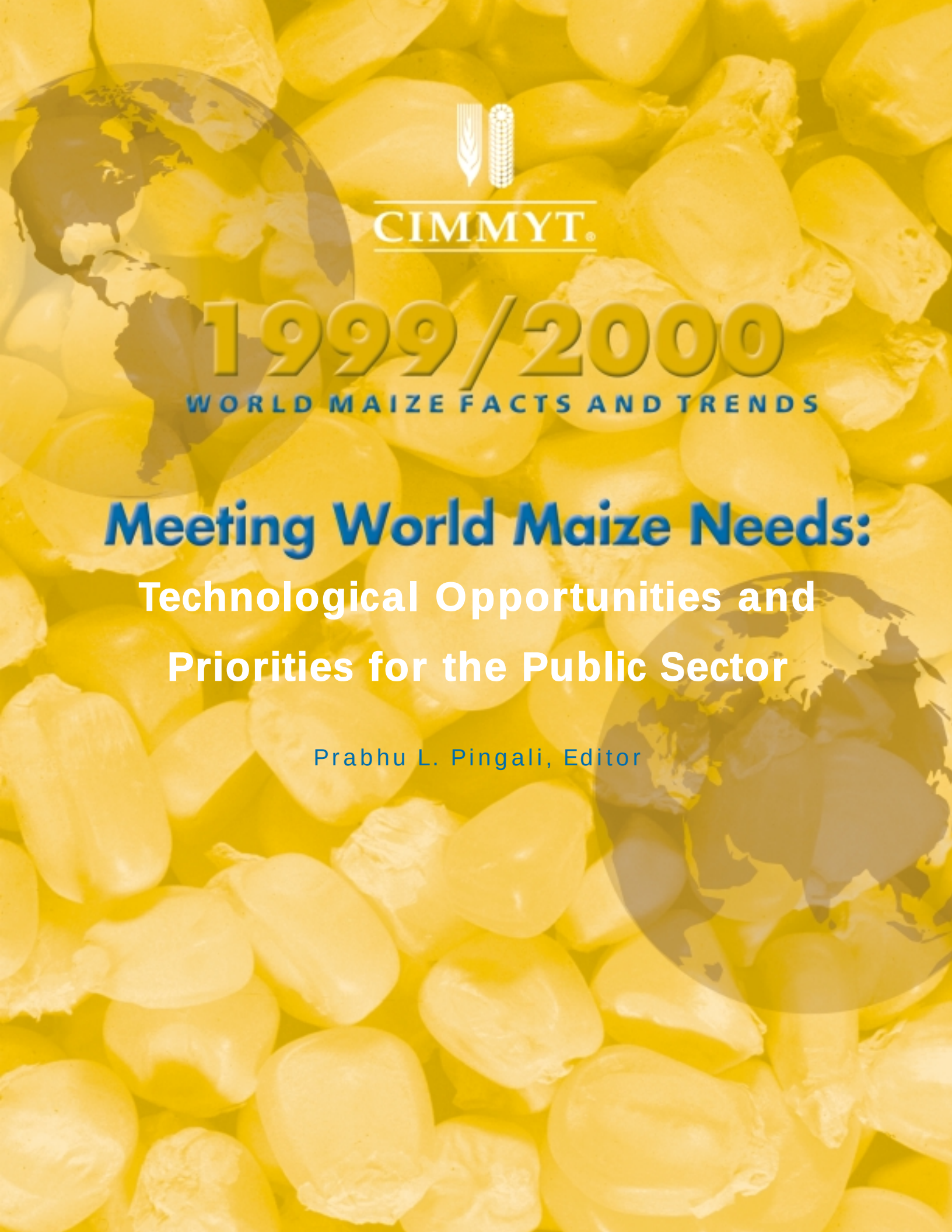
CIMMYT.
1999/2000
WORLD MAIZE FACTS AND TRENDS
Meeting World Maize Needs:
Technological Opportunities and Priorities for the Public Sector
Prabhu L. Pingali, Editor

Part 3

Current and Future Trends in Maize Production and Trade

Erika Meng and Javier Ekboir

Introduction

Total world maize production for 1999/2000 slightly exceeded 604 million tons, with approximately 11.5% of the total output traded internationally. Production for 2000/2001 is estimated to increase approximately 2%, due largely to a 9.5 million ton increase in production in the United States. The volume of trade forecast for the 2000/2001 marketing year is 70.8 million tons, which is the largest quantity traded during the last six years; this represents approximately the same percentage of total production as the previous year and, indeed, for the last decade (Table 1). A small number of countries are responsible for most exports, although not all of them are necessarily large producers. Table 2 lists the most significant maize producing countries of the last decade; information on maize importing and exporting countries is provided in Table 3 .

While the United States has continued to dominate world maize production, significant roles are also played by China, the nations of the Mercado Commun Sudamericano (MERCOSUR), and the European Union (EU). China alone has consistently accounted for more than 20% of world maize production during the last decade, while production in Argentina and Brazil together has averaged more than 8% over a similar period. In addition to being the largest maize producer, the United States is also the world's largest maize exporter. Argentina, likewise, is a major maize producer and exporter, but a high production level does not necessarily imply a large export role. For instance, all of Brazil's considerable output is consumed domestically, and nearly all of the EU's production is utilized by member countries. China is somewhat of an anomaly, having been both a significant maize exporter and importer during the last decade.

A closer examination of Asian maize imports reveals that they have consistently exceeded 30 million tons annually, primarily as a result of imports flowing into Japan and South Korea. Maize utilization and imports by Southeast Asian countries have also increased sharply in the last decade. Imports have largely been directed toward the expanding domestic livestock industries, which have been buoyed by higher income levels that have increased demand for meat products. Although

Table 1. World maize trade as percentage of total production ('000 t)

	1992/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	2000/01
World production	538,575	475,494	559,579	513,078	592,179	576,153	605,944	604,406	614,729
World trade	62,226	56,374	71,189	65,489	66,696	62,995	68,348	69,535	70,835
Percentage traded	0.116	0.119	0.127	0.128	0.113	0.109	0.113	0.115	0.115

Source: Constructed from USDA-FAS (2001a).

Table 2. World maize production ('000 t)

	1992/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	2000/01
United States	240,719	160,954	256,621	187,305	234,518	233,864	247,882	239,719	247,407
China	95,380	102,700	99,280	112,000	127,470	104,300	132,954	128,000	125,000
EU	30,242	30,487	28,298	28,952	34,794	38,522	35,295	37,241	38,765
Brazil	29,200	32,934	36,982	31,595	35,700	30,100	32,350	33,000	33,500
Mexico	18,631	19,141	17,005	16,000	18,922	16,934	17,788	19,000	19,000
Argentina	10,200	10,000	10,900	10,660	15,500	19,360	13,500	16,000	16,500
India	9,992	9,600	9,120	9,800	10,612	10,852	10,680	10,500	11,000
Romania	6,829	8,000	8,500	9,923	9,610	12,680	8,500	10,500	10,500
Canada	4,883	6,501	7,043	7,271	7,380	7,180	8,952	9,096	10,200
South Africa	9,990	13,275	4,845	10,200	10,136	7,693	7,700	9,700	9,500
Yugoslavia	6,650	5,912	7,500	8,300	8,300	10,500	8,700	9,500	9,300
Hungary	4,301	4,012	4,300	4,600	6,000	6,800	6,000	7,000	7,500
Indonesia	5,650	5,400	5,500	6,200	5,950	5,700	6,500	6,200	6,200
Egypt	4,500	4,980	5,650	5,738	5,825	6,010	5,605	5,678	5,800
Philippines	4,810	5,030	4,534	4,300	4,215	3,528	4,894	4,500	4,300
Thailand	3,400	2,900	3,800	3,700	3,900	3,700	4,300	3,800	4,100

Source: USDA-FAS (2001b).

Table 3. Major maize exporting and importing countries

	1992/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	2000/01
Exports ('000 t)									
United States	41,766	33,148	58,645	52,500	46,633	37,697	51,886	46,500	49,500
Argentina	4,779	4,230	6,046	6,700	10,210	12,756	7,849	8,800	9,500
China	12,623	11,796	1,413	250	3,892	6,173	3,340	9,000	6,000
Hungary	222	18	370	500	1,122	1,250	1,766	1,700	2,000
South Africa	-	3,006	2,525	1,600	1,581	1,125	790	1,200	1,300
Romania	1	1	47	750	537	874	400	400	300
Ukraine	-	-	-	-	22	593	35	100	200
EU	1,256	1,722	347	350	243	382	100	100	100
Thailand	198	88	160	100	-	-	-	-	-
Imports ('000 t)									
Japan	16,760	16,165	16,481	15,900	15,963	16,422	16,336	16,250	16,100
Korea, South	6,544	5,696	8,223	8,800	8,336	7,528	7,517	9,000	8,500
Taiwan	5,629	5,316	6,288	5,900	5,742	4,474	4,575	5,000	5,100
Mexico	396	1,691	3,166	6,400	3,141	4,376	5,615	4,600	5,000
Malaysia	1,957	1,977	2,415	2,300	2,332	2,195	2,388	2,500	2,600
EU	1,611	2,615	3,400	2,900	2,595	2,065	3,000	2,500	2,500
Brazil	1,170	1,134	1,435	150	514	1,491	968	1,600	1,400
Chile	395	439	551	425	783	851	1,268	1,200	1,300
Venezuela	1,126	945	1,170	1,200	1,494	1,161	1,500	1,250	1,300
Indonesia	357	962	1,738	900	895	516	475	450	600
Canada	1,190	585	1,108	650	879	1,418	903	800	500
Philippines	-	1	138	525	446	455	129	375	375
United States	166	519	245	385	285	126	388	325	325
Thailand	80	8	222	300	231	253	150	350	300
China	-	-	4,287	1,600	75	287	262	250	250

Source: USDA-FAS (2001a).

consumer demand for meat has slowed due to the Asian financial crisis of 1997/98, some gradual recovery in the region in the last few years has bolstered production and trade activity.

What can we expect to see in future trade patterns? Certainly they will continue to be determined by a complex interaction of many factors, including the domestic production environment and utilization trends, domestic and international trade policies, exchange rates, and commodity prices. Population growth and perhaps even more importantly, the rate of income growth, will also exert strong influences.

A reasonably good picture of future market development and activity can be obtained by looking at the pivotal roles played by three countries/regions: the United States, MERCOSUR, and Asia. We include the United States because of its indisputable role as a major player in international maize markets. The production and export potential of MERCOSUR, particularly Argentina and Brazil, also warrant serious consideration. Finally, the size, changes, and growth of the Chinese economy, as well as the potential of renewed growth of demand in other Asian countries, make Asia especially dynamic in terms of maize demand, production, and trade.

Changes in the U.S. Maize Market

Maize is cultivated throughout the United States, with most of the planted area in the nine neighboring Midwest states of the Corn Belt. Since maize yields have grown at slightly less than 2% per year during the last four decades, the greatest influences on U.S. maize production and trade are unlikely to come directly from changes in yield or area, despite some year-to-year variation due to weather and growing conditions. Rather, four other factors and their ramifications will heavily influence the production and trade environment: (1) changes in trade patterns and regulations; (2) ramifications of technical change, in particular, development of genetically modified (GM) maize and value-enhanced maize; (3) changes in domestic agricultural policy; and (4) changes in domestic demand for products containing maize, particularly for new products.

Changes in Trade Patterns and Regulations

In the last 15 years, U.S. trade and agricultural policies have become increasingly linked because of the growing share of agricultural output that is exported. Multilateral agreements aimed at reducing trade-distorting policies are further strengthening this linkage. Currently, more than 20% of U.S. maize output is exported. Negotiations in two specific areas will affect maize exports in the near future: (1) those carried out to create a freer trade environment, and (2) those for regulations on the trade of genetically modified organisms (GMOs).

In the area of freer trade, China's admission into the World Trade Organization (WTO) would have the greatest potential for affecting U.S. maize exports, possibly adding US$ 1.6 billion to annual U.S. exports of grains, oilseeds, oilseed products, and cotton by 2005 (USDA-ERS 2000e). The freer trade environment that is envisioned would

increase Chinese imports of maize and boost demand for U.S. maize. The net effect will depend on domestic demand for food and feed maize in China and elsewhere, as well as the evolution of agricultural production.

The overall impact of regulations concerning genetically modified organisms (GMOs) on trade is still uncertain. Currently, importing countries may require approval of new GM crop varieties under their national laws and regulations. Once approval has been granted, trade is subject to the same regulations as for other bulk commodities. Most countries have not placed restrictions on maize imports from the United States. But a considerable conflict has arisen over official European acceptance of U.S. maize and maize product exports. Although some GM varieties (specifically those carrying *Bt* genes) have obtained final EU approval during the last two years, a de facto moratorium currently exists on additional approvals. At the macro level, this conflict could affect intercontinental trade; at the micro level, it could affect the decisions of maize growers and processors now exporting to the EU, who may respond to the EU constraints by growing only conventional maize.

European Union purchases represent less than 1% of U.S. maize exports, hence the conflict should have little impact on the country's maize exports, 94% of which are concentrated in Latin America (in particular, Mexico and Colombia), Japan, South Korea, Africa, and the Middle East (USDA-ERS 2000b). Nevertheless, it is possible that the GMO controversy could spread to more important U.S. export destinations in the future, making trade in these regions much more complicated. A counteracting force could be the adoption of GM maize by other large exporters, such as Argentina, in which case importers may not readily find alternative sources for large volumes of non-GM maize (USDA-ERS 2000b).

Negative impacts on U.S. trade are more likely to come from labeling requirements than from direct trade regulations. Mandatory labeling could hinder market adjustment by increasing the cost of market segregation and of voluntary labeling that may occur in response to differentiating demands. A likely solution is that two separate marketing channels, one for GM maize and another for non-GM maize, will continue to evolve. Such product differentiation would represent an extension of a trend already established for high-value products in grain and oilseed markets.

Unlike the sudden shocks the global maize market has experienced in the past (e.g., due to adverse weather or government policy changes), changes regarding GMO preferences will probably be comparatively gradual. In the near future, U.S. maize exports will almost certainly be affected more by international competitors than by regulation of GM trade (USDA-ERS 2000b; Riley 1998).

Technological Change

New seed technology for maize can be classified into two categories: (1) technologies that generally reduce input use or lead to more effective input use, mainly developed through biotechnology; and (2) technologies that produce enhanced-value traits aimed at specific end-users (e.g., high oil maize, hard endosperm maize, waxy maize, and white maize), which are usually developed through conventional breeding. Herbicide resistant maize and *Bt* maize are the major products, to date, from the first category. Although the first wave of GM crops with built-in protection against pests and herbicides was rapidly adopted in the United States, adoption of the next wave of GM crops may proceed more slowly. Issues related to sharing the added value among different agents (producers, seed companies, storage elevators, and end-users), accommodation of specialized end-use characteristics, labeling controversies, and potential consumer resistance could all affect the next generation of GM goods (USDA-ERS 1999).

Expansion of value-enhanced maize will probably be less than that of GM maize. Area for the most widely grown product, high oil maize, was estimated in 1999 at slightly more than 900,000 acres, while total area of other value-enhanced products was estimated at less than 2 million acres, accounting for approximately 5% of output (USDA-ERS 1999). Although production has been hampered in the past by low yields, another important obstacle currently impeding the more widespread cultivation of value-enhanced maize is the lack of a widely recognized price mechanism for the specialty characteristics.

The growing emphasis on end traits, which require identity preservation (in some cases, segregation may be sufficient) and separate marketing channels, signals a departure from the traditional bulk commodity focus based on blending and large volumes. Future expansion of value-enhanced maize will likely require the evolution of completely segregated marketing channels. Niche markets for these non-GMO products

may develop, similar to the present market for organic foods, which is characterized by separate identity-preserved marketing and premium prices (USDA-ERS 1999; Riley 1998).

Changes in Domestic Agricultural Policy

The 1996 FAIR Act had major consequences for U.S. agriculture and for maize, the nation's primary domestically grown feed grain. It eliminated set-aside programs and offered greater flexibility to farmers, thus acting as a catalyst to switch from wheat, barley, oats, and sorghum to more profitable crops (e.g., maize and soybeans). Because of the greater planting flexibility, maize and soybean planting decisions are now based on a wider set of variables than previous planting history and the soybean to maize price ratio (Lin and Riley 1998). Relatively rapid changes have been observed in the crop distribution of the overall cropping area that may reflect another significant ramification of the policy change: increased volatility in maize area due to greater substitutability among crops.

Domestic Demand

Domestic demand for maize continues to be largely driven by the evolution of traditional markets (e.g., feed and food markets), as well as by industrial use and the development of alternative uses for maize. Given relatively small income elasticity of food demand in the United States, traditional markets are expected to grow at about the same rate as population. Total U.S. maize usage in 1999 was 59% for feed/residual, 6% for high fructose products, 6% for ethanol, 21% for exports, and 8% for all other uses (USDA-ERS 2000d). Maize demand, particularly in the poultry, hog, and sweetener industries is currently strong with projections of a 3% increase in 2001 from the preceding year. Maize demand in the ethanol industry has also remained strong due to increases in the price of gasoline (USDA-ERS 2000c). Several public and private initiatives exist to increase the market for ethanol and alternative uses for maize, among them, a research and development effort for bio-fuels and bio-based products that is coordinated by the U.S. government and involves the government, academia, industry, and producers.[1]

Maize Potential in the MERCOSUR Countries of South America

Although MERCOSUR was created in 1991, its governing treaty did not take effect until January 1995. The agreement introduced an imperfect customs union among its full members (Argentina, Brazil, Paraguay, and Uruguay) and its associated members (Bolivia and Chile).[2] The member nations of MERCOSUR produce a diversified basket of outputs, including soybeans, maize, wheat, sunflower, sorghum, barley, beef, poultry, and pork (Ekboir 2000b). Production data

[1] An example is the recent announcement by Cargill/Dow about their plans to produce PLA, a plastic polymer made from maize that can be used in a wide variety of consumer products.

[2] The four full members form a customs union with free movement of goods within the union and a common external tariff. The associated members have agreed to a phased integration into MERCOSUR and temporarily maintain tariffs for certain products, the most important being agricultural products.

Table 4. Maize, soybean, and wheat production for selected MERCOSUR countries (t)

	1980	1981	1982	1983	1984	1985	1986
Argentina							
Maize	6,400,000	12,900,000	9,600,000	9,000,000	9,500,000	11,900,000	12,100,000
Soybeans	3,500,000	3,770,000	4,150,000	4,000,000	7,000,000	6,500,000	7,100,000
Wheat	7,780,000	8,300,000	15,000,000	13,000,000	13,600,000	8,700,000	8,700,000
Brazil							
Maize	20,372,080	21,116,910	21,842,480	18,731,220	21,164,140	22,018,180	20,541,230
Soybeans	15,155,800	15,007,370	12,836,050	14,582,350	15,540,790	18,278,590	13,333,360
Wheat	2,701,613	2,209,631	1,826,945	2,236,700	1,983,157	4,320,267	5,638,470

Source: FAO 1994.

Table 5. Maize area and yield for selected MERCOSUR countries

Maize area (ha)	1980	1981	1982	1983	1984	1985	1986
Brazil	11,451,290	11,520,340	12,619,530	10,705,980	12,018,450	11,798,350	12,460,130
Argentina	2,490,000	3,394,000	3,170,000	2,970,000	3,024,800	3,340,000	3,231,000
Paraguay	226,000	195,000	231,000	170,000	168,000	156,000	154,000
Chile							
Bolivia	293,480	313,110	285,780	260,844	321,731	348,929	294,000
Uruguay	131,923	146,202	94,948	93,094	83,191	89,491	76,262
Maize yield (t/ha)	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**
Brazil	1.779	1.833	1.7308	1.7496	1.761	1.8662	1.6486
Argentina	2.5703	3.8008	3.0284	3.0303	3.1407	3.5629	3.745
Paraguay	1.5531	1.6103	1.4892	1.5412	1.4345	1.6987	1.7013
Chile							
Bolivia	1.3063	1.6087	1.5733	1.2927	1.5436	1.5875	1.5554
Uruguay	0.9538	1.2365	1.025	1.114	1.3441	1.2066	0.9913

Source: FAO: FAOSTAT.

for selected crops are given in Table 4. Maize in MERCOSUR is produced mainly by commercial large-scale farmers and is part of a crop management package that includes soybeans, wheat, sunflower, and sorghum, the latter two being of comparatively less economic importance. Maize area and yields for MERCOSUR countries may be found in Table 5. The substitutability among these crops is very high and depends largely on expected relative prices. In the mid-1980s, the MERCOSUR countries embarked on major structural reforms that increased their competitiveness in world grain and meat markets. Reforms included reduced import tariffs and export taxes on agricultural products, privatization of key services, elimination of government controls, and imposition of greater fiscal discipline. Farmers responded quickly to the improved policy environment by adopting a new technological package based on zero tillage cropping systems. In the 1990s, maize production in the region grew 74%, while soybean output grew 61% (FAO 1999).[3]

Zero tillage solved the vexing problems of soil compaction and erosion while allowing continuous planting in traditional agricultural regions. In addition, the improved soil moisture characteristics achieved with zero tillage allowed the expansion of agriculture into previously uncultivated marginal areas. Most importantly, however, zero tillage simplified production technology and reduced production costs for commercial farmers, allowing grain production to rise to its current level (Ekboir and Parellada 2000). While the area under zero tillage in the early 1970s was negligible, it is estimated that by 1999, the technology had been adopted on approximately 20 million hectares (Derpsch 1998).

Maize Production Potential in MERCOSUR

Brazil

Maize is produced in every state in Brazil. Traditionally, it was considered a subsistence crop, however, the expansion of the feed and poultry industries induced a transformation of maize producers into specialized and commercial farmers. With the termination of government intervention in the early 1990s, maize producers became more market oriented and open to the adoption

[3] In the same period, maize production in the United States increased 20% and soybeans increased 39%.

1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
9,250,000	9,200,000	4,900,000	5,400,000	7,684,800	10,700,500	10,901,000	10,360,000	11,404,000	10,518,000	15,536,000	19,100,000	13,700,000
6,700,000	9,900,000	6,500,000	10,700,000	10,873,500	11,315,100	11,045,400	11,715,100	12,133,000	12,448,000	11,000,000	17,200,000	18,000,000
9,000,000	8,540,000	10,000,000	10,991,900	9,884,000	9,874,400	9,659,000	11,306,000	9,445,000	15,914,000	14,733,000	10,500,000	13,000,000
6,786,650	24,749,550	26,589,870	21,341,200	23,739,000	30,556,630	30,004,490	32,487,400	36,274,580	32,185,180	34,601,900	30,073,000	32,503,600
6,977,150	18,011,650	24,051,670	19,887,640	14,938,110	19,184,920	22,558,400	24,912,340	25,651,270	23,562,280	26,430,780	31,271,800	30,821,200
6,099,111	5,745,670	5,555,184	3,093,485	2,921,297	2,795,979	2,152,760	2,092,420	1,534,150	3,359,450	2,440,860	2,492,520	2,348,250

1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
13,499,440	13,181,990	12,918,980	11,390,650	13,109,840	13,388,950	11,868,030	13,747,740	13,960,020	13,415,350	13,556,100	10,802,000	11,755,100
2,900,000	2,437,500	1,683,700	1,560,330	1,900,100	2,365,440	2,503,010	2,445,040	2,522,000	2,603,720	3,410,000	3,183,000	2,587,000
161,000	183,000	185,000	191,000	243,215	258,000	249,081	218,385	330,961	324,601	384,114	385,000	410,000
302,100	293,360	278,988	256,317	273,483	283,032	285,902	287,830	272,567	286,568	309,600	253,000	
87,510	74,328	48,994	60,677	66,133	69,304	64,402	51,048	44,216	54,701	61,300	87,000	78,000

1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1.9843	1.8775	2.0582	1.8736	1.8108	2.2822	2.5282	2.3631	2.5985	2.3991	2.5525	2.784	2.7651
3.1897	3.7744	2.9103	3.4608	4.0444	4.5237	4.3552	4.2371	4.5218	4.0396	4.556	6.0006	5.2957
1.8046	1.902	1.9889	2.1991	1.6501	1.743	1.7631	2.114	2.466	2.015	2.7483	2.4597	2.4
1.5912	1.5189	1.4353	1.5866	1.8657	1.5183	1.761	1.8658	1.9116	2.1395	2.1899	1.6443	
1.185	1.592	1.2278	1.851	1.751	1.6709	1.9922	1.629	2.452	2.171	2.6476	2.5931	3.109

of improved technologies (OECD 1997). Maize previously faced strong competition from soybeans because of the higher profitability of the latter and the greater availability of financing for soybeans from government export financing programs (USDA-ERS 1998). With the expansion of zero tillage, the competition between maize and soybeans decreased as both crops are needed in the rotation. Additionally, the shorter turnaround time allowed a third crop per year (known as *zafrinha*) in certain areas. The Empresa Brasileira de Pesquisa Agropecuaria's (EMBRAPA) Maize and Sorghum Center estimated that 7 million tons of maize were produced in the 1998 zafrinha (Ekboir 2000b).

During the last four decades, the area planted to maize in Brazil oscillated between 7 and 14 million hectares. In the same period, annual production increased from about 9 million tons to more than 30 million tons, due to yield gains that rose at an annual average rate of 2% between 1961 and 1995. The rate of yield growth accelerated in the late 1990s to 4.2%, based on FAO figures (1999), because of the introduction of new varieties. In recent years, private investment in the Brazilian seed industry has surged. However, since these investments are only replacing public research, it is expected that the rate of yield growth will eventually return to approximately 2% per year (Ekboir 2000b).

Expansion of the agricultural frontier in Brazil is hampered primarily by the lack of infrastructure, particularly in the *Cerrados*.[4] Should this area be developed, another 60 million hectares could be brought into production using currently available technologies. Even assuming that the maize area in Brazil remains relatively constant, production could reach 40 million tons by 2008 (USDA-ERS 1998).

Argentina

The area planted to maize in Argentina increased from 2.7 million hectares in 1961 to 4 million hectares in 1971, and then fell back to 2.6 million hectares in 1999. In the same period, annual production jumped from 4.9 to 13.7 million tons, after peaking at 19 million tons in 1998. Yields increased from 1.8 t/ha in 1961 to 6 t/ha in 1999, at a rate of about 1.6% per year (FAO 1999). During the 1970s and 1980s, maize production was displaced from the best agricultural land by soybeans, but it staged a comeback in the late 1990s because of a fall in soybean prices, better maize hybrids, greater demand by the cattle industry, and the expansion of zero tillage that requires maize in the rotation. The potential for area expansion in Argentina is more limited than in Brazil, but through a reduction of pastures and expansion into less favored environments, the crop area could be increased by at least 5 million hectares, given favorable conditions with respect to prices and costs of production. Future maize output growth in Argentina will also depend on the availability of new technologies that could either boost productivity or contribute to lower production costs.[5]

Paraguay

The pattern of land use in Paraguay changed rapidly in the 1970s and 1980s as foreign investment, favorable commodity prices, official settlement policies, and investment in new infrastructure all contributed to the penetration of its eastern region. The introduction of improved technologies, in particular new maize hybrids and modern management practices, contributed to a strong expansion of production (World Bank 1996). During 1995–99, average maize production reached 0.89 million tons. Maize yields in Paraguay have increased with the introduction of Brazilian hybrids. If these transfers continue, maize yields should increase at the same rate as in Brazil (approximately 2%). However, expansion of maize production has recently been hampered by marketing problems.

Uruguay

Between 1961 and 1994, the area planted to cereals and oilseeds in Uruguay decreased at an annual average rate of 3%; however, this reduced area was offset by a 3.1% increase in yield. Crop production area peaked in 1976 at 880,000 ha, with the ensuing decline reflecting increasing levels of competition from livestock, as well as declining profitability stemming from the termination of government crop subsidies. Maize production fell from 224,000 t in 1961 to 83,000 t in 1994. The last five years, however, have witnessed a surge in grain production with the largest increases coming in sunflower and maize, with the latter increasing to 243,000 t in 1999, despite a considerable drop in cultivated area. The dramatic increase in yields resulted from adoption of improved technologies, including new planting materials, and consolidation of small and medium-sized farms into larger units.

[4] The Cerrados is a vast savanna-like region that occupies the center, west and northern regions of Brazil. Loosely defined, the Cerrados accounts for between 180 and 207 million hectares, of which only 10% is planted to field crops. The Cerrados does not include the Amazon forest.

[5] Introduction of more intensive technologies for livestock and dairy could free substantial amounts of land for cultivation. However, it is impossible to forecast the magnitude of this shift, as it will depend on a number of factors such as relative prices of inputs and outputs, productivity of the new technologies, and economic policies both in Argentina and other exporting countries.

However, Uruguay's poor soil quality makes it the only country in the region with limited expansion potential (Ekboir 2000b).

Trade Impacts of MERCOSUR

The creation of MERCOSUR has realigned regional trade, with flows of goods and services within MERCOSUR expanding at the expense of nonpartner countries (Reca and Diaz Bonilla 1997; USDA-FAS 1998a). Maize imports, almost entirely attributable to Brazil, were 1.6 million tons in 1999/2000 compared to 479,000 t in 1989/90, representing a large part of total trade activity within MERCOSUR (USDA-FAS 1998a).

Domestic consumption of grains in Brazil between 1960 and 2000 increased faster than production, driven by the expansion of the poultry and hog industries.[6] These industries will continue to grow, but probably not at the strong rates they enjoyed during the last decade. Brazil is currently a major exporter of soybeans, beef, and poultry and a major importer of wheat and maize. The U.S. Department of Agriculture (USDA) estimates that feed demand in Brazil will continue to grow faster than production, implying that maize imports will increase to 2 million tons by the year 2007 (USDA-ERS 1998),[7] a position not universally held by others in the field. The Organization of Economic Cooperation and Development (OECD) estimates that Brazil could become a net maize exporter with a combination of higher yields, larger production area, and slower expansion of domestic demand (OECD 1997).

Domestic demand for maize in Argentina is satisfied by local production at a level close to saturation, meaning that any future output expansion must be exported. Per capita demand for maize for human consumption has remained stable for the last 40 years (Ekboir and Parellada 2000) and is not expected to grow substantially in the near future. The demand for feed grains in Argentina will depend on the evolution of the dairy and beef industries, but again, no dramatic increases are foreseen.

During the 1999/2000 marketing year, Argentina exported 8.8 million tons of maize, making it the world's second largest maize exporter. Argentina has exported an average of 57% of its annual production for the last decade and has seen its share of the international maize market increase from approximately 4% to almost 13%, with a peak of more than 20% in the 1997/98 marketing year. Brazil is a major export market, but Argentina also exports maize to approximately 50 other countries. Because of recent increases in storage capacity, Argentina has also become a year-round participant in the global market (USDA-FAS 1998b).

Argentina's current and future export potential, combined with Brazil's uncertain supply and demand situation and the possibility of expanding its maize area, mean that MERCOSUR could have a major impact on future international maize markets.

Maize Production and Utilization in Asia

Population and income growth have been the two most important catalysts for the recent rise in Asian demand for maize. The trend is expected to continue: the population of Asia is projected to increase by approximately 1.1 billion to 4.4 billion people by 2020, an increase of more than 33% over the estimated population in 1995. But the remarkable growth of maize demand in Asia goes beyond simple demographics to fundamental changes in diet and per capita income. Although maize utilization patterns across Asia vary greatly by country and region, generally maize used for direct human consumption is largely associated with subsistence households in relatively small areas of the region. Increases in income are unlikely to result in proportionate increases in demand for food maize. Rather, households with rising incomes are likely to substitute away from maize in favor of more refined grains such as rice and wheat (Falcon and Naylor 1998).

The most important component of the increased demand for maize in Asia has been indirect, through a growing demand for meat and livestock products. More than 50% of the maize grown in Asia is used for livestock feed (Falcon and Naylor 1998). The unprecedented increase in demand for meat results largely from the strong economic growth and rapid urbanization experienced by many of the continent's nations (Table 6).

Per capita consumption levels in several Asian countries approach those of western, developed countries (Table 7). However, the Asian financial crisis of 1997/98 seriously affected gross domestic product (GDP) and income levels, with negative consequences for consumer confidence and levels of meat consumption. The economic health of some countries (e.g., Japan, Indonesia, and Thailand) suffered very severely, while others, such as China, were able to escape relatively unscathed. In recent years, GDP levels appear to have

[6] Direct human consumption of maize is not significant (OECD 1997).
[7] The USDA import forecast is based on a production of 42.6 million tons of maize by 2007.

Table 6. Trends in real gross domestic product (GDP) for selected Asian countries (%)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	1982-91	1992-2001
Japan	1.0	0.3	0.6	1.5	5.0	1.6	-2.5	0.3	0.9	1.8	4.1	1.1
Korea	5.4	5.5	8.3	8.9	6.8	5.0	-6.7	10.7	7.0	6.5	8.9	5.7
Singapore	6.6	12.8	11.4	8.0	7.5	8.4	0.4	5.4	5.9	6.0	6.8	7.2
China	14.2	13.5	12.6	10.5	9.6	8.8	7.8	7.1	7.0	6.5	9.6	9.8
India	4.2	5.0	6.7	7.6	7.1	5.8	4.7	6.8	6.3	6.1	5.4	6.0
Indonesia	7.2	7.3	7.5	8.2	8.0	4.5	-13.2	0.2	3.0	3.5	5.5	3.6
Malaysia	8.9	9.9	9.2	9.8	10.0	7.5	-7.5	5.4	6.0	5.8	6.3	6.5
Philippines	0.3	2.1	4.4	4.7	5.8	5.2	-0.5	3.2	4.5	4.5	1.3	3.4
Thailand	8.1	8.4	9.0	8.9	5.9	-1.8	-10.4	4.2	4.5	5.0	8.1	4.2
Vietnam	8.6	8.1	8.8	9.5	9.3	8.2	3.5	3.5	4.5	5.5	5.9	7.0

Source: IMF (2000).

stabilized and in several countries have begun once again to exhibit positive growth.

The IMPACT trade model of the International Food Policy Research Institute (IFPRI) projects 85% and 45% increases in global demand for poultry and pork, respectively, between 1995 and 2020. The model, which separates Asia into East, Southeast, and South Asia, projects large increases in annual per capita meat demand in East Asia (rising to 63.7 kg) and Southeast Asia (26.5 kg). In contrast, the projected growth rates and level of per capita meat demand in South Asia remain relatively low at 8.5 kg (IFPRI 1999).

China will be a particularly important player, accounting for almost 25% of the total 690 million ton increase in global cereal demand projected for 2020, and more than 40% of the 115 million ton increase in the demand for meat products (IFPRI 2000). India's projected impact, while considerable, is much smaller than China's, at one-half of the latter's increased demand for cereals and one-tenth of its increased demand for meat products (IFPRI 1999). Given its predominant position, our focus in this section is on China. However, Southeast Asia is also briefly addressed because of the rapid changes taking place in the economies and maize and livestock industries of the region.

Table 7. Per capita consumption, pork and poultry (kg)

Poultry						
	1995	1996	1997	1998	1999	2000
China	7.3	8.2	8.8	9.0	9.5	9.7
Hong Kong	49.9	50.3	52.5	59.0	67.2	71.8
India	0.6	0.7	0.7	0.7	0.7	0.7
Indonesia	4.3	4.6	4.3	2.1	2.6	3.4
Japan	14.4	14.4	14.0	13.8	13.7	13.8
Korea, Republic of	10.0	10.8	10.8	9.5	10.4	10.7
Malaysia	32.2	33.1	34.0	29.4	29.1	30.1
Philippines	5.5	6.1	6.6	6.4	6.5	6.5
Singapore	33.7	34.0	33.7	34.7	37.7	37.8
Taiwan	29.4	31.1	34.1	33.6	34.8	34.3
Thailand	11.0	12.0	12.6	11.6	12.2	12.9
Pork						
	1995	1996	1997	1998	1999	2000
China	30.1	25.8	29.2	31.3	31.4	32.3
Hong Kong	54.4	49.9	52.7	54.9	54.3	53.5
Japan	16.7	16.9	16.5	16.6	17.0	16.9
Korea, Republic of	18.4	19.2	18.9	20.3	20.9	21.3
Philippines	10.4	11.6	11.9	12.1	12.5	12.8
Singapore	31.9	30.2	31.4	28.1	13.9	11.2
Taiwan	40.2	41.7	39.6	44.3	42.5	42.3

Source: USDA-FAS.
Data for 1999 and 2000 are projected.

China

China's maize production has fluctuated in the last decade from a low of 95.4 million tons in 1992/93 to a record high of 133 million tons in 1998/99. The large variation in production is a result of fluctuations in both yields and area, largely due to weather and policy changes. Domestic maize consumption, meanwhile, has increased by more than 40% during the last decade (USDA-FAS 2000b), considerably exceeding the population growth rate and indicating that additional demand side forces are at work. China enjoyed a sustained period of strong economic growth with annual real GDP growth levels occasionally exceeding 10% over the last decade. Equally fortuitous, China was able to avoid many of the serious repercussions of the 1997/98 Asian financial crisis that afflicted other Asian countries.

A closer examination of meat consumption in China suggests that much of the recent maize demand has been largely driven by changes in economic well-being. China's domestic livestock industry, primarily consisting of poultry and pork production, represents a large factor in the domestic demand for maize. Approximately 75% of maize production in China is used for animal feed with the remainder used for human consumption and industrial purposes (USDA-FAS 2000b).

Although average growth in China's poultry industry slowed to 2% between 1997 and 1999, following double-digit growth between 1985 and 1995, it is currently the second largest poultry producer in the world. China is also simultaneously the world's largest poultry importer (USDA-FAS 2000a). Advances in breeding technology and continuing improvements in production efficiency are expected to maintain production growth for at least the next several years (USDA-FAS 2000c). The gradual evolution of the Chinese hog industry from backyard operations with an average of 1–4 head (accounting for approximately 80% of current pork output) to larger, commercial facilities producing leaner, grain-based meat reinforces expectations for long-term growth in demand for feed maize (Fang et al. 2000). Market reform and structural adjustments in the 1980s (Tuan and Peng 2001) have also played a large role in promoting the growth of the livestock industry. Growth in the production of selected livestock products is shown in Figure 1.

Although per capita consumption of all livestock products in China remains relatively low compared with that of other northern Asian countries (Crook 1998), per capita consumption of pork, the most widely consumed meat in China, is more comparable to that of developed countries. Figure 2 shows the trends in per capita consumption of livestock and fishery products in rural and urban communities. Both poultry and pork consumption have increased with economic growth and the rise of incomes. Reductions in Chinese exports to previously lucrative Asian markets and currency devaluations by other Asian countries hit by the financial crisis resulted in a decline in the GDP growth rate in 1998 and 1999. These effects combined with government downsizing and policy changes related to previously fixed housing and other benefits have resulted in a more cautious approach to consumer spending (Tuan et al. 2000).

There has also been uncertainty regarding the impacts of China's future role in international maize markets. The debate centers on China's ability to provide the food needed to sustain its population and the ramifications of alternative options for meeting this goal. Chinese political leaders have always considered food security to be a crucial policy objective, particularly in staple crops such as maize. The extent to which food security goals take on the guise of food self-sufficiency differs with political leaders and with the political landscape. Although agriculture's share of China's total trade figures has declined (from 21% in 1980–84 to 8.7% in 1995–97), the total value of China's agricultural trade averaged a growth rate of 6% per year from 1980 to 1997 and had increased to US$ 25.2 billion by 1997 (Huang et al. 2000).

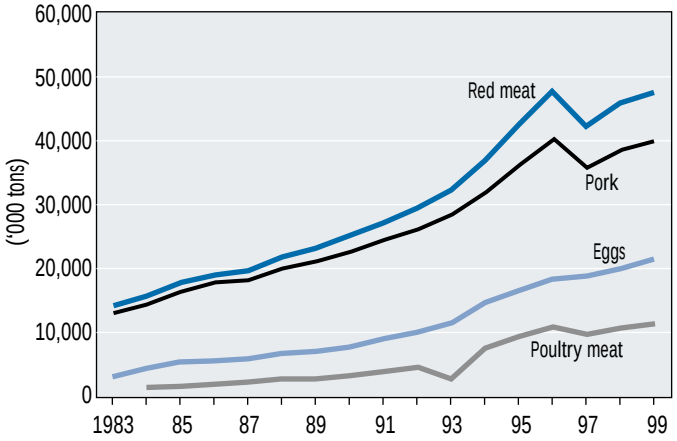

Figure 1. China's major livestock output, 1983-99.

Source: China *Statistical Yearbook* (various issues) as presented in Tuan and Peng (2001). All statistics after 1996 have been corrected by the National Bureau of Statistics according to China's agricultural census results.

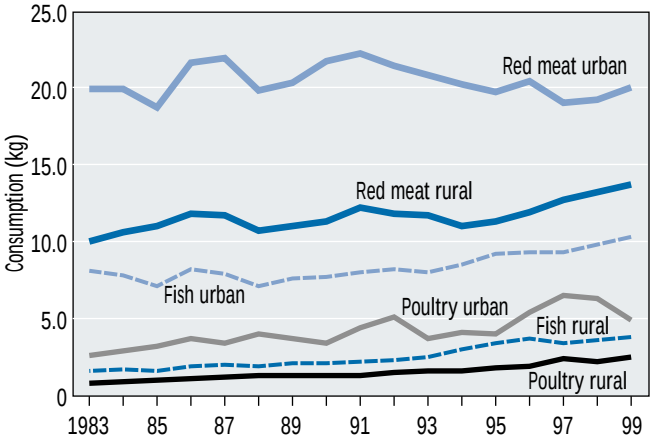

Figure 2. Per capita livestock and fish consumption, China, 1983-99.

Source: China *Statistical Yearbook* (various issues) as presented in Tuan and Peng (2001). All statistics after 1996 have been corrected by the National Bureau of Statistics according to China's agricultural census results.

China's involvement in global trade is likely to increase with its anticipated entry into the World Trade Organization (WTO). Access to China's import markets has historically been very restricted, with the China National Cereals, Oils, and Foodstuffs Import and Export Corporation (COFCO) controlling imports through a murky and ill-defined quota system. With a series of major reforms beginning in 1987, China's foreign trade sector has become more decentralized and market oriented; nevertheless, trade in agricultural products remains largely controlled by the state (Huang et al. 2000). In negotiating entry into the WTO, China has agreed to use a tariff-rate quota (TRQ) system and state trading for sensitive crops such as maize. Maize imports will be permitted at a low duty on a volume up to 4.5 million tons (to increase to 7.2 million tons after 2004), while imports above the quota level will be subjected to a much higher duty (USDA-FAS 2000a). Given total maize imports of 250,000 t in 1998, the WTO figures represent a very large potential increase in imports (USDA-FAS 2000a).

A free trade scenario simulated by Huang et al. (2000) goes beyond the anticipated impacts of WTO to project the maximum possible impact of trade liberalization on Chinese agriculture. In this scenario, the resulting grain deficit between domestic supply and demand totals 12% of China's 2005 grain consumption. With a fall in prices and large increases in demand for livestock feed, maize would be the most seriously affected grain. By 2005, maize imports would jump to 39.31 million tons, or one-fourth of the country's total consumption, making China the world's largest maize importer; increases in poultry and pork prices, combined with lower feed prices, would result in production and export growth in both industries (Huang et al. 2000). While other simulation models addressing this issue differ substantially in their assumptions (USDA-ERS 2000a; Zhou et al. 2001), they concur that China is unlikely to remain a maize exporter in the face of trade liberalization.

Southeast Asia

Economic growth, changing income levels, and rising demand for meat products also affect maize utilization, production, and trade in Southeast Asia. The strong growth in GDP experienced by the region during much of the previous decade contributed greatly to diversification in diet and to the increased ability of consumers to purchase meat products. Feed demand from the expansion of local poultry industries stimulated domestic maize production, local feed industries, and maize imports. The growth of the hybrid seed industry and the adoption of new varieties have been particularly rapid in the region. However, the financial crisis of 1997/98 resulted in negative growth rates for many of the region's countries. Higher unemployment and reduced consumer income and wealth created insecurity that effectively halted the growth in demand for meat with negative repercussions for local maize and feed industries.

The slight upturn in economic performance during 1999 and 2000 suggests that the worst of the transition may be over for these economies. However, continuing concerns regarding political instability in the region and the lack of meaningful structural reforms have dampened optimism. Growth is again slowing for Indonesia, the Philippines, and Thailand, which raises uncertainty about long-term income growth and stronger consumer demand for meat products.