptotic

size than its nominal size, the C-test provides a sufficiently good approximation to reject  $H_0$  (Davidson and MacKinnon, 1981; p. 783).

The test procedures described so far are designed to choose an appropriate model from the data and the model is subsequently estimated using the same data set. As Harvey (1990) indicates, the adequacy of the estimated model may then only be assessed by its ability to make predictions outside the sample data set. It is important to perform post-sample prediction tests to compare the relative accuracy of the competing models. The post-sample prediction procedures implemented are based on the mean square error (MSE), the mean percentage error (absolute [MAPE], and square [MSPE]), and turning points. The mean square error and similar measures do not have, as Harvey indicates, the drawbacks of other tests requiring the estimation of the error variance. The mean square error, the mean percentage error (absolute and square), and turning point procedures are calculated using the forecasts of the model under the various alternative expectations mechanisms. The calculated forecasts are out of sample because they are obtained without including any new information on both endogenous and exogenous variables, so that predicted values of the exogenous variables are used in the prediction period. The prediction period is three years (1983-85), and each specification is estimated with observations previous to the prediction period (1971-82). The models are then ranked according to these procedures and compared in order to select a final specification.

### 3.5.1 Estimation results

The equations have been estimated with quarterly data for the period 2/74-4/82. The data from 1/71 to 1/74 being used to provide data for the lagged variables in the equations. Autocorrelation has been detected in all equations ([32] to [39]) and has been corrected using a maximum likelihood procedure, calculating  $\rho$  by a grid search. Standard errors are given in parenthesis.<sup>35</sup> The smaller the AIC and SC statistics, clearly, the better the specification.

#### 3.5.1.1 Naive supply

The naive formulation is a special case of the supply equation [21] in which expected price is specified by a lagged price. These expectations can be viewed as either on hog and compound feed or just on hog price. Again, note that trend and dummy variables are included to estimate the effects of technology and seasonality in hog supply, respectively.

The results of estimating the naive supply equation are:

$$[32] \text{ QH}_t = 497.30 + 0.09 \text{ PH}_{t-4} - 1.10 \text{ PCF}_{t-4} - 0.09 \text{ PH}_{t-8}$$

(0.13)
(0.64)\*
(0.12)

---

<sup>35</sup> A star (\*) indicates that the coefficient is significant at a 5 percent level. Two stars (\*\*) indicate it is significant at a 0.5 percent level (One tailed test, presuming that the variable sign is correct).

$$\begin{array}{cccccc}
 -2.80 & PCF_{t-8} & +1.17 & T_t & -9.46 & D_{1t} & -58.21 & D_{2t} & -75.07 & D_{3t} \\
 (0.66)^{**} & & (1.36) & & (5.29)^* & & (5.21)^{**} & & (4.60)^{**} & 
 \end{array}$$

Sum of  
elasticities

PH     -0.01  
PCF    -0.96

$\rho = 0.37$   
(0.16)\*

$$\bar{R}^2=0.96 \quad DW=1.93 \quad AIC=289.46 \quad SC=305.01$$

All variables have the expected sign except  $PH_{t-8}$  but hog prices and trend are not significant. Some collinearity between  $PH_{t-8}$  and  $T_t$ , (condition number 202.54, condition index 14.23)<sup>36</sup> and between  $PH_{t-4}$  and  $PCF_{t-8}$  (condition number 63.31, condition index 7.96) is detected which may explain the fact that  $T_t$  and the hog price variables are barely significant.

The sum of elasticities for PH is negative, suggesting that even if the other measures indicate that this is a good specification, its use for structural analysis is limited. Supply would move in the wrong direction with changes in prices which could lead to misleading results in simulation when calculating surplus.

The dummy variables are significant and similar in size to those estimated in previous research (Caldentey and Titos, 1979). They identify a seasonal expansion in supply during fall and winter and its reduction during spring and summer.

The presence of collinearity in equation [32] gives rise to estimating the equation in ratios as a method to reduce its effect;

<sup>36</sup> Belsley et al (1980) indicate as a rule of thumb that a condition index greater than 30 denotes strong collinearity.

the number of coefficients to estimate is reduced allowing for a more parsimonious specification. However, this assumes that the elasticities for an increase in price are the same as for a decrease in compound feed price. The results of estimation using the ratio output to input price [PH/PCF] are:

$$[33] \text{QH}_t = 29.98 + 10.99 [\text{PH/PCF}]_{t-4} + 13.32 [\text{PH/PCF}]_{t-8}$$

(6.79)

(6.05)\*

$$+ 4.69 T_t - 16.42 D_{1t} - 57.11 D_{2t} - 73.66 D_{3t}$$

(0.70)\*\*

(4.75)\*\*

(4.78)\*\*

(4.07)\*\*

Sum of  
elasticities  
[PH/PCF] 0.47

$\rho = 0.76$   
(0.11)\*\*

$$\bar{R}^2=0.95 \quad DW=2.17 \quad AIC=292.24 \quad SC=304.68$$

These results suggest that the reduction in multicollinearity improves the significance of variables (smaller standard errors relative to the coefficients for the estimated price and trend variables) and the correspondence of signs with expectations. However, there is a trade-off between the increased precision and the reduction in the goodness of fit measures ( $\bar{R}^2$  and AIC but SC improves). The calculated elasticity,  $\epsilon=0.47$ , is somewhat smaller in magnitude than the elasticity calculated by Caldentey and Titos (1979) who obtain elasticities in the range 0.60 (partial adjustment) to 1.40 (polynomial) for the price ratio specification.

### 3.5.1.2 Polynomial supply

The polynomial formulation (equation [23]) assumes that expected prices are a function of lagged prices and that the weights of prices in production decisions follow an inverted V. In this formulation, individuals respond to expected prices for both hogs and compound feed. This procedure previously was used by Caldentey and Titos (1979).

The final specification of the polynomial supply is the result of some experimentation with the degree of the polynomial and the lag structure. This experimentation concentrated on second and third degree polynomials, with lag lengths close-by to t-2 to t-13. The rationale for these structures stems from previous findings and the possibility of having two decision points in supply response at t-4 and t-8 which could be captured by the third degree polynomial. Statistical performance measures ( $\bar{R}^2$ , AIC, DW,...) were used to identify the most likely specifications. Where small differences in these measures existed, more weight was placed in the reasonableness of the results in terms of variable signs, size of variable coefficients and size of elasticities.

Little variation in the  $\bar{R}^2$  exists when different lag lengths are considered (t-2 to t-13 versus t-2 to t-14, t-1 to t-13 and t-1 to t-14) or when the degree of the polynomial is 2 or 3. High-order polynomials (5 and up) give rise eventually to wrong signs in the coefficients. Although different lag lengths were considered for output and input prices (such t-2 to t-13 for output and t-3 to

t-14 for input prices), higher statistical measures are found when both output and input prices had the same lag length. With specifications of second and third degree, larger than t-2 to t-13 lag lengths yielded consistently inferior results, specially if the lag t-1 was included. While the elasticities varied for particular specifications, in general the sum of elasticities is around 0.7-1.0 for the lagged hog price variables and around negative 0.5-0.7 for the lagged feed price variables.

The final specification selected was a third degree polynomial with lag structures beginning at t-2 and ending at t-13. The supply estimated is:

$$\begin{aligned}
 [34] \text{ QH}_t = & -0.08 + 0.05 \text{ PH}_{t-2} + 0.09 \text{ PH}_{t-3} + 0.11 \text{ PH}_{t-4} + 0.12 \text{ PH}_{t-5} \\
 & \quad (0.01)^{**} \quad (0.02)^{**} \quad (0.03)^{**} \quad (0.03)^{**} \\
 & + 0.12 \text{ PH}_{t-6} + 0.11 \text{ PH}_{t-7} + 0.09 \text{ PH}_{t-8} + 0.08 \text{ PH}_{t-9} + 0.06 \text{ PH}_{t-10} \\
 & \quad (0.03)^{**} \quad (0.03)^{**} \quad (0.03)^{**} \quad (0.02)^{**} \quad (0.02)^{**} \\
 & + 0.04 \text{ PH}_{t-11} + 0.02 \text{ PH}_{t-12} + 0.01 \text{ PH}_{t-13} - 0.02 \text{ PCF}_{t-2} \\
 & \quad (0.02) \quad (0.03) \quad (0.05) \quad (0.05) \\
 & - 0.07 \text{ PCF}_{t-3} - 0.13 \text{ PCF}_{t-4} - 0.20 \text{ PCF}_{t-5} - 0.26 \text{ PCF}_{t-6} \\
 & \quad (0.05) \quad (0.06)^* \quad (0.08)^* \quad (0.11)^* \\
 & - 0.32 \text{ PCF}_{t-7} - 0.37 \text{ PCF}_{t-8} - 0.39 \text{ PCF}_{t-9} - 0.39 \text{ PCF}_{t-10} \\
 & \quad (0.14)^* \quad (0.16)^* \quad (0.18)^* \quad (0.18)^* \\
 & - 0.36 \text{ PCF}_{t-11} - 0.29 \text{ PCF}_{t-12} - 0.17 \text{ PCF}_{t-13} + 6.53 \text{ T}_t \\
 & \quad (0.17)^* \quad (0.14)^* \quad (0.08)^* \quad (0.36)^{**} \\
 & - 10.65 \text{ D}_{1t} - 57.59 \text{ D}_{2t} - 73.51 \text{ D}_{3t} \\
 & \quad (4.61)^* \quad (5.14)^{**} \quad (4.43)^{**}
 \end{aligned}$$

	Sum of lagged coefficients	Sum of elasticities	Mean lag	$\rho = 0.62$ (0.13)**
PH	0.91(0.25)**	1.02	6.34	
PCF	-2.97(1.25)*	-0.73	8.61	

$$\bar{R}^2=0.95 \quad \text{DW}=2.06 \quad \text{AIC}=304.76 \quad \text{SC}=326.53$$

In equation [34] the hog price elasticity is larger than the feed price elasticity as might be expected. Also, producers appear to respond more rapidly to own prices than input prices as the mean lags for PH and PCF indicate. The own price elasticity is considerably different from naive specification but the input price elasticity is similar to the naive.

A similar search procedure was used for the ratio formulation and a third-order polynomial with length spanning from 2 to 13 lags yielded the best results. The results for the ratio formulation are:

$$\begin{aligned}
 [35] \quad QH_t = & -2.81 + 2.03 [PH/PCF]_{t-2} + 3.37 [PH/PCF]_{t-3} + 4.12 [PH/PCF]_{t-4} \\
 & \quad (0.81)^* \quad (1.22)^* \quad (1.32)^{**} \\
 & + 4.38 [PH/PCF]_{t-5} + 4.23 [PH/PCF]_{t-6} + 3.78 [PH/PCF]_{t-7} \\
 & \quad (1.17)^{**} \quad (0.87)^{**} \quad (0.54)^{**} \\
 & + 3.12 [PH/PCF]_{t-8} + 2.34 [PH/PCF]_{t-9} + 1.53 [PH/PCF]_{t-10} \\
 & \quad (0.50)^{**} \quad (0.80)^{**} \quad (1.10) \\
 & + 0.80 [PH/PCF]_{t-11} + 0.24 [PH/PCF]_{t-12} - 0.06 [PH/PCF]_{t-13} \\
 & \quad (1.26) \quad (1.17) \quad (0.78) \\
 & + 4.82 T_t - 10.86 D_{1t} - 58.34 D_{2t} - 73.90 D_{3t} \\
 & \quad (0.58)^{**} \quad (4.37)^{**} \quad (4.91)^{**} \quad (4.20)^{**}
 \end{aligned}$$

	Sum of lagged coefficients	Sum of elasticities	Mean lag	
[PH/PCF]	29.90 (3.99)**	0.58	5.91	$\rho = 0.74$ (0.11)**

$$\bar{R}^2=0.95 \quad DW=2.18 \quad AIC=297.84 \quad SC=313.39$$

As in the previous equation, the results are not very sensitive to the exact specification (second versus third order and somewhat similar lag lengths). The estimated elasticities ranged from

0.40 to 0.60. The sum of elasticities is larger but similar to the naive formulation in ratio form. Also, worth noting is that the mean lag is about half way between the two decision points identified in the earlier part of the work. All coefficients have the correct signs except  $[PH/PCF]_{t-13}$ , which is not significant.

### 3.5.1.3 Adaptive supply

Adaptive expectations is formulated in two ways because of the difficulty in assuming expectations in both input and output prices separately. First, adaptive expectations are assumed only on the hog price. Second, an adaptive expectations formulation is assumed on the ratio of hog to feed price. Under adaptive expectations (equation [28]) both formulations imply non-linear constraints in the coefficients and are estimated using a maximum likelihood non-linear procedure. Estimation of equation [28] under the coefficients' non-linear constraints yields:<sup>37</sup>

$$\begin{aligned}
 [36] \quad QH_t = & 434.99 + 0.30 \underset{(0.14)^*}{t-4} PH_t^* - 2.20 \underset{(0.64)^{**}}{t-4} PCF_{t-4} + 0.03 \underset{(0.08)}{t-8} PH_t^* \\
 & - 1.23 \underset{(0.58)^*}{t-8} PCF_{t-8} - 6.82 \underset{(7.05)}{t} T_t - 18.85 \underset{(5.14)^{**}}{t} D_{1t} - 86.77 \underset{(16.02)^{**}}{t} D_{2t} - 111.66 \underset{(20.58)^{**}}{t} D_{3t} \\
 & \alpha_1 = -0.03 \\
 & \quad \quad \quad (0.15)
 \end{aligned}$$

<sup>37</sup> The autocorrelation coefficient calculated in estimating equation [28] is  $\rho = 1.03$  with an standard error of 0.02 (significant at 0.5 percent level). Note that the value of  $\rho$  is inappropriate (i.e. explosive perturbation term).

$$\alpha_2 = -0.46$$

(0.15)\*\*

$$\bar{R}^2=0.96 \quad DW=2.49 \quad AIC=291.24 \quad SC=309.90$$

The results are similar to the naive formulation - coefficients with limited significance, high degree of explanatory power and a trend variable that is not significant and even negative. A problem with this specification is that the signs of  $\alpha_1$  and  $\alpha_2$ , the parameters in the adaptive expectations formation formulas [26] and [27], are negative. In order for the adaptive hypothesis to hold these parameters should be positive. This indicates either the adaptive expectations formulation is inappropriate here or perhaps that there exists estimation problems due to the high number of collinear explanatory variables. Collinearity was checked and detected among variables  $QH_{t-8}$ ,  $QH_{t-12}$  and  $PCF_{t-16}$  (Condition number 3,981 and condition index 63).

A likelihood ratio test was performed to assess if the adaptive hypothesis was appropriate. The test which determines whether the non-linear restrictions introduced by adaptive expectations hold,<sup>38</sup> rejects the adaptive expectations formulation (The  $\lambda_{LR}=45.90$  and  $\chi_{11,0.05}^2=19.68$ ). The empirical evidence here suggests that equation [28] under the adaptive constraints may be inappropriate.

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<sup>38</sup> The null hypothesis in the likelihood ratio test is that the non-linear hypothesis hold and the alternative is that they do not hold. The likelihood functions of estimating equation [28] under the null and alternative hypothesis are calculated and from this the value of  $\lambda_{LR}$  is obtained.

The second specification of the adaptive expectation model (equation [28] in price ratio terms with the non-linear constraints) provides somewhat mixed results:<sup>39</sup>

$$[37] \text{QH}_t = 27.52 + 14.36_{t-4} [\text{PH/PCF}]_t^* + 1.60_{t-8} [\text{PH/PCF}]_t^* \\ + 5.67 T_t - 14.71 D_{1t} - 60.28 D_{2t} - 73.35 D_{3t} \\ (1.50) \quad (4.38) \\ (1.09)^{**} \quad (4.55)^{**} \quad (13.85)^{**} \quad (17.51)^{**}$$

$$\alpha_1 = 0.22 \\ (0.18)$$

$$\alpha_2 = -0.28 \\ (0.19)$$

$$\bar{R}^2=0.97 \quad DW=2.14 \quad AIC=275.48 \quad SC=291.03$$

The  $\bar{R}^2$  is high and the signs of the variables in the supply equation are correct but variables are not significant. Some collinearity is detected between variables  $\text{QH}_{t-12}$ ,  $T_t$ ,  $D_{2t}$  and  $D_{3t}$  (condition number 357, condition index 18.9) and between variables  $\text{QH}_{t-8}$  and  $[\text{PH/PCF}]_{t-8}$  (condition number 125, condition index 11.2). As in the previous specification, the adaptive hypothesis was assessed with a likelihood ratio test. The non-linear restrictions imposed by the adaptive hypothesis are accepted. (The  $\lambda_{LR}=7.34$  and  $\chi_{6,0.05}^2=12.95$ ). However, note that the lack of significance of the variables and the fact that the sign of  $\alpha_2$  is negative gives thus contradictory empirical evidence for the adaptive hypothesis in this case.

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<sup>39</sup> The autocorrelation coefficient calculated in estimating equation [28] in price ratio terms is  $\rho = 0.51$  with a standard error of 0.13 (significant at 0.5 percent level).

## 3.5.1.4 Demand

The demand equation corresponding to the naive, polynomial, and adaptive supply specifications is given by equation [22], with quantities in per capita terms and price and income deflated. The results of estimation are:

$$[38] \quad PH_t = 417.38 - 12.03 QHCA_t - 13.34 QBCA_t - 7.37 QCCA_t + 3.61 ICA_t$$

(6.21)\*                      (20.40)                      (11.04)                      (11.32)

$$+ 4.33 D_{1t} - 26.51 D_{2t} - 22.45 D_{3t}$$

(11.38)                      (13.75)\*                      (12.83)\*

## Flexibilities

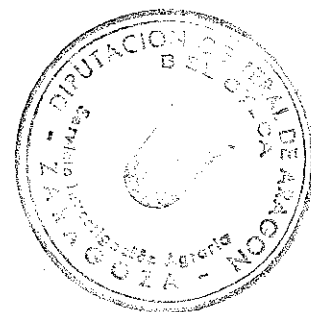
QHCA	-0.30
QBCA	-0.14
QCCA	-0.13
ICA	0.10

$$\rho = 0.92$$

(0.07)\*\*

$$\bar{R}^2 = 0.91 \quad DW = 1.69 \quad AIC = 303.50 \quad SC = 317.50$$

The coefficients of the variables have expected signs and the coefficient of determination is high, although t-values are low for variables QBCA<sub>t</sub>, QCCA<sub>t</sub> and ICA<sub>t</sub>. Collinearity was examined but not detected to any degree. Flexibilities are rather low with a large implied own-price elasticity of 3. Interestingly, this is similar in size to the elasticity found by Soria et al. (1976). Seasonality in demand is captured by D<sub>2t</sub> and D<sub>3t</sub> which indicate that demand in late spring and summer tapers off.



### 3.5.1.5 Rational specification

The rational expectations specification is given by equations [30] and [31] subject to the non-linear constraints in the coefficients. This specification is derived from equation [21] and [22'] when the rational expectations formation mechanism is assumed. The specification assumes only expectations in hog prices because of the complication in assuming expectations in both input and output prices. The specification uses total quantities and income in demand instead of per capita data to avoid further complexity with non-linearities in equations [30] and [31].

Estimation of equations [30] and [31] with the constraints is performed using a system SURE non-linear maximum likelihood procedure which can correct for autocorrelation. The exogenous variables forecasts ( ${}_{t-8}PCF^*_{t-4}$ ,  ${}_{t-4}QB^*_t$ ,  ${}_{t-8}QB^*_t$ ,  ${}_{t-4}QC^*_t$ ,  ${}_{t-8}QC^*_t$ ,  ${}_{t-4}I^*_t$  and  ${}_{t-8}I^*_t$ ) needed to estimate equations [30] and [31] are obtained from ancillary ARIMA models. These auxiliary ARIMA specifications are given by:<sup>40</sup>  $QB_t - ARIMA(3,0,0) \times (1,0,0)_4$ ;  $QC_t - ARIMA(1,0,0)$ ;  $I_t - ARIMA(4,0,1)$ ;  $PCF_{t-4} - ARIMA(1,0,0)$ . (See appendix II for more detail). The results of estimation are:<sup>41</sup>

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<sup>40</sup> In an ARIMA(p,d,q), p is the order of the autoregressive part, d is the order of differencing, and q is the order of the moving average part. An ARIMA(p,d,q) × (P,D,Q)<sub>s</sub> is a multiplicative seasonal ARIMA where s is the seasonal period.

<sup>41</sup> The autocorrelation coefficient obtained in estimating equation [30] is  $\rho = 0.20$  with an standard error of 0.13 (significant at 0.5 percent level). The autocorrelation coefficient for equation [31] is  $\rho = 0.87$  with an standard error of 0.07 (significant at 0.5 percent level).

$$\begin{aligned}
 [39] \quad QH_t = & 423.22 - 25.82 \text{ }_{t-4}PH_t^* - 0.06 PCF_{t-4} + 26.71 \text{ }_{t-8}PH_t^* \\
 & (6.16)^{**} \quad (0.02)^* \quad (6.09)^{**} \\
 & - 6.13 PCF_{t-8} + 4.10 T_t - 9.76 D_{1t} - 61.18 D_{2t} - 74.91 D_{3t} \\
 & (0.65)^{**} \quad (1.27)^{**} \quad (3.93)^* \quad (4.02)^{**} \quad (3.52)^{**}
 \end{aligned}$$

$$R^2=0.98 \quad DW=1.82$$

$$\begin{aligned}
 [40] \quad PH_t = & 145.99 - 1.03 QH_t - 0.04 QB_t - 0.01 QC_t + 0.01 I_t \\
 & (0.17)^{**} \quad (0.04) \quad (0.02) \quad (0.02) \\
 & + 9.96 D_{1t} - 4.22 D_{2t} + 1.47 D_{3t} \\
 & (3.83)^* \quad (4.22) \quad (3.74)
 \end{aligned}$$

$$R^2=0.96 \quad DW=1.72$$

System AIC=550.92

System SC=580.47

The search procedure for finding a global maximum was rather extensive, using as starting points variations on the naive supply estimates and demand estimates for the a's and b's in equations [21] and [22']. Both equations have a high coefficient of determination and correct signs, except for  $_{t-4}PH_t^*$  in the supply equation. However, the empirical evidence suggests that this specification may be inappropriate. The size of the coefficients of variables  $_{t-4}PH_t^*$  and  $_{t-8}PH_t^*$  in equation [38] is excessively large compared with other specifications. Furthermore, variable  $_{t-4}PH_t^*$  is significant and has the wrong sign. Also, the only economic variable that is significant in the demand equation is QH, which is the only economic variable that enters significantly in the single demand equation.

In part, these poor results can be explained by the presence

of severe collinearity between variables  $PCF_{t-4}$  and  ${}_{t-8}PCF^*_{t-4}$  (condition number  $2.54 \cdot 10^6$ , condition index 1595), and between variables  $T_t$  and  ${}_{t-4}QC^*_t$  (condition number 1642, condition index 40). Less severe collinearity also exists among other variables as well. The consequences are that small changes in the starting points for the non-linear estimation procedure imply large changes in the final coefficients. Also, small changes in the specification of the ancillary ARIMA models for the exogenous variables imply large changes in the estimated coefficients. For example, some preliminary estimation was done using less accurate predictions for QB from an ARIMA(4,0,1) and the estimated coefficients for  ${}_{t-4}PH^*_t$  and  ${}_{t-8}PH^*_t$  were 0.52 and 0.10, instead of the final -25.82 and 26.71, which are more similar to other specifications. Note that improving the forecasts of QB or of any exogenous variable means higher collinearity and increasing difficulties in obtaining precise estimates.<sup>42</sup>

The hypothesis testing on the overidentifying restrictions of the rational hypothesis was assessed by a likelihood ratio test. Surprisingly the results do not reject the rational hypothesis (The  $\lambda_{LR}=13.38$  and  $\chi^2_{23,0.05}=35.2$ ). However, because of previously discussed problems with the precision of the estimates, the test is not very compelling.

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<sup>42</sup> It is clear that under these circumstances the rational expectations specification must be viewed with caution.

### 3.5.2 Validation

The selection process to choose an expectations mechanism that explains best the behavior of producers in the Spanish hog market is performed by steps. First, the usual statistical tests and checks (significance, signs, size of coefficients) are examined. Given that the model will be used to calculate welfare measures, specifications with incorrect signs are largely discounted. Then the non-nested and post-sample predictive procedures are implemented and the models compared. Finally an overall assessment is performed and a final model selected.

Severe collinearity, and the corresponding lack of significance and wrong variables' signs make the use of the adaptive supply equation [36] and rational equations [38] and [39] questionable. For the naive and adaptive supply equations [32] and [37], the lack of significance in the variables and wrong signs in variables also make their use questionable. Only the naive-ratio and polynomial supply specifications provide significant findings with expected signs.

Examining table 13, the  $R^2$ 's for the different supply specifications are very close, varying from 0.95 (naive-ratio, polynomial, polynomial-ratio) to 0.97 (adaptive-ratio). The rankings of the different specifications by AIC and SC are quite similar to the  $R^2$  rankings except in the case of the naive-ratio supply, a parsimonious specification with a few number of parameters. The DW test shows some autocorrelation in the adaptive supply equation

Table 13 Selected statistical tests on the different specifications

	$\bar{R}^2$	AIC	SC	DW
<b>SUPPLY</b>				
Naive	0.96	289.46	305.01	1.93
Naive-ratio	0.95	292.24	304.68	2.17
Polynomial	0.95	304.76	326.53	2.06
Polynomial-ratio	0.95	297.84	313.39	2.18
Adaptive	0.96	291.24	309.90	2.49
Adaptive-ratio	0.97	275.48	291.03	2.14
<b>DEMAND</b>				
	0.91	303.50	317.50	1.69
	$R^2$	AIC	SC	DW
Rational		550.92	580.47	
Quantity	0.96			1.82
Price	0.92			1.72

[36], in the demand equation [37], and in the rational price equation [39].

In addition, while the discrimination procedures for selecting a specification are presented in table 13 ( $\bar{R}^2$ , AIC, SC), two embedding procedures, the J-test and C-test also are examined in tables 14 and 15. An embedding procedure combines two alternative hypothesis in a general model and tests each hypothesis as a restriction to the general model. The J-test is used when the null hypothesis is linear, and the C-test is a variation of the J-test when the null hypothesis is non-linear. In table 14 the adaptive and rational models have been estimated without the non-linear constraints on the coefficients and the J-test is used. In table 15 the adaptive and rational models have been estimated with the non-linear constraints on the coefficients and the C-test is used.

Tables 14 and 15 present the results from the J-tests and C-tests. The tests indicate that the naive, adaptive, adaptive-ratio and rational specifications are superior to naive-ratio, polynomial and polynomial-ratio specifications, because the numbers appearing in columns under  $H_1$ ,  $H_5$ ,  $H_6$  and  $H_7$  are, in general, larger than those appearing in columns under  $H_2$ ,  $H_3$ , and  $H_4$ . This outcome is similar to the information given by the  $\bar{R}^2$  statistic.

The out-of-sample forecast performance for each specification for the period 1/83 to 4/85 is given in figures 7 and 8, and in table 16. The values for the exogenous variables used to calculate these predictions were generated from ARIMA specifications. Results from the adaptive specification (equation [36]) are flawed and are

Table 14 J-test for the alternative expectations mechanisms

Supply. Pairwise tests for  $H_1$  to  $H_7$ .

Alternative Hypothesis.

		H1	H2	H3	H4	H5	H6	H7
Tested Hypothesis	H1	-135	1.10	1.18	1.13	4.15	1.87	3.15
	H2	4.69	-138	3.55	3.56	7.16	4.53	5.99
	H3	2.55	3.29	-138	3.17	7.78	4.33	6.78
	H4	4.85	3.69	3.58	-139	7.37	4.65	5.54
	H5	1.51	0.73	1.33	1.25	-127	1.49	1.75
	H6	4.26	3.38	3.71	3.60	6.14	-135	2.03
	H7	1.70	1.24	1.61	1.69	4.66	1.63	-266

Demand. Pairwise tests for non-rational (not  $H_7$ ) versus rational ( $H_7$ ) specifications.

Alternative Hypothesis.

		Not H7	H7
Tested Hypothesis	Not H7	-143	0.96
	H7	2.42	-266

$H_1$ : naive.

$H_3$ : polynomial

$H_5$ : adaptive.

$H_7$ : rational.

$H_2$ : naive-ratio.

$H_4$ : polynomial-ratio.

$H_6$ : adaptive-ratio.

Diagonal entries show the logarithm of the likelihood function. Logarithm of the likelihood function for the system in the rational hypothesis.



Table 15 J-test and C-test for the alternative expectations mechanisms when some supply equations are estimated by non-linear regression

Supply. Pairwise tests for  $H_1$  to  $H_7$ .

Alternative Hypothesis.

J-test

		H1	H2	H3	H4	H5	H6	H7
Tested Hypothesis	H1	-135	1.10	1.18	1.13	2.02	1.70	2.23
	H2	4.69	-138	3.55	3.56	4.53	4.23	5.13
	H3	2.55	3.29	-138	3.17	4.68	4.33	3.24
	H4	4.85	3.69	3.58	-139	4.71	4.61	4.89

C-test

H5	3.43	1.85	2.11	1.79	-134	3.71	4.79
H6	1.72	0.26	(-.62)	(-.40)	0.87	-128	2.73
H7	0.56	0.74	0.25	0.67	1.51	1.56	-259

Demand. Pairwise tests for non-rational (not  $H_7$ ) versus rational ( $H_7$ ) specifications.

Alternative Hypothesis.

		Not $H_7$	$H_7$	
Tested Hypothesis	Not $H_7$	-143	8.76	(J-test)
	$H_7$	0.99	-259	(C-test)

$H_1$ : naive.

$H_3$ : polynomial

$H_5$ : adaptive.

$H_7$ : rational.

$H_2$ : naive-ratio.

$H_4$ : polynomial-ratio.

$H_6$ : adaptive-ratio.

Diagonal entries show the logarithm of the likelihood function. Logarithm of the likelihood function for the system in the rational hypothesis.

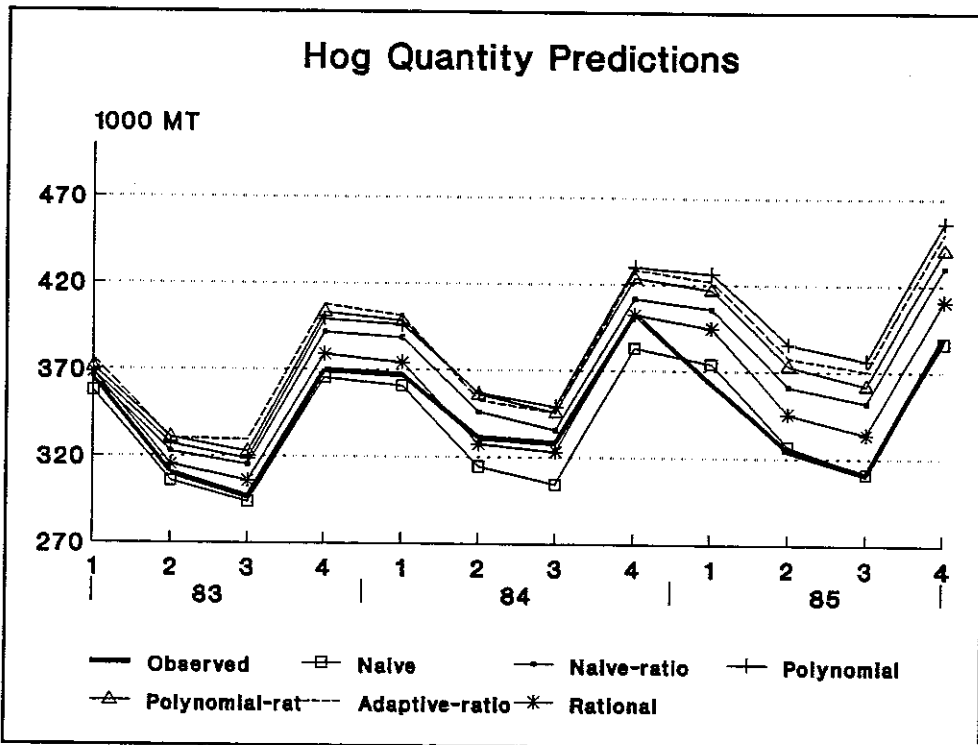


Figure 7 Out-of-sample hog quantity predictions by specification

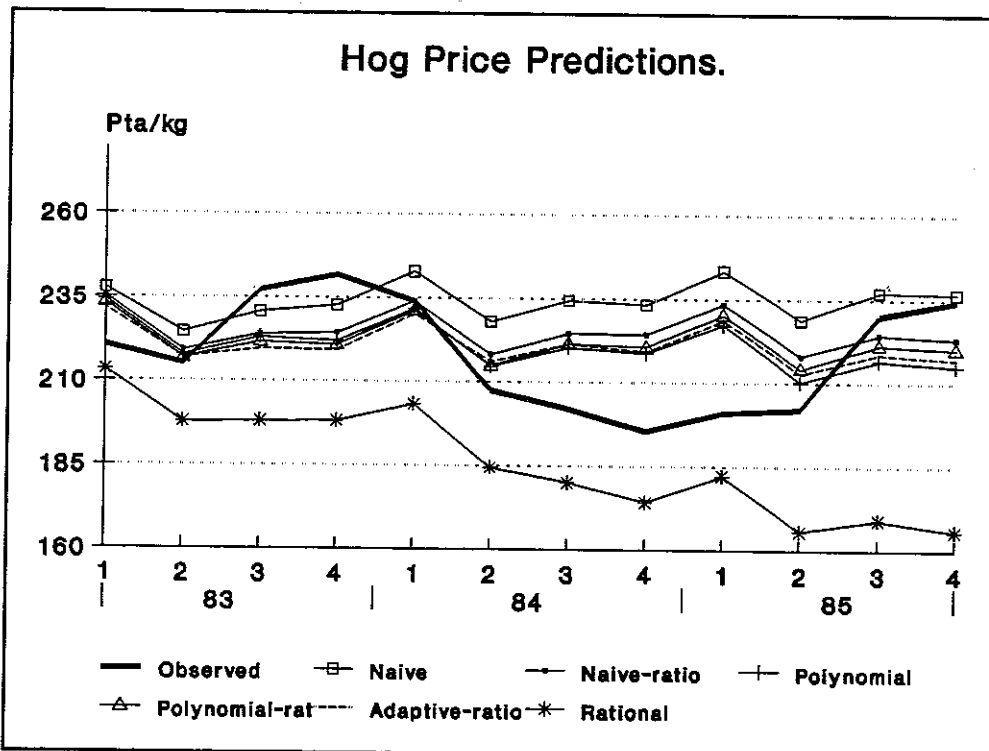


Figure 8 Out-of-sample hog price predictions by specification

not presented in the figures (because of the wrong signs in  $\alpha_1$  and  $\alpha_2$ , the parameters in the adaptive expectations formation formulas, the dynamic behavior of the specification is defective). Price forecasts from the rational specification are presented although they fall short of other specifications' forecasts.

The turning point forecasting ability of the different specifications is similar as demonstrated in figures 7 and 8.<sup>43</sup> The 5 turning points in supply are captured by all specifications. For the 3 turning points in hog prices, 2 are captured by all specifications, but all specifications predict 6 turning points that do not occur.

Table 16 presents prediction measures. Ranking of the models by the root mean square percentage error (RMSPE) suggests that the best hog quantity forecasts are from the naive and rational specifications and the worst come from the polynomial, adaptive-ratio, naive-ratio and polynomial-ratio specifications. The best hog price forecasts are associated with the polynomial, polynomial-ratio and adaptive-ratio specifications and the worst with the rational, naive and naive-ratio. These prediction results indicate that the adaptive and rational specifications should be eliminated.

For the remaining specifications (naive, naive-ratio, polynomial, polynomial-ratio and adaptive-ratio) problems with collinearity, lack of significance and wrong signs make questionable the use of the naive and adaptive-ratio specifications. They also per-

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<sup>43</sup> Here, a turning point is defined as a change in the movement of the series from increasing to decreasing or from decreasing to increasing.

Table 16 Out-of-sample prediction measures: mean square error, root mean square error, mean absolute percentage error and root mean square percentage error

Quantity.

	Naive	Naive- ratio	Polynom.	Polynom. ratio	Adaptive ratio	Rational
MSE	125.8	609.5	1732.4	1252.5	1595.3	225.7
RMSE	11.2	26.3	41.6	35.4	39.4	15.0
MAPE	2.4	6.5	10.4	9.3	10.5	3.4
RMSPE	3.2	7.7	12.1	10.3	11.6	4.4

Price.

	Naive	Naive- ratio	Polynom.	Polynom. ratio	Adaptive ratio	Rational
MSE	503.0	302.3	252.0	266.4	273.0	1355.7
RMSE	22.4	17.4	15.9	16.3	16.5	36.8
MAPE	8.8	7.0	6.5	6.6	6.8	14.6
RMSPE	11.1	8.4	7.5	7.8	7.8	16.2

form somewhat poorly in prediction (naive in price and adaptive-ratio in quantity). Therefore, these specifications also are eliminated.

Between the naive-ratio, polynomial and polynomial-ratio specifications, the selection tests indicate that in terms of AIC and SC, the naive-ratio specification is best, but it is impossible to differentiate between the three specifications in terms of the J-tests.

Out-of-sample quantity forecasts favors naive-ratio over polynomial-ratio and polynomial, but overprediction by polynomial and polynomial-ratio may be explained in part by the fact that actual input prices went up sharply during mid-1983 and 1984 which may have caused a reduction in the growth of hog production. Out-of-sample price forecasts favors polynomial over polynomial-ratio and naive-ratio, although this may not be too important because all these specifications basically use the same demand function.

In light of the test results there is little to choose between these last three specifications. The polynomial supply is selected because it permits more flexibility in specifying the supply elasticities; the output and input price elasticities do not have to be equal and opposite. Also, the polynomial supply elasticities are more similar to elasticities found in previous studies.

For purposes of the simulation an attempt to correct the overprediction of polynomial supply is made. The growth in supply resulting from technological change has been leveling off in recent years as the prediction results confirm (See figure 1, page 11).

Hence, the polynomial equation is re-estimated with  $T$  and  $T^2$  through 4/85, yielding the following results:

$$\begin{aligned}
 [41] \text{QH}_t = & -0.07 + 0.05 \text{PH}_{t-2} + 0.09 \text{PH}_{t-3} + 0.11 \text{PH}_{t-4} + 0.12 \text{PH}_{t-5} \\
 & \quad (0.01)^{**} \quad (0.02)^{**} \quad (0.03)^{**} \quad (0.03)^{**} \\
 & + 0.12 \text{PH}_{t-6} + 0.11 \text{PH}_{t-7} + 0.09 \text{PH}_{t-8} + 0.07 \text{PH}_{t-9} + 0.05 \text{PH}_{t-10} \\
 & \quad (0.03)^{**} \quad (0.03)^{**} \quad (0.03)^{**} \quad (0.02)^{**} \quad (0.02)^{**} \\
 & + 0.03 \text{PH}_{t-11} + 0.02 \text{PH}_{t-12} + 0.01 \text{PH}_{t-13} - 0.02 \text{PCF}_{t-2} \\
 & \quad (0.02) \quad (0.03) \quad (0.05) \quad (0.05) \\
 & - 0.07 \text{PCF}_{t-3} - 0.13 \text{PCF}_{t-4} - 0.19 \text{PCF}_{t-5} - 0.26 \text{PCF}_{t-6} \\
 & \quad (0.05) \quad (0.06)^* \quad (0.09)^* \quad (0.12)^* \\
 & - 0.31 \text{PCF}_{t-7} - 0.36 \text{PCF}_{t-8} - 0.38 \text{PCF}_{t-9} - 0.38 \text{PCF}_{t-10} \\
 & \quad (0.15)^* \quad (0.17)^* \quad (0.19)^* \quad (0.19)^* \\
 & - 0.35 \text{PCF}_{t-11} - 0.28 \text{PCF}_{t-12} - 0.16 \text{PCF}_{t-13} + 7.60 T_t \\
 & \quad (0.18)^* \quad (0.14)^* \quad (0.09)^* \quad (1.74)^{**} \\
 & - 0.03 T_t^2 - 12.80 D_{1t} - 59.26 D_{2t} - 73.95 D_{3t} \\
 & \quad (0.03) \quad (3.65)^{**} \quad (4.12)^{**} \quad (3.55)^{**}
 \end{aligned}$$

	Sum of lagged coefficients	Sum of elasticities	Mean lag	$\rho = 0.72$ (0.10)**
PH	0.88(0.27)**	0.78	6.33	
PCF	-2.90(1.35)*	-0.62	8.60	

$$\bar{R}^2=0.96 \quad DW=2.08 \quad AIC=399.02 \quad SC=426.77$$

In general the results are similar to equation [34] with the term in  $T^2$  showing the correct sign. The supply elasticities decline marginally but are close to the findings of previous research (Caldentey and Titos, 1979). Examination of the residuals for the polynomial specification estimated through 1985/4 showed no signs of overprediction in the last years.

In the next chapter, simulation is performed with the

polynomial supply and the demand equation. Demand is re-estimated with data from 1/71 to 4/85 and the results are:

$$[42] \quad PH_t = 445.26 - 16.32 QHCA_t - 9.45 QBCA_t - 13.79 QCCA_t + 7.63 ICA_t$$

(4.64)\*\*
(14.67)
(6.88)\*
(6.96)

$$-1.96 D_{1t} - 42.69 D_{2t} - 37.04 D_{3t}$$

(7.98)
(11.10)\*\*
(10.74)\*\*

Flexibilities

QHCA	-0.39	
QBCA	-0.09	ρ = 0.85
QCCA	-0.22	(0.07)**
ICA	0.20	

$$\bar{R}^2=0.94 \quad DW=1.49 \quad AIC=520.48 \quad SC=539.33$$

As the number of observations increases, the significance of variables in the demand equation improves and the values of flexibilities become more plausible. Note also the value of the DW test declining from 1.69 to 1.49 but remaining in the inconclusive region.

## CHAPTER IV USE OF THE MODEL FOR POLICY ANALYSIS

The effects on the hog market of the Spain's accession into the European Community are analyzed using the estimated hog model (equations [40] and [41]). The model is designed to include the essential features of the Spanish hog sector: dynamic and production characteristics of the hog sector as well as output and input prices. The model can be used to simulate the evolution of the hog market without integration. The effects of entry are determined comparing the evolution of the hog market with and without integration into the European Community for the period 1986 to 1990, and welfare measures are calculated. Structural change caused by the entry into the EC may affect the simulation results and surplus measures. Potential structural change is checked by examining if the model simulates properly the historical scenario (entry scenario) and further evidence of structural change may then be drawn from usual tests for structural change.

### 4.1 Welfare analysis

Welfare analysis is performed distinguishing two groups of market participants, hog producers and hog consumers. The welfare gains and losses accruing to these two groups are calculated using economic surplus measures. Economic surplus is given by the change

in the areas under the demand curve and above the supply curve for each scenario (See figure 9 in page 103).<sup>44</sup>

Demand is estimated at the wholesale level (live hog prices and carcass quantities) because no data are available at the final consumption level. Surplus measured along the wholesale demand is equal to final demand surplus under two conditions: when there are fixed proportions between marketing inputs and farm products and when marketing inputs are available at given prices (earn no rents).<sup>45</sup> The surplus measure presented here is used as an approximation and is most correct when these two conditions are met.

In the present analysis the surplus measure will indicate to what degree consumers and producers in the hog market are affected. This should provide the Spanish government and market participants with useful information to assess the effects of the enlargement on the groups associated with the sector.

Gains and losses are measured using the model estimated with

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<sup>44</sup> Both Deaton et al. (1980) and Just et al. (1982) indicate the problems arising from the use of producer and consumer surplus. The correct procedure is to employ the concepts of compensated variation or equivalent variation. Consumer surplus derived from Marshallian demand curves is only valid when preferences are homothetic, however since compensated and equivalent variation are difficult to determine, a solution is to use the Willig (1976) result that when income elasticity and relative change in surplus to total income are small, then consumer surplus is a good approximation to measure welfare (this is the case here because income elasticity is less than 0.5 and the calculated change in consumer surplus to total income is roughly below 1.2 percent). Note also that, as Just et al. indicate, the estimation error often has a larger magnitude than the error derived from using consumer and producer surplus.

<sup>45</sup> See Gardiner, 1990, pp. 223-37, and Just et al., 1982, p. 447.

observations up to 4/85, just before accession, for a four-year horizon, and the possibility of structural change in the model after 1986 is explored. Two scenarios are compared: Spain not joining the EC, and Spain joining the EC and welfare measures are derived from prices and quantities under both scenarios. Trade occurs only in the case of accession and it enters into the simulation through the identity: consumption = net imports + domestic production. In both scenarios, variables  $T$  and  $T^2$  take the corresponding next values and dummy variables take the values corresponding to the season.

The non-accession scenario of price and quantity is simulated based on the following premises: the exogenous variable compound feed (input) price is calculated for non-accession levels and the rest of the exogenous variables, beef and chicken quantities and income, are specified at their actual level during the simulation period.<sup>46</sup> The evolution of the compound feed price is an important factor to consider in the non-accession scenario. A suitable procedure to ascertain its evolution would be to use least-cost rationing formulation. The steps would be, first determine the ingredient prices for the non-accession scenario (e.g. world market prices for corn), second calculate the least-cost ration, and finally obtain a shadow price corresponding to this least cost. The series of this constructed price would be used as the non-accession scenario path of compound feed price. However, the work done along these lines indicates that information on least-cost formulation is

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<sup>46</sup> The use of actual as opposed to forecasted values is done to reduce the effects of their forecast errors in the analysis.

almost impossible to obtain (both at the aggregate and micro levels). Also, it is not clear that this least-cost rationing approximates well the behavior of compound feed firms which incorporate financial goals as well as the least cost mix.

An alternative would be to use barley price as a proxy (before accession, hog compound feed absorbed 80 percent of the large domestic barley production; Buxadé, 1988). However, since there have been large changes in ingredient utilization recently, it is judged preferable to make assumptions directly on the evolution of compound feed price. In this context, a more reasonable alternative for the non-entry scenario is that compound feed prices follow the historical pattern.

Producer and consumer surplus are derived from the supply and demand equations [40] and [41]. Producer surplus is given by the integral of the supply equation with respect to  $PH_t$  from  $PH_t^N$  to  $PH_t^E$ .<sup>47</sup> Producer surplus also depends on the path of prices and quantities because supply adjusts to lagged prices. Two producer surplus measures are defined following LaFrance and de Gorter (1985), "ex-ante" and "ex-post" (figure 9).<sup>48</sup> The "ex-ante" surplus is defined by the integral of the supply equation with respect to  $PH_t$  from  $PH_t^N$  to  $PH_t^E$  holding lagged hog prices and other supply shifters at actual levels ( $PH_t^E$  and  $PCF_t^E$ ),

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<sup>47</sup>  $PH_t^N$  is hog price in the non-entry scenario and  $PH_t^E$  is hog price in the entry scenario.

<sup>48</sup> Because the supply equation does not respond to contemporaneous output and input price changes, it is a perfect inelastic supply curve in period  $t$  (very short run) as depicted in figure 9.

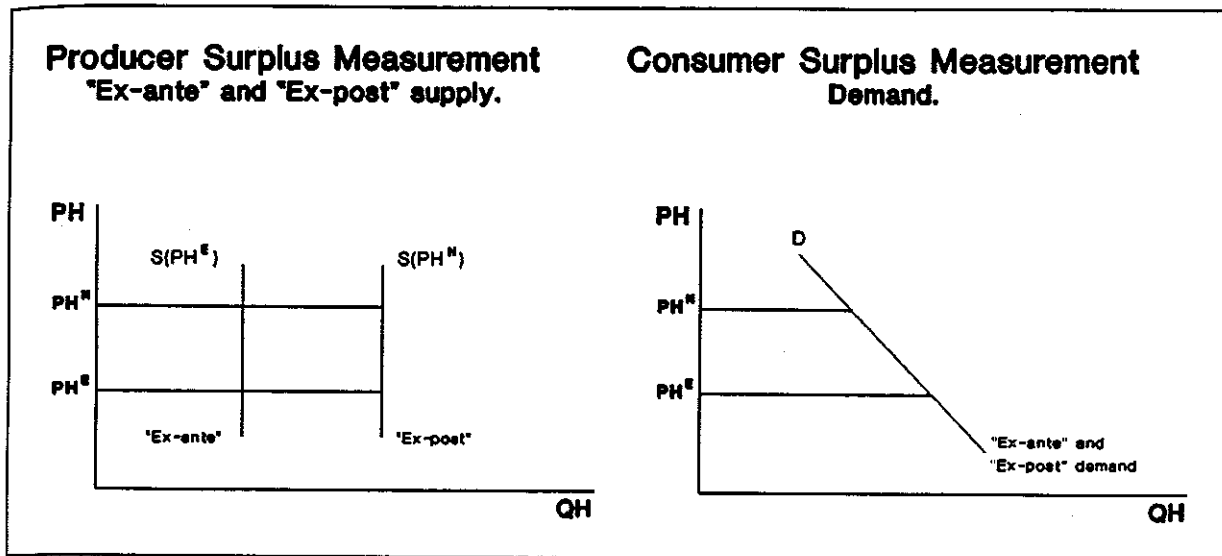


Figure 9 Producer and consumer surplus measurement

$$[42] \quad PS_t^E = \{ f_0 + f_1 PH_{t-2}^E + f_2 PCF_{t-2}^E + \dots + f_{23} PH_{t-13}^E + f_{24} PCF_{t-13}^E + f_{25} T_t + f_{26} T_t^2 + f_{27} D_{1t} + f_{28} D_{2t} + f_{29} D_{3t} \} (PH_t^E - PH_t^N)$$

Here the supply curve is presumed to adjust to actual entry prices  $PH_t^E$  and  $PCF_t^E$ , instead of to non-entry prices  $PH_t^N$  and  $PCF_t^N$ , implying that the shifts in the supply schedule are governed by entry prices and not by non-entry prices. LaFrance and de Gorter point out that this "ex-ante" approach is not consistent with simulation of non-historical (non-entry) prices and quantities ( $PH_t^N$  and  $QH_t^N$ ) contradicting the adjustments postulated in the model. Nevertheless, they indicate that the "ex-ante" approach is more precise because it relies on the levels of supply close to actual data.

The "ex-post" producer surplus is given by the integral of the supply equation holding prices at non-entry levels  $PH_t^N$  and  $PCF_t^N$



$$[43] \quad PS_t^N = \{f_0 + f_1 PH_{t-2}^N + f_2 PCF_{t-2}^N + \dots + f_{23} PH_{t-13}^N + f_{24} PCF_{t-13}^N + f_{25} T_t + f_{26} T_t^2 + f_{27} D_{1t} + f_{28} D_{2t} + f_{29} D_{3t}\} (PH_t^E - PH_t^N)$$

Consumer surplus is defined as the integral of the demand equation, expressed in quantity dependent form, with respect to  $PH_t$  from  $PH_t^E$  to  $PH_t^N$ :<sup>49</sup>

$$[44] \quad CS_t = \{h_0 + h_2 QBCA_t + h_3 QCCA_t + h_4 ICA_t + h_5 D_{1t} + h_6 D_{2t} + h_7 D_{3t}\} (PH_t^N - PH_t^E) \cdot POP_t + 1/2 h_1 (PH_t^N - PH_t^E)^2 \cdot POP_t$$

Consumer surplus is the same measured following the path of historical prices  $PH_t^E$  or the path of non-entry prices  $PH_t^N$ , because lagged prices do not shift the demand curve, i.e. there is no adjustment process in demand.

Simulation of the non-entry scenario is performed with the hog

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<sup>49</sup> Equation [44] comes from equation [41]. The steps to arrive at [44] are the following: first, QHCA is expressed in terms of the other variables (note the h's are the estimated coefficients for the individual variables divided by the estimated parameter for QHCA<sub>t</sub>),

$$(1) \quad QHCA_t = h_0 + h_1 PH_t + h_2 QBCA_t + h_3 QCCA_t + h_4 ICA_t + h_5 D_{1t} + h_6 D_{2t} + h_7 D_{3t}$$

and total quantity is:

$$(2) \quad QH_t = (h_0 + h_1 PH_t + h_2 QBCA_t + h_3 QCCA_t + h_4 ICA_t + h_5 D_{1t} + h_6 D_{2t} + h_7 D_{3t}) \cdot POP_t$$

then, the integral of quantity demanded with respect to  $PH_t$ , from  $PH_t^E$  to  $PH_t^N$ , gives the measure of consumer surplus:

$$(3) \quad CS_t = \{h_0 + h_2 QBCA_t + h_3 QCCA_t + h_4 ICA_t + h_5 D_{1t} + h_6 D_{2t} + h_7 D_{3t}\} (PH_t^N - PH_t^E) \cdot POP_t + 1/2 h_1 (PH_t^N - PH_t^E)^2 \cdot POP_t$$

model. Compound feed price is calculated from an ARIMA specification with the other exogenous variables (beef, chicken and income) all in per capita terms, taking the actual values.<sup>50</sup> The results are presented in table 17 and figures 10 and 11.

Under the non-entry scenario prices are higher than the corresponding values under entry and quantities level off. This is consistent with the prevailing lower prices in the EC markets which influenced the Spanish market under accession. Lower EC prices imply a surge in Spain's hog imports, a drop in the Spanish domestic price and an increase in domestic consumption as the total quantity available expands. Overtime, the actual expansion in total quantity is made up of relatively reduced domestic supply, because domestic prices are falling, and growing imports.<sup>51</sup>

Prices are much higher in the non-entry scenario than in the entry scenario specially in the winter of 1987 and spring of 1988. These low prices under entry involve large losses for hog producers and large gains for consumers.

The economic surplus calculations are derived from equations [42], [43] and [44], but first a discussion of structural change follows in the next section. If structural change exist, it affects the measurement of economic surplus and has to be taken into

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<sup>50</sup> See Appendix II for details on the ARIMA specification.

<sup>51</sup> In the structural change section, the demand equation [41] is simulated under the entry scenario. Because under the entry scenario there are imports coming to the Spanish market, these imports are included in the variable  $QHCA_t$ , hog consumption, in simulating the demand equation [41] and the demand equation incorporating structural change [45].

Table 17 Simulation of the non-entry scenario

	Non-entry		Entry	
	Domestic supply 1000 MT	Price pta/kg	Total supply <sup>a</sup> 1000 MT	Price pta/kg
1/86	380	249	359	231
2/86	338	225	363	225
3/86	330	224	339	225
4/86	412	230	406	201
1/87	407	239	398	187
2/87	369	214	346	181
3/87	363	215	366	183
4/87	445	221	434	167
1/88	437	228	460	154
2/88	395	206	434	148
3/88	384	210	408	170
4/88	460	219	470	167
1/89	449	225	469	172
2/89	404	207	454	170
3/89	392	211	402	204
4/89	468	219	457	181
1/90	457	222	483	164
2/90	413	204	421	162

<sup>a</sup> Total supply is made up of domestic supply and imports.

### Hog Quantity Simulation Scenarios for Spain not joining and joining the EC. Total hog availability.

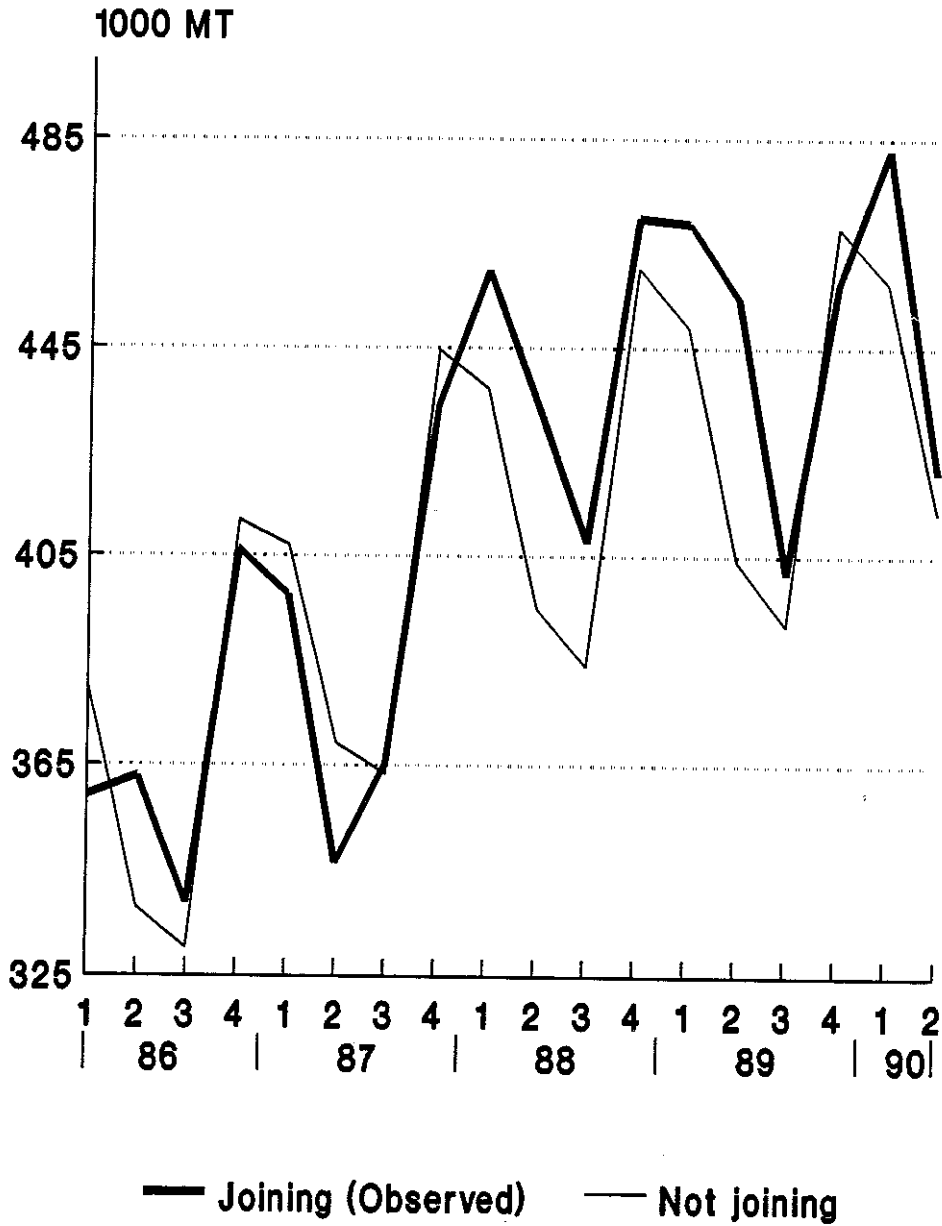


Figure 10 Simulation of hog quantity for the non-entry scenario

### Hog Price Simulation Scenarios for Spain not joining the EC and joining the EC



Figure 11 Simulation of hog price for the non-entry scenario

consideration.<sup>52</sup>

#### 4.2 Structural change

Structural change is examined by assessing the ability of the model to simulate the actual outcomes of the entry scenario. Further evidence is obtained by using the Chow and CUSUM tests (Krämer and Sonnberger, 1986). The model estimated through 1985 is utilized to calculate predictions of hog quantities and prices by using the actual values of the exogenous variables (compound feed price and per capita beef, chicken and income) and including imported hog quantities. The results are portrayed in figures 12 and 13, giving an indication of the ability of the model to track hog prices and quantities. It is clear that the primary problem lies in the demand equation which persistently overpredicts hog prices.

To examine more precisely the performance of each separate equation, the actual values for the right hand side variables are used in calculating predictions from the supply and demand equations. Figures 14 and 15 illustrate the outcome: while the average absolute percentage error for total hog quantity is 7.1 percent

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<sup>52</sup> Due to data limitations and the focus of the study, it is not possible to completely identify the welfare effects of the entry on hog producers with solely fattening operations and the cereal sector. These hog producers gain somewhat from piglet imports at low prices. However it seems that any gains to them derived from cost savings in buying piglets are largely offset by the steep drop in hog prices during the period. With respect to cereal producers, they are affected by developments in the hog market, specially barley growers. The effect can not be measured here, but it likely compounded the adverse effect of the EC policies of reducing cereal prices.

### Hog Quantity Simulation Simulation of the model for the entry scenario. Domestic supply.

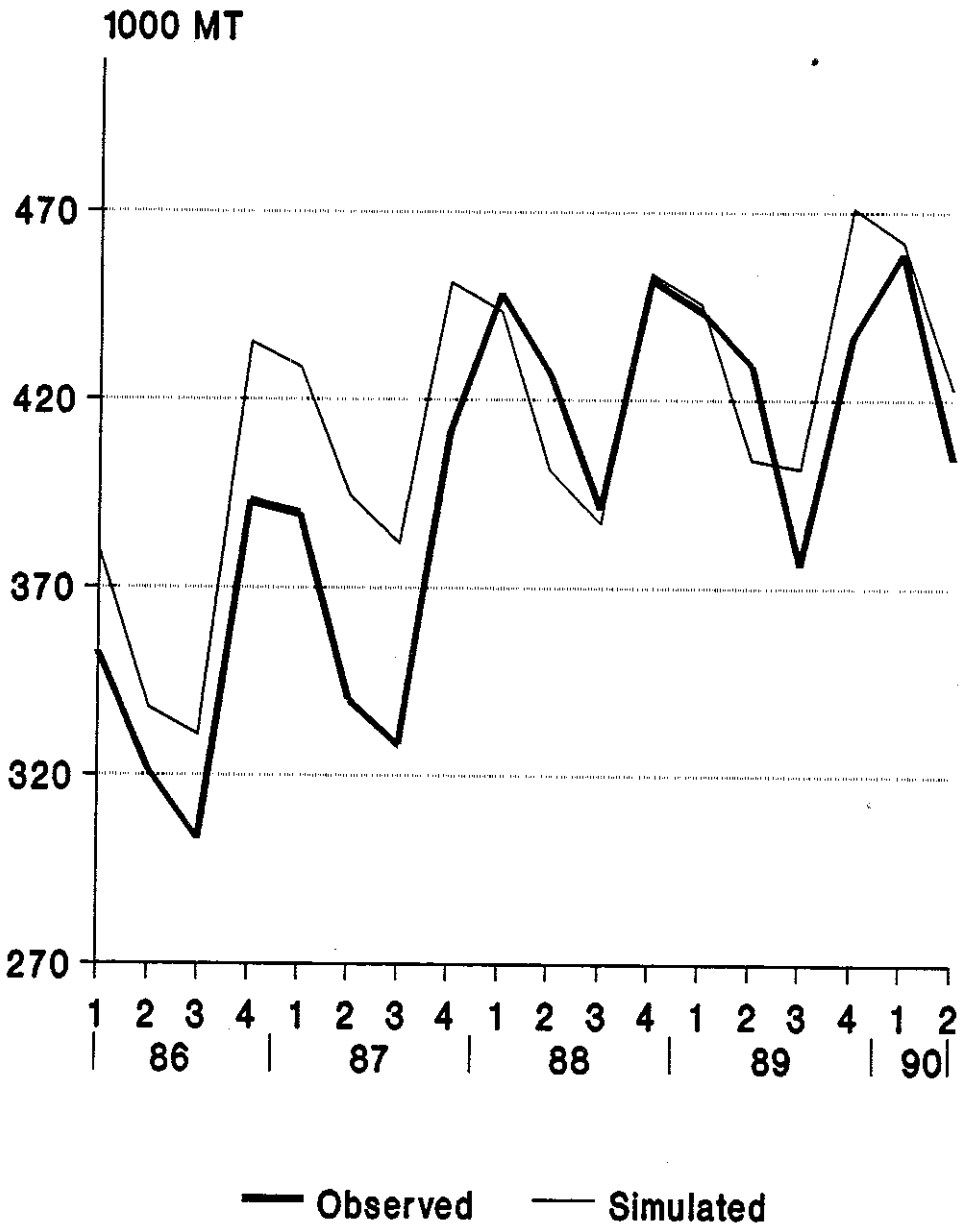


Figure 12 Simulation of hog supply under entry

### Hog Price Simulation Simulation of the model for the entry scenario

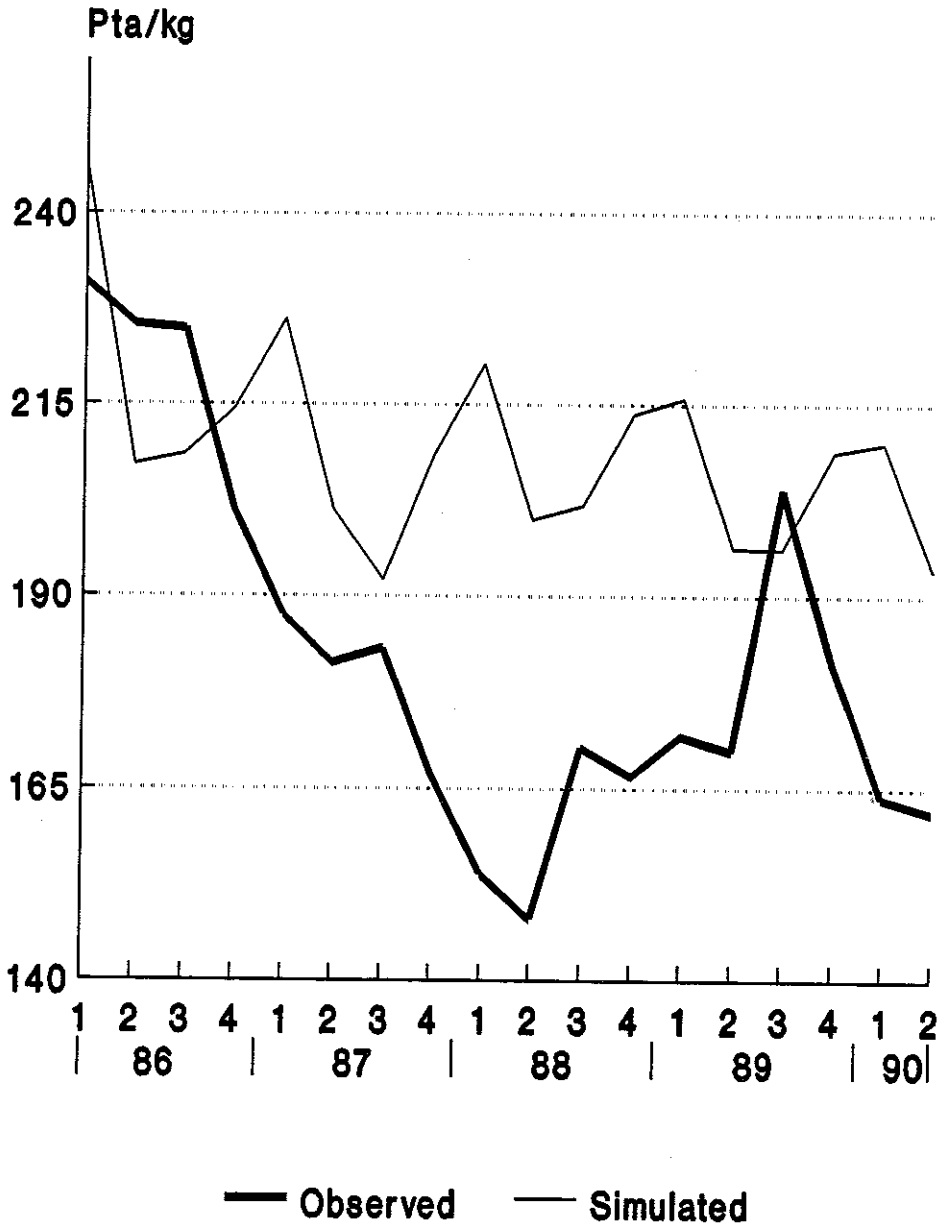


Figure 13 Simulation of hog price under entry

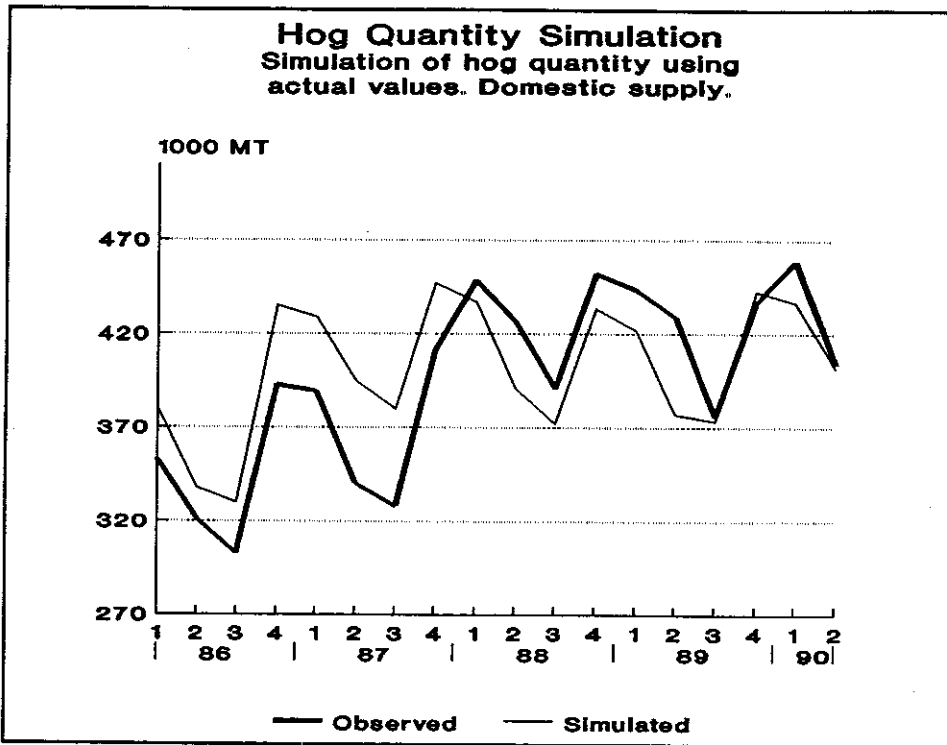


Figure 14 Simulation of hog quantity using actual values

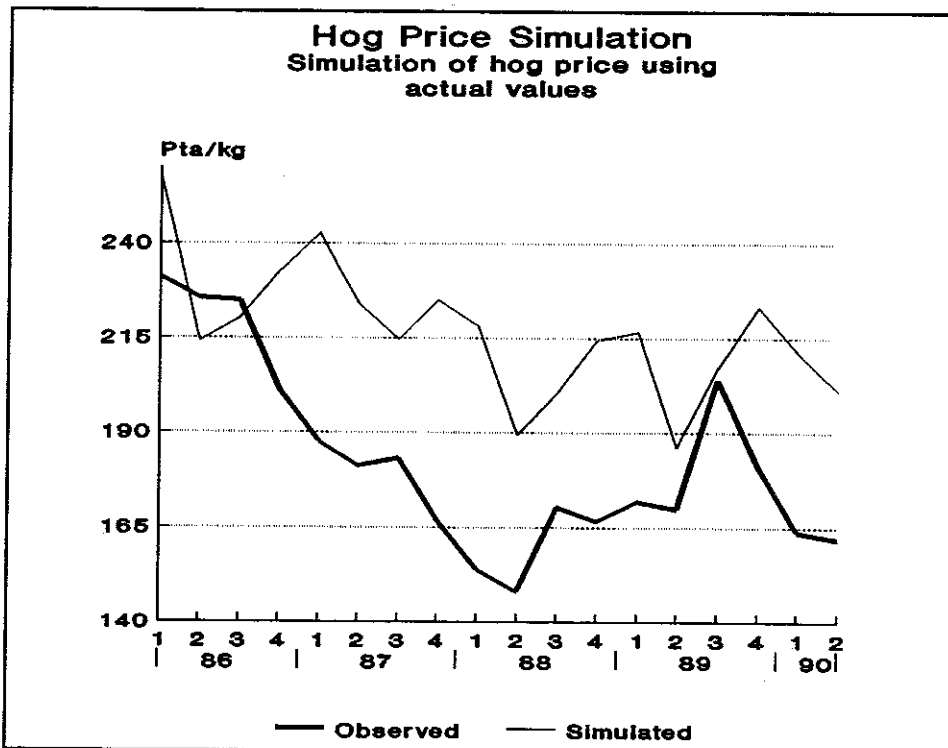


Figure 15 Simulation of hog price using actual values

indicating an adequate performance by the supply equation, the demand equation error in predicting hog price is 20.4 percent.

Structural change in supply and demand is checked by using the Chow and recursive residuals tests. Because previous testing was used to modify the specification, these structural tests must be viewed as diagnostics. The tests also are limited by the presence of autocorrelation in both supply and demand equations which may make the results frail.<sup>53</sup> Structural change is not detected by the CUSUM test neither in the supply nor in the demand equation. The Chow test is performed on the demand equation with break point around 1986 but it also fails to detect structural change. Because autocorrelation makes the tests results not very compelling, more emphasis is given to the poor prediction performance of the demand equation during the 1986-1990 period in considering the occurrence of structural change.

The persistent overestimation in hog prices indicates that demand may have become more inelastic. To capture structural change, the demand equation has been re-estimated up to 1990 allowing initially for a change in the coefficients of variables QHCA, QBCA and QCCA, with breaking point in 1/86. Because the estimation results were unexpected and imprecise, with an unexpected sign in QBCA and lack of significance in variables QBCA and QCCA, the focus in the analysis of structural change is placed in varia-

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<sup>53</sup> Krämer et al. (1986, p. 70) indicate that the Chow and recursive residuals tests "require that the assumptions of the standard linear regression model hold under the null hypothesis (possibly excluding normality)".

ble QHCA examining the possibility of a change in its slope.

The demand equation has been estimated imposing the constancy of the coefficients in variables QBCA and QCCA. This constancy was examined with a Wald test and the null hypothesis of constancy was accepted ( $\lambda_w=0.64$  and  $\chi^2_{2,0.05}=5.99$ ). Results of estimation are:

$$[45] \quad PH_t = 435.43 - (16.32 + 3.97) QHCA_t - 9.45 QBCA_t - 13.79 QCCA_t$$

(1.35)\*\*

$$+8.95 ICA_t - 3.59 D_{1t} - 39.72 D_{2t} - 32.18 D_{3t}$$

(5.46)\*                      (4.44)                      (5.33)\*\*                      (3.47)\*\*

Flexibilities

QHCA	-0.52	
QBCA	-0.10	$\rho = 0.82$
QCCA	-0.25	(0.06)**
ICA	0.27	

$$\bar{R}^2=0.95 \quad DW=1.49 \quad AIC=673.54 \quad SC=697.11$$

The results indicate a significant change in the slope of QHCA as the coefficient increases by 3.97 after entry. The incorporation of structural change in the demand equation implies a significant improvement in hog price predictions. The average absolute percentage prediction error decreases from 20.4 to 7.3 percent, and is similar to the prediction error found in the supply equation (figure 16).

Demand becomes more inelastic after entry into the EC, with implied elasticity dropping in absolute value from 2.6 to 1.9. Conceptually, this direction of change towards a more inelastic demand is somewhat puzzling. With accession into the EC the Spanish domestic market becomes part of a larger market with the number of

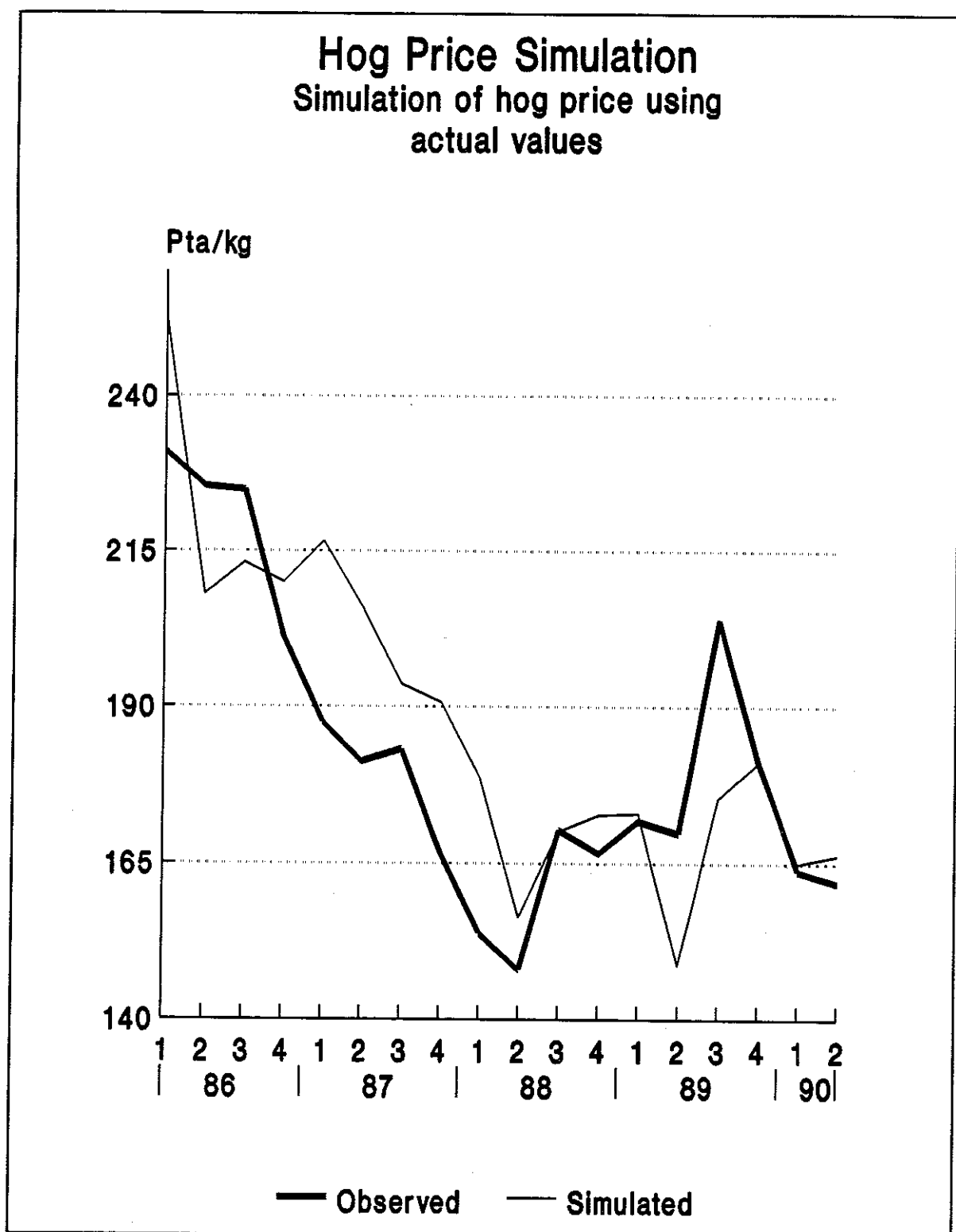


Figure 16 Simulation of hog price using actual values allowing for structural change

substitute products eventually expanding which would imply a more elastic demand. In part, this effect is offset by the relatively few number of substitute products available at the wholesale (carcass) level where product differentiation is less important.

Several other factors also may have resulted in the estimates of demand being more inelastic. Changes in consumer preferences related to dietary and health concerns may have reduced the consumption even as prices were falling after 1985.<sup>54</sup> Another possible explanation is that producer prices may have fallen due to some uncertainty over the effects of permitting imports in the Spanish market. In an environment where buyers face higher price uncertainty, a strategy that includes lower buying prices may assist in absorbing the greater market risk.

#### 4.3 Producer and consumer surplus changes

The economic surplus calculations are based on the non-entry and entry prices and quantities presented in table 17 and are given in million constant (1989) pesetas. "Ex-ante" and "ex-post" surplus changes are derived from equations [42], [43] and [44],<sup>55</sup> and presented in figure 17 and table 18.

Welfare analysis indicate that, regarding the hog market, gains from entry into the European Community exceed losses.

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<sup>54</sup> The amount of fat in pork is considerable and "per capita" consumption is quite high, above 40 kg/inhabitant/year.

<sup>55</sup> Equation [44] is the demand equation incorporating structural change.

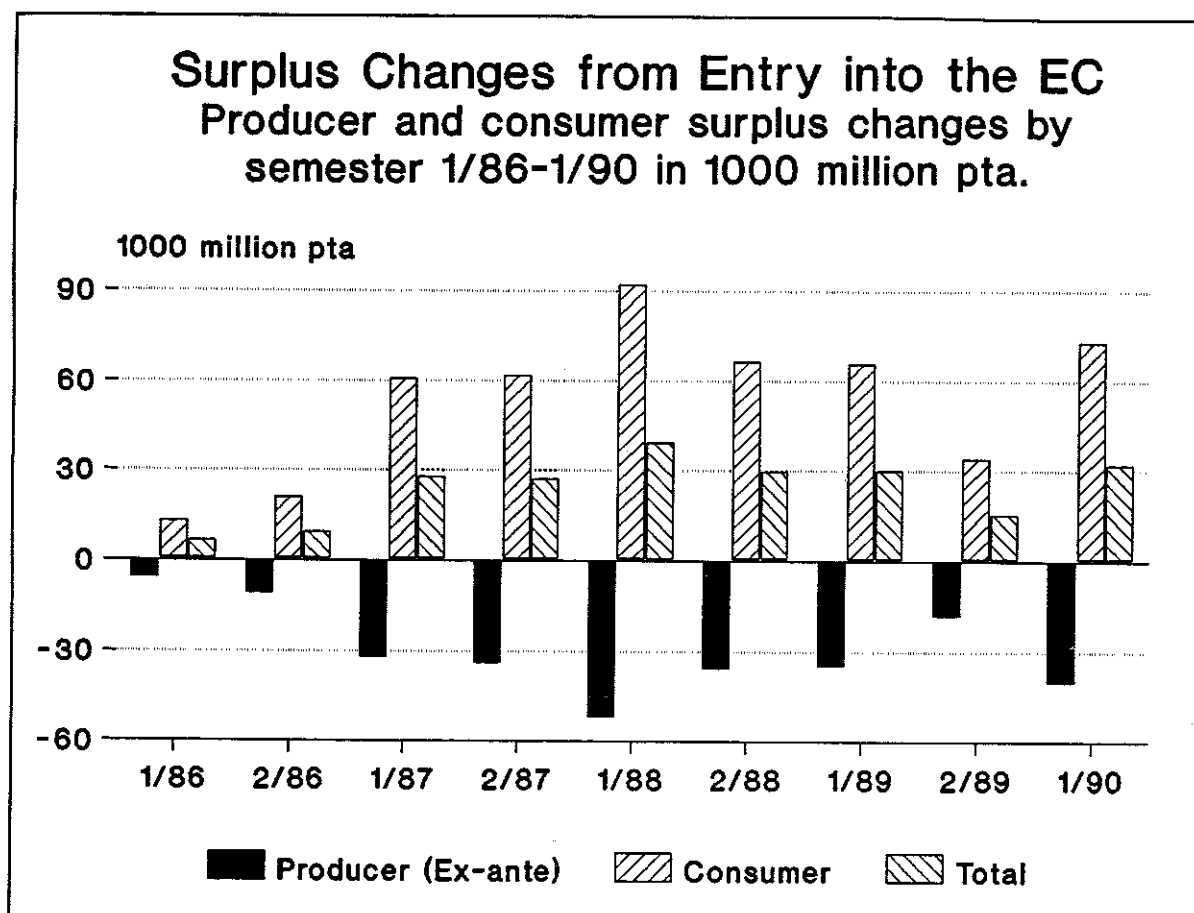


Figure 17 Economic surplus changes by semester 1986/1-1990/1 from the entry into the EC

However, losses are very large for hog producers and compensation to them has been limited. Total hog carcass market sales for the period 1/86 to 2/90 are 1,352 billion pesetas,<sup>54</sup> and total losses to producers range from the "ex-ante" 270 to the "ex-post" 284 billion pesetas estimates. These losses in producer surplus represent 20 percent of the total market sales over the period. The severity of the losses for hog producers is apparent during 1988 (figure 17); producer surplus losses average 32 percent of market sales for quarters 4/87 to 1/89 and 37 percent of market sales for

<sup>54</sup> Calculated from table 17.

Table 18 Economic surplus changes 1986/1-1990/2 from the entry into the European Community

	Surplus change in supply 10 <sup>6</sup> pta		Surplus change in demand 10 <sup>6</sup> pta		Total change in surplus 10 <sup>6</sup> pta	
	Ex-ante <sup>a</sup>	Ex-post <sup>a</sup>	Ex-ante and Ex-post		Ex-ante	Ex-post
1/86	-6780	-6780	13755		6975	6975
2/86	300	300	-636		-336	-336
3/86	352	353	-761		-409	-408
4/86	-11850	-11897	21679		9829	9782
1/87	-20672	-20779	37700		17028	16921
2/87	-12113	-12243	22839		10726	10596
3/87	-11468	-11719	22221		10753	10502
4/87	-23240	-23883	39461		16619	15578
1/88	-31125	-32311	53260		22135	20949
2/88	-21570	-22769	38620		17050	15851
3/88	-14260	-15320	27500		13240	12180
4/88	-22228	-23878	38725		16497	14847
1/89	-22018	-23885	39688		17670	15803
2/89	-13583	-14962	25959		12376	10997
3/89	-2482	-2749	5121		2639	2372
4/89	-16145	-17544	28790		12645	11246
1/90	-24635	-26606	43254		18619	16648
2/90	-16253	-17518	29669		13416	12151
<b>Total</b>						
1/86-2/90	-269770	-284190	486844		217074	202654

<sup>a</sup> The "ex-ante" surplus change is based on supply quantities calculated holding past hog and feed prices at "entry" levels ( $PH_t^E$  and  $PCF_t^E$ ). The "ex-post" change in surplus is calculated holding past hog and feed prices at "non-entry" levels ( $PH_t^N$  and  $PCF_t^N$ ).

quarters 4/87 to 2/88. The claim made by hog producers that they have suffered large losses derived from the entry into the EC seems warranted.

Upon entering the Community, Spanish agricultural policy makers were confronted with the stabilization in market support expenditures introduced by the reform of the Common Agricultural Policy (CAP). Their objective was to obtain large funds from the EC to be applied in underdeveloped or declining Spanish regions, and not in pressing for funds directed to sectors, such as the hog sector, that were suffering heavy losses because of the entry.<sup>57</sup> Furthermore, Sanchez (1989) indicates that from the 441 billion current pesetas that came from the EC agricultural intervention agency (EGGAF) to support agricultural markets' prices between 1986 and 1988, only 2.7 billions which is less than 1 percent of the total were applied to support the hog market and those funds were mostly in the form of export subsidies to non-EC countries. That is a very small fraction of the calculated 170-180 billion pesetas<sup>58</sup> in welfare losses absorbed by hog producers between 1986 and 1988.

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<sup>57</sup> There are three sources of EC financing for development of poor or declining regions; the European Agriculture Guidance and Guarantee Fund (EAGGF), The European Regional Development Fund (ERDF), and the European Social Fund (ESF). The "guarantee" section of EAGGF is the instrument to support market prices and the "guidance" section with much more limited resources is used to finance basic changes in the structure of the agricultural sector. ERDF and ESF funds go to poor and declining regions within the European Community. Expenditures in 1983 in current million ECU's were: EAGGF-Guarantee, 15848; EAGGF-Guidance, 750; ERDF, 2406; ESF, 1020. Clearly the strategy of Spanish decision makers is to press for enhanced development funds which would flow to poor regions in southern countries such as Spain.

<sup>58</sup> 1989 pesetas.

Clearly, there has been a trade-off for agricultural policy decision makers in Spain between pressing for EC development assistance and pressing for market support funds to be applied in depressed markets such as the hog market.

However, hog producers have been adversely affected and the compensation granted to them has been very limited covering less than 2 percent of their losses. The group of producers bearing the burden of adjustment to the new competitive Community environment has been the traditional or "family" type producers. Low hog prices are forcing many of them to go out of business and the remaining ones face an unfavorable outlook.

A second consideration for decision makers has been the gains accruing to consumers (and meat processors) from the expanded hog supply at low prices. Gains to consumers from 1-86 to 2-90 are 487 billion pesetas, which represent an average of 36 percent of total market sales during the period. These gains to consumers are considerable doubling the losses accruing to producers, and their importance should not be underestimated. The gains allowed policy decision makers to advance broader economic objectives such as reduced inflation goals.

A third consideration for decision makers, apart from the gains to consumers, has been the long-run effects of entry into the EC. A more competitive environment would facilitate technological improvements and lower costs, resulting in a more efficient hog sector with a vast potential market. Producers are being asked to face these new challenges and the new opportunities.

## CHAPTER V SUMMARY AND IMPLICATIONS

This study presents an examination of the effects on the Spanish hog industry of Spain's accession into the European Community. The hog industry is the largest component of the Spanish livestock sector and developments in this industry affects the whole Spanish agricultural system. Its intense growth in recent decades in production and consumption has been driven by technological advances and favorable price relationships. Its selection for analysis reflects its importance to the livestock sector and close linkages that exist to the grain sector and meat processing industries.

Hog producers have experienced increasing competition from European Community markets since accession, and have claimed that they suffered large losses because of entry into the EC. Due to falling prices, specially during 1987 and 1988, producers' organizations complained to the government and lobbied for protective measures, which were finally granted briefly to them in mid-1988 after large demonstrations in many parts of the country. This study analyzes the impact of accession into the EC on the Spanish hog market and identifies gains and losses to market participants. Based on an econometric representation of the Spanish hog market, gains and losses absorbed by the hog market economic agents are quantified. Recognition and measurement of these gains and losses,

as well as knowledge of the dynamics of the market, provides important information to policy decision makers, private and cooperative meat processing companies and farmers' organizations.

### 5.1 Summary

A quarterly econometric model capturing the constancies and operation of the hog market is used in the analysis. The model includes causal relationships, technological change and other information about this complex system. The relevancy of several price expectations mechanisms (i.e. naive, polynomial distributed lags, adaptive and rational expectations) to the Spanish hog market is examined. Structural change induced by accession also is assessed.

The model is used to derive the welfare consequences of accession by simulating the evolution of the hog market had Spain not entered the EC. The effects of entry are then assessed by comparing the evolution of the hog market with and without accession into the EC, and calculating from these two scenarios gains and losses to producers and consumers.

The Spanish hog industry is less productive than the leading European Community hog producers, Netherlands, Germany and Denmark, although integration by large companies in recent decades and the introduction of modern technology has improved the competitive position of the hog industry. In general, there are two groups of Spanish hog producers, traditional (or "family") and modern produ-

cers. Traditional producers lack up-to-date management and production techniques and are very small in size. This small size implies limited resource availability which precludes improvements in their production facilities. Modern producers use improved technology and are highly integrated. Spanish hog producers are integrated under two types of organization; integration by contract in a private company or integration by membership in a cooperative. The implications of integration for the hog sector are a high degree of sensitivity of production and input usage to price changes and to changes in technology. The improvement in production technologies driven by integration in large companies has resulted in a large expansion in hog production which has increased at a rate of more than 7 percent a year since 1965, and in a decreasing hog-compound feed price ratio. In spite of these improvements, there remains a sizable component of the sector consisting of small farms with outdated facilities. Two other factors which are important in considering the structure of supply are the existence of cycles in quantities and prices and the strong seasonality in output.

Consumption of pork "per capita" in Spain is near the EC average but meat consumption patterns for other meats differ greatly between Spain and the other EC countries. Pork consumption has expanded vastly in the last 20 years, an expansion facilitated by the moderate pork price. The drop in hog prices after entry into the EC has caused some additional expansion in hog consumption mainly derived from imports.

Hog trade after accession is almost exclusively done within

the EC. While hog exports were not allowed up to mid-1989, hog imports have been around 100,000 metric tons a year (6 percent of consumption) since entry in 1986, Netherlands being the main supplier. These imports are explained by the price differences and the good marketing networks of large foreign firms.

The hog market is represented by an econometric model consisting of a supply and a demand equation specified as linear. The model includes hog and compound feed prices and hog quantities, technology, income level, and behavior of related markets. Inventories are not included because they are very small and do not influence price determination. On the supply side, lack of data precludes disaggregating production into feeding and breeding components. External trade, although expanding after accession, has been historically insignificant; this lack of trade prior to accession prevents the estimation of a trade behavioral equation and as a consequence net imports enter the analysis exogenously.

Specifically, the supply equation was specified under alternative expectations mechanisms: naive, polynomial lags, adaptive and rational expectations. The alternative mechanisms are examined through parametric and non-parametric validation techniques using non-nested hypothesis testing and performance measures based on out-of-sample forecasts. The demand component of the model was formulated within a single equation price-dependent framework where price is influenced by quantity and substitutes' quantities, income, population and preferences.

The procedures used to estimate supply and demand depended on

the particular specification. Naive supply was estimated by ordinary least squares, and supply under polynomial distributed lags was estimated by a restricted least squares estimator where the polynomial structure on the lag weights is introduced as constraints to the initial model. Adaptive and rational expectations require a non-linear procedure if the structural rather than the reduced observable form coefficients need to be calculated. The equations were estimated with quarterly data for the period 1/71 to 4/82, the data for period 1/83 to 4/85 being used for post-sample prediction tests.

Selection of the best expectations mechanism is performed by first completing significance, sign and size checks and eliminating the specifications that fall short of minimum requirements. Then the models are compared by implementing non-nested and post-sample predictive procedures. A final model is selected through an overall performance examination.

Problems with collinearity, lack of significance, wrong signs, and inadequate prediction ability make questionable the use of the adaptive and rational specifications. Among the remaining specifications some tests favor the naive-ratio specification but other tests fail to differentiate between specifications.<sup>59</sup> In light of the tests results, there is little to choose between the naive and polynomial specifications. The polynomial supply is selected because it allows for more flexibility in specifying the supply

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<sup>59</sup> In the naive-ratio specification, supply is specified under naive expectations and prices are in a ratio form.

elasticities and also because these elasticities are more similar to elasticities found in previous studies. The characteristics of the polynomial supply are: third degree polynomial with lag lengths from  $t-2$  to  $t-13$ , the mean lag response for hog price is 6.33 and the mean lag response for compound feed price is 8.60 (supply responds more rapidly to output price changes than to input price changes), 0.78 hog price elasticity and -0.62 compound feed price elasticity.

The price dependent hog demand is specified in per capita terms. The more significant variables in the demand equation are pork consumption, income and the seasonal variables.

The estimated hog model is used to analyze the effects on the hog market of Spain's entry into the EC. The effects of entry are calculated comparing the evolution of the hog market with and without entry into the EC for the period 1986 to 1990, and computing welfare measures. Two groups of market participants are distinguished: hog producers and pork consumers. Economic surplus measures are used to compute gains and losses accruing to producers and consumers. Two producer surplus measures are defined, "ex-ante" and "ex-post" which depend on the path of past prices, supply adjusting to lagged prices. The "ex-ante" surplus change is based on supply quantities calculated at entry hog and feed price levels, a procedure which yields more precise results.

For the non-entry scenario, quantities are smaller and prices higher than the corresponding values of the entry scenario. Under entry there is a surge in hog imports, a drop in the Spanish domes-

tic price and an increase in domestic consumption, which expands total quantity available. This expansion is made up of reduced domestic supply, because domestic prices are falling, and growing imports. Hog prices are much higher in the non-entry scenario, specially in the winter of 1987 and spring of 1988. The low prices under entry involve large losses for hog producers and large gains for consumers.

Structural change is detected in the demand equation which affects the measurement of economic surplus. Incorporation of structural change in the demand equation results in a significant improvement in hog price predictions (the average absolute percentage error is reduced from 20.4 to 7.3). Demand becomes more inelastic with elasticity changing from -2.6 to -1.9. The income elasticity for the final equation is 0.5. Although this results may seem somewhat strange, there are reasons that explain this direction of change in the demand elasticity. One is the reduced availability of substitute products at the wholesale (carcass) market level. Other factors also may have resulted in the estimates of demand being more inelastic. Changes in consumer preferences may have reduced the consumption even as prices were falling after 1985. Another possible explanation is that producer prices may have fallen due to the uncertainty over the effects of permitting imports in the Spanish market. In an environment where buyers face higher price uncertainty, a strategy that includes lower buying prices may assist in absorbing the greater market risk.

Welfare measures indicate that in the hog market, direct gains

from entry into the European Community exceed direct losses. Consumers gained considerably through increased imports from the Community at lower prices. During the period 1/86 to 2/90, gains to consumers are estimated at 487 billion pesetas representing 36 percent of market sales. Clearly, these gains are very important to the pork consumer and permitted policy decision makers to further advance broader economic objectives such as reduced inflation.

However, losses for hog producers are very large and compensation has been limited. During the period 1/86 to 2/90, "Ex-ante" and "ex-post" producer surplus losses are estimated at 270 and 284 billion pesetas, respectively, representing 20 percent of market sales. The magnitude of the losses for hog producers was most pronounced during 1988. Producer losses average 32 percent of market sales for quarters 4/87 to 1/89 and 37 percent for quarters 4/87 to 2/88. Compensation granted to hog producers has covered less than 2 percent of their losses. It appears that the contention made by producers that they experienced large direct losses as a consequence of the entry into the European Community seems warranted.

Finally, in considering the more global effects from entry into the Community to the agricultural sector, it is important to note the development assistance for poor and declining regions. Further, entry into the Community will foster a more competitive environment which will likely increase technological adoption and lower costs resulting in a more efficient hog industry and agricultural sector.

## 5.2 Implications and directions for further research

The results from the study have several implications for developing a better understanding of Spanish agriculture. First, is the recognition of the decisive influence that entry into the EC is having on the hog market. Because of the entry, consumers have clearly improved their welfare and hog producers have been adversely affected. Gains to consumers surpass twofold the losses to producers which indicates a considerable benefit from entry. Meanwhile the government intervention in hog markets to enhance hog producers income have represented less than 2 per-cent of their losses.<sup>60</sup> Given the magnitude of the direct losses, the government might consider evaluating the more general effects of the entry on hog producers. Additional compensation to the hog sector may be warranted. This compensation would be most useful if directed to improve the competitive level of hog producers in Spain and develop marketing instruments to access Community markets.

A second implication comes from the result of the investigation on the expectation formation mechanism that producers pursue in the hog market. It appears that here a rather straightforward modeling procedure captures the flavor of the Spanish hog market. The expected price mechanisms tested are naive, polynomial distributed lags, adaptive and rational expectations. The empirical

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<sup>60</sup> That is in line with reduced EC intervention in the hog market and Spanish policy before accession regarding the hog market. However, national governments may supplement CAP with domestic programs.

evidence supports either the naive or the polynomial distributed lag specifications but not the adaptive and rational expectations hypothesis. Polynomial supply was selected because it allowed more flexibility and produced more reasonable supply elasticities. However, naive and polynomial specifications are less restrictive and can accommodate the data with less demanding requirements.

Selection of polynomial distributed lags does not necessarily indicate that producers are not rational in their outlook. It may suggest that application of the rational expectations framework has been hampered by the deficient quality of data and the complexity of the model. Also, it may suggest the empirical difficulties in using the rational expectations model in heterogeneous environment such as the Spanish hog market. While some producers may behave in a rational manner, there is a sizable group of "traditional" producers which may have a different behavior pattern. Even assuming that both producer groups behave in a rational manner, production constraints for each group may be different, resulting in distinctive response supply functions. With aggregation, rational producers might not be identified as such.

Other reasons that may explain the difficulties in confirming the rational hypothesis are the simplifying assumption that agents know with certainty the process generating the exogenous variables and the assumption that agents subjectivist probability equals the probability generated by the model. Another simplifying assumption is that all information available is used by agents, which contradicts the fact that information acquisition is costly. Previous

empirical studies which have not confirmed the rational hypothesis may also have suffered from these difficulties.<sup>61</sup>

A third implication results from the finding of structural change in demand. It appears that hog prices have become more sensitive to total hog availability. In the context of a Spanish market which is becoming more integrated within the Community market, this means a more rapid transmission of price fluctuations into the Spanish market. It is clear that prices will be determined in the larger European arena with the Spanish market interacting with the rest of the Community. A related research question is the economic structure that determines prices in the different European Community national markets and the degree of integration among markets. This requires a modeling effort capable of including the whole EC hog market.

Several other questions have been not addressed in this research and deserve further investigation. First is the effect of entry into the EC on other large Spanish agricultural sectors such as the cereal sector, and on the whole agricultural sector, and on the entire Spanish economy. Studies assessing the effect of entry on particular markets, as the present study, can be implemented by a partial equilibrium framework. However, a general equilibrium framework must be used to assess the effects of entry on the whole agricultural sector or the entire economy.

Second is the question of trying to distinguish between

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<sup>61</sup> For example, Shonkwiler (1982) tested rational expectations in the Florida escarole market and Baltas (1987) tested quasi-rational expectations for Greek cereals.

producers with breeding, fattening, and breeding to finish operations. Distinction between producers with breeding, fattening, and breeding to finish operations would permit a breakdown of welfare losses by group of producers. Distinction among them depends on data availability, so data collection here is a requisite.

It also is important to develop a better understanding of hog demand. This will require a more comprehensive study of the dynamics of the hog, cattle and poultry markets and the price transmission mechanisms between them. The hog demand equation implemented in this study is static, and non-contemporaneous relationships also may be needed. In addition to a dynamic specification, another possible refinement in the demand equation would be to consider the specification of non-fixed coefficients.

More detailed studies on hog demand, possibly using cross-section data and marketing research techniques, could complement the time series analysis and would give meat processors useful information on consumer preferences and on opportunities in different markets and products. This information is needed to strengthen the position of the hog industry in the domestic market and for expanding its activity to other Community markets. In terms of possible exports two groups of products can be considered: products directed at the wholesale market and products directed at the final consumer market. The more lucrative market is the final consumer market and different strategies may be followed. One is to elaborate pork products for mass consumption according to the

different national tastes. Another option would be to introduce and consolidate high quality Spanish products already used by some foreign consumers.

On balance, the progressive integration of the Spanish market into the EC market is important for decision makers in companies, government and farmers' organizations. The entry has directly affected various groups. The outlook for the industry depends on its ability to increase its competitive level within the EC. Technological change and integration by large firms has facilitated adoption of improved techniques but there is room for productivity improvements by increasing the size of farms and the proportion of more highly integrated farm operations. In addition, to compete in EC markets, it will be important to develop efficient marketing channels distributing pork products adapted to the different national market requirements and tastes. Government programs designed to induce further productivity advances and to facilitate Spanish exports into Community markets would be particularly useful.

**APPENDIX I**

Exchange rate and selected metric equivalences

Exchange rates. ECU, Green ECU<sup>a</sup> and US dollar  
in Spain's pesetas.

	ECU	Green ECU	US dollar
1986	137.5	147.8	139.7
1987	142.2	149.6	123.2
1988	137.6	155.8	116.4
1989	137.6	151.2	118.4
1990	133.6	148.1	96.5

Exchange rates. ECU and Green ECU (meat) by country  
in national currency (1988).

	Germany (DM)	France (FF)	Netherlands (HF)	Italy (LIT)	Spain (PTA)
ECU	2.074	7.036	2.335	1,538	137.6
Green ECU	2.631	7.696	2.647	1,631	155.8

Weight.

1 metric ton (MT) = 1,000 kilograms (kg)

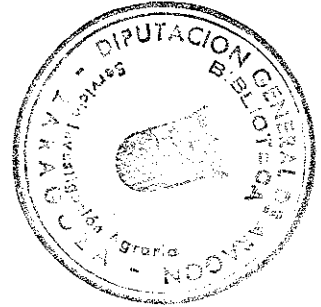
1 kilogram = 2.2 pounds

Capacity.

1 liter = 0.28 US gallons.

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<sup>a</sup> Green ECU exchange rates depend on the country and product under consideration. The green ECU exchange rates given correspond to Spain and pork products.



**APPENDIX II**

Ancillary ARIMA models for the exogenous variables

The auxiliary ARIMA specifications estimated with data up to 4/82, to calculate predictions of the exogenous variables for the 1/83 to 4/85 period are given by;  $QB_t$ : ARIMA(3,0,0)×(1,0,0)<sub>4</sub>,  $QC_t$ : ARIMA(1,0,0),  $I_t$ : ARIMA(4,0,1),  $PCF_{t-4}$ : ARIMA(1,0,0). The results from estimation of these models are:

$QB_t$  (beef quantity)

$$(1 \underset{(0.12)^*}{-0.88} L + \underset{(0.16)^*}{0.66} L^2 - \underset{(0.12)^*}{0.60} L^3) (1 \underset{(0.12)^*}{+0.09} L^4) QB_t = 20.76 + \epsilon_t$$

$$\bar{R}^2 = 0.70$$

$$DW = 2.06$$

$QC_t$  (chicken quantity)

$$(1 \underset{(0.02)^*}{-0.96} L) QC_t = 8.99 + \epsilon_t$$

$$\bar{R}^2 = 0.97$$

$$DW = 2.22$$

$I_t$  (income, deflated)

$$(1 \underset{(0.10)}{-0.06} L + \underset{(0.10)}{+0.11} L^2 - \underset{(0.09)}{0.001} L^3 - \underset{(0.09)^*}{0.74} L^4) I_t = 90.81$$

$$+ (1 \underset{(0.18)^*}{+0.48} L) \epsilon_t$$

$$\bar{R}^2 = 0.82$$

$$DW = 1.79$$

PCF<sub>t-4</sub> (compound feed price, deflated)

$$(1 \underset{(0.04)^*}{-0.96} L) \text{PCF}_{t-4} = 0.85 + \epsilon_t$$

$$\bar{R}^2 = 0.93$$

$$\text{DW} = 1.77$$

The PCF<sub>t-4</sub> ARIMA specification is re-estimated with data up to 4/85 and predictions from 1/86 to 2/90 are calculated. These predictions are used in simulation. Estimation yields:

PCF<sub>t-4</sub> (compound feed price, deflated, data set up to 4/85)

$$(1 \underset{(0.03)^*}{-0.96} L) \text{PCF}_{t-4} = 1.97 + \epsilon_t$$

$$\bar{R}^2 = 0.94$$

$$\text{DW} = 1.69$$

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