CHAPTER 14

The Agricultural Sector in Argentina: Major Trends and Recent Developments

Sergio H. Lence

1. INTRODUCTION

Historically, Argentina has been among the world leaders in the production and/or export of agricultural products. The main reason for this is that it is a country relatively sparsely populated but richly endowed with natural resources for production agriculture. According to data from the Food and Agriculture Organization (FAO) (FAOSTAT database), in 2006 Argentina accounted for only 0.59% of the world's population, but for a much higher 2.10% of the world's total land area. Furthermore, Argentina's shares of the world's arable land and the planet's area with permanent meadows and pastures were even higher, at 2.23% and 2.96%, respectively.

As shown in Table 14.1, Argentina produced 8.4% of world agricultural output and accounted for 2.9% of world agricultural trade over the period 2005-07. Such figures make Argentina the eighth-largest producer and the twelfth largest exporter of agricultural commodities in the world. Argentina's much smaller share of world exports (2.9%) compared to its share of world output (8.4%) is largely explained by the fact that Argentina tends to export commodities with relatively low value-added levels. Commodities for which the country is particularly relevant in world markets are soybeans and its associated products, soybean oil and soybean meal. Argentina is the top exporter of soybean oil and soybean

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Table 14.1. Argentina's world share and world ranking in production and exports of selected agricultural commodities, average 2005-2007

	Production		Exports	
Commodity	World Share (%)	World Ranking	World Share (%)	World Ranking
Total agricultural products	8.4	8	2.9	12
Crop products				
Apples	2.0	11	2.8	11
Corn	2.6	5	10.8	2
Grapes	4.3	8	1.3	16
Lemons and limes	10.7	3	11.2	3
Soybeans	19.3	3	13.7	3
Soybean meal	17.4	3	36.1	1
Soybean oil	17.4	3	46.9	1
Sunflower meal	13.9	3	17.5	2
Sunflower oil	13.9	3	19.8	2
Sunflower seed	12.3	3	3.3	9
Wheat	2.4	13	6.7	7
Wine	5.6	5	1.7	11
Animal products				
Bovine meat	4.8	4	5.2	7
Cow milk	1.8	15		
Dairy products			1.4	16
Poultry meat	1.4	13	0.8	19

Source: All figures calculated from FAOSTAT data.
Notes: Production shares and rankings based on physical units, except for "Total Agricultural Products" which are based on quantities valued at the 1999-2001 average international commodity prices. Export shares and rankings based on actual dollar values of traded commodities.

meal, with 46.9% and 36.1% of the world's export market, and the third-largest exporter of soybeans. For all three commodities, Argentina ranks third among all producers, with almost one-fifth of world output. In addition, Argentina is the world's second-largest exporter of corn, sunflower meal, and sunflower oil. The country is also the fourth-largest beef producer, with 4.8% of the world's output, but it only ranks seventh among beef exporters. A major reason for this is that Argentineans consume the most beef per capita of all world consumers of beef, averaging 54 kilograms per capita per year over 2001-03 (FAOSTAT).

Given the relevance of Argentina to world agricultural markets, an in-depth investigation of the recent evolution of its agricultural sector should be of interest. Better knowledge of the main developments that have characterized Argentinean agriculture in the past should help in making inferences about its

potential course for the future. In the process, one should also gain a better understanding of the likely effects on the world markets of the commodities for which Argentina is or can be a significant supplier. Therefore, the purpose of this chapter is to analyze the major output, export, and productivity trends experienced by Argentinean agriculture in recent decades, and to study the main drivers behind such developments.

First, general background information is provided to put Argentinean agriculture in perspective. Second, the evolution of agricultural policies in Argentina and their impacts are discussed. Third, the most important developments in Argentinean production agriculture since 1990 are analyzed. Fourth, the major trends in productivity for individual factors of production are examined. This is followed by a review of the measures of Argentina's total factor productivity growth estimated by the recent literature.

2. ARGENTINEAN AGRICULTURE IN CONTEXT

This section provides basic information about Argentinean agriculture, to aid in the analysis provided later. First, the role of agriculture in Argentina's economy is addressed, which should be useful in understanding the policies affecting the sector. This is followed by a general characterization of the country's agriculture.

2.1. Agriculture and Argentina's Economy

Table 14.2 reports the evolution of some key economic indicators for Argentina since 1960, as well as some indicators of the role of the agricultural sector in the entire economy. With an average gross domestic product (GDP) of about U.S.$5,600 per capita in 2005-07, Argentina is classified as an upper middle-income economy by the World Bank. Consistent with the country's moderate level of development, the services sector is the most important contributor to GDP, followed by the industrial sector. As the economy has developed over time, agriculture's share of GDP has tended to fall. However, this share has almost doubled since 2000, and over 2005-07 agriculture accounted for a sizable 9% of GDP. Agriculture has accounted for an even larger share of total employment, indicating that wages in the sector have been smaller than wages in the services and manufacturing sectors.

The sector is estimated to have contributed almost one-fifth of Argentina's GDP in 2003-05 if activities directly related to primary agriculture are included (Fundacion Producir Conservando 2007). In 2003, about 5.59 million people

Table 14.2. Evolution of general and agricultural economic indicators for Argentina, 1960-64 through 2005-07

	1960-64	1965-69	1970-74	1975-79	1980-84	1985-89	1990-94	1995-99	2000-04	2005-07
Population (million)	21.3	22.9	24.8	26.9	29.0	31.2	33.5	35.7	37.6	39.1
Gross domestic product (GDP) per capita (current U.S. dollars)	n.a.	1,211	1,813	2,142	2,921	3,289	6,294	7,879	4,982	5,616
Agricultural share of employment (%)	19	17	15	14	13	12	12	10	9	n.a.
Agricultural share of GDP (%)	n.a.	10	11	8	8	8	6	5	7	9
Agriculture and food share of merchandise exports (%)	93	90	79	74	73	65	60	53	48	48
Agriculture and food share of merchandise imports (%)	13	17	14	11	9	9	7	7	6	3
Net exports as percentage of exports plus imports of agriculture and food (%)	79	73	73	79	81	85	78	76	85	87
Agriculture and food index of revealed comparative advantage[a]	3.2	3.5	3.6	3.8	4.4	4.4	4.7	4.9	5.4	6
Exports of goods and services as percentage of GDP (%)	n.a.	n.a.	n.a.	12	12	10	8	10	18	25

Sources: Sandri et al. 2007 for data up to and including 2004. For 2005-07, data on population, GDP per capita, agricultural share of GDP, and exports of goods and services as a percentage of GDP were obtained from the World Bank's World Development Indicators. Other figures for 2005-07 were calculated from the World Trade Organization's statistical database (http://www.wto.org/english/res_e/statis_e/statis_e.htm).
[a]Agriculture and food share of merchandise exports for Argentina as a ratio of this share for the world.

were either directly employed by the food and agriculture sector or indirectly employed by it through upstream and downstream linkages, amounting to about one-third of the country's total employment in 2003 (Llach, Harriague, and O'Connor 2004). Furthermore, the taxes paid by agriculture and the activities directly related to it accounted for about 40% of the total taxes collected by the Argentinean government in 1997-2001, and for more than 45% in 2002-05 (Fundacion Producir Conservando 2007).

The importance of agriculture to Argentina's economy is most evident when examining the country's balance of trade (see Table 14.2). In the 1960s, exports of agricultural and food products amounted to more than 90% of total merchandise exports. This share has steadily declined since then, but over the period 2000-07 almost half of the exports consisted of agricultural and food products. In contrast to exports, imports of agricultural and food products have traditionally been a small percentage of total merchandise imports, averaging only 3% over 2005-07. With net exports well in excess of 80% of the sum of exports plus imports of agricultural and food products, Argentina is clearly a net supplier of such products in world markets.

The large magnitude of exports from the agricultural sector is underscored by the fact that total merchandise exports were equivalent to 25% of Argentina's GDP in 2005-07. The agriculture and food index of revealed comparative advantage, calculated as the agriculture and food share of merchandise exports for Argentina relative to the world food share, averaged a value of six in 2005-07. This considerably large index value provides strong evidence that the country's relative strength lies in producing and exporting agricultural and food products as opposed to manufactured goods. Further, the index has steadily increased, from slightly above three in 1960-64, suggesting that, if anything, the comparative advantage of Argentina's agricultural sector has risen over time.

In addition to its important contributions to GDP, employment, trade, and fiscal revenues, the agricultural sector provides three key staples of the Argentinean diet, namely, bread, beef, and milk. As pointed out earlier, on a per-capita basis, Argentina is the world's leading consumer of beef. Per capita wheat consumption of bread, which averaged 119 kilograms per capita per year in 2001-03, is among the highest in the world (e.g., only 4 out of the 66 countries classified as high-income economies by the World Bank ranked higher). Per capita consumption of dairy products is also large and significantly above the world average. The large incidence of wheat, beef, and milk in the domestic diet has

made these products traditionally sensitive from a policy-making standpoint. For example, starting in 2007, bans and other types of restrictions on their export have been imposed in an attempt to ensure ample supplies and low prices in the domestic market (IICA 2007).

2.2. A Succinct Characterization of the Agricultural Sector

According to FAO's production index number, slightly over 60% of Argentina's agricultural output value in 2005-07 originated from crops and almost 40% from livestock. As depicted in Figure 14.1, the value of crop production has increased at a significantly faster rate than the value of livestock output over the last few decades, implying that the relative incidence of livestock in the sector has declined steadily over time. The relative incidence of crops in exports is even larger, as crops and their products accounted for 80% of the total exports by the sector in 2005-07. As for production, the export share of livestock has exhibited a clear downward trend.

Figure 14.2 shows the breakdown of the value of the sector's output by commodity for the years 2005-07. The most striking feature of the graph is the high concentration of the value of output in a handful of commodities. In particular, beef and soybeans alone contribute more than half of the value of Argentina's agricultural production, each accounting for slightly over a quarter of the total value. They are followed by wheat, corn, and milk, with shares of 8%, 6%, and 5%, respectively. The value of the top five commodities makes up approximately three-fourths of the total value of agricultural output.

Underlying the aggregate index trends displayed in Figure 14.1 are substantial changes in the trends for individual commodities. In the case of crops, Figure 14.3 shows that corn and wheat output grew at a relatively constant pace since the 1960s. Output of sunflower seed, in contrast, increased sixfold between the late 1970s and 2000, only to decline by almost half since 2000. Among crops, the most important development was the explosive growth of soybeans, which went from being essentially unknown in the early 1970s to becoming by far the most important crop. In 2005-07, more than half of the crop area and about 45% of the value of crops produced corresponded to soybeans. The evolving patterns in crop output were induced by changes in the relative profitability of the various crops, largely arising from shifts in world supply and demand, the introduction of new technologies, and domestic agricultural policies. The latter two topics are discussed in greater detail in later sections.

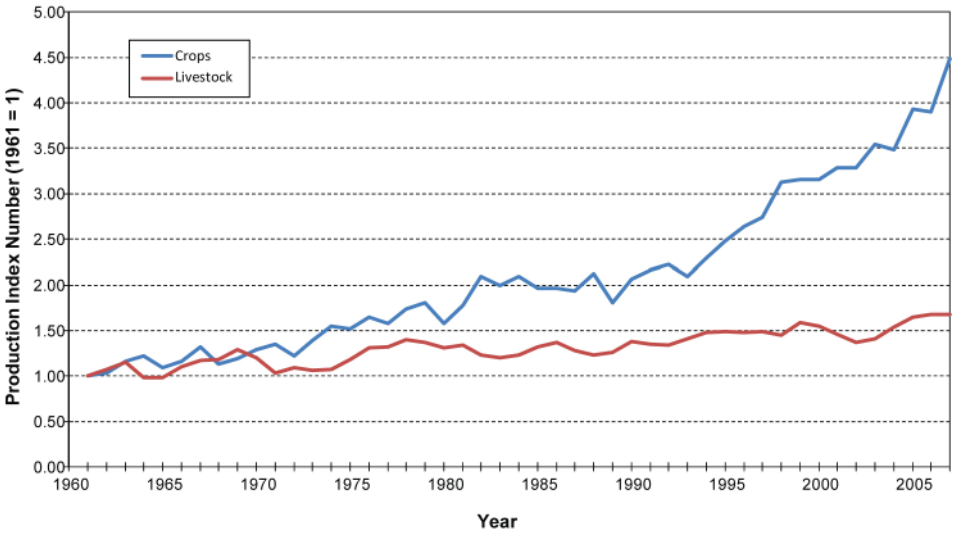

Figure 14.1. Production index numbers for agricultural production in Argentina, 1961-2007

Source: Prepared using data from FAOSTAT.

Notes: Production indexes are the sum of price-weighted quantities of different agricultural commodities relative to the year 1961. The prices used for weighing the production quantities of each commodity are the average international commodity prices over 1999-2001.

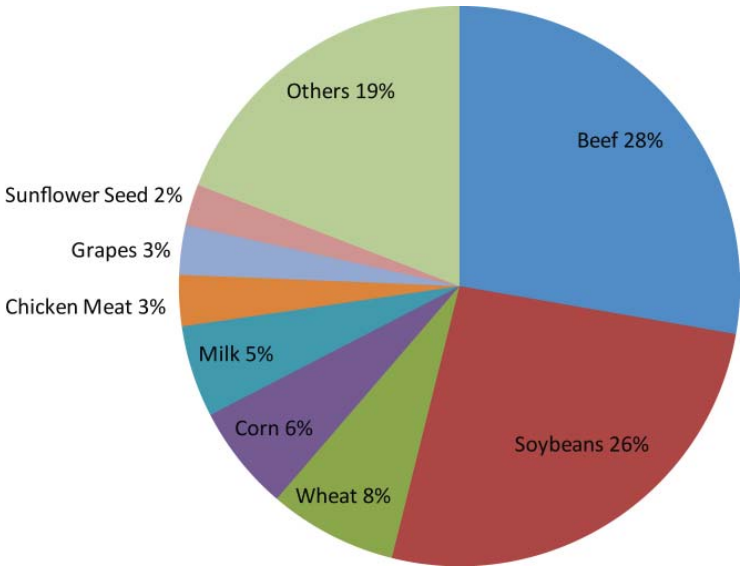

Figure 14.2. Commodity shares of the total value of agricultural production in Argentina, 2005-2007

Source: Prepared using data from FAOSTAT.

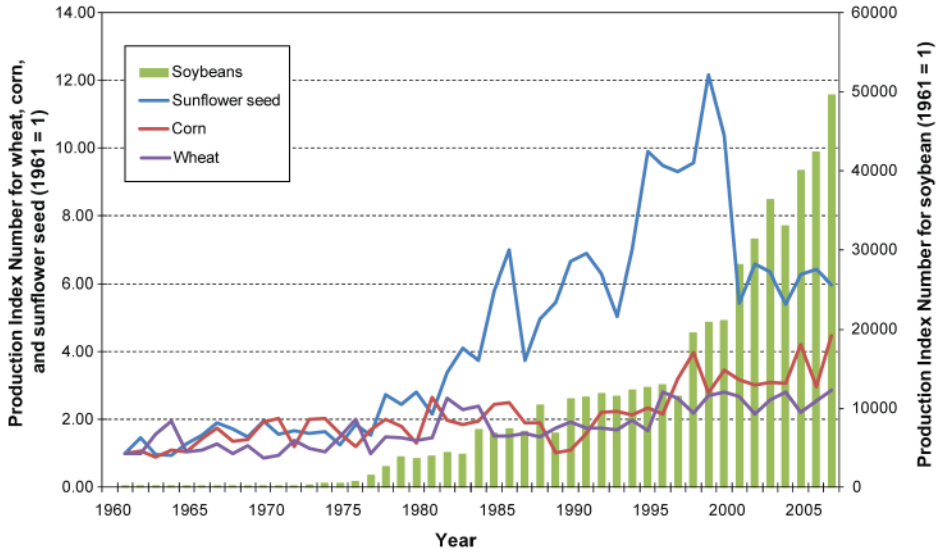

Figure 14.3. Production index numbers for major crops in Argentina, 1961-2007

Source: Prepared using data from FAOSTAT.

Note: Production indexes are calculated as the quantities produced relative to the year 1961.

Subsectors of the livestock industry fared quite differently (see Figure 14.4). Since 1961, sheep and goat meat production declined by two-thirds. Production of cattle meat has shown no clear trend since the late 1970s, and the same is true of pig meat output. Milk production, in contrast, more than doubled between 1961 and 2007. Over this period, the livestock industry with the highest growth was poultry, as it increased more than 25-fold. The lack of growth in beef production over the last three decades can be attributed to the substitution of pastures in the more fertile areas for crops, pushing cattle production toward more marginal areas, and unfavorable events such as the closure of the most profitable export markets because of foot-and-mouth disease.

As illustrated by Figure 14.5, agricultural exports are even more concentrated than output, with shipments of the soybean complex (i.e., soybeans, soybean oil, and soybean meal) accounting for 45% of the total in 2005-07. The next largest share corresponds to exports of the cattle complex (i.e., meat and leather), with 11%, followed by exports of the wheat and corn complexes, with 8% and 7%, respectively. Approximately 75% of the total value of exports stems from the largest five commodity complexes. In the interest of space, graphs illustrating trends for the main agricultural exports are not shown. However, as implied by

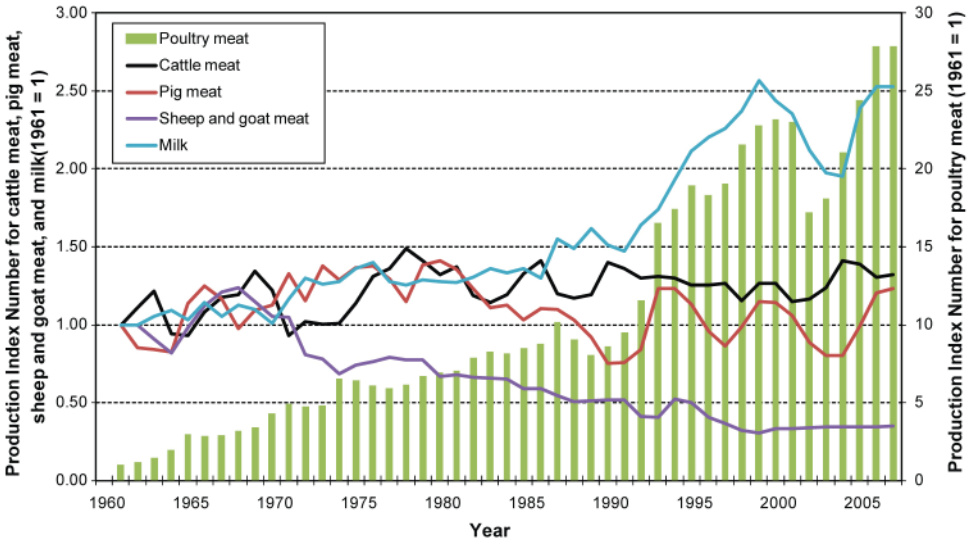

Figure 14.4. Production index numbers for livestock products in Argentina, 1961-2007

Source: Prepared using data from FAOSTAT.

Note: Production indexes are calculated as the quantities produced relative to the year 1961.

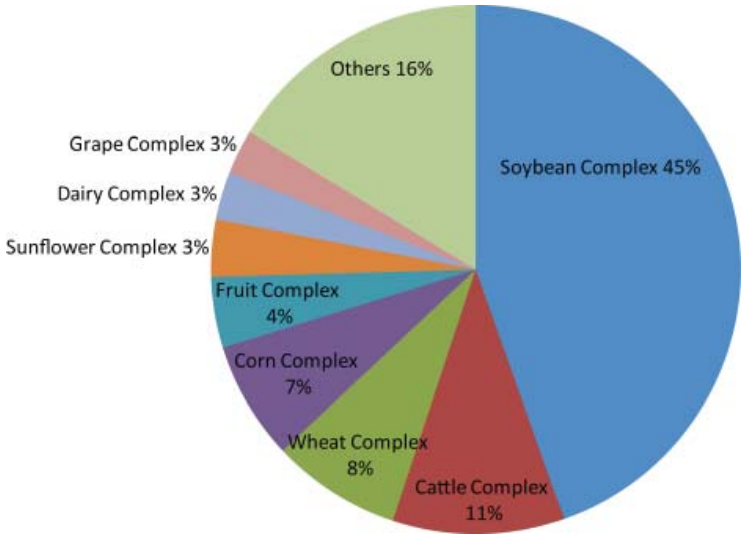

Figure 14.5. Commodity shares of Argentina's total value of exports of agricultural products, 2005-2007

Sources: Prepared using data from Argentina's Instituto Nacional de Estadisticas y Censos (INDEC) and the World Trade Organization.

Note: "Complex" means the primary commodity and its products (e.g., the soybean complex consists of soybean, soybean oil, and soybean meal).

the trends in output values for specific commodities (see Figures 14.3 and 14.4), exports for many individual products have evolved quite differently from aggregate exports over the last four decades.

Argentina is a large country, spanning regions of quite different suitability for agriculture. From a geographical point of view, its agricultural production can be classified into two main categories, namely, output from the Pampean region, and output from the non-Pampean region or "regional economies." The Pampean region comprises the center and East of the country and produces most of the grains, oilseeds, cattle, and milk. The non-Pampean region consists of the rest of the country, and it produces a relatively large range of agricultural goods. These include sheep in the South (Patagonia); grapes and other fruits in the irrigated areas of the West; sugar, citrus, and tobacco leaf in the Northwest; and cotton, tea, and mate (a local herbal drink) in the Northeast. The Pampean region accounts for most of the value of the output and exports of Argentina's agricultural sector. Only one regional product is among the top eight commodities by output value (grapes, with a 3% share), and only two regional commodity complexes are among the top eight exports (fruits and grapes, with 4% and 3% shares, respectively). Pampean agriculture has been the more dynamic of the two regions, as well. Primary agricultural exports from the Pampas and the non-Pampean regions increased by 46% and 29%, respectively, between 2000 and 2004 (World Bank 2006).

A major common denominator of the agricultural products from the non-Pampean region is that they tend to be mostly consumed by the domestic market (Reca 2006). Many of the non-Pampean agricultural products come from perennial plants (e.g., fruits, grapes, tea, and mate), rendering them unresponsive to short-run demand shifts (Reca 2006). Other distinguishing characteristic of agriculture in the Pampas region as compared with the non-Pampean is that the Pampas is generally more intensive in the use of machinery and management, and more extensive in the use of land and labor (Sturzenegger and Salazni 2008). Importantly, unlike most products from the Pampas, large components of the non-Pampean output have traditionally received some form of government protection (Reca 2006).

3. EVOLUTION OF ARGENTINEAN AGRICULTURAL POLICIES SINCE THE 1940S

Argentina enjoys a very favorable natural endowment for agricultural production, consisting of a large area of arable land characterized by temperate climate, adequate rainfall, and in close proximity to ports accessible by grain

vessels. This favorable environment has allowed Argentinean agriculture to grow and prosper, even though, starting in the mid-1940s, the sector has suffered from policies aimed at promoting industrial development by transferring resources from the agricultural and rural sectors to the industrial and urban ones (World Bank 2006).

Policies transferring resources from agriculture to the manufacturing sector started to be implemented immediately following World War II. These policies were the result of the difficulties experienced by Argentina's agricultural exporters, and the favorable outlook for manufacturers in the domestic market. Argentina's agricultural exports had first suffered because of the large drop in world agricultural prices that accompanied the Great Depression of the 1930s. Then, piles of unsold grain accumulated during World War II because of restrictions on naval trade during the war. At the same time, the war also made it extremely difficult to import manufactured goods, which greatly improved the outlook for producing such goods to satisfy the needs of the domestic market (Sturzenegger and Salazni 2008).

The polices that began after World War II were aimed at promoting industrial growth by favoring import substitution (i.e., the domestic production of imported manufactures), and using resources from the agricultural sector to support them. The agricultural sector was taxed by means of a combination of export duties, overvalued exchange rates, and public marketing boards (World Bank 2006). In the case of wheat, for example, this translated into a discrimination exceeding 50% (Sturzenegger and Salazni 2008). Sturzenegger (1990) estimated that as of the early 1980s, such policies had transferred over 60% of agricultural GDP to other sectors in the economy. Several studies have shown that these policies had a substantial negative effect on Argentina's agricultural sector. For example, Reca and Parellada (2001) reported that average annual agricultural production over 1950-52 was 20% smaller than over the period 1940-42.

Soon after World War II, a comprehensive set of welfare state policies was also introduced by the Peron administration. This was initially financed with assets that the government had accumulated during the war, which stemmed from the account surplus associated with the lost import opportunities at the time of the armed conflict. As those assets were depleted over time, financing the welfare state became a recurrent problem for the government. According to Sturzenegger and Salazni (2008), this lies at the heart of the chronic fiscal struggle and inflationary pressure that Argentina has faced since then.

In the early 1990s, major policy changes took place that had a substantial impact on the agricultural sector. General policy changes included trade liberalization, deregulation, privatization of many state enterprises, the creation of Mercosur (the Southern Common Market), and, perhaps most important of all, a currency convertibility program (Sturzenegger and Salazni 2008). The currency convertibility program was designed to eliminate the main source of inflationary pressures, that is, the creation of money to finance the public sector deficit. The convertibility program consisted of a currency board that fixed a nominal relation of one peso to one U.S. dollar.

Policy changes directly concerning agriculture involved the abolition of quantitative restrictions and the reduction of tariffs on imports of inputs (e.g., fertilizers, herbicides, machinery, and irrigation equipment), the removal of export taxes, the elimination of commodity boards, the significant reduction of inefficiencies and red tape in the marketing channel (e.g., transportation and ports), and the elimination of tax distortions in fuels (World Bank 2006). As depicted in Figure 14.6, these policy changes triggered substantial increases in the imports of fertilizers, pesticides, and agricultural machinery, which translated into much greater usage of these inputs (see, e.g., Figure 14.7). As a result, the area harvested with the main annual crops expanded by about one-quarter during the 1990s (see Figure 14.8). Not surprisingly, crop production grew at a much faster pace in the 1990s than in previous decades. Livestock production, however, did not show faster growth over this decade (see Figure 14.1).

Unfortunately, the economic crisis experienced by Argentina's main trade partner, Brazil, and record low world agricultural commodity prices combined to negatively affect the Argentinean economy at the end of the 1990s. The peso became increasingly overvalued against the currencies of Argentina's main trade partners (Brazil and the European Union), and problems continued to mount within the economy until it collapsed at the end of 2001, along with the convertibility program scheme. The economic debacle triggered a huge capital outflow, a devaluation in excess of 200%, and a default in external and public debts (Sturzenegger and Salazni 2008). According to data from Argentina's Instituto Nacional de Estadisticas y Censos (INDEC), GDP sunk by more than 10% between 2001 and 2002, and in 2002 unemployment and the percentage of population living below the poverty line exploded to 22% and 54%, respectively, all figures illustrative of the depth of the economic crisis suffered by the country.

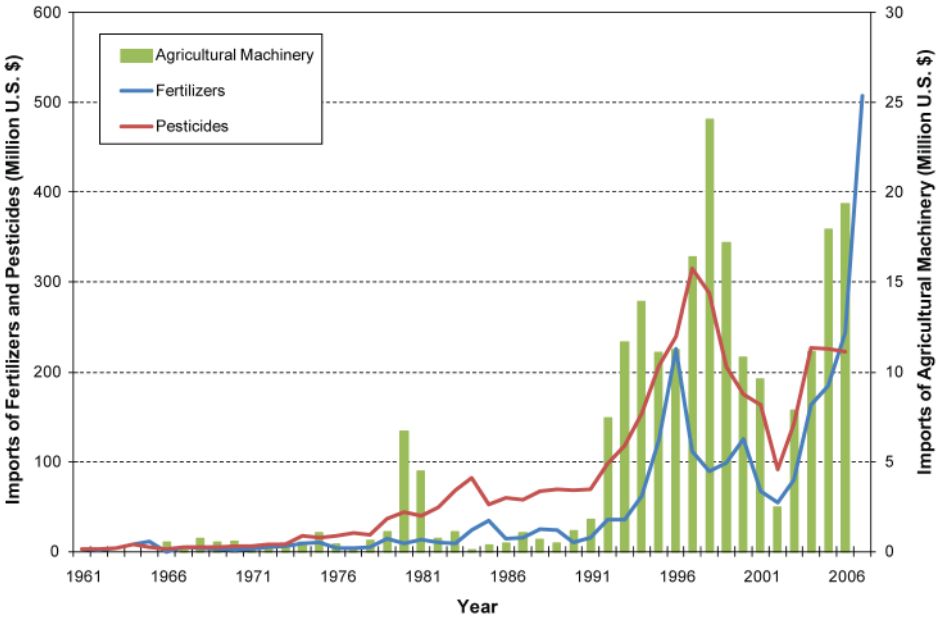

Figure 14.6. Imports of fertilizers, pesticides, and agricultural machinery by Argentina, 1961-2007

Source: Prepared using data from FAOSTAT.

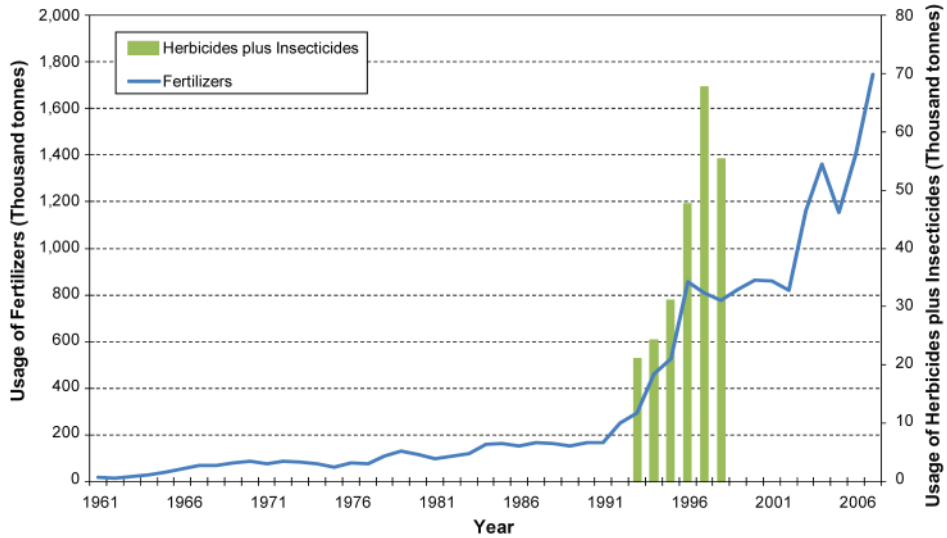

Figure 14.7. Usage of fertilizers and herbicides plus insecticides in Argentina, 1961-2007

Source: Prepared using data from FAOSTAT.

Note: Data for herbicides plus insecticides are not available for 1961-1992 and 1999-2007.

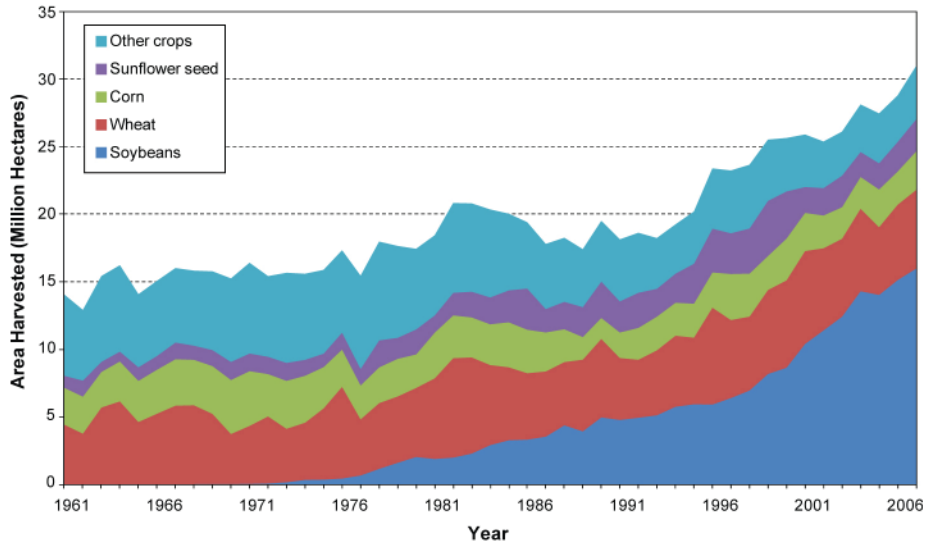

Figure 14.8. Area harvested in Argentina, 1961-2007
Source: Prepared using data from FAOSTAT.

In the few years following the 2001 collapse, the economy experienced a strong recovery, with GDP growing by 41% between 2002 and 2006, employment falling to slightly less than 10% in 2007, and the percentage of population living under the poverty line reduced by almost half in 2006 compared to 2002. The recovery was spurred by the restoration of confidence in the economy, induced by sensible macroeconomic measures such as a restructuring of the public debt, the restoration of a fiscal surplus, and the accumulation of international monetary reserves by the Central Bank. The agricultural sector played a major role in regard to the fiscal surplus and the accumulation of reserves, because the crisis prompted the government to impose taxes on agricultural exports once again to obtain much-needed hard currency. Interestingly, the party in power since the crisis has been the one founded by Peron, who was instrumental in promoting policies that discriminated against agriculture in favor of the domestic manufacturing sector after World War II.

Fortunately, the years following the crisis were characterized by very favorable conditions in the world markets for Argentina's main agricultural products, which allowed a significant expansion of agricultural exports, and with it tax revenues and foreign reserves. Between 2002 and 2005, taxes on exports originating in the agricultural sector averaged 2.2% of GDP, 9.2% of the value of exports, and 9.9% of all tax revenues (Nogues and Porto 2007). Ultimately, however, high international

commodity prices led to the current tug-of-war between the Argentinean government and the agricultural sector (Bisang 2008).In the case of staples of the Argentinean diet, high world prices put pressure on the government to avoid increases in their domestic prices. Exports of meat and dairy products, initially taxed at about 15%, were either banned or restricted to meet this goal (Nogues and Porto 2007, IICA 2007 and 2009). For wheat and corn, a complex compensation scheme was instituted so that domestic users could buy these grains at a more favorable price than that available to exporters (Nogues and Porto 2007; IICA 2007 and 2009). In the case of soybeans, which are barely consumed in the domestic market, high world prices induced the government to raise the export taxes to increase fiscal revenues. Export taxes on soybeans were successively raised from 13% to 23.5%, to 27.5% in early 2007, and to 37.5% in mid-2007. At the same time, domestic prices of imported inputs continued to increase following the world markets. In 2008, the government decision to increase soybean export taxes even further to 45% and to make them variable (so that any world price increases would trigger automatic tax increases above 45%) triggered an unprecedented set of farm strikes (Bisang 2008; IICA 2009). Eventually, the variable export tax scheme was defeated in Congress by the narrowest of margins, and the crisis is likely a major reason for the defeat of the Peronist administration in the mid-elections of 2009.

After losing the recent mid-term elections, the present administration has successfully managed to stick to its policies of heavily discriminating against agriculture. However, large losses in the agricultural sector during the past year due to a widespread drought, less favorable world market conditions, and the significant taxes on exports have induced the country's leaders to break with the past and seek political alliances aimed at reversing the traditional policies of taxing agriculture to favor the industrial sector. As of the present writing, it is very difficult to predict the future course of agricultural policies, because it greatly depends upon which of the confronting power groups prevails. If the views of the present administration succeed, it seems clear that agricultural policies in the future will resemble the ones that characterized the period between World War II and 1991. The opposite situation would be more in line with the experience during the 1990s, during which Argentinean agriculture flourished.

3.1. Quantifying the Discrimination Against Agriculture

The discriminating nature of Argentina's policies against agriculture were quantified by two recent studies conducted by Sturzenegger and Salazni (2008)

and Sturzenegger (2007). To this end, the authors computed the nominal rate of assistance (NRA) for product j (NRA_j), defined as

$$NRA_j = (RP_j - UP_j)/UP_j. \quad (1)$$

In equation (1), RP_j denotes the (distorted) price received by domestic producers of good j, whereas UP_j represents the respective undistorted price. That is, NRA_j measures the percentage by which the actual price of commodity j differs from its price without government intervention.

Figure 14.9 depicts five-year averages of NRAs for aggregated tradable products from the agricultural and non-agricultural sectors for 1960-65 through 2000-05. The graph nicely illustrates the extent to which Argentinean policies have historically discriminated against agricultural products and in favor of manufactures from the industrial sector. For the period examined, discrimination against agriculture was at its highest in 1960-65, when NRA was -25.3%. This means that, in aggregate, different forms of government intervention effectively reduced prices of agricultural products by one-fourth of the non-distorted level over 1960-61. Discrimination against agriculture gradually declined until 1995-99, when it reached its lowest level, with an NRA of only -4%. Since then, however, discrimination against the sector has increased by a large amount, with NRA averaging -16.2% in 2000-05. Further, the discrimination worsened after the studies were conducted, because of the increase in export tariffs and the imposition of quantity restrictions on exports that took place after 2005.

The bias against agriculture stands in sharp contrast to the support provided to non-agricultural manufactures. In the first half of the 1960s, prices of non-agricultural tradable goods were effectively being subsidized by 61.4%, while agricultural tradable prices were taxed at a rate of 25.3%. The favorable treatment toward the manufacturing sector has continued since then but at diminishing rate. Over the period covered by Sturzenegger and Salazni (2008) and Sturzenegger (2007), support of tradable manufactures was at its lowest in 2000-05, when NRA averaged 5.3%.

To better appreciate the extent to which the agricultural sector is being discriminated against by governmental policies, it is instructive to compare the agricultural NRA values for Argentina and other countries. To this end, Figure 14.10 ranks the countries included in the set of the world's top 20 agricultural producers, or the world's top 20 exporters of agricultural products, or both, according to their average NRA indexes for agriculture over the period 2000-05.

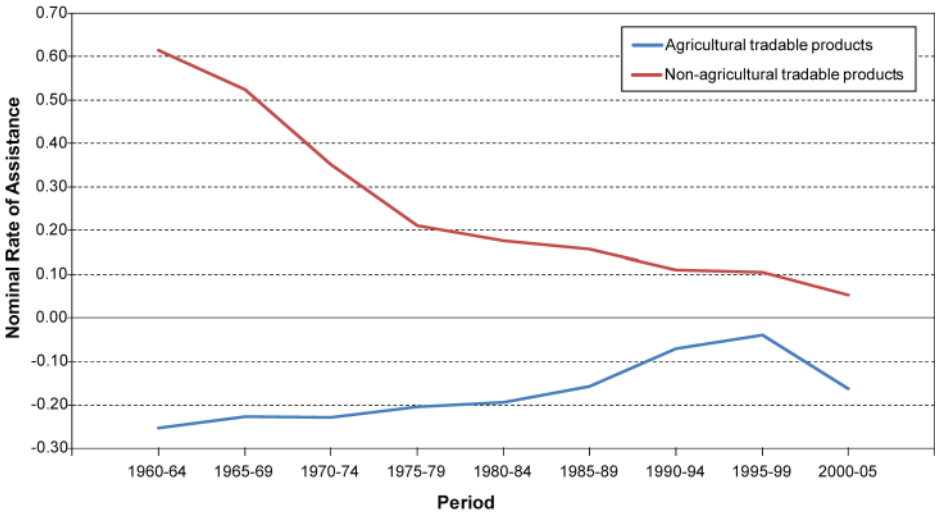

Figure 14.9. Nominal rate of assistance (NRA) for tradable products, five-year averages, 1960-64 through 2000-05

Source: Prepared from data in Table 2.3 in Sturzenegger and Salazni 2008.

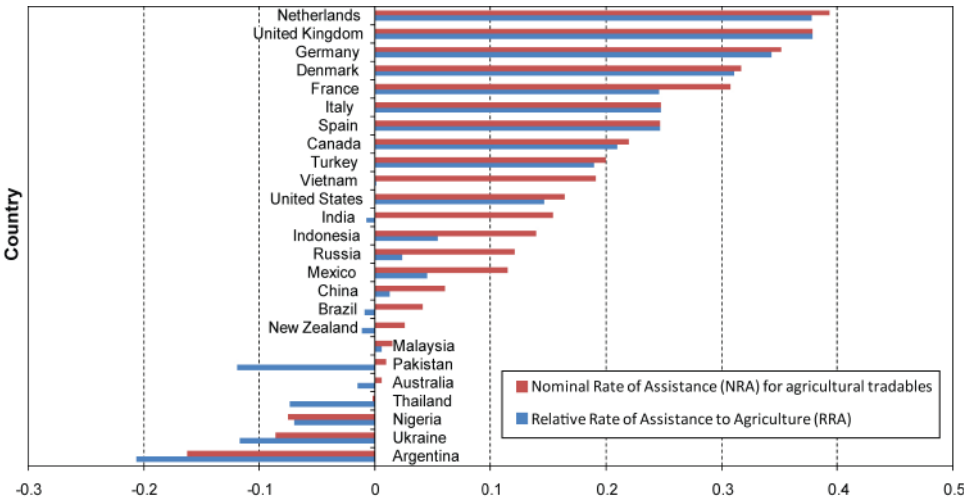

Figure 14.10. Nominal rate of assistance (NRA) for agricultural tradables and relative rate of assistance to agriculture for selected countries, average 2000-05

Source: Prepared with data from Anderson and Valenzuela 2008.

Note: The selected countries are among the top 20 producers of agricultural products or the top 20 agricultural exporters, or both, over 2005-07, according to value of production and trade data reported by FAOSTAT.

Interestingly, only 4 of the 25 countries in the set have negative NRAs, i.e., discriminate against agriculture, and Argentina has the smallest NRA value of them all. Figure 14.10 also displays the relative rate of assistance to agriculture (RRA), which is defined in equation (2):

$$RRA = (1 + NRA_{AgTrad})/(1 + NRA_{NonAgTrad}) - 1, \quad (2)$$

where NRA_{AgTrad} and $NRA_{NonAgTrad}$ are the NRA aggregate indexes for the country's agricultural tradable products and non-agricultural tradable goods, respectively. Therefore, RRA quantifies the extent to which policies are biased in favor (if positive) or against (if negative) the agricultural sector relative to the non-agricultural sector. By this measure, only 9 of the 25 countries in the selected set shown in the graph had policies biased against agriculture (i.e., had negative RRA values) over the 2000-05 period, and Argentina's policies were clearly the most biased against the sector.

The smoothness of the five-year NRA average for agricultural tradables displayed in Figure 14.9 masks wide annual variations among the NRA indexes for individual commodities. This can be observed in Figure 14.11, which shows the annual NRA values for wheat, corn, soybeans, sunflower, beef, and milk. The

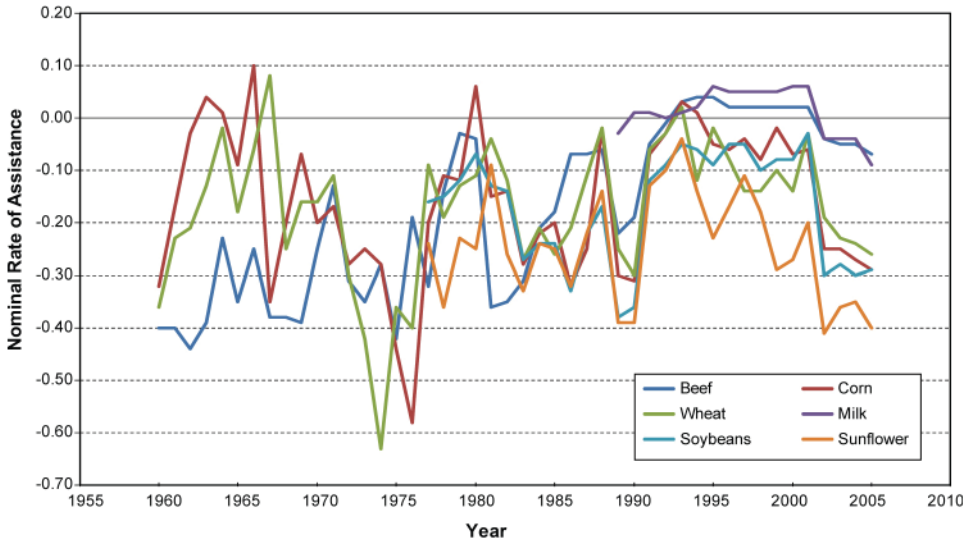

Figure 14.11. Nominal rate of assistance (NRA) for major agricultural products in Argentina, 1960-2005

Source: Prepared from data in Appendix Table B.1 in Sturzenegger and Salazni 2008.

common denominator among the reported NRA series is that, except for a few observations, they are all negative. Based on an econometric analysis of corn, wheat, soybeans, and beef, Sturzenegger (2007) found that their NRAs fall when the world prices for the respective commodities rise, and when the real exchange rate goes up. From this, the author concluded that Argentinean trade policies toward agriculture have had a "compensatory" role; more specifically, they have tended to smooth the time variability in farmland rents. He also found the econometric results consistent with the hypothesis that the level of discrimination against agriculture has been historically determined by a "political market," consisting of representatives from agriculture on one side and representatives from other sectors on the other. At times when profitability for individual agricultural commodities decreased, those in the agricultural sector tended to exert more pressure on the political market to reduce the bias against them. The opposite was true when profitability for agricultural products increased.

4. MAIN DEVELOPMENTS IN ARGENTINEAN PRODUCTION AGRICULTURE SINCE 1990

It is evident from the previous discussion that a major structural change seems to have occurred in Argentinean agriculture in the early 1990s. For example, growth in the value of crop output has been significantly larger after 1990 than over the three preceding decades (see Figure 14.1). Similarly, production of oilseeds underwent a major expansion relative to grain production, and the total area harvested grew at a noticeably faster pace after 1991 (see Figures 14.3 and 14.8). At the same time, annual usage of fertilizers and pesticides greatly exceeded the amounts used in any year prior to 1990 (see Figure 14.7). Several developments took place in Argentinean production agriculture that contributed to the increased growth rate in crop value observed after the early 1990s. The most important ones, however, were (a) the modernization of the technologies used by agricultural producers, (b) the expansion of the crop frontier, (c) the greater intensity in the usage of farmland in the Pampean region, and (d) the advent of "planting pools." In the case of beef production, the most noteworthy development has been the explosive growth of feedlots over the last decade. These developments are discussed next.

4.1. Technological Modernization

After the 1990s, Argentina's agricultural sector underwent a significant technological modernization. Trade liberalization in the 1990s favored imports

of less expensive and more efficient machinery for agriculture (see Figure 14.6). Liberalization also allowed local producers of agricultural machinery to buy foreign inputs, greatly reducing their costs and improving the quality of their products (Chudnovsky and Lopez 2005). Greater usage of fertilizers and agrochemicals was spurred by the liberalization of trade and the increase in the local capacity to produce these inputs (see Figure 14.7) (Chudnovsky and Lopez 2005). Storage capacity in permanent facilities more than doubled after the late 1980s, from 32 million tons in 1987, to 56 million tons in 2000, to 70 million tons in 2007 (Lopez and Oliverio 2008). The late 1990s also witnessed the introduction and widespread adoption of disposable storage bags, which greatly expanded storage capacity and provided crop producers with much greater flexibility in the commercialization of their crops. It is estimated that storage bags accounted for 30% of Argentina's grain storage capacity as of 2007 (Lopez and Oliverio 2008).

Another major technological change was the introduction of genetically modified (GM) organisms in the mid-1990s, such as glyphosate-resistant soybeans and Bt corn. In 1996, glyphosate-resistant soybeans became the first transgenic crop commercially released in Argentina (Trigo and Cap 2006). As evident from Figure 14.12, glyphosate-resistant soybeans proved to be hugely popular among producers, who increased the area planted with it from an almost negligible amount in 1996 to essentially 100% after 2004. GM corn was also rapidly accepted by Argentinean producers, with an adoption rate of 20% in 2000 and stabilizing at about 70% after 2003. The adoption rate for GM cotton, on the other hand, was low for several years, but it exploded to over 90% in 2006. Notably, Argentina has consistently ranked second in the world (after the United States) in terms of area planted with GM crops.

Linked to both the modernization of machinery and the widespread adoption of glyphosate-resistant soybeans is the incorporation of zero-tillage technology. According to Ekboir and Parellada (2002), zero tillage constitutes the most significant agricultural technology introduced in Argentina over the last 50 years. Zero tillage consists of planting crops in soil without previous tillage, by opening only a slot in the soil with the smallest dimensions consistent with the appropriate coverage for the desired seeds. Testing of the zero tillage technology started in the 1970s, but it became widely adopted in the late 1990s. In 2001, it was estimated that 7.3 million hectares were planted using zero tillage in Argentina, or one-third of the area planted with annual crops at the time (Cetrangolo

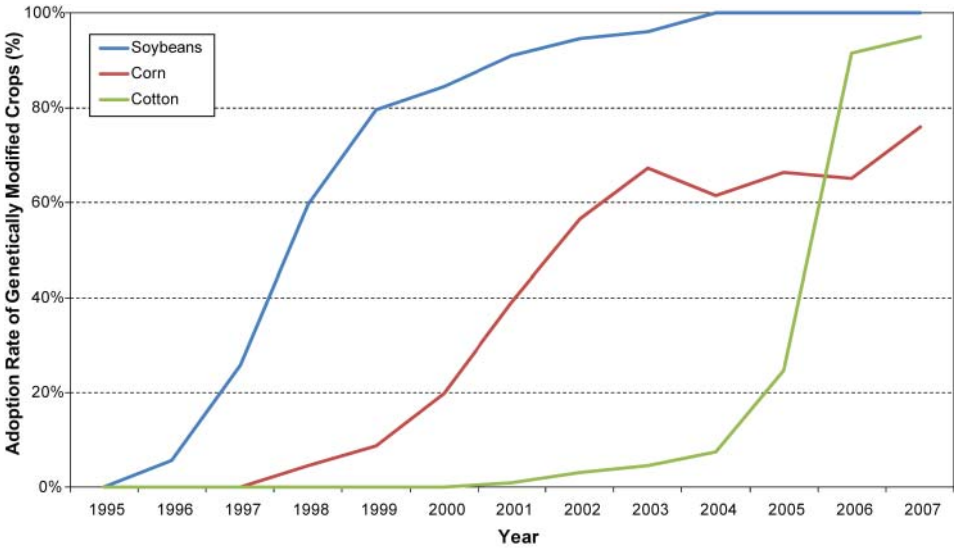

Figure 14.12. Adoption rates of genetically modified crops in Argentina, 1996-2007

Sources: Prepared using data from Trigo and Cap 2006; James 2006, 2007; and FAOSTAT.

et al. 2007). A critical factor underlying the widespread adoption of zero tillage in Argentina was the introduction of glyphosate-resistant soybeans, because glyphosate resistance allows for a very thorough and cost-effective weed control. The soybean crop uses zero tillage most prevalently, with 75% of first-crop soybean area and 83% of the second-crop soybean area planted with this technology in 2007 (SAGPyA). In 2007, adoption rates of zero tillage for the other major crops were 74% for corn, 72% for wheat, and 45% for sunflower (SAGPyA).

Zero tillage has contributed to the expansion of agricultural production in several ways. First, it has significantly reduced production costs. Zero tillage requires costly and specialized planting machines, but it eliminates the need to till the soil and perform other types of work associated with conventional crop production technologies. Second, zero tillage has allowed planting in areas poorly suited to conventional crop production methods, contributing to the expansion of the crop frontier and the more intensive use of land (see Section 4.2). Third, by reducing the deterioration of land caused by conventional tillage, zero tillage has permitted the conversion of some land from crop-pasture rotations to permanent agriculture. Under traditional tillage, rotations with pastures were required to restore soil structure and fertility after several years of cropping. In contrast, well-managed zero tillage (i.e., using appropriate rotations of low-stub-

ble crops such as soybeans and high-stubble crops such as wheat and corn) can preserve soil resources. Finally, zero tillage has also greatly facilitated the planting of soybeans immediately following the wheat harvest, resulting in two crops in the same year.

4.2. Expansion of the Crop Frontier

As illustrated in Figure 14.13, the area planted with crops in the non-Pampean regions remained relatively stable at slightly over four million hectares until the mid-1990s, but it has essentially doubled since then. The main expansion took place in the Northeast and Northwest regions where soybeans were planted. According to the national census, between 1988 and 2002 the planted area in those two regions jumped from 2.5 to 4.3 million hectares. This means that the Northeast and Northwest increased their share of Argentina's total area with crops from 13.7% in 1988 to 17% in 2002. A key factor underlying this expansion was the aforementioned introduction of zero tillage, which made it possible to grow crops profitably in areas too marginal for conventional planting technologies.

4.3. More Intensive Land Usage in the Pampean Region

The area planted with annual crops in the Pampas grew by about 50% between the early 1990s and 2007, from slightly over 15 million hectares to around 23 million hectares (see Figure 14.13). Land usage in the Pampean region became more intensive by increasing the area planted with crops relative to permanent pastures, and by relying more heavily on double-cropping. In a substantial proportion of the area, the traditional scheme of rotating crops with permanent pastures, used to restore soil structure and fertility, was changed, either by shortening the cycle with pastures or by eliminating it altogether and switching to continuous cropping. At the same time, double cropping wheat and soybeans (and, to a much smaller extent, barley and soybeans) became a very popular choice for agricultural producers in the Pampas. Between 1996 and 2007 the area planted with soybeans as a second crop is estimated to have increased by about 130%, from 1.9 to 4.4 million hectares (see Figure 14.14). As noted earlier, a major contributor to the popularity of second-cropping was the introduction of zero tillage together with glyphosate-resistant soybeans and glyphosate. The glyphosate technology package preserves soil moisture, saves planting time at a critical period, and greatly facilitates weed control.

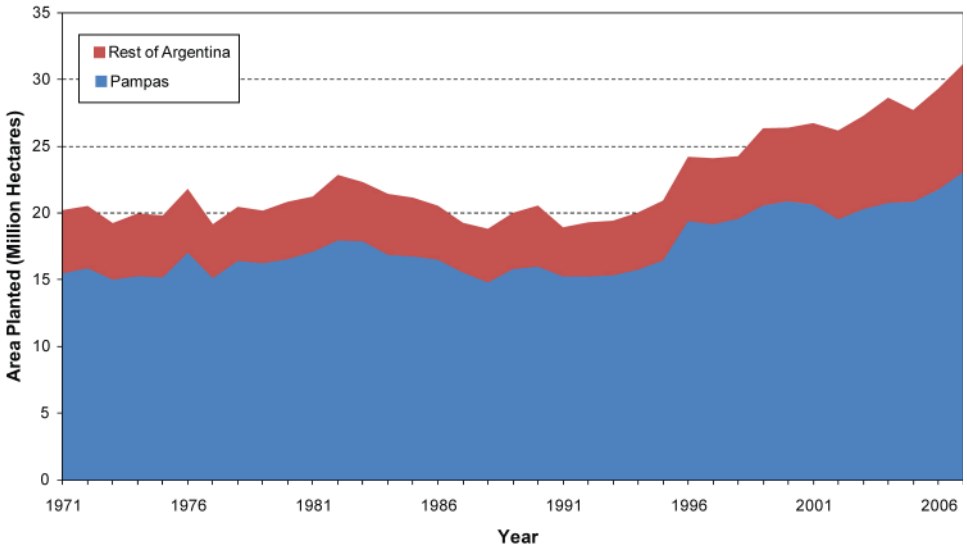

Figure 14.13. Area planted with cereals and oilseeds in the Pampas and the rest of Argentina, 1971-2007

Source: Prepared using data from SAGPyA.

Note: "Pampas" is being approximated here by the provinces of Buenos Aires, Santa Fe, and Cordoba.

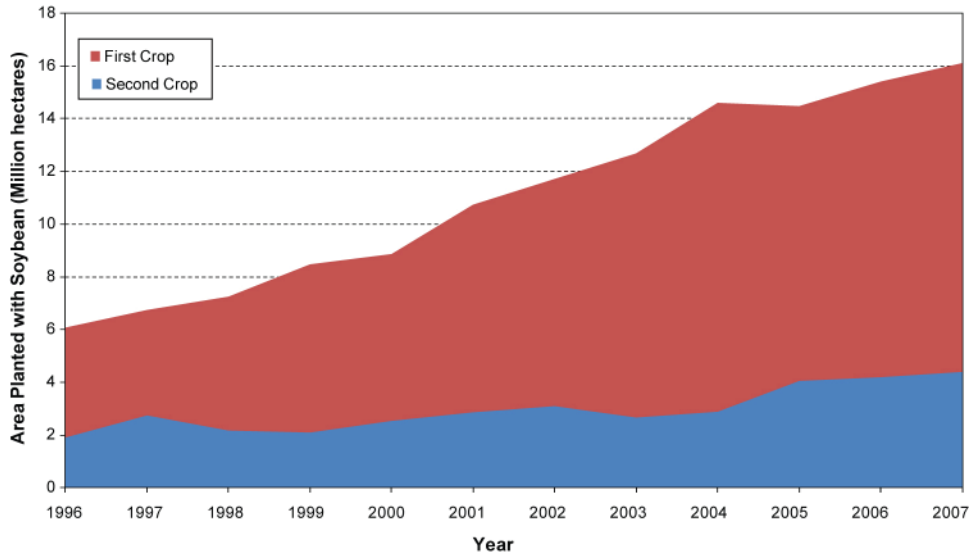

Figure 14.14. Area planted with soybeans as first and second crop in Argentina, 1996-2007

Sources: Prepared using data from Trigo and Cap 2006 and SAGPyA.

4.4. Planting Pools

In the mid-1990s, a new organizational form of production agriculture appeared in Argentina, namely, the "planting pool." Planting pools consist of agreements among producers and other agents that provide for various factors that enter the production and/or commercialization process (e.g., in-kind inputs, labor, and financing). Arrangements may vary greatly, including some in which the producer keeps managing the farm and the planting pools provide for technical assistance, financing, and risk diversification. In other instances, the pools rent vast tracts of farmland, which allows them to exploit economies of scale and benefit from the geographic diversification of risks. Some pools have even expanded to farm land in neighboring countries (e.g., Paraguay, Uruguay, Bolivia, and Brazil). As of 2002, over 50% of operations involved mainly in crop production farmed third-party farmland under various contractual arrangements. Planting pools are now quite common in Pampean agriculture (World Bank 2006).

Planting pools have contributed to the expansion of agricultural output in Argentina in various ways. First, they are a major source of financing for agricultural production. Some studies argue that the perennial lack of adequate financing in Argentinean agriculture was a major reason for the advent of planting pools (World Bank 2006). In recent years, planting pools captured funds from both short- and long-term investors outside of agriculture. Some of the largest pools have also successfully issued equity shares aimed at attracting capital from foreign investors. Second, planting pools tend to incorporate better production practices and more advanced technology. Data from the 2002 agricultural census shows that planting pools are more likely to perform soil analysis and monitor pests. Finally, planting pools tend to use more effective tools to manage risks (e.g., insurance, hedging, and geographic diversification), which provides them with an edge over more traditional forms of organizing agricultural production (World Bank 2006). Overall, planting pools have greatly contributed to the separation of land ownership from the management of agricultural production (Bisang 2008).

4.5. Beef Production Using Feedlots

In recent years, the most noticeable development in the livestock sector has been the widespread use of feedlots to produce beef. Traditionally, Argentinean cattle were raised on pastures. However, the strong trend toward the replacement of pastures by crops, which accelerated after 1990, motivated the adoption

of feedlots as a way to produce beef using less land. Because the best-suited lands for crops are in the Pampas, a relative relocation of cattle from the Pampas to the non-Pampean regions took place along with this shift in farmland usage. The share of the cattle stocks in the Pampas fell from 62% in 1994 to 58% in 2003, and fell further to 50% in 2008 (Canosa, Iriarte, and Tonelli 2009). Together with better management of pastures and technology (e.g., fertilization and genetics), production of beef in feedlots is one reason why meat production has remained at relatively stable levels despite the reductions in pasture area and the total stock of cattle (see Figures 14.4 and 14.15) (Canosa, Iriarte, and Tonelli 2009).

Initially, feedlots were used seasonally as a means to counteract the seasonal drops in the supply of forage from natural pastures. Over time, however, feedlots have tended to become year-round operations, with substantially more uniform and higher-capacity utilization rates. In 2008, capacity utilization for the feedlot industry reached record levels, with no month falling under a rate of 70% (Camara Argentina de Feedlots 2009). In addition to the switch in land use from pastures to crops, there are two factors that have contributed to the increased popularity of feedlots, one of them driven by demand and the other related to supply. On the demand side, stricter requirements by domestic buyers, in terms of both meat quality and uniformity, have clearly favored animals fattened in feedlots over traditional grazing-based beef. On the supply side, a scheme of government reimbursements

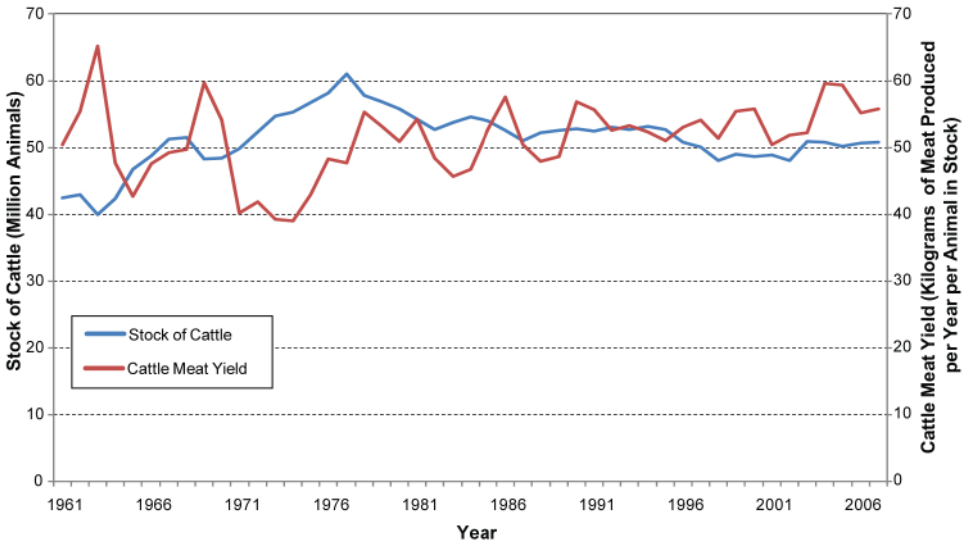

Figure 14.15. Stock of cattle and cattle meat yield in Argentina, 1961-2007
Source: Prepared using data from FAOSTAT.

to feedlots instituted in early 2007, by which registered operations are offered partial refunds for the cost of grains used for feeding cattle in feedlots, has been instrumental in the recent further surge in feedlot production.

According to official statistics, in September 2008 there were 1,400 registered feedlots, which produced 3.6 million animals in the previous year, or about 30% of the total amount of fat cattle slaughtered in Argentina in that year. However, these figures underestimate the actual incidence of feedlots, as many of the operations are not officially registered. It is estimated that slaughter of cattle produced in feedlots increased from 1.5 million animals in 2001 to between 4.5 and 5 million animals in 2009. Nowadays, feedlots consume almost one-fifth of the total corn output produced by Argentina (Camara Argentina de Feedlots 2009).

5. PARTIAL PRODUCTIVITY TRENDS

As pointed out earlier in connection with Figures 14.1 and 14.3, crop production in Argentina has consistently increased since 1960, and its growth seems to have accelerated after the early 1990s. Over the same period, land planted with crops also went up, particularly since the early 1990s (see Figure 14.8). Overall, however, growth in crop production outpaced the increase in land utilization, resulting in positive trends in the yields of all of the major crops (see Figure 14.16). Corn had the largest yield increase, as its output per hect-

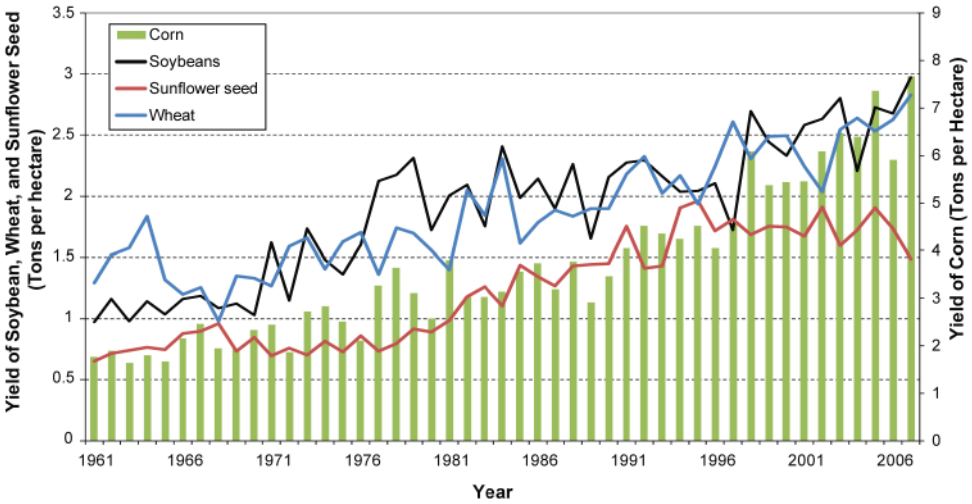

Figure 14.16. Yield per hectare of soybeans, corn, wheat, and sunflower seed in Argentina, 1961-2007
Source: Prepared using data from FAOSTAT.

are almost quadrupled, from 1.8 tons in 1961-63 to 7.0 tons in 2005-07. Next was soybeans, whose yield rose from 1.0 ton per hectare in 1961-63 to 2.8 tons per hectare in 2005-07, for a gain of over 150%. The yield of sunflower seed improved until the mid-1990s, with output per hectare more than doubling between 1961-63 (0.7 tons) and 1994-96 (1.7 tons). However, sunflower seed yield stagnated afterward. Finally, wheat yield increased by about 80%, from 1.5 to 2.7 tons per hectare between 1961-63 and 2005-07. Overall, the positive trend in crop yields can be traced back to the use of better genetic materials, greater use of inputs such as fertilizer and pesticides (more to follow), and better technologies. Among the technologies, worthy of mention is the technological package involving zero tillage, glyphosate-resistant soybeans, and glyphosate. The increase in average crop yields is even more impressive considering that it took place at the same time that vast areas of more marginal lands were being incorporated into crop production.

As shown in Figure 14.6, usage of fertilizers and pesticides rose substantially beginning in the 1960s, and particularly so after the early 1990s. Unfortunately, partial productivity measures by crop for either input cannot be calculated because data about usage of pesticides by individual crops are not available. However, for crops as a whole, it is clear from Figures 14.1 and 14.6 that productivity of both fertilizers and pesticides fell over the period under analysis, because use of both inputs has grown at a significantly faster pace than crop output.

The evolution of labor and machinery inputs in Argentinean agriculture is depicted in Figure 14.17. As with fertilizers and herbicides, there are no disaggregated series for labor or machinery by agricultural activity. Overall, however, the decline in the number of people employed in the sector indicates that labor productivity improved over the period analyzed. The picture is mixed for machinery inputs as represented by the number of tractors, because this number increased until the late 1980s but fell at a small but steady rate afterward (see Figure 14.17). Although no better series for machinery inputs is available, it is important to note that using the number of tractors to measure machinery inputs has severe limitations. For example, the number of tractors does not take into account the increase in the average power of individual tractors that has taken place since the 1960s. In addition, the adoption of zero tillage has greatly reduced the number of operations needed to grow crops. For these reasons, it seems premature to reach strong conclusions regarding the partial productivity of machinery.

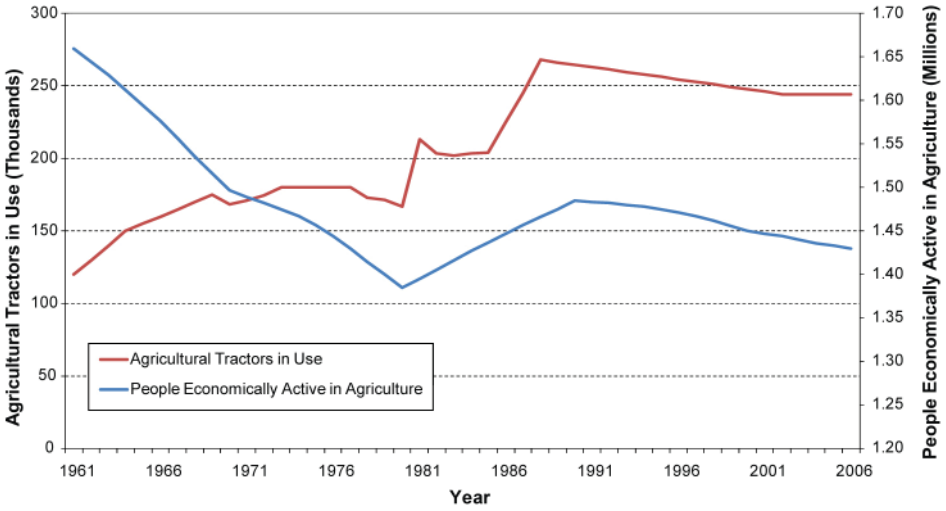

Figure 14.17. Number of people economically active in agriculture and agricultural tractors in use in Argentina, 1961-2007
Source: Prepared using data from FAOSTAT.

In the case of beef production, land productivity increased in recent decades, because total output remained relatively unchanged (see Figure 14.4) while the area devoted to pastures shrunk by a significant amount. Cattle stocks fell by about 10 million animals from the late 1970s, to around 50 million head in 2007 (see Figure 14.15). However, total production of meat remained relatively stable because the fall in stocks was offset by the upward trend in meat yield per animal in stock (see Figures 14.4 and 14.15). The improvement in the productivity of the cattle stock can be attributed to the use of better genetics, better usage of pastures, and improved overall management (Canosa, Iriarte, and Tonelli 2009). Importantly, productivity improved despite the fact that the substitution of crops for pastures displaced cattle stocks toward more marginal areas. More recently, the adoption of feedlots by a significant proportion of finishing operations has contributed to the rise in productivity.

Figure 14.4 shows that milk output increased by about 50% in the three decades following 1960, and then it experienced an explosive and uninterrupted growth of 75% in the 1990s. Milk production fell by more than a quarter between 1999 and 2004, but it improved after that, reaching the peak it had achieved a decade earlier. Between 1960 and the mid-1980s, the productivity of the dairy cattle was essentially flat at about 1.9 tons of milk per year per cow in stock (see Figure 14.18). In the following two decades, however, it increased by more than 150%,

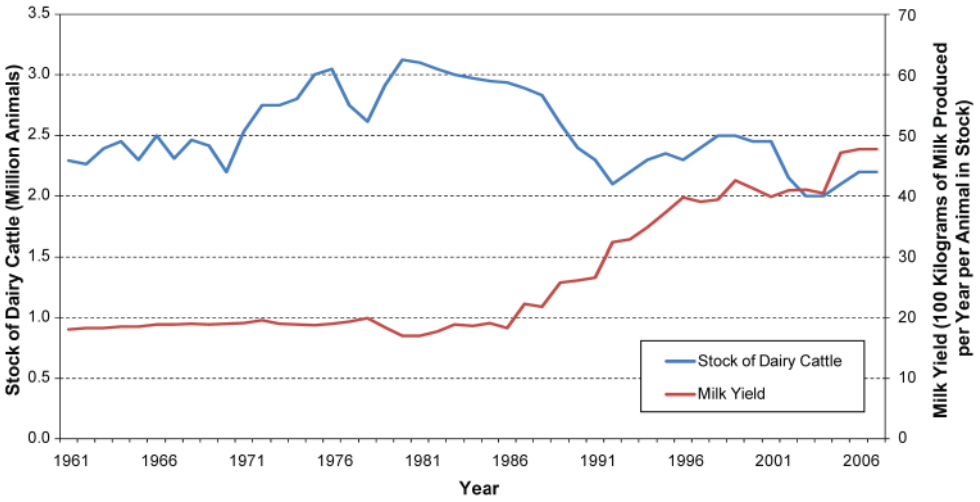

Figure 14.18. Stock of dairy cattle and milk yield in Argentina, 1961-2007
Source: Prepared using data from FAOSTAT.

to 4.8 tons of milk per year per cow in stock. The main factors underlying the advances in productivity are better animal genetics, technology (e.g., artificial insemination and more advanced milking machines), and management (e.g., fertilization and rotation of pastures, and better genetic materials for pastures).

5.1. Some International Comparisons

Figures 14.19 and 14.20 are drawn to compare the productivity of cropland and animal stocks, respectively, for Argentina and other relevant countries. The countries chosen for this purpose are the United States, overall the largest producer and exporter of the main crops and livestock produced by Argentina, and the other top five exporters of each commodity.

Soybean yield in Argentina compares well with the soybean yield that characterizes the country's main competitors in world markets, because it is almost the same as in the United States and more than 20% higher than the average for the other top five exporters. Further, soybean yield in each of the other top countries is below Argentina's. For corn, yield in Argentina is about one-quarter smaller than in the United States. It is important to note, however, that the United States has the highest corn yield among the world's largest corn exporters. Relative to the average of the top five corn exporters, Argentina's corn yield is about 20% larger. Wheat yield is about the same in Argentina as in the United States, but it is one-third smaller than the average

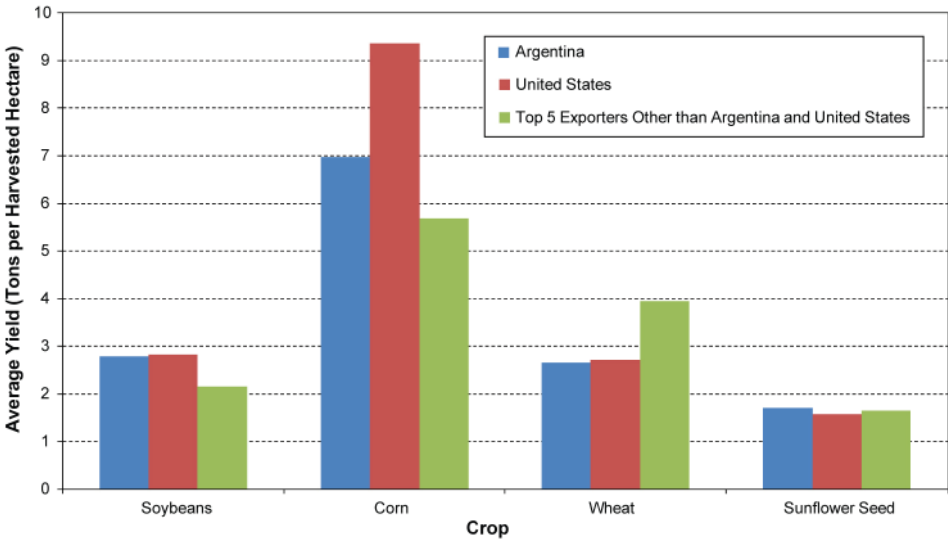

Figure 14.19. Average yield per harvested acre for Argentina and selected countries, 2005-2007

Source: Prepared using data from FAOSTAT.

Note: The top five exporters other than Argentina and the United States are (a) Brazil, Paraguay, Canada, Uruguay, and China for soybeans; (b) France, China, Brazil, Hungary, and the Ukraine for corn; (c) Canada, France, Australia, the Russian Federation, and Germany for wheat; and (d) France, Bulgaria, Hungary, Romania, and the Russian Federation for sunflower seed.

for the other top five wheat exporters. Most noticeably, there is a very large gap between wheat yields in Argentina (2.7 tons per hectare) and in Germany (7.2 tons per hectare), the country with the highest yield from among the other top exporters. Finally, yield of sunflower seed in Argentina is 1.7 tons per hectare, or almost 10% higher than in the United States and about the same as the average for the other top five exporters. In terms of sunflower seed yield among the world's largest exporters, Argentina ranks third behind France and Hungary, but these two countries have significantly larger yields (2.4 and 2.1 tons per hectare, respectively).

According to the graphs displayed in Figure 14.20, Argentina clearly lags its main competitors in terms of livestock productivity. Argentina's meat production per animal in stock is less than half relative to the United States, and almost one-fourth less than the average of the other top five exporters. Among top exporters, only Brazil has lower productivity of cattle stocks than Argentina. The situation is similar regarding the productivity of Argentina's dairy cattle compared to that of the United States and the other top five exporters. In this instance, New Zea-

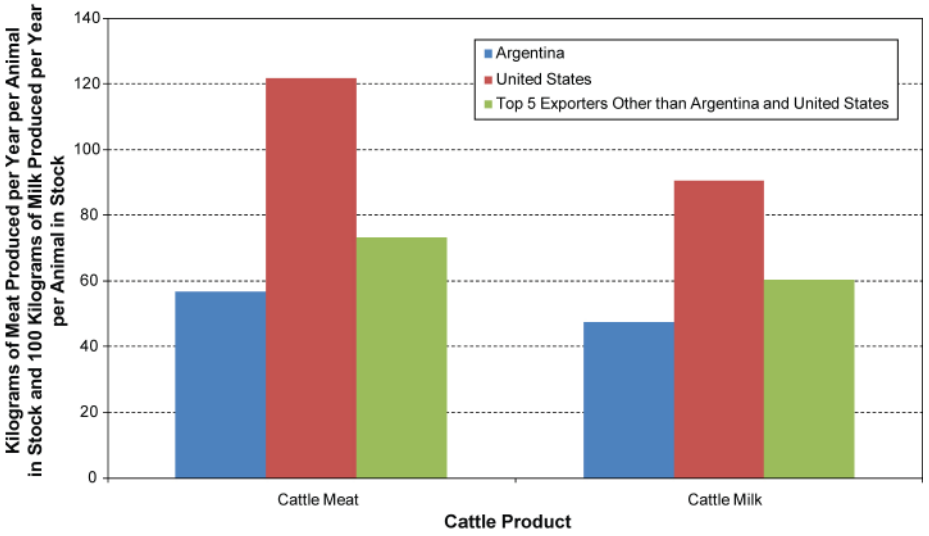

Figure 14.20. Average yield of cattle meat and milk per animal in stock for Argentina and selected countries, 2005-2007
Source: Prepared using data from FAOSTAT.
Note: The top five exporters other than Argentina and the United States are (a) Brazil, Australia, Ireland, New Zealand, and the Netherlands for cattle meat; and (b) Germany, France, the Netherlands, New Zealand and Belgium for cattle milk.

land is the only country among the major milk exporters whose productivity is below Argentina's.

6. TRENDS IN TOTAL FACTOR PRODUCTIVITY

The previous section addressed partial productivity measures for the agricultural sector in Argentina. They quantify the effect on output of individual factors of production, without controlling for the usage of other factors of production. To analyze the productivity of the entire set of inputs entering agricultural production, it is necessary to look at total factor productivity (TFP) measures. This section focuses on TFP measures for Argentinean agriculture.

Outputs and inputs can be aggregated following different methods, leading to alternative ways to measure TFP. Following Coelli, Rao, and Battese (1998), such methods can be classified into four categories: (a) econometric estimation of models based on production functions, (b) accounting relationships, (c) data envelopment analysis (DEA), and (d) stochastic frontiers. Each method has its own advantages and disadvantages, based on the data requirements for estimation, underlying assumptions, and purpose of the analysis. For example, to estimate TFP

growth at the country level, the first method assumes that the country production is technically efficient, and it only requires a sufficiently long time series of data for the country. The second method assumes that payments to all inputs are equal to the total value of production but can be estimated with as little data as observations at two distinct points in time. The third and fourth methods allow for technically inefficient production but require data on a cross-section of countries.

Table 14.3 summarizes the results of the eight studies that were performed over the last decade and reported TFP growth measures for the Argentinean agricultural sector for a period ending in 1997 or later. Of these studies, three were based on the estimation of production functions (Artana, Cristini, and Pantano 2001; Bravo-Ortega and Lederman 2004; and Lanteri 2005), two used accounting relationships (Lema 1999; and Dias Avila and Evenson 2004), two relied on DEA (Coelli and Rao 2005; and Nin and Yu 2008), and one estimated a translog stochastic frontier production function (Bharati and Fulginiti 2007). The studies also differed in the data sources used, as three of them employed mainly data from government agencies in Argentina (Lema 1999; Artana, Cristini, and Pantano 2001; and Lanteri 2005), whereas the other five used FAO's database (Bravo-Ortega and Lederman 2004; Dias Avila and Evenson 2004; Coelli and Rao 2005; Bharati and Fulginiti 2007; and Nin and Yu 2008). In this regard, it must be noted that FAO's database allows estimation of TFP for Argentina only up to 2003, because some of the input data series are missing for 2004 and later years.

The numbers shown in Table 14.3 reveal large differences in the TFP growth estimates, as these range from a low indicating an average TFP contraction of 2.7% per year over the period 1980-2000 (obtained by Coelli and Rao 2005) to a high postulating an average TFP growth of 2.88% per year over 1964-2003 (reported by Nin and Yu 2008). The wide range of the reported estimates is noticeable. The earlier discussion about the significant changes that Argentina's agricultural sector experienced after the early 1990s would suggest that such changes may have rendered TFP more difficult to measure with reasonable precision, thus explaining the lack of consensus across TFP estimates. However, the literature indicates that this is not the case, as earlier studies show contradictory results regarding TFP growth for Argentinean agriculture over previous periods. For example, Lanteri (1994) estimated that TFP grew at an average annual rate of 1.9% between 1964 and 1992, and Elías (1992) reported average annual TFP growth rates of 0.49% and 1.09% over the decades 1960-1970 and 1970-1980, respectively. In contrast, according to Arnade (1998), agricultural TFP in Ar-

Table 14.3. Summary of total factor productivity (TFP) growth rates for Argentinean agriculture estimated by recent studies

Study	Period Analyzed	Annual TFP Growth (%)	Method Used	Data Type (Source)
Lema 1999	1970-1997	1.55	Accounting relationship	Time series (SAGPyA)
Artana, Cristini, and Pantano 2001	1981-1999	2.2	Estimated production function	Time series (SAGPyA, INDEC)
Dias Avila and Evenson 2004	1961-1980	1.83	Accounting relationship	Time series (FAOSTAT)
Dias Avila and Evenson 2004	1981-2001	2.53	Accounting relationship	Time series (FAOSTAT)
Bravo-Ortega and Lederman 2004	1961-2000	1.84	Estimated translog production function	Panel of 77 countries (FAOSTAT)
Coelli and Rao 2005	1980-2000	-2.7	Malmquist TFP index from DEA analysis with constrained shadow prices	Panel of 93 countries (FAOSTAT)
Coelli and Rao 2005	1980-2000	0.4	Tornqvist TFP index from DEA analysis with constrained shadow prices	Panel of 93 countries (FAOSTAT)
Lanteri 2005	1955-2003	-0.941	State-space Hicks-neutral estimation of translog cost function	Time series (SAGPyA, INDEC, FAOSTAT)
Bharati and Fulginiti 2007	1972-2002	2.15	Estimated stochastic translog production frontier	Panel of 10 Mercosur countries (FAOSTAT)
Bharati and Fulginiti 2007	1972-1981	3.47	Estimated stochastic translog production frontier	Panel of 10 Mercosur countries (FAOSTAT)
Bharati and Fulginiti 2007	1982-1991	1.38	Estimated stochastic translog production frontier	Panel of 10 Mercosur countries (FAOSTAT)

Table 14.3. Continued

Study	Period Analyzed	Annual TFP Growth (%)	Method Used	Data Type (Source)
Bharati and Fulginiti 2007	1992-2002	2.39	Estimated stochastic translog production frontier	Panel of 10 Mercosur countries (FAOSTAT)
Nin and Yu 2008	1964-2003	2.88	Malmquist TFP index from DEA analysis with constrained shadow prices	Panel of 72 countries (FAOSTAT)
Nin and Yu 2008	1964-2003	2.30	Malmquist TFP index from DEA analysis with unconstrained shadow prices	Panel of 72 countries (FAOSTAT)
Nin and Yu 2008	1984-2003	1.97	Malmquist TFP index from DEA analysis with constrained shadow prices	Panel of 72 countries (FAOSTAT)

gentina contracted at an average annual rate of 1.85% from 1961 through 1993. Trueblood and Coggins (2002) also estimated a contraction in TFP over a similar period (1961-1991), although at a greater average annual rate (2.63%), and Fulginiti and Perrin (1997) found an even greater annual rate of TFP contraction (4.8%) between 1961 and 1985.

Closer inspection of the estimates reported in Table 14.3 reveals additional inconsistencies and/or problems with the recent estimates of TFP growth for Argentinean agriculture. First, the estimates from Nin and Yu (2008) imply that TFP grew at a slower pace over 1984-2003 than over 1964-1983. This is true because the authors estimated an average annual growth rate of 1.97% for the first period, compared to an average annual growth rate of 2.88% over the entire 1964-2003 period. In contrast, using data from the same source (FAOSTAT), Dias Avila and Evenson (2004) found higher TFP growth over 1981-2001 (with an average of 2.35% per year) than over 1961-1980 (with an average of 1.83% per year).

Second, Coelli and Rao (2005) calculated an average annual TFP contraction of 2.7% over 1980-2000, whereas Nin and Yu (2008) estimated that TFP grew at an average annual rate of 1.97% over 1984-2003. These contradictory results are puzzling because the periods they cover largely overlap, they are both based on a very large cross-section of countries from FAOSTAT, and their estimates are both based on calculating a Malmquist TFP index from DEA. The fact that Coelli and Rao (2005) left shadow prices unconstrained for the estimation and Nin and Yu (2008) constrained them doesn't seem to explain the stark difference between their results, as Nin and Yu (2008) show that imposing such a constraint only reduces the average annual TFP growth from 2.88% to 2.30% over the period 1964-2003.

Third, the studies that simultaneously estimate TFP growth for Argentina and other countries show substantially different rankings for Argentina. For example, Argentina's TFP growth ranked 89th among the 93 countries examined by Coelli and Rao (2005), whereas it ranked either second (when shadow prices are constrained) or fourth (with unconstrained shadow prices) among the 73 countries analyzed by Nin and Yu (2008). According to Dias Avila and Evenson (2004), Argentina's agricultural TFP growth ranked 25th and 20th among 78 countries of Latin America, Asia, and Africa over the periods 1961-1980 and 1981-2000, respectively.

Fourth, some of the assumptions adopted for estimation purposes seem to have a major impact on the calculated rates of TFP growth. For example,

Coelli and Rao (2005) showed that by using a Tornqvist TFP index instead of a Malmquist TFP index, the estimated average change in TFP increases from a contraction of 2.7% per year to a growth of 0.4% per year. Less dramatic but nonetheless substantial is the impact of relaxing the assumption of Hicks-neutral TFP changes, reported by Lanteri (2005). Lanteri found an average annual TFP contraction of 0.941% over 1955-2003 when imposing Hicks neutrality, compared to virtually no TFP change on average (i.e., an annual contraction of 0.005%) over the same period when allowing for Hicks non-neutrality.

Fifth, the estimation method may have a major impact on TFP growth estimates. Evidence of this is that using DEA, Fulginiti and Perrin (1997) estimated that TFP contracted at an average annual rate of 4.8% between 1961 and 1985. In contrast, employing a stochastic frontier approach, Bharati and Fulginiti (2007) found that TFP grew at averages of 3.47% per year from 1972 through 1981 and 1.38% per year from 1982 through 1991. An implausibly large contraction in TFP over the decade 1961-1971 would be required for the results from the two studies to be consistent with each other.

In summary, the results reported in Table 14.3 strongly indicate that existing estimates of TFP growth for agriculture in Argentina are quite imprecise. Exploring the reasons for this state of affairs is beyond the scope of the present study, but suffice it to say that likely potential culprits include poor quality of data and unwarranted theoretical assumptions regarding the theoretical models used to fit the data. Regarding data quality, it must be noted that, for example, none of the input series employed by the cited studies is adjusted for quality (e.g., one unit of land in sub-Saharan Africa is assumed to be the same as one unit of land in Argentina). Also, as noted in connection with Figure 14.17, FAOSTAT's number of agricultural tractor series seems a very poor approximation for the usage of agricultural machinery. As per the theoretical assumptions, for example, DEA assumes that unexplained residuals are entirely attributable to inefficiencies, which seems at odds with the sizable shocks due to weather, pest infestations, and other factors so characteristic of most agricultural production activities.

Unfortunately, the imprecision in the estimates reported by the literature does not allow conclusive answers to two very important questions concerning Argentina's agricultural sector, that is, whether TFP contracted or grew in recent decades, and whether the rate of change has slowed down or picked up pace over the same period. For this reason, efforts to predict the course of Argentinean agriculture's TFP in the future seem unwarranted at present.

7. CONCLUDING REMARKS

Argentina is a country richly endowed with natural resources appropriate for agricultural production. Such resources have allowed it to be a major player in international markets, despite the strong discrimination against agriculture that characterized the country's policies since World War II.

Existing studies have found mixed results regarding the performance of Argentinean agriculture in terms of total factor productivity growth. However, the experience from the 1990s, when discrimination against agriculture reached the smallest level in decades, strongly suggests that the sector is extremely responsive to economic incentives. The 1990s witnessed a massive adoption of modern technologies, the expansion of the crop frontier, an intensification of land usage in traditional areas, the advent of new forms of production organization, and substantial shifts from livestock to crops and among crops. More recently, feedlots have been widely adopted for beef production. During this period there were substantial gains in the productivity of land planted with major crops, and in the stocks of beef and (especially) dairy cattle.

The economic debacle experienced by Argentina at the end of 2001 marked a reversal toward more discriminatory policies against agriculture. The change was motivated by the country's dire need to obtain hard currency and improve fiscal revenues. Historically, the agricultural sector accounted for a significant share of the country's balance of trade and tax revenues, and that share increased following the economic crisis. The discrimination against the sector has become ever stronger since 2001, particularly after 2007. The current administration belongs to the party founded by Peron, who was instrumental in laying out and implementing the policies against agriculture and the welfare state that started after World War II. As such, despite losing mid-term elections in 2009 (arguably in part because of a confrontation with the agricultural sector), the current administration seems keen on reverting to the extent possible to the kinds of policies first instituted by Peron.

As of this writing, it seems unclear whether in the long run Argentina's agricultural policies will be as discriminatory as they were through much of the country's history and as they are now, or less so, as in the 1990s. The outcome will depend on how political forces shape up in the future. Importantly, the present discussion strongly suggests that such an outcome is likely to have critical implications for the future performance of Argentinean agriculture. The sec-

tor tended to languish when policies were highly discriminatory against it, but it quickly prospered under a more favorable economic environment.

Some recent studies conclude that Argentina has the potential to significantly increase its agricultural output over the next few years (e.g., Cap and González 2004; Oliverio and Lopez 2008). However, there are studies that also caution about the way agriculture has expanded in the recent past and/or question the sustainability of some of the current practices used in Argentina's production agriculture (e.g., World Bank 2006; Pineiro and Lopez Saubidet 2008). Paramount among these are the environmental issues connected with the conversion of natural ecosystems in marginal areas to agriculture, the high threat of soil degradation due to more intensive cropping, and the risks associated with having a single crop (soybeans) account for such a large share of the sector's output and trade.

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