SUPPLY RESPONSE IN ARGENTINA: AGGREGATE PLANTED AREA IN CROP PRODUCTION

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by

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Abstract

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This study attempts to explain the variation in aggregate crop acreage in Argentina in the period 1960-97. It improves on previous studies by incorporating an expected yield variable and input price variables, extending the period of analysis, and attempting an aggregate crop acreage supply response of six crops. A single equation model is developed and the naive, moving average and simple weighted average price expectation mechanisms are examined. Results show that a moving average specification of price expectation accounts better for the data.

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I dedicate this paper to my children, Megan and Nicolas. Now they can play on the computer!

CHAPTER 1

Introduction

Supply Response in Argentina: Aggregate Planted Area in Grain Production

Argentina is well known for its beef, which is raised on extensive natural pastures. Argentina also produces a substantial amount of grain and oilseeds, which include wheat, corn, sorghum, soybeans and sunflower. Sixty-five percent of Argentina's 279 million hectares is suitable for either agriculture or livestock. Of the 183 million acres of arable land, in 1992, approximately 80 percent was in natural pasture, the remaining land in annual or perennial crops. Annual crop acreage in 1992 was approximately 19.75 million hectares, and the cattle stocks was approximately 53 million head. In 1996, annual crop acreage increased by 14.2 percent to 26.4 million hectares, while cattle stock decreased 3 percent to approximately 51 million head. In recent years, analysts have predicted that with grain prices rising faster than cattle prices, most of the pasture land would shift into grain production even further.

There have been periods in Argentina's agricultural history when government has played a major role in affecting the uses of arable land. Today, the Argentine farmer is free of any government regulation, and the use of the land is based on his/her decision. This decision regarding the use of land is primarily based on income. Consequently, as the prices of grains, and yields, have risen, farmers have shifted to crop production.

Studies conducted on the supply response of crops to prices in Argentina are not very extensive.

Reca (1980) examines pricing policy in Argentina from 1950 to 1975 for seven major agricultural products: wheat, corn, grain sorghum, beef cattle, wool, rice, and cotton. Reca presents three estimates of the Argentine producer's price responsiveness: aggregate crop production, crop production in the Pampas, and outside the Pampas.[1] Using a Nerlovian model, Reca analyzed aggregate output as a function of prices lagged one year, credit availability, technology and weather. These last two variables were entered as dummy variables. Reca concludes that "the model discussed strongly supports the contention that product prices were one of the key determining variables of the behavior of agricultural production in Argentina in the last twenty-five years."

To analyze the supply responsiveness in the Pampas region, Reca's linear regression model described area planted to crops and oilseeds as a function of 'expected' product prices, prices of substitutes, level of technology, availability of credit, and weather. These included product price lagged one year, yield, and credit availability, beef cattle slaughter, and stock of beef cattle as independent variables. The yield variable was determined as a dummy variable instead of the actual yield. Reca concludes that the influence of cattle production appears strong, and that cattle and crops compete for the use of land.

A second study conducted by Wainio (1983) looked at the effects of government intervention on the responsiveness of grain area to price movements during the late 1940's through the late 1970's. His linear model consisted of four equations, one for each of the following crops: wheat, corn, flaxseed, and sunflowerseed. He includes in his model the price of each crop lagged one year, price of cattle lagged one year, and acreage planted to the crop lagged one year (partial adjustment). His decision to lag prices one year was based on the results of Reca's study. Input costs and crop yields were not included in the regression model. Wainio's study also did not include soybeans since they were not very important during the period of the analysis. Wainio determines that farmer's price expectations seemed to be based on prices received for the previous harvest, however, these same expectations had a delayed effect on subsequent years' decisions as well.

In a third study, Sturzenegger describes the effects of intervention on output between 1961 and 1985. He assumes the producer maximizes profit as a function of price of wheat, corn, sorghum, soybean, sunflower, beef, variable inputs and fixed inputs. No variable for crop yield is included in the estimation model. All variable inputs are combined into one input variable due to lack of information. The fixed inputs represent soil conditions, rainfall and sunlight. Sturzenegger includes a coefficient of adjustment which is extrapolated from two previous empirical studies.

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[1] The bulk of the grain and oilseed production in Argentina comes from the Pampas. Grain crops and oilseeds compete with beef cattle for the use of land in the Pampas.

In the U.S. and other countries, studies on the response of crops to prices are extensive. Askari and Cummings summarize most of the work performed until 1976. Until then, most of the studies mentioned were directly or indirectly based on Nerlove's supply response model, published in 1958. Studies on the measurement and analysis of price responsiveness of agricultural supply has continued since then. More recently, many studies have incorporated the rational expectations hypothesis and risk in their modeling to analyze and measure supply response. (Gardner (1976), Fisher (1982), Eckstein (1984), Holt and Johnson (1987), Holt and Arduhyala (1992))

With the implementation of Argentine President Carlos Menem's Convertibility Plan (CP) in 1991, the Argentine economy has improved drastically and this may have affected the Argentine agricultural producer's behavior. The stabilization of the economy has allowed the Argentine farmer to change his farming practices in several ways, primarily by being able to purchase imported goods less expensively, purchasing and adopting new technology, and by not having to keep cattle as a capital investment due to rising inflation.

Menem's CP also reduced government intervention in Argentine agriculture. The government has reduced the trade taxes drastically, and it does not intervene in the determination of grain prices. The ports and elevators have been privatized and the National Grain Board has been dismantled. In signing Mercosur, the trade agreement with Brasil, Paraguay and Uruguay, Argentina has removed all taxes on trade with these countries.

Reca and Wainio's analysis did not include soybean since it was not a relevant crop during their period of study. The first commercial scale soybean production did not occur until 1975 when about 0.5 million hectares were planted. By 1997, there were 7.2 million hectares of soybean seeded acres, becoming one of the nation's most important crop.

Cattle is still an important aspect of Argentine agricultural production, primarily since domestic consumption of beef is still very high. However, with the improved economy and high world grain prices, and that most of the grain production is exported, the Argentine producer has increased his grain production at the expense of cattle pasture. Several Argentine analysts, through personal interviews, predict that more acreage will be shifted from pasture to grain production.[2]

This study works towards explaining the variations in aggregate grain acreage in the line of Reca and Wainio. This study improves on theirs in that the period of analysis is extended to 1997, it includes soybeans (an increasingly important crop), and it improves on their model specifications by incorporating an expected yield variable and input price variables. Other price expectation behaviors, aside from naive price expectations where the previous period's price is used as the expect price for this period, are also analyzed.

[2] Sparks America del Sur and Secretaria de Agricultura, Ganaderia y Pesca.

Aside from an attempt at analyzing the aggregate crop acreage, the results obtained from this paper may benefit those in the industry who might be able to use this information in their organizations' strategic plans.

The purpose of this study is to develop a single equation econometric model that explains the variation in aggregate crop acreage in Argentina. It is a simple comparative advantage model between cattle and crop. It will examine several price expectation mechanisms, adjustment processes, and the explanatory variables needed to explain the aggregate acreage put into crop production.

It is expected that the:

- Argentine producers have naive price expectation behavior,
- Argentine producers experience a significant lag between economic shocks and crop production, and
- Cattle and grain prices, input costs and technology affect grain production acreage.

The chapters to follow include a background on Argentina and its agriculture, a literature review on supply response studies in Argentina and on other supply response studies, a conceptual and empirical model, results and discussion of the econometric model, and conclusions.

CHAPTER 2

Argentina

"Until the Great Depression of the 1930's, agriculture was the staple sector of the Argentine economy."[3] Between 1860 and 1930, the exploitation of the rich land of the Pampas strongly pushed economic growth. During this period, Argentina grew more rapidly than the United States, Canada, Australia, or Brazil, countries similarly endowed with rich land, which also accommodated large inflows of capital and European immigration. During the first three decades of this century, Argentina outgrew the other four countries in population, total income, and per capita income as shown in the table below.

Table 1: Comparative Growth in Income and Population 1900-1984

Period/Item					
1900-04 to 1925-29	Argentina	Australia	Brazil	Canada	United States
Population	2.8	1.8	2.1	2.2	1.1
Income	4.6	2.6	3.3	3.4	2.9
Per capita Income	1.8	0.8	1.2	1.2	1.3
1925-29 to 1980-84					
Population	1.8	1.7	2.5	1.5	1.3
Income	2.8	3.9	5.5	3.9	3.1
Per capita income	1.0	2.2	3.0	2.4	1.8

(Average annual rates in percentages, Cavallo and Mundlak, 1989)

However, beginning in the 1930's, the Argentine economic vigor deteriorated rapidly. This loss in vitality was especially dramatic in agriculture.

2.1 Policies

The Great Depression in the 1930's reduced Argentine agricultural exports. The Argentine government's response to this was to start an import-substitution program for manufactured goods, a multiple exchange rate scheme, and a price support program to stimulate farm production. Two central government agencies were created, the National Grain Board (JNG) for grain and oilseed production and National Meat Board (JNC) for meat and its derivative products. Support prices were fixed, which exceeded market levels for wheat, corn and flaxseed during 1933-35, and supported by JNG purchases. The price support program together with favorable exchange rates for agricultural exports, began a large expansion of grain and oilseed area in Argentina. Strong export demand during the last half of the thirties stimulated further growth.

World War II brought difficult times for agricultural producers and traders. Disrupted market and shipping activities produced the largest grain surpluses in Argentine history. However, storage was inadequate and losses were great. After WWII, agricultural prices rose substantially, and had it not been for government intervention, this would have been a good opportunity for Argentina to increase its exports. The government of Juan Peron implemented a strong protection for domestic

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[3] Mundlak, Yair and Domingo Cavallo, "Agriculture and Economis Growth in Argentina, 1913-1984", p.12.

manufacturers and high taxation on agricultural exports. As manufacturing and urban services were more labor intensive than export oriented agriculture, the policies implemented reflected Peron's main concern for income redistribution to labor. Specific agricultural objectives of the Peron government were to shift economic and human resources from rural to urban sectors, redistribute resources within the agricultural sector from landed class to the landless tenants and workers, and generate revenue and foreign reserves for industrial development through agricultural exports. The government nationalized mass transportation, warehousing, port operations, and communication services. Intervention extended to electrical generation and distribution, to controls in banking and foreign trade which limited imports mainly to raw materials and semi-manufactured goods for use by beginning domestic industries. The Argentine Institute for the Promotion of Trade (IAPI) controlled agricultural trade. It controlled all exports and, as sole buyer, made all domestic purchases of grains and oilseeds. IAPI also controlled imports of food and agricultural inputs. The government fixed producer prices and subsidized retail food prices through 1946-55, with substantial subsidization of domestic wheat consumption. Farmgate prices were announced before harvest time. The government nationalized the railroads in 1946-47 when trains carried the bulk of the internal grain shipments. The futures market closed and wasn't reopened until the late 1980's. In the late forties and early fifties (in 1951, Argentina experienced a severe drought causing an agricultural crisis), some price and marketing regulations were eased in an attempt to stimulate production and exports of Argentina's major agricultural exports, however, not in time to impede the steady decline in grain production due to a full decade of inadequate incentives.

In 1955, Peron's government was overthrown by the military, beginning a period of political instability which lasted until 1973. The Argentine economy slowly became more market oriented through this period. The NGB took over most of the duties of IAPI (which was closed) and refrained from direct market intervention except when it imported grains to offset production shortfalls. International grain and oilseed trade gradually returned to the private sector. Market determined prices set by daily quotations replaced administered prices on the commodity exchanges. Export duties were generally low except for a 25% grain export duty imposed in 1958. At the end of the 1950's, the National Institute of Agricultural Technology (INTA) was created and was responsible for technological research and extension.

In 1973, Peron was re-elected and most of the first Peron government's policies were reintroduced. The state once again became the only buyer of wheat, corn, sorghum and sunflower. Fixed producer prices became effective at the farmgate for wheat in 1974 and for the other three products in 1975. High export taxes and exchange rate controls were implemented again. The government banned vegetable oil exports between 1973 and 1976 to insure domestic supplies and control consumer prices.

A military junta took over in March 1976 and gradually returned control of the economy to the private sector. The government removed domestic price controls and returned domestic marketing to the private traders. In late 1979, private traders could invest in terminal port facilities and to rent state-owned storage capacity. The government removed export taxes on all major grains and oilseeds by November 1976. The NGB continued to administer the commodity price support program for grains and oilseeds (although market prices were higher than support prices for the entire period), to manage government-owned storage facilities, to collect export taxes, to issue export licenses and to set export quotas when necessary.

Taxes on exports varied from 2 to 13 percent, and restrictions on imports and exchange controls shifted from extremely high levels in 1975 to almost complete elimination by 1980. Tariffs on permitted imports varied in an opposite direction from the quantitative restrictions and the exchange controls, moving from a subsidy of 6 percent in 1975 to an actual tariff of 26 percent in 1984.

As a consequence of the policies implemented during the period 1970-84, the rate of inflation rose to historical high levels, becoming volatile while the economy stagnated, except for a short-lived boom during the world commodity crisis in 1973-74.

A fourth economic period in Argentina began in 1989 with the election of President Carlos Menem, and the implementation of the "Convertibility Plan" (CP), devised by the Minister of Finance Domingo Cavallo, in 1991. President Menem's political agenda was to drastically change the nation's economic structure. This change in structure included: the convertibility to dollars of the Argentine currency, the Central Bank's autonomy, fiscal adjustments, modernization of the government, opening the economy to foreign investors, privatization of public companies and the deregulation of the commodity markets.

The CP, implemented in April of 1991, fixed the Argentine peso to the U.S. dollar at 1:1 parity and obliged the Central Bank to fund this convertibility with gold in reserves valued at market prices. The same law prohibits the Central Bank to finance the Treasury deficit and to give loans to the government, national, provincial or municipal. These laws have been strictly enforced, even during the Mexican financial crisis of 1995.

Since the implementation of the CP, inflation has been greatly reduced, from an annual rate of 84% in 1991 to 0.1% in 1996. Another consequence of the new plan, Argentina's gross domestic product (GDP) in 1996 increased 4.4% from 1995. The economy is improving and inflation is non-existent.

Market deregulation and reduction in export taxes and import tariffs were also established by the CP. The elimination of commercial obstacles has led to a dynamic market environment. Until 1990, there was a certain anti-commerce and anti-export bias, manifested by the barriers to imports and exports. In 1991, when the CP came into effect, these barriers were slowly reduced. Average tariffs decreased from 39 percent in 1988 to 10 percent in 1995, together with the elimination of almost all export licenses. In 1992, all export taxes were annulled, with the exception of those on oilseeds and cowhides. As a consequence, Argentine total exports, which totaled US$11,977 million in 1991, reached US$23,774 in 1996.

The CP also greatly affected the agricultural sector. Widespread privatization has improved the network of country and terminal elevators, railroads, and waterways. These improvements have lead to an increase in storage and loading/unloading capabilities, and quality of service. An improved economy and non-existent inflation has also allowed the Argentine producer to improve technology, i.e. purchase of new farm equipment, purchase fertilizer, purchase better seed.

2.2 Geography and Land Occupancy

Argentina encompasses distinct climactic zones, from sub-tropical to arctic, which allows for the production of a wide variety of agricultural commodities. The bulk of Argentina's arable land is in the Temperate Zone. Sixty five percent of Argentina's 279 million hectares of land are suitable for either crop or livestock. Sixteen percent is forested, and the remainder is unsuitable for either cultivation or forestry. In 1993, of the arable land, 23 million hectares was used as annual or perennial crop production, 15 million hectares was under improved pasture, and 145 million hectares was natural pasture (McCarry and Schmitz).

The major geographic zones are: the Pampas, the Chaco, the Andean zone, and Patagonia.

- The Pampas is that largest ecological zone and the dominant grain-producing area. Its 45 million hectares spread out from the city of Buenos Aires and covers most of the provinces of Buenos Aires, Cordoba, La Pampa, Santa Fe and Entre Rios. The area has temperate climate, between 750 and 1000 mm of rainfall annually, and contains about 50 percent of Argentina's arable land. Two thirds of the Pampas area has deep fertile soils similar to the Great Plains of the United States.
- The Chaco is the northern lowlands along the River Plate. This area has heavier rainfall and poorer soils, especially in the northeast, and contains important forest resources. The principal agricultural products are cotton, nuts, tea, rice, tobacco, citrus, and cross-bred cattle.
- The Andean zone, west and northwest of the Pampas, is hilly to mountainous, poorly watered, and with a few exceptions, can only be cultivated under irrigation. The principal agricultural products are sugar, tobacco, citrus, grapes for wine, and miscellaneous cash crops, including beans.
- Patagonia, about the same size as the Pampas, receives only minimal rainfall, is sparsely populated, and is devoted mainly to sheep farming and to the production of some high quality temperate-zone fruits (McCarry and Schmitz).

2.3 Agricultural Sector

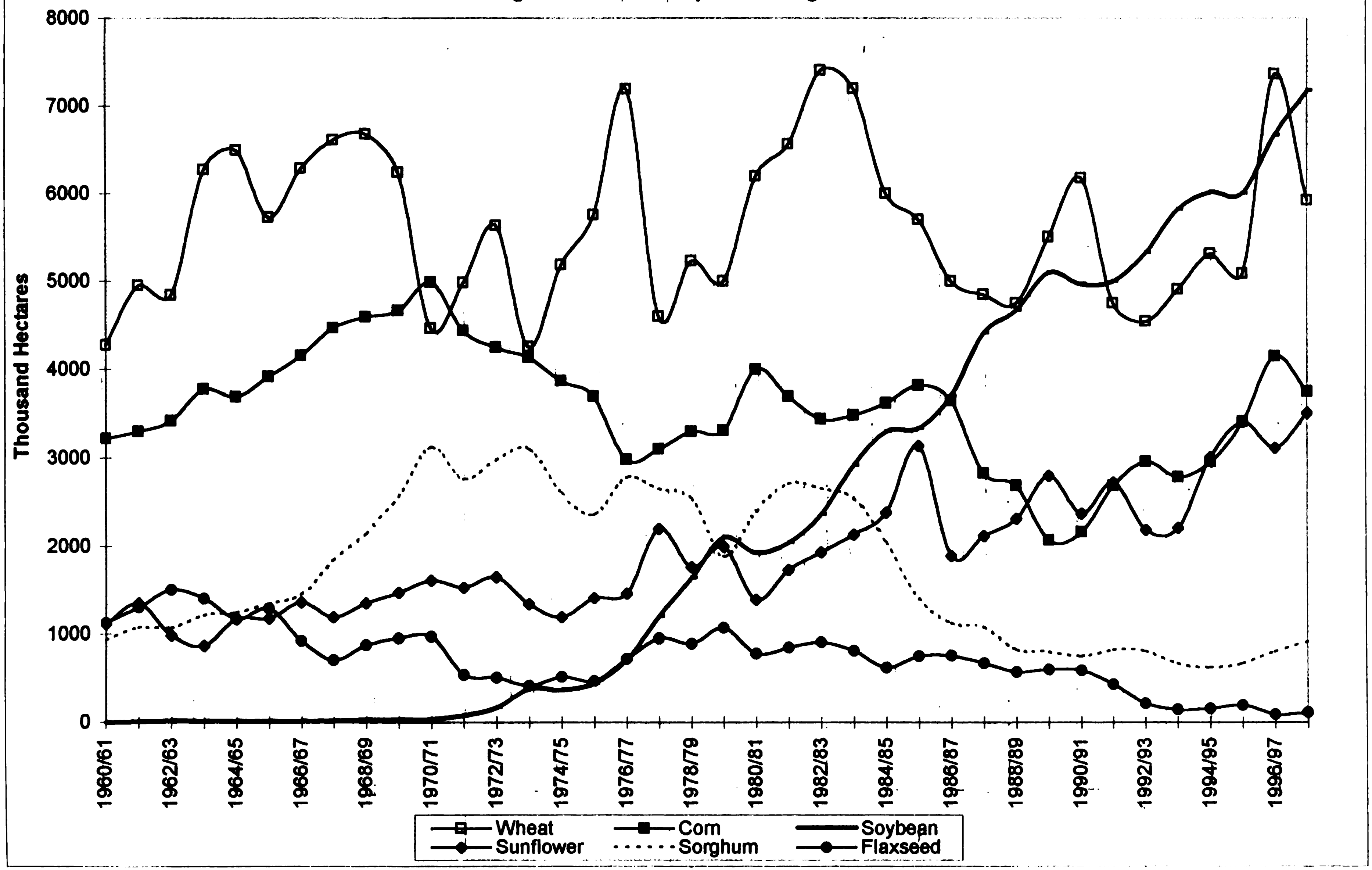
According to Reca, between 1960-1974, the share of crops in total agricultural production grew at the expense of livestock. The increased share of crops was due to a number of factors, which included the introduction of improved crop varieties and technologies, which increased the relative profitability of crops, and the considerable cyclical fluctuations in beef prices which discouraged development in this sector. Within crops, grains and oilseeds increased their proportion of production in the period mentioned at the expense of industrial crops (cotton, sugarcane, tobacco, wine grapes, etc...). The share of fruits and vegetables remained constant. The composition of livestock production showed some changes, but not enough to alter substantially the picture prevailing at the beginning of the 1950's. The share of beef production increased slightly, but remained close to two-thirds of all livestock production.

2.3.1 Grain and Oilseed Production

Wheat was the first crop grown in the Pampas area of Argentina, and is Argentina's most important crop. In 1996, 7366 thousand hectares were planted. Wheat is sown in the fall and harvested in late spring and early summer (November/December). Wheat yields have improved due to the use of improved varieties and the use of chemical inputs in the 1990's. The most significant event in wheat production was the introduction of semi-dwarf wheats in the mid-1970's. An estimated "96 percent of the area used for wheat is now sown to these high-yielding varieties."[4] The greatest advantage derived from the introduction of these varieties is an earlier maturity of the crop. Use of early-maturing varieties has enabled farmers to double-crop wheat with

[4] Lacroix, Richard, Michael J. McCarry, Matthew McMahon, and Lowell Hill, "Argentina: Grain and Marketing, Institutions and Policies", p.12.

Figure 1: Planted Crop Area in Argentina



soybeans. See Figure 1 for planted area per crop.

The seeded area of corn in Argentina has been declining primarily due to the increase in wheat-soybean cropping. Over "80 percent corn grown comes from northern Buenos Aires, southern Santa Fe and southeastern Cordoba provinces."[5] Though the seeded area has decreased, corn yields have been increasing, as a result of several factors, including the introduction of hybrids and the use of improved agronomic practices (such as planting at higher densities and increased use of fertilizer). Corn is sown in October/November and harvested in May.

Soybean is a relatively new crop in Argentina and did not become economically significant until the mid-1970's. Argentina is now one of the world's four main producer of soybeans as a consequence to the increase in production. Production technology was introduced to Argentina from the United States, and Argentine farmers have adopted this new crop into their rotation quite rapidly. This increase in production was stimulated by worldwide demand for vegetable oils and oilseed meals and the availability of agricultural technology. Area sown to soybean is concentrated to the "Pampa Humeda", which comprises northern Buenos Aires, southern Santa Fe and southeastern Cordoba, however, soybeans have also spread both south and west into drier areas. Soybeans are sown in July/August for the first crop and December/January for the second crop and harvest begins in April. Expansion in soybean seeded area is being achieved at the expense of area sown to corn, sorghum

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[5] Ibid. p.15.

and permanent pasture. Since 1980, soybean yields have been constant due to a buildup of pests and diseases in the traditional areas and to the expansion of soybean cropping into less favorable land.

Sunflower is a traditional crop in Argentina. Production was stimulated in the 1970's by the same factors that stimulated soybean production, i.e. world demand for vegetable oil and oilseed meals. Sunflower production began in southern Buenos Aires province. In the 1980's, the area sown expanded northwards. This increase in area sown was in response to improved technology, especially the introduction of superior hybrids, as depicted in the increase in yields. Sunflower is normally sown in September and harvested in March.

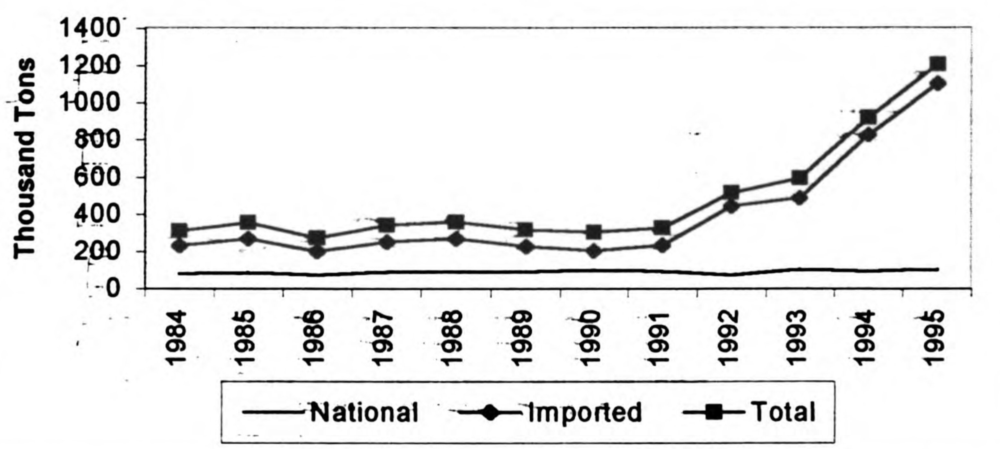
Sorghum production in Argentina is declining due to the fall in world sorghum prices. Sorghum is normally sown in the drier areas of the Pampas towards the west. However, sorghum is being replaced by soybean and sunflower. It is sown in October/November and harvested in March/April. Sorghum yields have been practically stagnant since the introduction of hybrids in the '60's and '70's.

Flaxseed production in Argentina has been declining during the period of this study due to decreasing world prices and at the expense of increasing wheat acreage. Flaxseed is sown in May/June and harvested in December/January. It is normally sown in the eastern Buenos Aires province, Entre Rios, Santa Fe and Cordoba.

2.3.2 Fertilizer

Argentina does not produce sufficient fertilizer to satisfy domestic demand, consequently, imports are required. According to Argentine Secretary of Agriculture, since the CP in 1991, the apparent domestic consumption of fertilizer has increased tremendously. The favorable outlook of grain prices, substandard soil nutrients and the genetic yield potential with fertilizer application were the major incentives for the increase in fertilizer consumption.

Figure 2: Fertilizer Consumption in Argentina, 1984-1995



As Figure 2 shows, fertilizer consumption during the 1980's fluctuated between 280 thousand tons and 350 thousand tons. This apparent consumption implies a "6 or 7 kilogram of fertilizer per hectare of arable land usage."[6] Despite the apparent low consumption of fertilizer, the Argentine producer compensated for this by incorporating crop residuals into the soil after harvest and by rotating crops on the

[6] SAGYP

land. According to Wainio (1980), about 75% of the fertilizer consumed is applied to intensively cultivated crops such as sugar cane, wine grapes, and fruits and vegetables. The remaining 25% is used on grains. The most heavily fertilized grain is wheat, although only about 15.5% of total wheat acreage is fertilized.

According to SAGyP, the fertilizers most used by Argentine producers are urea and diammonium phosphate.

CHAPTER 3

Literature Review

There have been few Argentine studies conducted on the supply response of crops to prices. The literature on supply response is, however, extensive. What follows is a review of the Argentine studies, and selected studies pertaining to risk, and pricing behaviors and rational expectations.

3.1 Supply Response in Argentina

One of the Argentine studies looks at the shift in the cattle industry with respect to prices and economic incentives during the mid 1930's through the mid 1960's conducted by Jarvis in 1969. Jarvis believed previous studies were oversimplified for the cattle industry in Argentina, and these studies resulted in negative short-run responses on cattle for slaughter. According to Jarvis, these oversimplified studies extrapolated the negative short-run response into long-run responses, not taking into consideration that with less slaughter, what results is a growing herd through larger calf crops, which would lead to increased slaughter over time. Consequently, he developed microeconomic models to illustrate his views, and from this, he built an economic model that may be used to explain the historical reaction of the cattle sector to exogenous shocks such as those caused by climatic variation and by changes in the domestic demand for beef or for other related agricultural products. According to

Jarvis, results show that cattle producers systematically reallocate their "portfolios"--that producers are price responsive--and due to the interactivity shift with the agricultural sector between grains and livestock, this also implies supply response by field crop producers.

The study performed by Reca in 1980 examines pricing policy in Argentina from 1950-1975 for seven major agricultural products: wheat, corn, grain sorghum, beef cattle, wool, rice, and cotton. As part of this, Reca explores the relationship between prices and agricultural output, since it has important economic and political consequences. Reca presents three estimates of the Argentine producer's price responsiveness: in the aggregate, crop production in the Pampas, and outside the Pampas (the latter not discussed in this study).[7] Using a Nerlovian type linear model, Reca analyzed aggregate output as a function of prices lagged one year, credit, technology and weather. The agricultural WPI (Wholesale Price Index) relative to non-agricultural products lagged on year was used. Technology and weather were entered as dummy variables. Reca defined two different technological levels, one covering the period of 1950-64, and the other the rest of the period. Reca admitted that this was a very crude approximation to a difficult problem. Different alternatives were analyzed. Reca concludes that "the coefficients show a remarkable stability.[...]Keeping in mind the conceptual and statistical limitations of the analysis carried out, the model discussed strongly supports the contention that product prices were one of the key

[7] The bulk of the grain and oilseed production in Argentina comes from the Pampas. Grain crops and oilseeds compete with beef cattle for the use of land in the Pampas.

determining variables of the behavior of agricultural production in Argentina in the last twenty-five years."[8]

To analyze supply response in the Pampas region, Reca's regression model described area planted to crops and oilseeds as a function of 'expected' product prices, prices of substitutes, level of technology, availability of credit, and weather. Price was determined as a weighted sum of the previous year prices of the five crops. The structure of weights used to construct the price series changed according to the relative importance of each crop in aggregate production value in three different periods: 1950-59, 1960-68, 1969-74. Yield was determined as a dummy variable, taking on a value of zero until 1965, one thereafter. Credit, beef cattle slaughter, and stock of beef cattle were the other independent variables. Reca's equation does not include the price of cattle (price of a substitute) as an independent variable, nor does it include input prices. Reca concludes from this regression study that, in terms of policy, " an artificially depressed price may not cut down substantially production from one year to the next...One crop may very well expand in area, but this will not hold for all the crops taken together. The effects of artificially low prices for crops will become evident some time later through the disinvestment process in agriculture which they will inevitably trigger." One of Reca's hypotheses was that even though there is some flexibility in the animal unit/land ratio, a larger stock of cattle requires more land which is then excluded from crop use. Based on his regression coefficient, which was only

[8] Reca, Lucio G., "Argentina: Country Case Study of Agricultural Prices and Subsidies", World Bank Staff Working Paper No. 386, April 1980.

marginally significant, he concluded that his hypothesis was not correct. It must be noted that by including the stock of cattle as an independent variable, one might be causing multicollinearity since there might be a relationship between independent variables, for example, if price of grain increases, stock of cattle might decrease, requiring less pasture acreage. Reca also concludes that the influence of cattle production also appears strong, and that cattle and crops compete for the use of land.

A study by Wainio in 1983 looked at the effects of government intervention on the responsiveness of grain area to price movements during the late 1940's through the late 1970's. In this study, Wainio calculated short and long-run price elasticities, together with cross price elasticities for wheat, corn, flaxseed, and sunflowerseed (the four important grains competing for land during the length of the study), under government intervention and non government intervention price programs. His linear regression model consisted of four separate equations (one for each crop) with the following explanatory variables: acreage planted to the m^{th} crop lagged one year; deflated price of each crop lagged one year; and deflated price of beef lagged one year. The decision to lag prices only one year was based in part on the results of Reca's study which yielded better results with a simple one year lag than with a more sophisticated geometric lag of a series of past annual prices. Beef prices were included to capture the competitive relationship between grains and livestock. Wainio did not include input costs in the regression model. A partial adjustment process is hypothesized for each of the four commodities. These four equations were estimated simultaneously, using Seemingly Unrelated Regression (SUR). In order to test whether government intervention influenced producer decisions, zero-one dummy variables representing market-managed periods were included. Price indices for the four crops were a three month average based on the three months after the crop was harvested. These prices were deflated by the cost of living index. Acreage data was aggregated at the national level. From this, Wainio learns that farmers react differently, but not uniformly, for different crops and in different price determining environments. Wainio also determines that farmer's price expectations seemed to be based on prices received for the previous harvest, however, these same expectations had a delayed effect on subsequent years' decisions as well. For wheat, approximately 65 percent of the total wheat area adjustment took place in the year following the harvest. For corn the first year adjustment averaged approximately 20 percent; for flax about 25 percent; and for sunflowers, about 50 percent. Wainio's study did not include soybeans since they were not very important during the period of the analysis.

A fourth study by Sturzenegger describes the effects of intervention on output, between 1961 and 1985, where he assumes the producer maximizes profit as a function of price of wheat, corn, sorghum, soybean, sunflower, beef, variable inputs and fixed inputs. Due to lack of information, all variable inputs are combined into one input variable. The fixed inputs represent the fixed agronomical conditions for agricultural production, such as soil conditions, rainfall, and sunlight. No variable for crop yield is included in the estimation equation. Specific one month averages for each crop were used for the calculation for producer prices (January values for wheat, May values for corn, sorghum, soybean and sunflower) and an annual average for beef cattle. Sturzenegger deducts transportation and distribution costs from the quoted market price to derive a farmgate price in domestic currency per ton. A coefficient of adjustment is also included in Sturzenegger's study, however, the size of the coefficient is extrapolated from two previous empirical studies. Sturzenegger's results are then compared to Mundlak, Cavallo and Domenech's and Fulginiti's study[9]

In Mundlak, Cavallo and Domenech's, "Agriculture and Economic Growth in Argentina, 1913-84", the authors examine the relationship between agriculture and overall economic growth, particularly, the influences of economic policies of three sectors: agriculture, nonagriculture excluding government, and government; with a special emphasis on examining the important role of the real rate of exchange. It is a "comprehensive and formal analysis of the causes behind the poor performance of the Argentine economy" during most of the 20th century. The main conclusion derived by the authors is that incorrect economic policies led Argentina to lag behind the trend growth of countries with similar potential.

In a study by the USDA and INTA of supply and demand for selected agricultural products from 1946-1965, supply projections for grains and oilseeds (the only agricultural products discussed in this review) are derived. Area of grain and oilseed production was estimated as a function of real price of product, real price of competing or complementary product, real price of major inputs used in production,

[9] Fulginiti performed a study on "The Structure of Agricultural Technology: The Case of Argentina" in 1986. Fulginiti's results are published in Sturzenegger's study.

yield and climatic conditions. Price variables were lagged for different periods of time in weighted and non weighted form. Each product (crop) was estimated using a linear equation model for each region and for the country as a whole.[10] The best model was chosen (based on estimated signs of the coefficients, statistical test of significance and magnitude of the partial regression coefficients) and used to make the supply projections. Since the products estimated were numerous, a review of the wheat and sunflower acreage estimation is detailed here. For the northern Santa Fe region (which produces about 4% of total wheat production) after more than 35 alternative linear equations obtained by combining the various variables (price of wheat, price of corn, price of flaxseed, price of beef cattle, input prices, yields, weather, and seeded acreage to wheat lagged one year), the authors obtained an equation with what they deemed a decent R-squared of 0.61. However, it entailed removing two variables that had unexpected signs (input prices and yield lagged one year) and using the support price of wheat rather than the market price of wheat. For the La Pampa and western Buenos Aires province (which produces about one-third of Argentina's wheat) after the 35 linear equation attempts, no equation was deemed satisfactory due to the magnitude of the statistical coefficients, therefore the projection of the wheat seeded area for this region was made using a linear trend method. In the case of sunflower acreage, after several multiple linear regressions with results that did not allow the choice of an equation suitable for projection purposes, the authors derived a linear trend equation for the area seeded to sunflower.

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[10] The country is divided into specific agricultural production regions for each crop.

3.2 Review of Other Supply Response Literature

Askari and Cummings (1976) detailed at least 500 studies in supply response analysis, directly or indirectly related to the basic framework proposed by Nerlove in 1958. Studies on the measurement and analysis of price responsiveness of agricultural supply has continued since then. Below is a brief summary of the most representative articles of what has been accomplished since Nerlove.

Supply response analysis has evolved to include risk. It is understood that output response in the case of a risk averse producer would respond negatively to related price variability. Just (1974) introduced the concept of price uncertainty into supply response. Just proposed including the variance (or standard deviation) of past prices as an explanatory variable in the supply response model. Aradhulla and Holt (1989) obtained good results in such a framework for the broiler industry. In Chern and Just's (1978) supply response and demand model for processing tomatoes in California, they formulate supply and demand equations in which they include the producer's expected price and expected yield in their Nerlovian adaptive expectation model. While making price and yield predictions, the producer is subject to making errors in prediction. The fact that the grower has to make decisions in an unsure environment is called uncertainty or risk. The widely adopted mean-variance criterion is used to measure risk and uncertainty by incorporating the variance (or standard deviation) of past yields and prices in addition to the expected yield and price as another explanatory variable in the supply response model.

It was not until the early 1980's that price rationality was introduced in agricultural supply response as a price expectation mechanism for econometric modeling and estimation based on the work of Muth (1961). Irwin and Thraen (1991) evaluate that literature in detail. They concluded that results about rational expectation in supply response are mixed. Although results in Goodwin and Sheffrin (1982) give support to the hypothesis, in the broiler chicken industry, while studies in the soybean sector are not that conclusive.

Some studies, Gardner (1976), used futures prices as a proxy for rational expectations price behavior held by producers. However, several doubts can be put in this type of approach, since futures prices are "endogeneity determined". In his article, "Futures Prices in Supply Analysis", Gardner hypothesizes that the price of a futures contract for next year's crop reflects the market's estimate of next year's cash price.

3.3 Summary

Previous studies on supply response in Argentina have basically three limitations. The three limitations are: the use naive price expectation behavior, the omission of a yield variable and/or inputs price variables, and they do not include soybeans in their analysis which has become an important crop in Argentina. These three limitations are addressed in the model analyzed.

CHAPTER 4

Econometric Modeling: Conceptual and Empirical

4.1 Background and Conceptual Model

It is assumed that Argentine producers want to maximize their profits given their production constraints, that of two outputs (crops and cattle) and various inputs. In Argentina, cattle and crops compete for the use of land. Let the production function be

$$y_1 = f(x_{11}, x_{21} \ldots x_{n1}) \quad \text{(i)}$$

$$y_2 = g(x_{12}, x_{22} \ldots x_{n2}) \quad \text{(ii)}$$

where y_1 and y_2 are vectors denoting the two outputs, f and g the production functions for y_1 and y_2, and the first subscript on each x denotes the input, the second subscript denotes the product to which it is applied.

The total amount of x_1 and x_2 used in the production of y_1 and y_2 are

$$x_1 = x_{11} + x_{21} + \ldots + x_{n1}$$

$$x_2 = x_{12} + x_{22} + \ldots + x_{n2}$$

Total revenue R from the sale of y_1 and y_2 is

$$R = p_1y_1 + p_2y_2 \qquad \text{(iii)}$$

$$= p_1f(x_{11}, x_{21}...x_{n1}) + p_2g(x_{12}, x_{22}...x_{n2}) \qquad \text{(iv)}$$

where p_1 is the price of y_1 and p_2 is the price of y_2.

The total cost is the sum of the quantities of inputs multiplied by their respective prices

$$C = v_1x_1 + v_2x_2 + ... + v_nx_n \qquad \text{(v)}$$

$$= v_1(x_{11} + x_{12}) + v_2(x_{21} + x_{22}) + ... + v_n(x_{n1} + x_{n2}) \quad \text{(vi)}$$

Profit is revenue minus cost:

$$\Pi = R\text{-}C \qquad \text{(vii)}$$

$$= p_1y_1 + p_2y_2 - v_1x_1 - v_2x_2 - ... - v_nx_n \qquad \text{(viii)}$$

$$= p_1f(x_{11}, x_{21}...x_{n1}) + p_2g(x_{12}, x_{22}...x_{n2}) - v_1(x_{11} + x_{12}) - v_2(x_{21} + x_{22}) - ... - v_n(x_{n1} + x_{n2}) \quad \text{(ix)}$$

Maximizing profits entails taking the first derivative of the profit function with respect to each input used in the production of the output and setting it equal to zero:

$$\partial\Pi/\partial x_{11} = p_1\partial f/\partial x_{11} - v_1 = 0 \qquad \text{(x)}$$

$$\partial\Pi/\partial x_{21} = p_1\partial f/\partial x_{21} - v_2 = 0 \qquad \text{(xi)}$$

$$\partial\Pi/\partial x_{n1}=p_1\partial f/\partial x_{n1}-v_n=0 \qquad (xii)$$

$$\partial\Pi/\partial x_{12}=p_2\partial g/\partial x_{12}-v_1=0 \qquad (xiii)$$

$$\partial\Pi/\partial x_{22}=p_2\partial g/\partial x_{22}-v_2=0 \qquad (xiv)$$

$$\partial\Pi/\partial x_{n2}=p_2\partial g/\partial x_{n2}-v_n=0 \qquad (xv)$$

From the system of equations x through xv we can solve to obtain the input demand equations.

$$x_{11}= f_{11}(p_1, p_2, v_1, v_2,\ldots, v_n) \qquad (xvi)$$

$$x_{21}= f_{21}(p_1, p_2, v_1, v_2,\ldots, v_n) \qquad (xvii)$$

$$x_{n1}= f_{n1}(p_1, p_2, v_1, v_2,\ldots, v_n) \qquad (xviii)$$

$$x_{12}= f_{12}(p_1, p_2, v_1, v_2,\ldots, v_n) \qquad (xix)$$

$$x_{22}= f_{22}(p_1, p_2, v_1, v_2,\ldots, v_n) \qquad (xx)$$

$$x_{n2}= f_{n2}(p_1, p_2, v_1, v_2,\ldots, v_n) \qquad (xxi)$$

Substituting xvi through xxi into i and ii, the output functions are obtained:

$$y_1= f_1(p_1, p_2, v_1, v_2,\ldots, v_n) \qquad (xxii)$$

$$y_2= f_2(p_1, p_2, v_1, v_2,\ldots, v_n) \qquad (xxiii)$$

In the case of crop production, output is determined by acreage allocation and weather conditions affecting crop growth, acreage being the single most important input whose usage level the producer has to choose.

From the input demand equation above obtained, a functional relationship of crop acreage to product prices and other input prices can be stated.

$$A = f(p_1, p_2, v_1, v_2, \ldots, v_n) \qquad \text{(xxix)}$$

Total agricultural output is a function of planted area and weather. Supply response models in agriculture are typically modeled as planted area and not total output due to the difficulty in modeling weather.

Most agricultural commodities take time to produce. Characteristically, decisions about resource allocation are taken well before output is generated, due to the very nature of the biological processes involved. Consequently, the realized output and actual resulting income may differ from the ones prevailing at the time the decisions are taken. Typically, resource allocation decisions are tied to the expectation of the final outcome and price.

As one of many possible functional forms, Nerlove proposes a model to measure the responsiveness of acreage to prices: desired acreage is a linear function of expected prices, as follows:

$$A^*_t = a_0 + a_1 P^*_t + a_2 Z_t + U_t \qquad (1)$$

where A^*_t is the expected acreage in period t, P^*_t is the expected price in period t, Z_t is the other factors that affect supply/production in period t, and U_t is the error term. However, the desired acreage is not directly observable, therefore, Nerlove proposes the following hypothesis of desired acreage behavior:

$$A_t - A_{t-1} = \gamma(A^*_t - A_{t-1}) \quad (2)$$

where $A_t - A_{t-1}$ measures the actual change in acreage between two periods, $A^*_t - A_{t-1}$ is the desired change in acreage between two periods, and γ is known as the coefficient of adjustment, such that $0<\gamma<=1$. The actual change in acreage in any given period t is some fraction γ of the desired change. Equation 2 can be written as:

$$A_t = \gamma A^*_t + (1-\gamma)A_{t-1} \quad (3)$$

And, substituting equation 1 into 3, we derive an equation for acreage with observable acreage variables, using Nerlove's partial adjustment hypothesis:

$$A_t = \gamma a_0 + \gamma a_1 P^*_t + \gamma a_2 Z_t + \gamma U_t + (1-\gamma)A_{t-1} \quad (4)$$

Once we estimate equation 4, we can derive the coefficient of adjustment, and in so doing, also derive the constant term, a_0, and the coefficients, a_n, for the variables. Equation 4 can be written as:

$$A_t=\beta_0+\beta_1 P^*_t+\beta_2 Z_t+\beta_3 A_{t-1}+\mu_t \qquad (5)$$

where γa_{n-1} is substituted by β_{n-1} and $1-\gamma=\beta_3$ on the lagged acreage variable, forming a partial adjustment acreage response model. However, equation 5 still contains one unobservable variable, P^*_t. Several different price behavior hypotheses can be proposed to derive an observable equation for acreage responsiveness to prices. The first price expectation formation behavior hypothesis is naive behavior, in which the producer looks at last period's price to form his next period's price expectation, as follows:

$$P^*_t= P_{t-1} \qquad (6)$$

Substituting equation 6 into 5, we derive an acreage response model using naive price expectation:

$$A_t=\beta_0+\beta_1 P_{t-1}+\beta_2 Z_t+\beta_3 A_{t-1}+\mu_t \qquad (7)$$

An alternative hypothesis is the moving average price expectation behavior, in which the producers form their price expectation for period t as an average of past prices for several periods:

$$P^*_t=(P_{t-1}+P_{t-2}+\ldots P_{t-n})/n \qquad (8)$$

Substituting equation 8 into 5, we derive an acreage response model using moving averages price expectation:

$$A_t=\beta_0+\beta_1(P_{t-1}+P_{t-2}+\ldots+P_{t-n})/n+\beta_4Z_t+\beta_5A_{t-1}+\mu_t \qquad (9)$$

A third approach to solve for the unobservable price variable in equation 5 is to propose a weighted average price formation hypothesis in which the producer takes a weighted average of past prices for this period's price expectation, as follows:

$$P^*_t=cP_{t-1}+(1-c)P_{t-2} \qquad (10)$$

Re-writing equation 10 so as to calculate weight c, assuming that $P^*_t= P_t$ so as to be able to use available data:

$$P_t=cP_{t-1}+P_{t-2}-cP_{t-2}$$

$$= c(P_{t-1}-P_{t-2})+P_{t-2}$$

$$P_t- P_{t-2}= c(P_{t-1}-P_{t-2}) \qquad (10a)$$

If we assume:

$$P_t- P_{t-2}=a_t$$

$$P_{t-1}-P_{t-2}=b_t$$

we can re-write equation 10a as:

$$a_t = c^*b_t \qquad (10b)$$

Equation 10b will be used to estimate weight c. Once the weight is derived, substituting equation 10 into 5, we derive an acreage response model using weighted average price expectation:

$$A_t=\beta_0+\beta_1cP_{t-1}+\beta_2(1-c)P_{t-2}+\beta_4Z_t+\beta_5A_{t-1}+\mu_t \qquad (11)$$

In order to analyze for different hypotheses of producer's price expectation behavior, equations 7, 9 and 11 will be the models used in this study.

Based on the Argentine supply response studies described in Chapter 3 and these studies' results, it is assumed that a linear functional form is a acceptable representation of Argentine agricultural supply response.

The models presented above assumed constant input quality, input technology, and knowledge. The model also does not address all the dynamics in the crops versus livestock issue.

In order to maximize his/her profits, it is assumed that the Argentine producer decides on acreage based on the expected gross income (his/her expectation of prices multiplied by expected yield per hectare) less input (production) costs. These input costs are represented by variable Z (the other factors that affect supply (production) in period t) in equation 11. Theoretically the input costs should include: prices of fertilizer, pesticides, fuel, seed, and labor for the product(s) (i.e. crops and livestock) being produced. Other factors that affect supply represented by the Z variable are technological changes, government policy, and weather.

Cattle production competes with crop production for land use. However, the decision to increase or decrease the herd is not instantaneous. If the Argentine producer were to decide to decrease the herd because of lower cattle prices, and consequently reduce the amount of land on pasture, the producer would liquidate the herd and till the land for crop production. This process would not happen in one period; there would be a lag between the time the producer made the decision to decrease cattle production and the time acreage in crop production increased. This is the concept of lags: an economic cause, for example, a price change, produces its effect only after some lag in time. A distributed lag implies that the effect produced by an economic cause is noticed over more that one period.

Incorporation of distributed lags with respect to price changes into a supply response equation would result in an equation as follows:

$$A_t=\alpha_0+\alpha_1 P_{t-1}+\alpha_2 P_{t-2}+\alpha_3 P_{t-3}+\ldots+\alpha_n P_{t-n}+\alpha_Z Z_t+\mu_t \qquad (12)$$

where A_t represented acreage, P_{t-1} represented price of the crop being studied in the previous period, n represented the number of periods needed for the full effect of the economic cause to produce its effect, and Z_t represents other factors that affect supply.

Equation 12 is distinct from equation 9 in that the partial adjustment is not included. The distinction between partial adjustment and distributed lags is that with the partial adjustment there is no explanation why the partial adjustment occurs since it is not based on optimization behavior (i.e. do not know what causes the partial adjustment to occur, whether it is prices, technology, capital constraints, etc…). The partial adjustment coefficient captures the process of the producers' slow adjustment to economic causes (shocks) as proposed by Nerlove and demonstrated in equation 2.

In a supply response model of crop acreage, in order to incorporate the competing cattle production, cattle prices should be included as an explanatory variable. If one were to use the distributed lag equation 12 to analyze acreage response, one would have to include crop prices and cattle prices distributed n periods, which would increase degrees of freedom and reduce the measurement power of the equation in econometric analysis. Consequently, the decision is whether to estimate the aggregate supply response using distributed lags, or whether to use partial adjustment. In this supply response analysis, the partial adjustment hypothesis will be used to represent the adjustment cost of switching acreage from cattle to crop production.

4.2 Econometric Estimation Issues

A supply response equation includes several explanatory variables. Two consequences of this are muticollinearity (where a linear relationship between explanatory variables exits) and degrees of freedom can decrease as more explanatory variables are included which reduces adjusted R squared[11]. One way around including so many explanatory variables is to work with expected income, calculated as expected price multiplied by the expected yield.

$$Inc^*_t = P^*_t * Y^*_t \qquad (13)$$

where Inc^*_t represents the expected income in period t, P^*_t represents the expected price in period t, and Y^*_t represents the expected yield in period t. The expected yield can be calculated by estimating a linear trend based on historical data:

$$Y^*_t = C_0 + C_1 Trend \qquad (14)$$

where the trend variable represents the year. Trend yield rather than lagged yield is used since it would be more representative of the producer's expectations.

[11] Degrees of freedom are defined as the number of observations minus the number of coefficients estimated (including the constant) or n-K-1, where n is the sample size and K is the number of explanatory variables.

A useful method to detect multicollinearity is to check if the R squared is high with no significant individual t-tests, and if the simple correlation coefficients between the explanatory variables are high. Determination of how high is high for the R squared and simple correlation coefficients is based on the fact that previous supply response studies on Argentina had R squared results of 0.80 or higher. It is assumed that a R squared of 0.80 is high and that a simple correlation higher than 60% is deemed high.

Heteroskedasticity occurs when the variance of the error term is not constant. The consequences of heteroskedasticity are: it increases the variance of the estimated β's distribution; it causes OLS to tend to underestimate the variances (and standard errors) of the coefficients; and it does bias the estimated standard errors, although the estimated β's are not biased. A test for heteroskedasticity is the White test, which regresses the squared residuals on the original explanatory variables. The decision rule of the White test is: if nR^2 (the test statistic) is larger than the critical chi-squared value, reject the null hypothesis of no heteroskedasticity; if nR^2 is less than the critical chi-square value, the null hypothesis cannot be rejected. If the supply response model has been specified correctly, the White test should detect no heteroskedasticity. Heteroskedasticity can be caused by a specification error, such as an omitted variable. An omitted variable can cause a heteroskedastic error term because the portion of the omitted effect not represented by one of the included explanatory variables must be absorbed by the error term. If this effect has a "heteroskedastic component, the error term of the misspecified equation might be heteroskedastic even if the error term of the true equation is not"[12].

In time series data, a large external shock to an economy in one period may linger on for several time periods, implying serial correlation where the error terms are correlated with each other. In Argentina, there have many economical and political changes that might have caused such shocks. Serial correlation may also be present in an incorrectly specified equation since the error term includes a portion of the effect of the difference between the proper functional form and the equation being estimated The consequence if there is serial correlation is increased variances of the estimated β coefficients. If this is due to improper specification, the coefficient estimates may be biased. Therefore, a test to detect if there is serial correlation in the three price expectation hypotheses regressions should be performed. However, due to the partial adjustment, a lagged dependant variable, as an independent variable, the Durbin-Watson d test is potentially invalid and a Durbin h test should be performed. The equation for Durbin h statistic is:

$$h=(1-0.5*d)[n/(1-n*S_{\lambda}^{2})]^{\frac{1}{2}}$$

where d is the Durbin-Watson statistic, n is the sample size, and S_{λ}^2 is the square of the estimated standard error of β_{At-1}, the estimated coefficient of the lagged dependant variable. Durbin h is normally distributed, therefore to determine the critical z-value, a

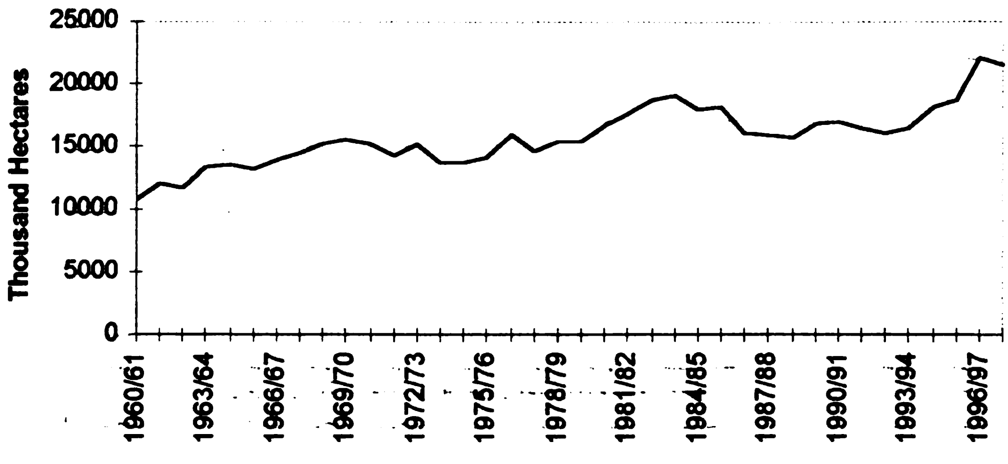
[12] Studenmund, A.H., Using Econometrics, p. 372.

two-tailed test at a determined significance level is calculated. The decision rule of the Durbin h test is: if the absolute value of h is greater than the critical z-value, reject the null hypothesis of no serial correlation; if the absolute value of h is less than critical z-value, do not reject the null hypothesis of no serial correlation.

4.3 Empirical Model

The Pampas region of Argentina was chosen as the area of focus since it is the largest agricultural crop producing region in Argentina. Six of the major crops grown in this region, wheat, corn, sorghum, soybean, sunflower, and flaxseed, are the focus for aggregate grain production. Planted area data from 1960 to 1997, on a crop year of June through May, for each of the six crops was collected from the Bolsa de Cereales (Grain Exchange) annual statistics, and totaled to derive a total planted area series, in thousands of hectares. Due to double cropping, actual planted area may exceed actual land in crop production.

Figure 3: Total Crop Planted Area in Argentina



Annual yields in tons per hectare for each of the six crops were collected from the Bolsa de Cereales. Using each crop's yield, a trend yield was calculated to determine expected yields. It is assumed that yield per hectare is a good proxy for technological improvement.

Price data were also collected from the Bolsa de Cereales annual statistics from 1960 to 1996. Monthly average prices for each of the six crops, in pesos per ton, were used to calculate a price index. In Argentina, almost of all the crops are marketed during the first six months of the season (January through June). The first crop seeded is wheat in May or June. Before this seeding time, the Argentine producer needs tomake a decision about what crops to produce. It is assumed that the prices the producer looks at are the prices during the period of January to June. Due to this assumption, monthly prices from the first six months of every year were used as the best indicators for the producers seeding decisions. These prices were converted to US dollars per

Figure 4: Crop Yield in Argentina

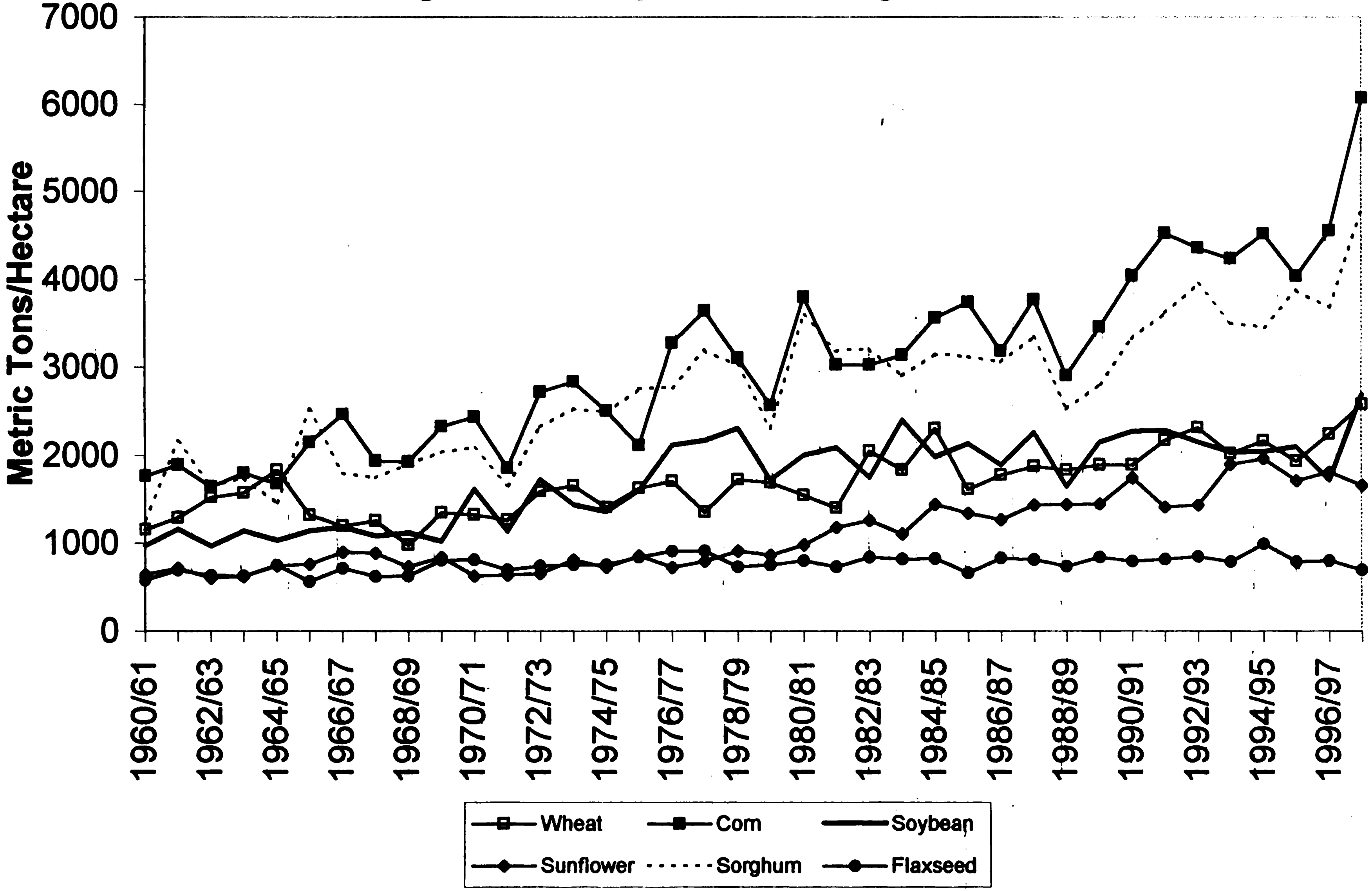
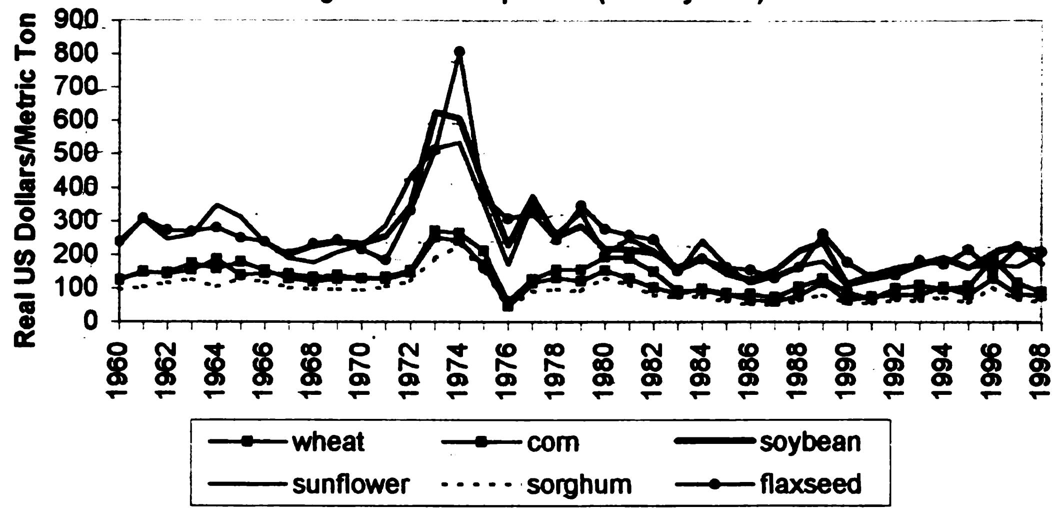


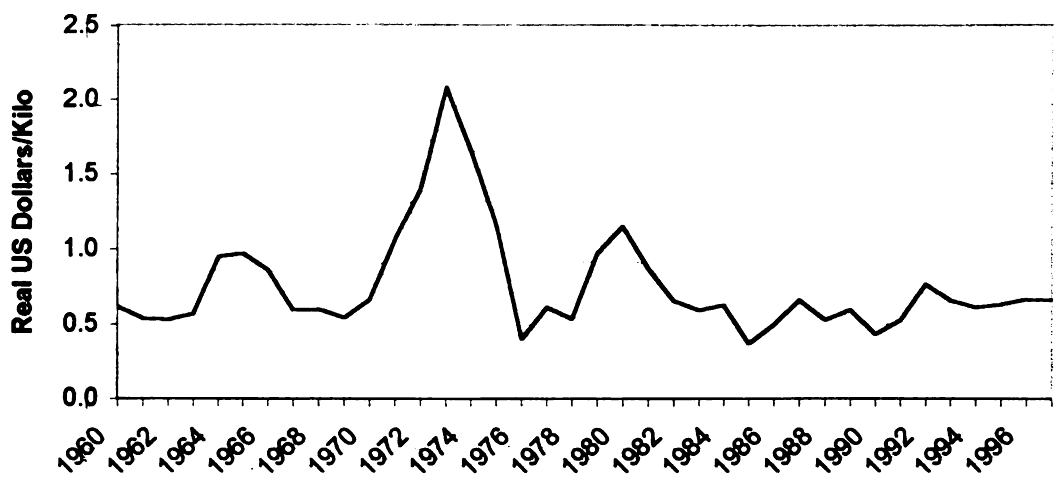
Figure 5: Real Crop Prices (January-June)



metric ton using official exchange rate figures, due to the fact that export prices are quoted in US dollars per metric ton, and since most of the grains and oilseeds are exported and thus directly related. These prices in US dollars per metric ton were then deflated by the US Producer Price Index (PPI). The real price series for each of the six crops is then used in the gross expected income calculation.

Cattle price data were gathered from the National Meat Board (Junta Nacional de Carne), Bolsa de Cereales, and the Secretaria de Agricultura, Ganaderia y Pesca (SAGyP). Monthly prices from the first six months of every year, in pesos per kilo from 1960 to 1997, converted to US dollars per kilo (using official exchange rates), deflated by the US PPI, were used as the cattle price series. The first six months were used since the same was used for the grain price series.

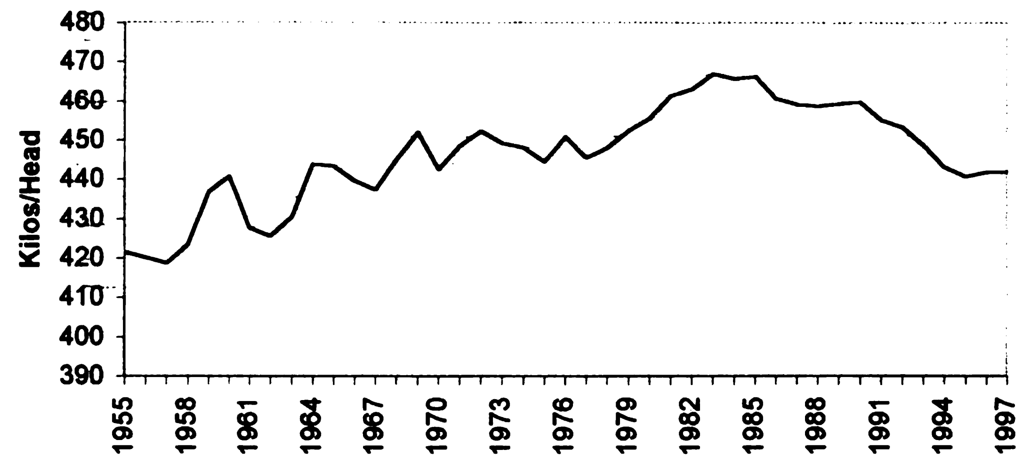
Figure 6: Real Cattle Price (January-June)



Cattle weight data, in kilos per head, were gathered from FIEL (Latin American Foundation for Economic Research). This is the annual average weight per head of the cattle sold to market. Using the annual weight, a linear trend weight was calculated to determine expected weight (cattle yield) for gross expected income calculation.[13] It is also assumed the cattle weight trend is a good proxy for technological improvement in cattle raising.

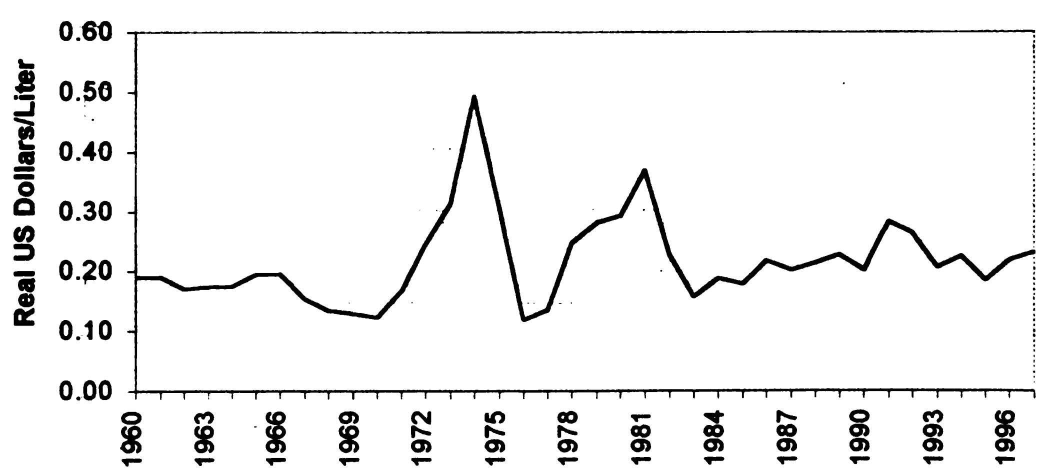
[13] Average cattle weight increased during 1955-82, and then began decreasing. A quadratic function might be a better trend line, but it does not appear reasonable that average cattle weight will continue decreasing. The three price behavior expectation models were estimated with the expected cattle gross income calculated using a quadratic trend line and a linear trend line. Results were not significantly different. Further work is required to determine the reason for decreasing average cattle weight.

Figure 7: Average Cattle Weight in Argentina



From various personal conversations with sources in Argentina, it was determined that the major variable input costs for Argentine grain production were diesel fuel (gasoil), labor wages, and urea (a nitrogenous fertilizer). Farm labor wage data were not available, and it was determined that an index of industrial wages (the only wage series obtained by this author) was not an adequate substitute due to it being from a different sector and government policy influences in that sector. Monthly average diesel prices,

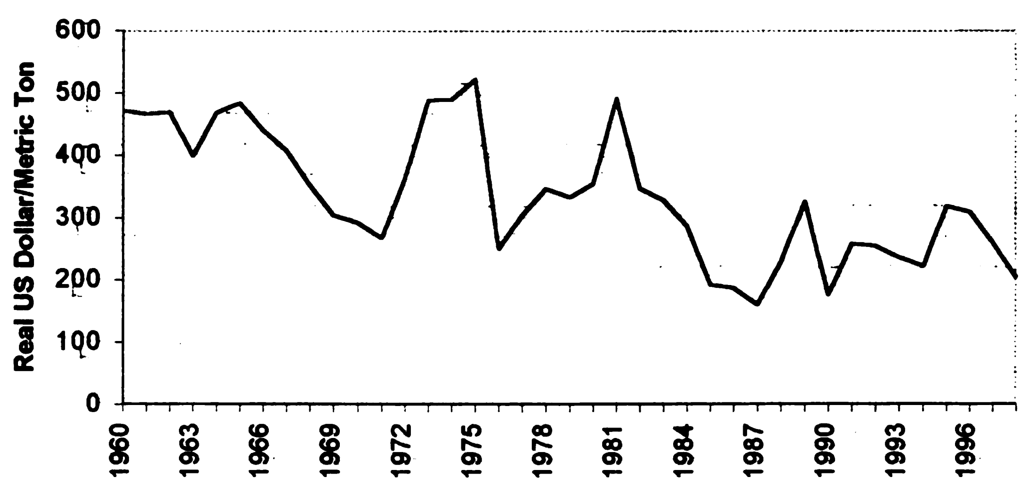
Figure 8: Real Diesel Price (January-June)



in pesos per liter, were obtained from FIEL. These prices were converted to US dollars per ton using official exchange rate data and then deflated by US PPI. The diesel price series was composed of the first six months of each year.

Urea price data were gathered from the SAGyP for the period 1970-1998. Appendix A provides a detailed description of the urea price series. As with diesel, grain and cattle prices, the urea price data used was composed of January to June prices.

Figure 9: Real Urea Price (January-June)



Weather was assumed not to be an important factor affecting total seeded area, if weather prevented seeding of one crop, another crop might have been sown.

4.3.1 Model Specification

Equation 7 can be re-written to incorporate the specific above mentioned variables.

$$A_t=\beta_0+\beta_1 GP_{t-1}+\beta_2 CP_{t-1}+\beta_3 GY^*_t+\beta_4 CY^*_t+\beta_5 UreaP_t+\beta_6 GasP_t+\beta_7 A_{t-1}+\mu_t \quad (7a)$$

where A represents total seeded area in thousand hectares in the period t, GP represents the grain price series in US$ per ton in the period t-1, CP is cattle price series in US$ per kilo in the period t-1, GY^* is expected grain yield per hectare in period t, CY^* is expected cattle yield (weight) in kilos per head in period t, UreaP is urea price in the period t, and GasP is diesel price in the period t.

The price variables and the expected yield variables can be combined into a gross income variable:

$$GInc_t=\sum \alpha_{it-1}(GP_{it-1}*GYT_{it}) \quad (15)$$

$$CInc_t=(CP_{t-1}*CYT_t) \quad (16)$$

where,

$$GY^*_t=GYT_{it}$$

$$CY^*_t=CYT_{it}$$

where GInc is expected grain gross income per hectare in period t, CInc is expected cattle gross income per kilo in period t, CP_{t-1} is the cattle price in the period t-1 (naïve expectations), GP_{it-1} is the grain price in the period t-1 for crop i, GYT_{it} is trend grain yield of crop i in period t, CYT_t is trend cattle yield (weight) in period t, and α_{it-1} is the proportion of crop i in period t-1, in annual in aggregate planted area. The trend yields on grain and cattle were calculated using a simple trend regression for the entire sample of historical data gathered, as stated in equation 14.

Since it was determined earlier that urea and diesel are important inputs in grain production, these two inputs will be used as explanatory variables in the three aggregate crop planted area equations. With the omission of a labor price variable, a possible relevant independent variable, estimated coefficient results may be biased. According to Studenmund (1997), an omitted variable may be detected if an estimated coefficient is significant and has an unexpected sign, or if the model has a surprisingly poor fit.

Incorporating the expected gross income variables into equation 7, the aggregate crop planted area response is:

$$A_t=\beta_0+\beta_1 GInc_t+\beta_2 CInc_t+\beta_5 A_{t-1}+\beta_6 UreaP_t+\beta_7 GasP_t+\mu_t \qquad (7b)$$

Equation 7b will be used to analyze the first price behavior hypothesis: naïve expectations.

To analyze the second price behavior hypothesis, moving average expectation, equation 8 is substituted into equation 15 and the expected gross income is calculated as follows:

$$MAGInc_t=\sum \alpha_{it-1}([(GP_{it-1}+GP_{it-2})/2]*GYT_{it}) \qquad (15a)$$

$$MACInc_t=([(CP_{t-1}+CP_{t-2})/2]*CYT_t) \qquad (16a)$$

where MACInc is an average of the last two periods for cattle prices, α_{it-1} is the proportion of crop i in the previous period, and MAGInc is an average of the last two periods for grain prices. These new moving average expected gross incomes are then substituted into equation 9 to derive an aggregate crop planted area response with moving average price behavior expectation:

$$A_t=\beta_0+\beta_1 MAGInc_t+\beta_2 MACInc_t+\beta_3 A_{t-1}+\beta_4 UreaP_t+\beta_5 GasP_t+\mu_t \qquad (9a)$$

Two period moving average is used for the above stated equation based on personal interviews which stated that it appeared that Argentine producers do not 'remember' or take into consideration prices from before two periods prior.

The third price behavior hypothesis to be analyzed is the simple weighted average of past prices. Substituting equation 10 into equation 15, we derive the simple weighted average expected gross income as follows:

$$SWGInc_t=\sum \alpha_{it-1}((c_{iG}GP_{it-1}+(1-c_{iG})GP_{it-2})*GYT_t) \quad (15b)$$

$$SWCInc_t=((c_C CP_{t-1}+(1-c_C)CP_{t-2})*CYT_t) \quad (16b)$$

where SWGInc is the simple weighted average of grain prices, α_{it-1} is the proportion of crop i in the previous period, c_{iG} is the calculated price weight for crop i, SWCInc is the simple weighted average of cattle prices, and c_C is the calculated price weight for cattle. The weight, c, is estimated using equation 10a and 10b as follows:

$$GP_{it}-GP_{it-2}=c_{iG}(GP_{it-1}-GP_{it-2}) \quad (10c)$$

such that:

$$GP_{it}-GP_{it-2}= a_{it}$$

$$GP_{it-1}-GP_{it-2}= b_{it}$$

$$a_{it}= c_{iG}b_{it} \quad (10d)$$

and:

$$CP_t-CP_{t-2}=c_C(CP_{t-1}-CP_{t-2}) \quad (10e)$$

Equations 10d and 10e estimated individual crop and cattle weight results are used to calculate the simple weighted average expected gross crop and cattle income in equations 15b and 16b. Substituting the simple weighted expected gross margins into equation 11, we derive an aggregate crop planted area response with simple weighted price behavior expectation:

$$A_t=\beta_0+\beta_1 SWGInc_t+\beta_2 SWCInc_t+\beta_3 A_{t-1}+\beta_4 UreaP_t+\beta_5 GasP_t+\mu_t \qquad (11a)$$

Equations 7b, 9a, and 11a are used to estimate Argentina's aggregate crop acreage supply response under three different price behavior hypotheses. Determination of the best structural equation (model) is based on four criteria:

1. The signs of the estimated coefficients,
2. Statistical significance of estimated coefficients
3. Adjusted R-square is high.
4. The reasonableness of the results.

Ordinary least squares, using E-Views software Version 1.0, is used to estimate the above equations.

CHAPTER 5

Results

This chapter presents the regressions results for the three price expectation behavior hypothesis models used to estimate Argentina's aggregate crop planted area supply response. These are:

Naive:

$$A_t=\beta_0+\beta_1 GInc_t+\beta_2 CInc_t+\beta_5 A_{t-1}+\beta_6 UreaP_t+\beta_7 GasP_t+\mu_t \qquad (7a)$$

Moving Average:

$$A_t=\beta_0+\beta_1 MAGInc_t+\beta_2 MACInc_t+\beta_3 A_{t-1}+\beta_4 UreaP_t+\beta_5 GasP_t+\mu_t \qquad (9a)$$

Simple Weighted Average:

$$A_t=\beta_0+\beta_1 SWGInc_t+\beta_2 SWCInc_t+\beta_3 A_{t-1}+\beta_4 UreaP_t+\beta_5 GasP_t+\mu_t \qquad (11a)$$

5.1 Results

Below is a table of empirical regression results for the three linear price expectation behavior models: naive, moving average, and simple weighted average. In Appendix B, the results of the three price expectation behavior models estimated using a log-log functional form are presented as a comparison to the linear form presented below. In summary, the log-log model results are not much different than those presented below.

Table 2: Results of aggregate crop planted area using three specifications of price expectation behavior, Argentina 1960-1997

Model	Naive		Moving Average		Simple Weighted Average	
	β	t Statistic	β	t Statistic	β	t Statistic
β_0	-934.11	-0.37	-1037.04	-0.47	-802.86	-0.32
$Area_{t-1}$	1.04	7.77	0.99	8.29	1.03	7.67
$UreaP_t$	4.04	1.37	4.69	1.74	3.62	1.23
$GasP_t$	-8132.09	-2.34	-8376.59	-2.55	-8794.66	-2.53
Ginc	0.0070	2.18				
Cinc	-2.56	-1.57				
MAGinc			0.0115	3.51		
MACinc			-4.71	-2.60		
SWGinc					.0070	2.15
SWCinc					-1.95	-1.38
n	37		37		37	
Adj. R^2	0.82		0.85		0.81	

Model	Naive	Moving Average	Simple Weighted Average
White Test	10.68	13.43	11.19
Durbin h Test	1.64	0.85	-1.09

It was stated in Chapter 4 that the criteria to determine the best structural model are: signs of the estimated coefficients, statistically significant estimated coefficients, adjusted R^2, and reasonableness of results. As the table shows, adjusted R^2 for all three models are above 0.80. The moving average price expectation model has the highest adjusted R^2 of the three. In comparison, Reca's adjusted R^2 for his grain subsector model were between 0.82 to 0.88, and for his aggregate model were between 0.82 to 0.87. Wainio's average R^2 for his four single equations was 0.90.

The signs on the estimated coefficients are not all as expected. The constant coefficient in all three models has a negative sign, however they are not significantly different from zero, even at the 20% significance level. According to Studenmund (1997), one cannot rely on the estimates of the constant term for inference for two reasons. The first is that the "constant term acts as a garbage collector, with an unknown amount of the mean effect ...of the omission of marginal independent variables...being dumped into it" and second, "the origin often lies outside the range of sample observations".

The urea price variable, in all three models, the sign is positive and it is statistically significant in the naive model at a 18% significance level, in the moving average model at a 9% level, and in the simple weighted average model at a 23% level. The expected sign of the estimated coefficient depended on whether the input is a complement or substitute to planted area. The 'a priori' expected sign was negative, however, according to Helmberger and Chavas (1996), a possible reason for the positive sign on the urea price variable is that fertilizer and planted area are substitute inputs. An increase in the price of fertilizer increases the producer's demand for land. Another possible explanation of the estimated positive sign is that there is a correlation of urea price with soybean planted area (soybean area has expanded considerably at the expense of flaxseed and sorghum, and also as a result of double cropping with wheat). A last possible explanation for the positive sign is as a result of an omitted variable problem, although the estimated coefficient is only significant at a 9% level (using Studenmund's (1997) suggestion of detection for an omitted variable). Further study is required to determine the reason for a positive sign for the urea price variable.

In the naive price expectation model, the estimated coefficients are statistically significant at a 5% significance level, except for the estimated coefficient of the cattle gross income variable which is statistically significant only at a 13% level and the urea variable mentioned above. In the moving average price expectation model, the only estimated coefficient which is not statistically significant at a 5% significance level is the urea price variable. In the simple weighted average price behavior model, the estimated coefficient of the diesel variable is statistically significant at a 2% level, while the simple weighted grain gross income estimated coefficient is significant at an 4% level and the simple weighted cattle gross income is significant at a 18% significance level.

5.1.1 Diagnostics for Multicollinearity, Heteroskedasticity, and Serial Correlation

Using the simple correlation coefficients between the explanatory variables in the three price behavioral models, none of the models appeared to show serious multicollinearity. In the naive model, the simple correlation between diesel price and grain gross income at 0.75, and diesel price and cattle gross income at 0.64 are higher than the 0.60 specified as the criteria in Chapter 4, together with the simple correlation between grain gross income and cattle gross income at 0.70. However, these two naive model variables are statistically significant at a 4% significance level and 13% level respectively. The simple correlations between urea price and the other explanatory variables are low, however, urea price is only statistically significant at a 18% significance level, therefore it may be concluded that multicollinearity is not evident. In the moving average model, as in the naive model, the simple correlation of the diesel price variable and moving average grain gross income variable at 0.75 and diesel price and the moving average cattle gross income variable at 0.71 are high, together with the simple correlation of and moving average cattle gross income variables at 0.72. All of these variables, except for the urea price variable, are statistically significant at a 2% significance level or lower, therefore it may be concluded that multicollinearity in this model is not a concern. In the simple weighted average model, the simple correlation of diesel and simple weighted grain income variables at 0.75 and simple weighted grain gross income and simple weighted cattle gross income at 0.67 are high. The diesel and simple weighted grain gross income variables are statistically significant at a 4% level or lower, while the simple weighted cattle gross income is significant at a 18% level. Using the criteria that R^2 is above 0.80 and that the diesel variable is statistically significant at a 2% level, multicollinearity does not appear to be a concern in this model.

The hypothesis testing which follows is conducted at a 5% significance level for the following reasons:

- It is believed that the data, except for a few assumptions in the urea price series, is accurate, the variance of the data is high and that the sample size is reasonable at 37 years.
- It is assumed that the models being tested are well specified.

- The 'costs' of making a Type I error (rejecting the hypothesis when it is true) are large to those who might be interested in an Argentine aggregate crop supply response.

Testing the hypothesis that there is no heteroskedasticity on the three price expectation behavior models, where:

H_O: Homoskedasticity

H_A: Heteroskedasticity

It was determined, with degrees of freedom equal to 10, the test statistic at 5 percent level of significance, the critical chi-squared value is 18.31, that:

1. In the naive model, with a nR^2 of 10.68 as shown in the above table, the null hypothesis of *homo*skedasticity[14] cannot be rejected.
2. In the moving average model, with a nR^2 of 13.43, the null hypothesis of homoskedasticity cannot be rejected.
3. In the simple weighted average model, with a nR^2 of 11.19, the null hypothesis of homoskedasticity cannot be rejected.

Using the Durbin h test for serial correlation, and the hypothesis that there is no serial correlation in the three price expectation behavior models, where:

H_O: No serial correlation

H_A: Serial correlation

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[14] If an error term is homoskedastic, the variance of the distribution of the error term is constant.

It is determined, with a two-tailed test at a 5 percent significance level implying a critical z-value of 1.96, that:

1. In the naive model, since the Durbin h test is 1.64, the null hypothesis of no serial correlation cannot be rejected.
2. In the moving average model, with a Durbin h test of 0.85, the null hypothesis cannot be rejected.
3. In the simple weighted average model, with a Durbin h test of −1.09, the null hypothesis cannot be rejected.

Before determining which is the best structural model, the results of the weight estimation for the simple weighted average price behavior model is discussed below.

5.1.2 Weight Estimation for Simple Weighted Average Price Model

Estimated individual crop price weights used in the calculation for the aggregate grain simple weighted average model[15] is presented below:

Crop	Weight
Wheat	0.95
Corn	0.94
Soybean	1.04
Sunflower	0.89
Sorghum	1.02
Flaxseed	0.86
Cattle	1.21

[15] Equation 10c and 10e in Chapter 4.

Therefore, this implies that the weights for the second lagged period, where the weight is defined as 1-c, are:

Crop	2nd Lagged Period Weight
Wheat	0.05
Corn	0.06
Soybean	-0.04
Sunflower	0.11
Sorghum	-0.02
Flaxseed	0.14
Cattle	-0.21

The price weights for soybean, sorghum and cattle for the first lagged period are greater than one, which imply a negative weight for the second lagged period. This would imply that the Argentine producers consider the previous period's price and not the second previous period. This is implies a naive expectation price behavior for these three variables. It must be mentioned that the above calculated price weights were not statistically significant at a 20% level.

The calculated weight results do not appear reasonable. Interpretation of these results imply that a combination of naive and simple weighted price behavior mechanisms are being analyzed. Further work is required to determine these results, and consequently, this model is not considered a potential structural model.

5.2 Best Structural Model

Given the above mentioned results for the three price behavior models, it appears that a moving average behavior of expected price is a better representation of the sample data than a naive expectation.

The moving average price expectation behavior model was chosen as the best structural model for the following reasons:

- It had the highest adjusted R^2, at 0.85, of the three estimated model, implying that this model explains 85% of the variation around the average area.
- The estimated coefficients which had the correct sign also had the highest t-tests of the three models considered, implying that the probability that these estimated coefficients equal to zero are smaller.
- Calculated weights in the simple weighted average price behavior model do not appear reasonable and theoretically consistent.
- The rate of adjustment for the naive and simple weighted average price behavior models are negative, -0.04 thousand hectares for the naive model and –0.03 thousand hectares for the simple weighted average model, and statistically significant at a 0% level. It does not make sense that a producer would have a negative rate of adjustment (it would imply that the producer 'go backwards') due to an economic shock.

5.2.1 Moving Average Price Expectation Behavior Model Interpretations

As stated above, the adjusted R squared is 0.85 which implies that this equation explains 85% of the variability in area, adjusted for the degrees of freedom. The sign of the coefficient for expected grain gross income is positive as theory suggests; as grain prices increase, seeded area increases. Since this is a moving average of expected grain income, this implies that as the moving average of two previous periods' grain income increases, Argentine seeded area increases.

The coefficient of adjustment (the lagged area variable) is statistically significant at a zero significance level implying that the rate of adjustment the Argentine producer responds (adjusts) to changes (shocks) in prices is 0.01 thousand hectares, which implies that Argentine producers are slow in responding to changes in prices.[16]

The elasticities of this model are[17]:

Table 3: Short and Long Run Elasticities

Elasticity	Short Run	Long Run
GasP	-0.12	-1.2
MAGinc	0.21	2.1
MACinc	-0.10	-1.0

[16] Conceptually, the coefficient for the partial adjustment, β_n, represents $(1-\gamma)$, where γ is the measure of adjustment where $0<\gamma<1$. If $\gamma=1$, then the actual planted area is equal to the desired planted area. If $\gamma=0$, then the planted area in this period is equal to the planted area in the previous period, and the desired planted area will never be reached.

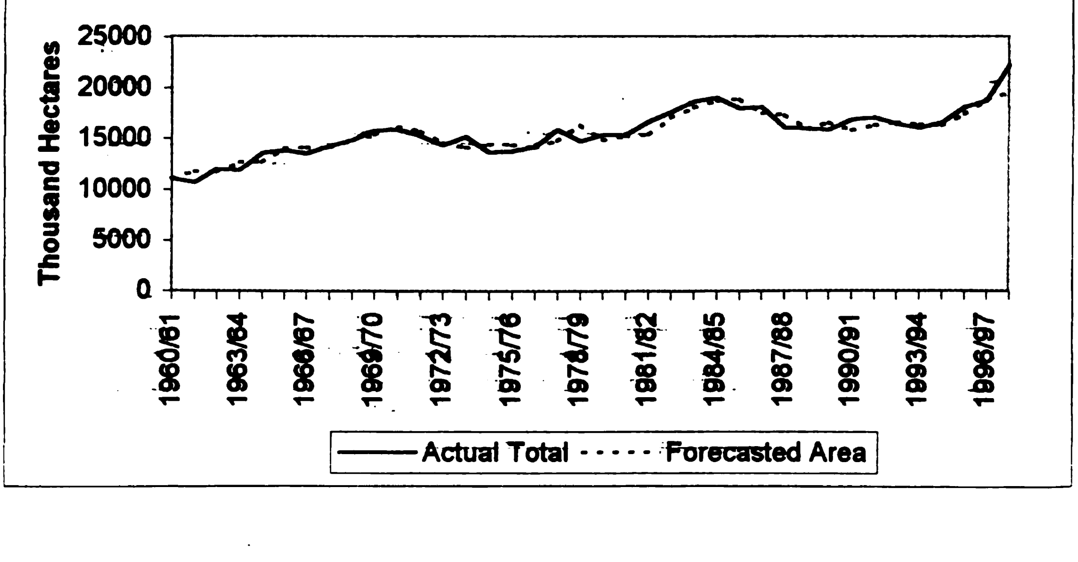
[17] Short run elasticities calculated as follows: $SR\xi_X=\beta_X(X/Y)$, where $X=(X_1+\ldots+X_n)/n$ and $Y=(Y_1+\ldots+Y_n)/n$. Long run elasticities calculated as follows: $LR\xi=SR\xi/(1-\beta_{AREAt-1})$. The coefficient for the partial adjustment is used in calculating the long run elasticity since it estimates the long term adjustments to prices.

Urea elasticity was not calculated since the estimated coefficient was insignificant at a 5% level.

A one percent increase in a two period (year) moving average grain income will increase seeded acreage by 0.21 percent in the short run, while a one percent increase in a two period moving average cattle income will decrease acreage by 0.10 percent in the short run. A one percent increase in diesel prices will decrease seeded acreage by 0.12 percent in the short run.

Long run elasticities give the effect of a permanent change in expected price. A one percent increase in Argentina's two period moving average grain income would imply a 2.1 percent increase in seeded acreage. A one percent increase in Argentina's two period moving average cattle income would imply a 1.0 percent decrease in seeded acreage.

Figure 10: Actual versus Forecasted Planted Area, Argentina 1960-97



Comparison of actual planted area with forecasted planted area shows that the moving average price expectation behavior is a good representation of the data. The forecast error of the moving average model is 4%.

CHAPTER 6

Conclusions

Previous studies of planted area supply response in Argentina assume that the producer wants to maximize his profit, therefore theory implies that the Argentine farmer decides on acreage based on the expected income (his/her expectation of prices multiplied by expected yield per hectare) less input (production) costs. The input costs should include: price of fertilizer, pesticides, fuel, seed, and labor for the product(s) (i.e. crops and livestock) being produced. Other factors that affect supply are technological changes, government policy, and weather. Reca's, Wainio's and Sturzenegger's studies incorporate the above mentioned theory with some difficulty due to lack of data or omission. This study works towards explaining the variations in aggregate crop acreage while improving the specification of a profit maximizing producer by: a) incorporating input variables and yield variables, b) incorporating a longer period of analysis to include recent data, and c) including soybeans in the analysis due to the increasing importance of its production to the nation.

The primary objective of this study was to develop a single equation model to predict Argentine aggregate planted area supply response to various variables. Secondary objectives were: 1) determine how Argentine producers form their price expectations, 2) determine the period of adjustment between economic shocks and its effect on planted area, and 3) determine the explanatory variables needed to explain the area in crop production. The model is a simple comparative advantage model between cattle and crops. Using a simplified Nerlove linear model specification of aggregate planted area of six crops dependant on expected grain gross income (grain price multiplied by grain trend yield), competing expected cattle gross income (cattle price multiplied by cattle trend weight), diesel price, urea price and a partial adjustment variable, three different price expectation behaviors were analyzed.

The three price expectation behaviors analyzed were naive, moving average and simple weighted average. Results show that the moving average model is a better representation of the sample data. This implies that Argentine farmers respond to a moving average of the previous two years' prices. Previous studies have found that Argentine producers respond to the previous period's price, i.e. naive expectations. This moving average price expectation behavior appears reasonable if one were to take into consideration that it takes more than one year to adjust from cattle production to grain production given that the cattle stock needs to be liquidated and the land prepared for grain production. The implication that Argentine producers take at least two periods to adjust their crop acreage is also corroborated by the partial adjustment coefficient which also shows that the Argentine producer is reasonably slow in adjusting crop acreage to economic shocks, although the actual length of adjustment is not determined.

An attempt at a well specified supply response model appears to be successful, as implied by the adjusted R^2 of 0.85 (which is comparable to the other Argentine supply response studies by Reca, Wainio, and Sturzenegger). The following explanatory variables were included in the models: a yield variable, product price variable, competing product price variable, and input price variables. These explanatory variables' statistical significance at a 2% significance level or lower is in agreement with profit maximizing theory. Results show that, in making his/her crop production decision, the producer is influenced by expected cattle gross income, expected grain gross income, and input prices. Estimated elasticities of expected grain gross income are 0.21 in the short run and 2.1 in the long run which compares to Wainio's wheat short run elasticity of 0.48 and long run of 0.67. Estimated elasticities of expected cattle gross income is –0.10 in the short run and –1.0 in the long run, which compares to Wainio's beef price elasticity on wheat acreage of 0.10 in the short run.

This analysis improves on previous efforts by using more recent data. Studies on supply response in Argentina were last performed with data through 1985 by Sturzenegger. In an effort to update the analysis, this study uses data through 1997, which incorporates an entirely new economic period in Argentina, that of President Carlos Menem's Convertibility Plan, which has removed government intervention in agriculture, and has stabilized the economy.

This study also attempts an aggregate crop planted area supply response, instead of individual crop planted area response, to determine the variations in total crop planted area in Argentina. In addition, soybeans were included in this study, where in other studies mentioned soybeans were not included. Soybeans only became an important crop in the late 70's when planted area was 0.5 million hectares. By 1996, soybean planted area was 7.2 million hectares, becoming one of the nation's most important crops.

The explanatory variables in this study included input prices. These inputs were limited to crop production. Inclusion of inputs related to cattle production would improve the aggregate crop acreage supply response model.

The inclusion of urea and diesel price variables appear to explain the variation in planted crop area. However, further work is needed to determine whether the positive sign on the estimated coefficient of the urea price variable is a result of an omitted variable or if in fact it demonstrates that urea price is a substitute input with land, as suggested by Helmberger and Chavas (1996).

In order to improve the present aggregate supply response model, further work could include risk, government intervention in the form of subsidies, and cattle as a capital good. A producer, by the very nature of crop production, has to make production decisions based on potential output and price scenarios since the actual scenario is not known at decision time. There are many uncontrollable factors that affect these potential scenarios, such that the expected output and price scenario may not be realized. Incorporation of Just's concept of price uncertainty into supply response by including the variance (or standard deviation) of past prices over the period of analysis as an explanatory variable might be one possible method of improving this supply response model. The producer is also faced with yield uncertainties when making his production decision, therefore inclusion of yield risk into the model in the same manner as in price uncertainties should also be investigated.

Although this study incorporated government intervention in price determination (for 1973-76) by using domestic prices converted into US dollars (the domestic price in domestic currency is the final outcome of government pricing policy, and converting the domestic price into US dollars takes into consideration government exchange rate policy), this does not address all of the ways in which government intervened in Argentine agriculture. For example, inclusion of the availability of credit in the aggregate supply response may improve the model.

As mentioned previously in this study, cattle and crops compete for area in Argentina. Historically, cattle has been an important product in Argentina because it has allowed the producer to 'hedge' against economic instability. As a part of his study of supply response in cattle industry in Argentina, Jarvis addresses the concept of cattle as capital goods. Jarvis maintains that producers considered cattle production as an investment opportunity. Inclusion of such in this aggregate crop planted area supply response might also improve the model.

Moving land from cattle to crops requires liquidating the cattle stock and preparing the field for crop production. This process takes time. In this study, a two year period is analyzed (a moving average price expectation of two periods). It is possible that a cattle producer needs to see the price change last for longer than two years before he/she makes the decision to shift from cattle production to crop production due to the capital investment involved. Incorporation of the more complex dynamics involved would improve the present aggregate planted area supply response.

Further work might include the role of budgeting in resource allocation. An Argentine producer, if one assumes profit maximization, is going to look at his potential income, costs and determine his/her allocation based on his budget. His budget may be imposed by capital, resources, or personal requirements (i.e. time off during the winter).

Further work on this aggregate crop planted area supply response might test for different price expectation behaviors, such as adaptive expectation and rational expectations. Although this study shows that it is likely, given the data used, that Argentine producers form a moving average price expectation, analysis of other price behavior expectations might show different results. Analysis of rational expectation price behavior, where the producer forms his price expectation by looking towards the future and analyzing potential supply/demand scenarios, would be interesting given that access to information in Argentina is improving, the Argentine producer is becoming a more sophisticated and educated manager, and that Argentina is an important agricultural world producer.

In conclusion, a single equation aggregate crop planted area supply response model for Argentina was specified and estimated, resulting in a respectable model. This model may be used by the those in the industry which could benefit from being able to forecast aggregate crop planted area.

APPENDICES

APPENDIX A

Urea Price Series Construction

Summary

An Argentine domestic urea price series was located for the period 1970-1997, however, the period of study is 1960-1997, therefore an attempt was made to estimate domestic urea prices for the missing data. Taking a World Bank publication's example calculation of importing urea into Argentina, a domestic urea price series was estimated[18]*. There were many assumptions that had to be made due to lack of information, but it is believed that the estimated Argentine domestic urea price series is a reasonable representation of the actual price series. Consequently, it is believed that for the period 1960-1970, the estimated urea price series can be used as an index to complete the price series located.*

Domestic urea price series from 1970 to date was obtained from the Argentine Secretaria de Agricultura, Ganado y Pesca (SAGyP). Any price before 1970 is unavailable. Since the period of study is 1960 to 1997, an attempt to estimate domestic prices for the missing data is described below.

[18] World Bank, Argentina, Economic Memorandum, p. 156.

To estimate Argentine domestic urea prices, Free On Board (FOB) Europe urea prices from International Monetary Fund (IMF) were obtained, together with dry bulk voyage charter index from United Nations Committee on Trade and Development (UNCTAD), Argentine import tax from various sources[19], and Value Added Tax (VAT) from various sources[20]. In a World Bank Country Study, Argentina, Economic Memorandum (1983), an example of how one would calculate the costs of importing urea for June 1983 into Argentina was obtained, which is the calculation used, and is presented below.

Table 4: Calculation of Argentine Fertilizer Imports

Calculation of fertilizer imports	June-83
FOB, Western Europe bagged	120.0
Insurance and freight charges	26.8
CIF Buenos Aires	146.8
Import tax (25% CIF price)	36.7
Consular, custom charges, freight and other costs	20.8
Bagging	15.0
Subtotal	219.3
Financing costs (4.5%)	9.9
Cost to importer	229.2
Importer's margin (10%)	22.9
Wholesale Price	252.1
Farmer's price (18% VAT)	297.5

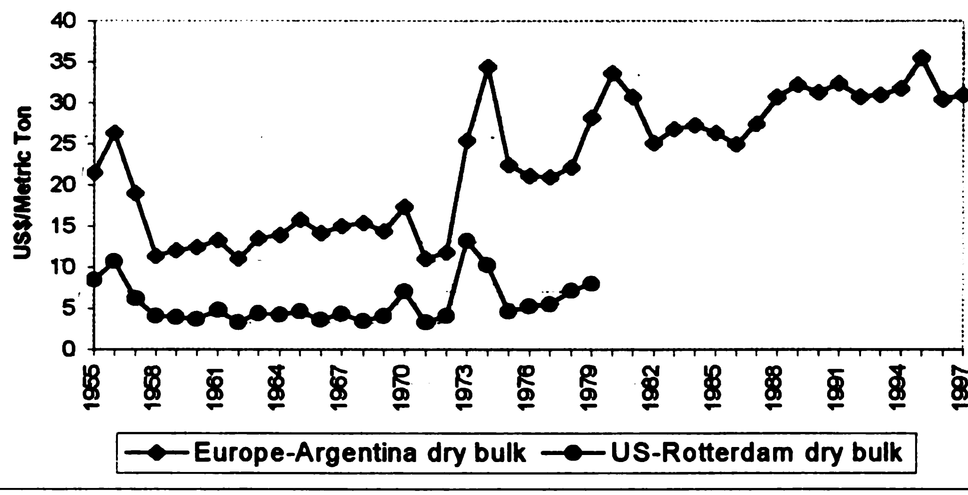
US$/ton

A historical series for dry bulk freight from Europe to Argentina is not available. In order to arrive at some approximation of what freight might be, the dry bulk voyage charter index series (an annual average of dry bulk freight) was used to calculated a dry bulk Europe to Argentina freight series, using the freight for June 1983 from the

[19] McCarry, Michael J. and Andrew Schmitz, The World Grain Trade: Grain Marketing, Institutions, and Policies, 1992.

World Bank study. The June 1983 Europe to Argentina freight rate divided by the dry bulk voyage charter index for 1983 was multiplied to the index to arrive at a simulated freight rate series. In order to check that my simulated freight series was representative of the actual freight market, the United States to Rotterdam dry bulk freight rates[21] was plotted against the estimated freight series. See Table 5 for the calculation of the simulated Europe to Argentina dry bulk freight series and below a graph with the US to Rotterdam versus the simulated Europe to Argentina series. It appears that the simulated series is a good representation of the actual freight market for the period 1960-1980.

Figure 11: Freight Rate Comparison

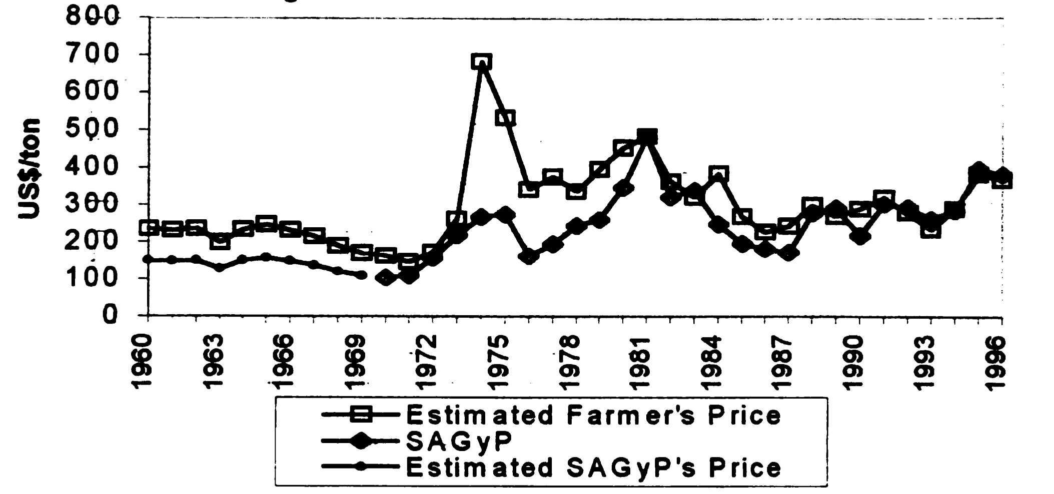


Below is a description of the calculation of the Argentine farmer's price for imported urea (see Table 4 for calculation worksheet).

[20] World Bank, Argentina, From Insolvency to Growth, 1992 and from World Bank, Argentina, Economic Memorandum, 1983.
[21] Series from UNCTAD, St. Lawrence to Rotterdam.

1. The Cost Insurance and Freight (CIF) price is calculated by summing the FOB Europe Urea price and the freight (the simulated dry bulk freight rate series was used).
2. The import tax is then calculated, using a import tax series compiled from various sources as mentioned above, by multiplying the CIF price by the import tax.
3. Due to lack of information for other costs associated with importing fertilizer, it is assumed that the US$35.00 used in the World Bank's calculation is a good approximation, and is used throughout the series. These other costs are then added to arrive at a subtotal of CIF*Import tax+Costs.
4. Financing costs are then calculated, using the World Bank's interest rate for 1983 of 4.5% (and assumed for the remainder to the series), from the subtotal.
5. An importer's margin of 10% (assumed for the entire series) is then calculated to arrive at a wholesale price.
6. A VAT is then computed, using a series compiled as mentioned above, and summed to arrive at the farmer's price.

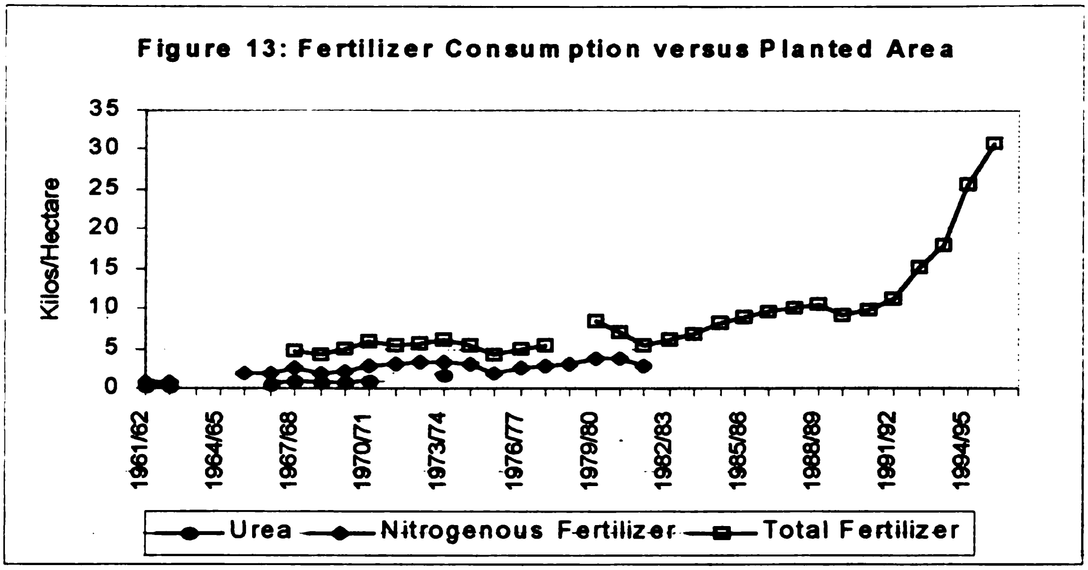
Figure 12: Estimated Urea Price



Comparison of the calculated farmer's price for imported urea to the series provided by SAGyP demonstrates that, although the assumptions are many, the estimated urea price series resembles SAGyP's series, except for the period 1974 to 1979 where the trend is followed but the difference is much larger. The two data sets have a correlation of 0.554. (If one were to calculate the correlation of the two data sets omitting 1974-1979, the correlation is 0.886.)[22]

Given the above, data on domestic consumption for urea in Argentina was analyzed to determine how important urea was during 1960-1970. Data was taken from FAO and Argentine Secretary of Agriculture, and although it is not complete, it appears that urea consumption between 1960-70 was minimal compared to other nitrogenous fertilizer or other fertilizers. In 1968/69, urea consumption was estimated at 10,459

[22] Note: The Argentine government during 1974 through 1976 set grain prices at a fixed rate to curb inflation. Once this was abandoned, domestic grain prices sky rocketed. There is no mention that the government fixed prices for fertilizers, but it may be assumed that some policy was implemented that



metric tons, nitrogenous fertilizer at 30,661 metric tons, and total fertilizer at 67,666 metric tons.

To put this fertilizer consumption into perspective, a ratio of urea, nitrogenous and total fertilizer consumption versus seeded acreage for the six crops being analyzed was derived. In 1968/69, usage of urea was 0.7 kilos/hectare, versus nitrogenous fertilizer at 2.2 kilos/hectare and total fertilizer at 5.0 kilos/hectare. It appears that urea consumption was minimal during 1960-1970.

Given the above mentioned analysis, there appears to be two methods of handling the missing domestic urea price series for 1960-1970:

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affected domestic fertilizer prices. Also note that FOB European fertilizer prices increased drastically in 1974.

- The first method would be to use a constant price for the missing data period, since urea consumption appears to be minimal, using the last known price, i.e. 1970 price provided by SAGyP.
- The second method would be to use the estimated urea price series for the missing data period as an index to calculate a series based on the 1970 price provided by SAGyP. Urea consumption appears to be minimal, the estimated urea price series appears to resemble SAGyP's price series and has a high correlation when data for 1974-1979 is omitted.

The second method, using the estimated urea prices for the period 1960-1970 as an index, was to complete the urea price series provided by SAGyP.

APPENDIX B

Log-log Aggregate Crop Planted Area Supply Response Model

The table below lists the results of the three price behavior expectation models in a log-log functional form. These are:

Naive:

$$lnA_t=\beta_0+\beta_1 lnGInc_t+\beta_2 lnCInc_t+\beta_5 lnA_{t-1}+\beta_6 lnUreaP_t+\beta_7 lnGasP_t+\mu_t$$

Moving Average:

$$lnA_t=\beta_0+\beta_1 lnMAGM_t+\beta_2 lnMACM_t+\beta_3 lnA_{t-1}+\beta_4 lnUreaP_t+\beta_5 lnGasP_t+\mu_t$$

Simple Weighted Average:

$$lnA_t=\beta_0+\beta_1 lnSWGInc_t+\beta_2 lnSWCINc_t+\beta_3 lnA_{t-1}+\beta_4 lnUreaP_t+\beta_5 lnGasP_t+\mu_t$$

Table 6: Results of aggregate crop planted area using three specifications of price expectation behavior in logarithms, Argentina 1960-1997

Model	Naive		Moving Average		Simple Weighted Average	
	β	t Statistic	β	t Statistic	β	t Statistic
β_0	-1.26	-.97	-1.78	-1.50	-1.24	-0.95
$lnArea_{t-1}$	0.97	7.98	0.93	8.63	0.99	8.01
$lnUreaP_t$	0.06	1.06	0.08	1.61	0.06	1.04
$lnGasP_t$	-0.10	-2.13	-1.11	-2.57	-0.11	-2.17
lnGinc	0.11	1.82				
lnCinc	-0.06	-1.35				
lnMAGinc			0.20	3.17		
lnMACinc			-0.12	-2.67		
lnSWGinc					0.09	1.49
lnSWCinc					-0.04	-1.28
n	37		37		37	
Adj. R^2	0.83		0.86		0.83	

In a log-log specification, the three price expectation behavior estimation results are not markedly different than the linear specification. Adjusted R^2 on all three equations are approximately the same. The signs are the same as in the linear specification; once again, the urea price is positive and the constant is negative . The level of significance for the estimated coefficients is also comparable to the linear specification.

STATISTICAL TABLES

Table 5: Calculation of Freight Cost Series

1955	173	136	21.47
1956	212	167	26.32
1957	153	120	18.99
1958	91	72	11.30
1959	97	76	12.04
1960	100	79	12.41
1961	107	84	13.28
1962	89	70	11.05
1963	109	86	13.53
1964	112	88	13.90
1965	127	100	15.76
1966	114	90	14.15
1967	121	95	15.02
1968	124	98	15.39
1969		91	14.35
1970		110	17.34
1971		70	11.04
1972		75	11.82
1973		161	25.38
1974		218	34.37
1975		142	22.39
1976		134	21.12
1977		133	20.97
1978		140	22.07
1979		179	28.22
1980		213	33.58
1981		195	30.74
1982		159	25.07
1983		170	26.80
1984		173	27.27
1985		167	26.33
1986		158	24.91
1987		174	27.43
1988		195	30.74
1989		204	32.16
1990		198	31.21
1991		205	32.32
1992		195	30.74
1993		196	30.90
1994		201	31.69
1995		225	35.47
1996		193	30.43
1997		196	30.90
1998			

UNCTAD, Dry Cargo Tramp Voyage Charter, except for '55-'68 w/base 1960=100,USD/mt

Table 7: Planted Area in Argentina

	Wheat	Corn	Soybean	Sunflower	Sorghum	Flaxseed	Total
1959/60	4792	3062	0.9	1250	730	1228	11063
1960/61	4275	3222	1	1122	937	1129	10686
1961/62	4952	3300	10	1351	1075	1307	11995
1962/63	4847	3420	21	983	1072	1503	11846
1963/64	6276	3778	14	873	1218	1409	13568
1964/65	6497	3693	18	1173	1246	1172	13799
1965/66	5724	3921	17	1181	1346	1294	13483
1966/67	6291	4157	18	1362	1454	924	14206
1967/68	6613	4473	23	1194	1841	711	14855
1968/69	6680	4595	31	1354	2151	879	15690
1969/70	6239	4666	30	1472	2568	952	15927
1970/71	4468	4993	38	1614	3122	973	15208
1971/72	4986	4439	80	1533	2759	539	14335
1972/73	5627	4251	169	1652	2974	509	15183
1973/74	4252	4134	377	1342	3114	415	13633
1974/75	5183	3871	370	1196	2602	520	13741
1975/76	5753	3696	443	1411	2358	471	14132
1976/77	7192	2980	710	1460	2780	722	15844
1977/78	4600	3100	1200	2200	2650	950	14700
1978/79	5230	3300	1640	1766	2540	893	15369
1979/80	5000	3310	2100	2000	1884	1070	15364
1980/81	6196	4000	1925	1390	2400	780	16691
1981/82	6566	3695	2040	1733	2712	851	17597
1982/83	7410	3440	2362	1930	2657	910	18709
1983/84	7200	3484	2920	2131	2550	810	19095
1984/85	6000	3620	3300	2380	2040	620	17960
1985/86	5700	3820	3340	3140	1400	750	18150
1986/87	5000	3650	3700	1891	1127	758	16126
1987/88	4850	2825	4413	2117	1075	671	15951
1988/89	4750	2685	4670	2313	830	574	15822
1989/90	5500	2070	5100	2800	800	600	16870
1990/91	6178	2160	4967	2372	752	590	17019
1991/92	4751	2686	5004	2724	823	431	16420
1992/93	4548	2963	5320	2187	810	215	16043
1993/94	4910	2781	5817	2206	670	148	16533
1994/95	5308	2958	6011	3010	622	156	18065
1995/96	5088	3415	6002	3411	671	196	18781
1996/97	7367	4153	6670	3120	804	94	22207
1997/98	5919	3752	7176	3511	920	116	21394
Bolsa de Cereales 90, in thousand hectares, SAGyA for data 1970-96							

Table 8: Argentine Real Crop Price in US$/Metric Ton

	Wheat	Corn	Soybean	Sunflower	Sorghum	Flaxseed
1960	124.97	122.69		231.70	96.10	238.16
1961	150.05	148.52		305.06	103.09	306.97
1962	142.29	145.81		245.37	114.59	273.09
1963	152.64	175.13		258.62	125.85	268.05
1964	185.32	157.72		348.22	103.52	281.02
1965	139.06	178.19		311.70	129.50	249.34
1966	143.71	153.68		235.58	118.79	238.78
1967	142.25	127.87	200.67	189.84	100.77	200.12
1968	131.72	118.24	226.37	176.45	96.41	232.69
1969	137.86	126.53	237.25	207.22	96.18	244.59
1970	128.28	128.38	232.96	228.35	94.60	215.86
1971	132.30	125.94	254.85	287.84	103.05	183.98
1972	152.84	146.44	347.47	434.93	120.26	331.20
1973	270.75	251.16	625.81	515.62	190.11	513.03
1974	264.24	242.31	608.16	534.88	226.77	808.72
1975	211.41	169.68	409.17	353.18	148.15	372.01
1976	61.48	45.89	227.69	171.45	42.85	307.73
1977	126.01	114.30	373.81	352.14	90.19	323.80
1978	156.20	131.29	254.24	265.48	95.89	243.68
1979	154.67	120.18	286.53	326.08	92.59	346.64
1980	194.08	154.21	218.73	203.80	130.55	277.08
1981	190.31	128.60	214.92	247.15	111.24	258.50
1982	149.36	101.76	204.51	212.85	80.19	244.95
1983	92.51	85.03	163.29	148.51	73.48	150.66
1984	94.99	97.89	192.56	243.45	75.08	187.88
1985	80.17	84.69	144.38	166.31	63.64	162.92
1986	82.72	64.95	124.86	114.31	52.75	155.69
1987	73.19	59.95	154.42	136.20	49.00	130.35
1988	102.71	78.50	212.85	167.25	63.18	163.53
1989	128.52	116.52	237.35	181.73	82.20	262.07
1990	88.42	64.39	113.89	109.09	54.35	178.59
1991	69.40	75.24	138.69	126.05	54.84	134.70
1992	100.54	79.81	160.48	139.71	65.95	140.43
1993	109.13	82.73	172.97	171.33	63.21	184.82
1994	98.71	103.58	192.59	190.51	74.12	171.98
1995	107.96	81.73	162.22	164.42	56.73	217.29
1996	192.22	130.59	206.45	172.95	105.79	154.68
1997	117.28	85.01	229.58	167.57	66.40	226.68
1998	90.95	77.87	175.76	205.37	63.57	211.13

Source: Bolsa de Cereales and SAGyP

Table 9: Argentine Crop Yield

	Wheat	Corn	Soybean	Sunflower	Sorghum	Flaxseed	Total
1960/61	1160	1767	977	651	1265	587	1068
1961/62	1295	1894	1163	718	2159	698	1321
1962/63	1522	1648	972	611	1660	638	1175
1963/64	1575	1801	1146	628	1751	634	1256
1964/65	1835	1678	1035	746	1458	752	1251
1965/66	1321	2150	1147	765	2524	568	1413
1966/67	1198	2466	1188	902	1805	721	1380
1967/68	1260	1942	1089	891	1752	625	1260
1968/69	983	1929	1124	737	1908	630	1219
1969/70	1352	2330	1032	846	2040	809	1402
1970/71	1329	2442	1624	632	2085	816	1488
1971/72	1267	1862	1143	644	1663	700	1213
1972/73	1591	2721	1732	658	2328	748	1630
1973/74	1657	2840	1440	815	2539	762	1676
1974/75	1410	2508	1363	728	2493	761	1544
1975/76	1626	2117	1603	862	2758	845	1635
1976/77	1711	3278	2121	733	2776	915	1922
1977/78	1355	3647	2174	890	3194	916	2014
1978/79	1729	3107	2313	918	3033	734	1972
1979/80	1692	2570	1724	868	2314	760	1655
1980/81	1549	3801	2005	984	3595	806	2123
1981/82	1400	3028	2090	1184	3187	734	1937
1982/83	2049	3030	1754	1262	3214	845	2026
1983/84	1837	3140	2406	1106	2911	820	2037
1984/85	2305	3563	1988	1441	3155	829	2214
1985/86	1617	3745	2141	1346	3125	669	2107
1986/87	1778	3189	1897	1268	3067	835	2006
1987/88	1879	3774	2264	1435	3347	817	2253
1988/89	1836	2910	1653	1444	2531	742	1853
1989/90	1892	3461	2156	1451	2812	848	2103
1990/91	1896	4044	2275	1752	3331	797	2349
1991/92	2173	4523	2291	1413	3621	823	2474
1992/93	2320	4355	2158	1435	3952	854	2512
1993/94	2022	4237	2039	1902	3506	793	2417
1994/95	2166	4522	2045	1963	3459	996	2525
1995/96	1936	4039	2105	1718	3876	792	2411
1996/97	2241	4556	1721	1812	3685	808	2471
1997/98	2585	6078	*2700*	1661	*4800*	702	3088

Source: Bolsa de Cereales and SAGyP, in tons per hectare

Table 10: Real Argentine Cattle Price, Cattle Weight, Real Diesel Price and Real Urea Price

	Real Cattle Price	Cattle Weight	Real Diesel Price	Real Urea Price
1959/60	0.5151	437	0.1899	472
1960/61	0.6135	441	0.1909	466
1961/62	0.5389	428	0.1703	470
1962/63	0.5281	426	0.1746	399
1963/64	0.5675	431	0.1755	468
1964/65	0.9473	444	0.1945	484
1965/66	0.9726	443	0.1958	441
1966/67	0.8585	440	0.1541	408
1967/68	0.5940	437	0.1342	352
1968/69	0.5952	445	0.1297	304
1969/70	0.5401	452	0.1228	291
1970/71	0.6599	443	0.1667	267
1971/72	1.0634	449	0.2444	362
1972/73	1.4020	452	0.3139	487
1973/74	2.0820	449	0.4933	490
1974/75	1.6547	448	0.3044	522
1975/76	1.1654	444	0.1200	249
1976/77	0.3987	451	0.1360	303
1977/78	0.6095	445	0.2482	346
1978/79	0.5313	448	0.2822	333
1979/80	0.9698	452	0.2934	354
1980/81	1.1509	456	0.3691	491
1981/82	0.8682	461	0.2288	347
1982/83	0.6550	463	0.1576	328
1983/84	0.5905	467	0.1883	286
1984/85	0.6224	466	0.1790	191
1985/86	0.3656	466	0.2178	186
1986/87	0.4930	461	0.2018	160
1987/88	0.6585	459	0.2129	228
1988/89	0.5226	459	0.2273	325
1989/90	0.5948	459	0.2014	175
1990/91	0.4305	460	0.2820	257
1991/92	0.5248	455	0.2641	254
1992/93	0.7652	453	0.2057	236
1993/94	0.6576	449	0.2241	222
1994/95	0.6082	443	0.1846	318
1995/96	0.6296	441	0.2173	308
1996/97	0.6669	442	0.2310	260
1997/98	0.6631	442	0.0000	203

Prices: January-June

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