Argentina: the sustainable growth potential of the production possibilities frontier in the agricultural sector. An outlook.

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ARGENTINA: THE SUSTAINABLE GROWTH POTENTIAL OF THE PRODUCTION POSSIBILITIES FRONTIER IN THE AGRICULTURAL SECTOR. AN OUTLOOK.

Eugenio J. Cap[1]

EXECUTIVE SUMMARY

Should all farmers implement all currently available technologies, the agricultural sector of Argentina would increase its output by not less than 60%, measured by its total production value. That figure represents an additional 16 million tons of grains and oilseeds and 5 million tons of beef (liveweight) per year[2]. A significant number of restrictions that slow down the rate of adoption of productivity-enhancing innovations are being steadily eased, either as a consequence of deliberate government policies or due to the dynamics of the private sector itself. The most resilient of those restrictions is the lack of operating capital. Innovative arrangements are making it possible for groups of farmers to achieve, through resource and factor-pooling, economies of scale that drive down operating costs and allow for a higher level of input utilization, with no significant increases in the cash-flow requirements. The government plays a catalytic role in this process. In addition, it provides highly skilled technical assistance to optimize the farmers' production functions. Simultaneously, new actors, most of them with good access to sources of capital, are getting into intensive precision-farming. Innovative farmers, banks, food processing industries, supermarkets and other investors (domestic and foreign), are changing the picture of the sector at an increasing rate. Should this trend continue, and there is every reason to support this assumption, the potential for a major shift in the supply schedule of foodstuffs will be well within reach by the end of this century.The startup of MERCOSUR, on January 1st 1995, has created a free-trade and customs union zone that integrates four economies (Argentina, Brazil, Paraguay and Uruguay) that make up a combined gross product of about one trillion US dollars. MERCOSUR is made up of food exporters, and after accounting for intra-zone trade, the block still shows a very large net surplus, which it is likely to grow over the long run, as a consequence of both, domestic productivity increases due to technological innovations at the domestic level and as a result of MERCOSUR-wide specialization and market-driven divisions of labor in the agricultural sector.

By early next century MERCOSUR will have, under a moderately optimistic scenario[3], a sustainable yearly excess supply of 6.7 million tons of wheat, 11.8 million tons of corn, 15.8 million tons of soybeans, 5 million tons of sunflower and 550 thousand tons of beef.

For decades and due to the stiff competition from the treasuries of the US and Western Europe, coupled with domestic macroeconomic policies strongly biased in favor of protected industrial sectors, Argentine farmers were in no position to embark in high-input schemes. That means that their production systems have traditionally been (not always by choice), ecologically sensitive, especially with regard to soil and water pollution and toxic residues on foodstuffs. The world agricultural trade picture is slowly changing in favor of non-protectionist producers (Uruguay GATT Round, progressive dismantling of subsidies due to high fiscal costs, etc.). Thus, in search of competitiveness on a more leveled playing field, and learning from other nations' errors, Argentina will very likely become a dependable large scale supplier of high quality (nutrition- and health-wise) food products, ranging from commodities to sophisticated processed goods, on a sustainable basis, thanks to its state-of-the-art resource base management capabilities. To that effect, unprecedented institutional innovations are in the process of being implemented within its agricultural research and development system, involving a wide array of actors, from farm input suppliers to the food industry. These new arrangements will enhance the industry's global competitiveness, given that the consumer (domestic and foreign) has become the subject around whom the generation and transfer of new agricultural technology will revolve.

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[1] Ingeniero Agrónomo, Ms.Sc., Ph.D. Director of Strategic Planning. INTA (National Institute of Agricultural Technology).
[2] For a summary of estimations on selected commodities, see Table 1.
[3] Scenario **C** as defined in Table 1.

Table 1.a: Impact on six selected crops of the adoption by farmers of currently available technology in three alternatives scenarios, for a simulation horizon of 5 years.

Item	Base year (1995)		Scenarios for year 2000		
			A [1]	B [2]	C [3]
WHEAT (4,887,000 ha)	Production (000 t) Yield (t/ha) Increase in production (000 t)	9,651.8 1.98 0	11,941.6 2.44 2,289.8	13,893.3 2.84 4,241.5	20,448.3 4.20 10,796.4
CORN (2,756,480 ha)	Production (000 t) Yield (t/ha) Increase in production (000 t)	10,281.7 3.73 0	12,707.6 4.61 2,420.4	14,758.8 5.35 4,471.6	18,378.4 6.70 8,091.3
SOYBEAN (5,664,811 ha)	Production (000 t) Yield (t/ha) Increase in production (000 t)	11,408.9 2.01 0	14,131.4 2.49 2,722.5	16,410.7 2.90 5,001.8	16,948.1 3.00 5,539.2
SUNFLOWER (2,135,951 ha)	Production (000 t) Yield (t/ha) Increase in production (000 t)	3,876.7 1.82 0	4,819.2 2.26 942.5	5,208.3 2.44 1,331.5	5,544.9 2.60 1,668.2
COTTON (710,594 ha)	Production (000 t) Yield (t/ha) (unprocessed fiber) Increase in production (000 t)	1,041.6 1.47 0	1,290.4 1.82 248.8	1,499.5 2.11 457.9	1,700.4 2.40 658.8
POTATO (103,305 ha)	Production (000 t) Yield (t/ha) Increase in production (000 t)	2,362 22.87 0	2,967 28.72 604	3,431 33.21 1,069	4,489 43.90 2,126

The average yield increases by:

[1] Scenario A: 10% in LTL (Low tech level), 20% in MTL (Medium tech level) and 30% in HTL (High tech level).
[2] Scenario B: 30% in LTL, 40% in MTL and 50% in HTL (for sunflower: 20, 30 and 40 % respectively).
[3] Scenario C: The productivity gap is closed. The average national yield reaches the values currently observed in demonstration plots or equivalent (weighted averages).

Table 1.b: Impact on productivity indicators of the predominant beef production systems of the adoption by farmers of currently available technology in three alternatives scenarios, for a simulation horizon of 10 years.

Item	Base year (1995)		Scenarios for year 2005		
			A (1)	B (2)	C (3)
BEEF Breeding (29,018,129 ha)	Production (000 t) Yield (kg/ha/year) (liveweight) Increase in production (000 t)	1,472.6 50 0	1,837.6 63 364.9	2,139.4 73 666.7	3,421.8 118 1,949.2
BEEF Breeding & fattening (30,927,539 ha)	Production (000 t) Yield (kg/ha/year) (liveweight) Increase in production (000 t)	2,188.4 70 0	2,742.4 88 554.0	3,194.4 103 1,006.0	4,791.7 155 2,603.3
BEEF Fattening (7,656,460 ha)	Production (000 t) Yield (kg/ha/year) (liveweight) Increase in production (000 t)	1,141.1 149 0	1,417.7 185 276.6	1,652.6 215 511.5	2,535.9 331 1,394.8

The average yield increases by:

(1) Scenario A: 10% in LTL (Low tech level), 20% in MTL (Medium tech level) and 30% in HTL (High tech level).
(2) Scenario B: 30% in LTL, 40% in MTL and 50% in HTL.
(3) Scenario C: The productivity gap is closed. The average national yield reaches the values currently observed in demonstration plots or equivalent (weighted averages).

INTRODUCTION

The agricultural sector of Argentina can be characterized (globally) as an underperformer when comparisons are made on the basis of physical productivity (yields) with other large producers. A combination of failed past domestic macroeconomic policies and the gross distortions introduced in the world markets by protectionism should be assigned most of the blame.

However, things are changing rather rapidly in both arenas. Radical reforms have been implemented by the National Government, including wide deregulation, virtual elimination of both tariff and non-tariff barriers to free-trade, structural reform, fiscal discipline and price stability. At the same time, the subject of trade in agricultural products, a virtual taboo in international negotiations for decades, was finally included in the Uruguay Round agreements that lead to the implementation of the World Trade Organization. The relevant issue is no longer **if** but **when** will the web of government interventions in the international markets of agricultural goods be eased to the point where it will no longer play a significant role in world trade.

The concept of "underperformance" is closely associated with that of unrealized potential. A previous study on the subject[4] estimated the magnitude of that potential. The results are astonishing: by simply adopting currently available technologies (field tested and adjusted to the pertinent

[4] Cap, E., Castronovo, A. and Miranda, O. (1993). **Competitividad del Sector Agropecuario Argentino. Análisis comparativo de niveles de producción y de rendimiento** (Competitiveness of the Argentine Agricultural Sector. A national and international comparative analysis of production levels and yields). INTA. Dirección Nacional Asistente de Planificación. Dirección de Planificación Estratégica. Buenos Aires, Argentina.

agroecological regions), the total output of the agricultural sector would increase by some 60% in value[5]. When the generation and implementation of **new** productivity-enhancing technology (currently in different stages within the R&D "pipeline") is introduced into the picture, those numbers reach significantly higher levels.

A PROSPECTIVE ANALYSIS

The above mentioned study on unrealized potential was based on a previous one[6], which made it possible to characterize production systems based on the technological level of farms, classified into three distinctive groups: low-, medium- and high-tech. The dynamics of the adoption of productivity-enhancing technologies was studied with some detail and a simulation model (Surplus by Adoption of Technology -SAT-), and a computer program (SIGMA V 1.1) were developed for the specific purpose of estimating the potential impact on total output of the generation and diffusion of technology at the farm level[7]. The theoretical details of the model have been summarized in Annex I. A number of simulations was run using SIGMA v 1.1 for some selected tradable commodities, under three alternative scenarios. The most optimistic one (C), assumes that after 5 years[8], farm productivity will reach, on average, the level currently reported for demonstration plots. In all cases and to keep the analysis on the conservative side, it is assumed that no new technologies will be made available during that period. The results of the runs have been summarized in Tables 2 through 10

WHEAT

Table 2a. Estimated increases in yield, in three scenarios for the year 2000.

Technological Level	Yield (t/ha)			
	Base Year	Scenarios for year 2000		
	(1995)	A (1)	B (2)	C (3)
LTL	1.40	1.54	1.82	4.20
MTL	2.10	2.52	2.94	4.20
HTL	2.70	3.51	4.05	4.20
National Avrg.	1.98	2.44	2.84	4.20
Increment (%)		23.72	43.95	111.86

(1) Scenario A: The average yield increases (in 5 years) by 10% in LTL, by 20% in MTL and by 30% in HTL.
(2) Scenario B: The average yield increases (in 5 years) by 30% in LTL, by 40% in MTL and by 50% in HTL.
(3) Scenario C: The productivity gap is closed. The average national yield reaches (in 5 years) the values currently observed in demonstration plots or equivalent (weighted averages).

[5] This estimate was made using 1993 world prices for tradable commodities and it would very likely be higher should current prices be used.
[6] Cap E. et al (1993). **Perfil Tecnológico de la Producción Agropecuaria Argentina** (Technological Profile of the Argentine Agricultural Production). INTA. Dirección Nacional Asistente de Planificación. Dirección de Planificación Estratégica. 2 Vol. Buenos Aires, Argentina.
[7] Cap, E. and Miranda, O. (1994). **Un modelo de simulación para estimar el impacto de la investigación y transferencia de tecnología agropecuaria** (A simulation model for impact assessment of the generation and diffusion of agricultural technology). INTA. Dirección Nacional Asistente de Planificación. Dirección de Planificación Estratégica. Buenos Aires, Argentina.

Table 2b. Impact flow (total output and average national yield).

Year	Output [4] (000 t)			Increment (000 t)			Yield (t/ha)		
	A	B	C	A	B	C	A	B	C
Year 0=1995	9,651.8	9,651.8	9,651.8	0	0	0	1.98	1.98	1.98
Year 1=1996	10,247.9	10,777.2	12,619.9	596.1	1,125.4	2,968.1	2.10	2.21	2.58
Year 2=1997	10,780.7	11,774.9	15,207.1	1,128.9	2,123.1	5,555.3	2.21	2.41	3.11
Year 3=1998	11,324.1	12,791.6	17,824.9	1,672.3	3,139.8	8,173.1	2.32	2.62	3.65
Year 4=1999	11,710.9	13,497.0	19,566.4	2,059.1	3,845.2	9,914.6	2.40	2.76	4.00
Year 5=2000	11,941.6	13,893.3	20,448.3	2,289.8	4,241.5	10,796.4	2.44	2.84	4.20

[4] *Estimates for 4,887,000 ha.*

CORN

Table 3a. Estimated increases in yield, in three scenarios for the year 2000.

Technological Level	Yield (t/ha)			
	Base Year (1995)	Scenarios for year 2000		
		A [1]	B [2]	C [3]
LTL	2.90	3.19	3.77	6.70
MTL	3.70	4.44	5.18	6.70
HTL	4.50	5.85	6.75	6.70
National Avrg.	3.73	4.61	5.35	6.70
Increment (%)		23.53	43.47	78.65

[1] Scenario A: The average yield increases (in 5 years) by 10% in LTL, by 20% in MTL and by 30% in HTL.
[2] Scenario B: The average yield increases (in 5 years) by 30% in LTL, by 40% in MTL and by 50% in HTL.
[3] Scenario C: The productivity gap is closed. The average national yield reaches (in 5 years) the values currently observed in demonstration plots or equivalent (weighted averages).

Table 3b. Impact flow (total output and average national yield).

Year	Output [4] (000 t)			Increment (000 t)			Yield (t/ha)		
	A	B	C	A	B	C	A	B	C
Year 0=1995	10,287.1	10,287.1	10,287.1	0	0	0	3.73	3.73	3.73
Year 1=1996	10,931.6	11,492.5	12,516.1	644.4	1,205.3	2,228.9	3.97	4.17	4.54
Year 2=1997	11,501.6	12,553.0	14,457.0	1,214.5	2,265.8	4,169.9	4.17	4.55	5.24
Year 3=1998	12,081.1	13,630.3	16,419.5	1,793.9	3,343.1	6,132.3	4.38	4.94	5.96
Year 4=1999	12,482.4	14,364.0	17,722.1	2,195.3	4,076.8	7,434.9	4.53	5.21	6.43
Year 5=2000	12,707.6	14,758.8	18,378.4	2,420.4	4,471.6	8,091.3	4.61	5.35	6.70

[4] *Estimates for 2,756,480 ha.*

[8] In the case of beef, the same process is assumed to take 10 years.

SOYBEAN

Table 4a. Estimated increases in yield, in three scenarios for the year 2000.

Technological Level	Yield (t/ha)			
	Base Year (1995)	Scenarios for year 2000		
		A[(1)]	B [(2)]	C [(3)]
LTL	1.50	1.65	1.95	3.00
MTL	2.00	2.40	2.80	3.00
HTL	2.40	3.12	3.60	3.00
National Avrg.	2.01	2.49	2.90	3.00
Increment (%)		23.86	43.84	48.55

[(1)] Scenario A: The average yield increases (in 5 years) by 10% in LTL, by 20% in MTL and by 30% in HTL.
[(2)] Scenario B: The average yield increases (in 5 years) by 30% in LTL, by 40% in MTL and by 50% in HTL.
[(3)] Scenario C: The productivity gap is closed. The average national yield reaches (in 5 years) the values currently observed in demonstration plots or equivalent (weighted averages).

Table 4b. Impact flow (total output and average national yield).

Year	Output [(4)] (000 t)			Increment (000 t)			Yield (t/ha)		
	A	B	C	A	B	C	A	B	C
Year 0=1995	11,408.9	11,408.9	11,408.9	0	0	0	2.01	2.01	2.01
Year 1=1996	12,132.0	12,754.4	12,936.7	723.1	1,345.5	1,527.8	2.14	2.25	2.28
Year 2=1997	12,772.6	13,939.7	14,265.9	1,363.6	2,530.8	2,857.0	2.25	2.46	2.52
Year 3=1998	13,424.4	15,144.7	15,607.9	2,015.5	3,735.8	4,198.9	2.37	2.67	2.76
Year 4=1999	13,876.8	15,967.0	16,498.7	2,467.9	4,558.1	5,089.7	2.45	2.82	2.91
Year 5=2000	14,131.4	16,410.7	16,948.1	2,722.5	5,001.8	5,539.2	2.49	2.90	3.00

[(4)] *Estimates for 5,664,811 ha.*

SUNFLOWER

Table 5a. Estimated increases in yield, in three scenarios for the year 2000.

Technological Level	Yield (t/ha)			
	Base Year (1995)	Scenarios for year 2000		
		A[1]	B [2]	C [3]
LTL	1.30	1.43	1.56	2.60
MTL	1.80	2.16	2.34	2.60
HTL	2.30	2.99	3.22	2.60
National Avrg.	1.82	2.26	2.44	2.60
Increment (%)		24.31	34.35	43.03

[1] Scenario A: The average yield increases (in 5 years) by 10% in LTL, by 20% in MTL and by 30% in HTL.
[2] Scenario B: The average yield increases (in 5 years) by 20% in LTL, by 30% in MTL and by 40% in HTL.
[3] Scenario C: The productivity gap is closed. The average national yield reaches (in 5 years) the values currently observed in demonstration plots or equivalent (weighted averages).

Table 5b. Impact flow (total output and average national yield).

Year	Output [4] (000 t)			Increment (000 t)			Yield (t/ha)		
	A	B	C	A	B	C	A	B	C
Year 0=1995	3,876.7	3,876.7	3,876.7	0	0	0	1.82	1.82	1.82
Year 1=1996	4,125.2	4,231.2	4,337.5	248.5	354.5	460.8	1.93	1.98	2.03
Year 2=1997	4,346.1	4,544.9	4,738.0	469.3	668.2	861.2	2.03	2.13	2.22
Year 3=1998	4,570.9	4,864.1	5,141.5	694.1	987.4	1,264.8	2.14	2.28	2.41
Year 4=1999	4,728.4	5,084.9	5,409.4	851.7	1,208.2	1,532.7	2.21	2.38	2.53
Year 5=2000	4,819.2	5,208.3	5,544.9	942.5	1,331.5	1,668.2	2.26	2.44	2.60

[4] *Estimates for 2,135,951 ha.*

COTTON

Table 6a. Estimated increases in yield, in three scenarios for the year 2000.

Technological Level	Yield (unprocessed fiber: t/ha)			
	Base Year (1995)	Scenarios for year 2000 A [(1)]	B [(2)]	C [(3)]
LTL	1.00	1.10	1.30	2.40
MTL	1.50	1.80	2.10	2.40
HTL	1.80	2.34	2.70	2.40
National Avrg.	1.47	1.82	2.11	2.40
Increment (%)		23.89	43.97	63.25

(1) Scenario A: The average yield increases (in 5 years) by 10% in LTL, by 20% in MTL and by 30% in HTL.
(2) Scenario B: The average yield increases (in 5 years) by 30% in LTL, by 40% in MTL and by 50% in HTL.
(3) Scenario C: The productivity gap is closed. The average national yield reaches (in 5 years) the values currently observed in demonstration plots or equivalent (weighted averages).

Table 6b. Impact flow (total output and average national yield).

Year	Output [(4)] (000 t)			Increment (000 t)			Yield (t/ha)		
	A	B	C	A	B	C	A	B	C
Year 0=1995	1,041.6	1,041.6	1,041.6	0	0	0	1.47	1.47	1.47
Year 1=1996	1,107.2	1,164.1	1,223.1	65.5	122.5	181.4	1.56	1.64	1.72
Year 2=1997	1,165.5	1,272.3	1,381.1	123.9	230.7	339.5	1.64	1.79	1.94
Year 3=1998	1,224.9	1,382.5	1,540.7	183.3	340.9	499.1	1.72	1.95	2.17
Year 4=1999	1,266.5	1,458.1	1,646.8	224.9	416.5	605.2	1.78	2.05	2.32
Year 5=2000	1,290.4	1,499.5	1,700.4	248.8	457.9	658.8	1.82	2.11	2.40

(4) *Estimates for 710,594 ha.*

POTATO

Table 7a. Estimated increases in yield, in three scenarios for the year 2000.

Technological Level	Yield (t/ha)			
	Base Year (1995)	Scenarios for year 2000		
		A [(1)]	B [(2)]	C [(3)]
LTL	17.70	19.47	23.01	43.90
MTL	20.90	25.08	29.26	43.90
HTL	25.50	33.15	38.25	43.90
National Avrg.	22.87	28.72	33.21	43.90
Increment (%)		25.61	45.26	90.04

[(1)] Scenario A: The average yield increases (in 5 years) by 10% in LTL, by 20% in MTL and by 30% in HTL.
[(2)] Scenario B: The average yield increases (in 5 years) by 30% in LTL, by 40% in MTL and by 50% in HTL.
[(3)] Scenario C: The productivity gap is closed. The average national yield reaches (in 5 years) the values currently observed in demonstration plots or equivalent (weighted averages).

Table 7b. Impact flow (total output and average national yield).

Year	Output [4] (000 t)			Increment (000 t)			Yield (t/ha)		
	A	B	C	A	B	C	A	B	C
Year 0=1995	2,362	2,362	2,362				22.87	22.87	22.87
Year 1=1996	2,526	2,655	2,951	164	292	589	24.46	25.70	28.57
Year 2=1997	2,670	2,910	3,463	308	548	1,101	25.85	28.17	33.52
Year 3=1998	2,816	3,168	3,979	454	806	1,617	27.26	30.67	38.52
Year 4=1999	2,914	3,341	4,319	552	979	1,957	28.22	32.35	41.82
Year 5=2000	2,967	3,431	4,489	604	1,069	2,126	28.72	33.21	43.90

[4] *Estimates for 103,305 ha*

BEEF
(Breeding)

Table 8a. Estimated increases in yield, in three scenarios for the year 2005.

Technological Level	Yield (kg/ha/year) (liveweight)			
	Base Year (1995)	Scenarios for year 2005		
		A [1]	B [2]	C [3]
LTL	36	38	41	77
MTL	51	56	61	85
HTL	74	85	93	97
National Avrg.	51	57	62	85
Increment (%)		12.40	22.77	67.97

[1] Scenario A: The average yield increases (in 10 years) by 10% in LTL, by 20% in MTL and by 30% in HTL.
[2] Scenario B: The average yield increases (in 10 years) by 30% in LTL, by 40% in MTL and by 50% in HTL.
[3] Scenario C: The productivity gap is closed. The average national yield reaches (in 10 years) the values currently observed in demonstration plots or equivalent (weighted averages).

Table 8b. Impact flow (total output and average national yield).

Year	Output [4] (000 t)			Increment (000 t)			Yield (kg/ha/year)		
	A	B	C	A	B	C	A	B	C
Year 0=1995	1,472.6	1,472.6	1,472.6	0	0	0	50	50	50
Year 1=1996	1,483.2	1,489.0	1,509.9	10.6	16.3	37.2	51	51	52
Year 2=1997	1,497.4	1,512.3	1,569.8	24.8	39.7	97.1	51	52	54
Year 3=1998	1,524.9	1,561.7	1,713.5	52.2	89.1	240.8	52	53	59
Year 4=1999	1,577.1	1,659.3	2,012.1	104.4	186.7	539.4	54	57	69
Year 5=2000	1,655.3	1,807.9	2,473.6	182.6	335.2	1,000.9	57	62	85
Year 6=2001	1,734.3	1,957.9	2,937.8	261.6	485.2	1,465.2	59	67	101
Year 7=2002	1,788.2	2,058.6	3,242.7	315.5	585.9	1,770.0	61	70	111
Year 8=2003	1,817.6	2,111.5	3,393.4	344.9	638.8	1,920.7	62	72	116
Year 9=2004	1,829.8	2,129.5	3,418.0	357.1	656.9	1,945.4	63	73	117
Year 10=2005	1,837.6	2,139.4	3,421.8	364.9	666.7	1,949.2	63	73	117

[4] *Estimates for 29,018,129 ha.*

BEEF
(Breeding/Fattening)

Table 9a. Estimated increases in yield, in three scenarios for the year 2005.

Technological Level	Yield (kg/ha/year) (liveweight)			
	Base Year (1995)	Scenarios for year 2005		
		A [1]	B [2]	C [3]
LTL	46	48	53	101
MTL	78	86	94	118
HTL	109	126	137	133
National Avrg.	71	80	87	114
Increment (%)		12.66	23.10	61.28

[1] Scenario A: The average yield increases (in 10 years) by 10% in LTL, by 20% in MTL and by 30% in HTL.

[2] Scenario B: The average yield increases (in 10 years) by 30% in LTL, by 40% in MTL and by 50% in HTL.

[3] Scenario C: The productivity gap is closed. The average national yield reaches (in 10 years) the values currently observed in demonstration plots or equivalent (weighted averages).

Table 9b. Impact flow (total output and average national yield).

Year	Output [4] (000 t)			Increment (000 t)			Yield (kg/ha/year)		
	A	B	C	A	B	C	A	B	C
Year 0=1995	2,188.4	2,188.4	2,188.4	0	0	0	70	70	70
Year 1=1996	2,206.0	2,214.7	2,239.3	17.5	26.2	50.8	71	71	72
Year 2=1997	2,228.8	2,251.3	2,320.5	40.3	62.9	132.0	72	72	75
Year 3=1998	2,270.9	2,326.3	2,513.3	82.5	137.8	324.9	73	75	81
Year 4=1999	2,349.1	2,472.4	2,912.8	160.7	283.9	724.3	75	79	94
Year 5=2000	2,465.5	2,693.9	3,529.4	277.1	505.5	1,341.0	79	87	114
Year 6=2001	2,583.2	2,917.8	4,149.4	394.8	729.3	1,961.0	83	94	134
Year 7=2002	2,664.3	3,069.2	4,556.7	475.9	880.7	2,368.3	86	99	147
Year 8=2003	2,709.7	3,150.0	4,758.3	521.2	961.6	2,569.9	87	101	153
Year 9=2004	2,729.2	3,178.0	4,788.2	540.7	989.6	2,599.8	88	102	154
Year 10=2005	2,742.4	3,194.4	4,791.7	554.0	1,006.0	2,603.3	88	103	154

[4] *Estimates for 30,927,539 ha.*

BEEF
(Fattening)

Table 10a. Estimated increases in yield, in three scenarios for the year 2005.

Technological Level	Yield (kg/ha/year) (liveweight)			
	Base Year	Scenarios for year 2005		
	(1995)	A [1]	B [2]	C [3]
LTL	103	108	118	217
MTL	165	182	199	250
HTL	217	251	274	278
National Avrg.	149	167	183	243
Increment (%)		12.14	22.56	62.90

[1] Scenario A: The average yield increases (in 10 years) by 10% in LTL, by 20% in MTL and by 30% in HTL.
[2] Scenario B: The average yield increases (in 10 years) by 30% in LTL, by 40% in MTL and by 50% in HTL.
[3] Scenario C: The productivity gap is closed. The average national yield reaches (in 10 years) the values currently observed in demonstration plots or equivalent (weighted averages).

Table 10b. Impact flow (total output and average national yield).

Year	Output [4] (000 t)			Increment (000 t)			Yield (kg/ha/year)		
	A	B	C	A	B	C	A	B	C
Year 0=1995	1,141.1	1,141.1	1,141.1	0	0	0	149	149	149
Year 1=1996	1,149.6	1,154.1	1,168.1	8.5	13.0	27.0	150	150	152
Year 2=1997	1,160.8	1,172.5	1,211.3	19.7	31.4	70.2	151	153	158
Year 3=1998	1,181.8	1,210.5	1,314.4	40.7	69.4	173.3	154	158	171
Year 4=1999	1,221.1	1,285.2	1,528.4	79.9	144.0	387.2	159	167	199
Year 5=2000	1,279.6	1,398.6	1,858.8	138.5	257.4	717.7	167	182	242
Year 6=2001	1,338.9	1,513.2	2,191.3	197.8	372.1	1,050.1	174	197	286
Year 7=2002	1,379.7	1,590.6	2,409.7	238.6	449.5	1,268.6	180	207	314
Year 8=2003	1,402.4	1,631.8	2,517.9	261.3	490.7	1,376.8	183	213	328
Year 9=2004	1,411.6	1,645.0	2,534.0	270.5	503.9	1,392.9	184	214	330
Year 10=2005	1,417.7	1,652.6	2,535.9	276.6	511.5	1,394.8	185	215	331

[4] Estimates for 7,656,460 ha.

A DISCUSSION ON THE LIKELIHOOD OF POSSIBLE OUTCOMES

Based upon the information available at this point in time, the pessimistic scenario (A) should be considered the least likely to occur. The dynamics of the ongoing transformation process referred to in an earlier section of this document suggest that scenario (C) should be associated with a high probability of occurrence, for all six field crops. This is so since the yields recorded for demonstration plots (or equivalent) are based on extensive farming systems. The yields associated with the "best practice" production function under intensive farming conditions (irrigation + fertilization) are considerably higher, reaching, for example, levels of up to 15 t/ha in corn and 7 t/ha in wheat. Thus this outcome would be the result of the combination of two processes developing simultaneously: an uneven (across tech levels) adoption of available technological innovations (in progress for some time) and the upward shift of the production function, associated especially with the HTL farms, beyond the present state-of-the-art possibilities frontier, due to new technologies either not yet available or not tested for all relevant agroecological conditions. This phenomenon is much more recent and thus its impact cannot be captured by time-series data. It is worth noting that simulations involving R&D processes are less dependable since one more dimension of uncertainty (the potential productivity increase) is added and for that reason they have not been included in this document. With that *caveat* in mind, it is worth noting that, should this variable be considered, an even more optimistic outlook than scenario (C) could very well be built.

In the case of beef, instead, the maximum likelihood should be associated with scenario (B). This is attributable to bottlenecks identified with installed capacity constraints at the industrial stage, that would prevent -through a price signals mechanism-, the full expression of the agroecological and technological potentials at the farm level. Should the rate of investments in export-oriented processing facilities increase significantly over the very near future, the whole sector would be in a position to improve its overall performance, which would be reflected in growth of its export potential.

IMPLICATIONS FOR ARGENTINA'S FOREIGN TRADE

Table 11 summarizes the impact in terms of excess supply (export capacity) at the national level for the year 2000, of the realization of the three scenarios (A, B and C). The figure on domestic consumption at that time has been calculated by assuming that demand will increase by 10% (from the values of 1995) over the relevant five-year period, for all items with the exception of beef, which stays at the 1995 level (although it is currently trending downward).

Table 11. **ARGENTINA**: estimated total output, domestic consumption and excess supply of selected commodities in the year 2000 for three scenarios (in 000t).

Item	Output			Domestic demand[1]	Excess Supply		
	A	B	C		A	B	C
WHEAT	11,941	13,893	20,448	4,950	6,991	8,943	15,498
CORN	12,707	14,758	18,378	4,400	8,307	10,358	13,978
SOYBEAN	14,131	16,410	16,948	600	13,531	15,810	16,348[2]
SUNFLOWER	4,819	5,208	5,545	530	4,289	4,678	5,015[3]
BEEF [4]	2,970	3,245	4,324	2,250	720	995	2,074
COTTON [5]	430	500	566	110	320	390	456
POTATO	2,967	3,431	4,489	2,002	965	1,429	2,487

[1] Source: *Mercosur Agropecuario. Actualidad y Perspectivas*. SAGyP. Dirección de Economía Agraria y Asuntos Internacionales. Año 1. N^0 1. Buenos Aires, Argentina. January 1995 and Rodríguez, A., *CIARA Report*. Buenos Aires, Argentina, August 1995.

(2) Of this total approximately 9.5 million t of grain will be exported as flour and some 2 million as oil.
(3) Of this total approximately 4 million t of grain will be exported processed as flour and oil.
(4) Packing house-processed weight (a conversion factor of 0.55 x liveweight was used).
(5) Industrial fiber (a conversion factor of 0.33 x unprocessed fiber weight was used).

MERCOSUR AS A NET FOOD EXPORTER

To simplify the analysis, it will be assumed that the agricultural sectors of Argentina and Brazil are, once their outputs and domestic demands are added together, large enough in comparison to the other two partners (Paraguay and Uruguay) to set the trend in terms of excess supply of foodstuffs for the entire customs union. In fact, should it be an error, it would be more in the nature of an underestimation, since Brazil is the only significant agricultural commodity importer of the block.

Table 12 summarizes the excess supply estimated for the year 2000 for Argentina + Brazil, under the three scenarios (A, B and C) as previously defined and for the seven commodities that have been studied with some detail in this document. The excess demand for Brazil in 2000 was estimated by assuming that its domestic demand would increase by 10% from its 1995 level, while its total output remains constant at 1995 levels throughout the 5-year period.

Table 12. MERCOSUR: estimated excess supply of selected commodities in the year 2000 for three scenarios (in 000t).

Item	Argentina Excess Supply			Brazil Excess demand(1)	MERCOSUR Excess Supply		
	A	B	C		A	B	C
WHEAT	6,991	8,943	15,498	8,800	-1,809	143	6,698
CORN	8,307	10,358	13,978	2,200	6,107	8,158	11,778
SOYBEAN	13,531	15,810	16,348	550	12,981	15,260	15,798(2)
SUNFLOWER	4,289	4,678	5,015	60	4,229	4,618	4,955(3)
BEEF (4)	720	995	2,074	440	280	555	1,634
COTTON (5)	320	390	456	330	-10	60	126
POTATO	965	1,429	2,487	220	745	1,209	2,267

(1) Source: *Mercosur Agropecuario. Actualidad y Perspectivas*. SAGyP. Dirección de Economía Agraria y Asuntos Internacionales. Año 1. N^{0} 1. Buenos Aires, Argentina. January 1995 and Rodríguez, A., *CIARA Report*. Buenos Aires, Argentina, August 1995.
(2) Of this total approximately 9.5 million t of grain will be exported as flour and some 2 million as oil.
(3) Of this total approximately 4 million t of grain will be exported processed as flour and oil.
(4) Packing house-processed weight (a conversion factor of 0.55 x liveweight was used).
(5) Industrial fiber (a conversion factor of 0.33 x unprocessed fiber weight was used).

Even in the least optimistic scenario -(A)-, MERCOSUR appears as a net exporter for 5 of the 7 commodities considered. Wheat would be in excess demand by some 1.8 million tons and cotton by 10 thousand tons. In the case of wheat, however, since Uruguay is a wheat exporter, the net result could be considered as neutral. Nevertheless, it must be kept in mind that (A) is also the scenario with the least likelihood, as discussed above. Considering the most likely scenario (B for beef and C for the rest), starting in the year 2000, MERCOSUR would be in a position to supply to the world markets some 40 million tons of cereals and oilseeds (grain + processed products), over 500 thousand tons of beef, 126 thousand tons of cotton and almost 2.3 million tons of potatoes[9]. As mentioned above, total output for Brazil was assumed to remain constant at 1995 levels throughout the 5-year period. That is not a realistic assumption, since productivity gains at the farm level are being reported in Brazil for most crops. This again would induce to an error by underestimation. Hence, the prospects for MERCOSUR to become a major exporter of agricultural commodities are exceedingly promising.

ARGENTINE AGRIBUSINESS AND THE ENVIRONMENT

For decades and due to the stiff competition from the treasuries of the US and Western Europe, coupled with domestic macroeconomic policies strongly biased in favor of protected industrial sectors, Argentine farmers were in no position to embark in high-input schemes. That means that their production systems have traditionally been (not always by choice), ecologically sensitive, especially with regard to soil and water pollution and toxic residues on foodstuffs. The world agricultural trade picture is slowly changing in favor of non-protectionist producers (Uruguay GATT Round, progressive dismantling of subsidies due to high fiscal costs, etc.). Thus, in search of competitiveness on a more leveled playing field, and learning from other nations' errors, Argentina will very likely become a dependable large scale supplier of high quality (health-wise) food products, ranging from commodities to sophisticated processed goods, on a sustainable basis, thanks to its state-of-the-art resource base management capabilities. To that effect, unprecedented institutional innovations are in the process of being implemented within its agricultural research and development system, involving a wide array of actors, from farm input suppliers to the food industry. These new arrangements will enhance the industry's global competitiveness, given that the consumer (domestic and foreign) has become the subject around whom the generation and transfer of new agricultural technology will revolve.

[9] All estimates are based on 1992/93 distribution of agricultural land. Changes in the vector of output relative prices would induce substitution between items within the same production possibilities frontier (*e.g.* beef <=> grains; corn <=> soybean; etc.).

ANNEX I

EX-ANTE ANALYSIS OF AGRICULTURAL RESEARCH IMPACT:
THE SURPLUS BY ADOPTION OF TECHNOLOGY (SAT) MODEL.[10]

1.INTRODUCTION

The permanent desire to reduce the uncertainty associated with the future, has created a demand for tools to assist decision-makers at different levels in the process of agricultural research resource allocation.

There exists a significant body of previous work related to *ex-ante* evaluation of returns to investments in agricultural research (Piñeiro, 1984; Pinstrup-Anderson, 1977; Scobie, 1979; Davis, 1984; Davis, Oram and Ryan, 1987; da Cruz, de Castro, Tollini y Sugai, 1988; Evenson, 1988). The most commonly used approach is that of the estimation of the economic (producer + consumer) surplus attainable as a consequence of supply function shifts attributable to the adoption of technological innovations.

The study to be presented in this paper applies a methodology that differs considerably from the most commonly used ones. It assumes that a single aggregate supply curve for agricultural products does not accurately describe the reality, especially in LDCs. Should this assumption be correct, the observed variability in the universe of agricultural firms should be taken into account before attempting to evaluate the consequences of alternative decisions concerning investments in generation and transfer of agricultural technology.

2. THE MODEL.

SAT is a tool that consists of a mathematical simulation model that allows for *ex-ante* analysis of aggregate sector impact (measured as changes in total output) of alternative strategies for agricultural research resource allocation. **SAT** estimates how much more would be produced, compared to current levels projected into a given time horizon, IF SPECIFIC TECHNOLOGIES ARE GENERATED AND TRANSFERRED.

The following assumptions are made:

There exist three technological levels (TL) among farmers of homogeneous agroecological areas: low (LTL), medium (MTL) and high (HTL), respectively associated with a set of techniques, inputs and a resulting productivity indicator (average yield) (see Fig. 1).

10 Based on Cap, E.; Miranda, O.: "An<lisis "*ex-ante*" de impactos de la investigación agrícola en la Argentina para siete rubros productivos en escenarios alternativos" (*Ex-ante* analysis of agricultural research impacts in Argentina for seven productive activities under alternative scenarios). In: ***Actas del Simposio Internacional: La Investigación Agrícola en la Argentina. Impactos y Necesidades de Inversión*** (Proceedings of the International Symposium: Agricultural Research in Argentina. Impacts and Investment needs). Eds.: Cirio, F.; Castronovo, A. 1994. INTA, Bs. As., Argentina.

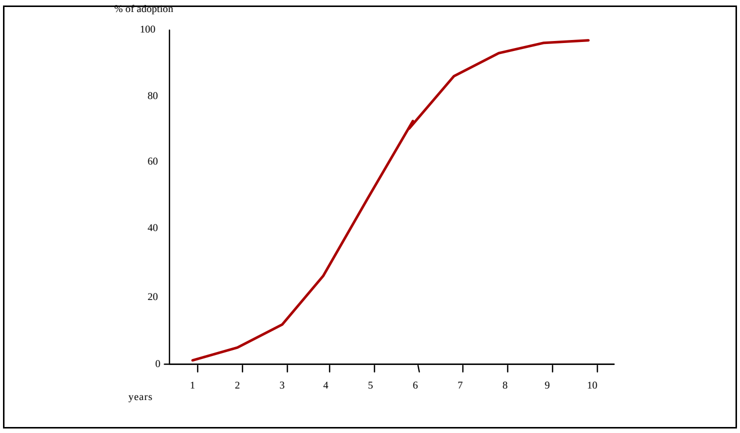

Figure 1. *Stylized representation of technologies implemented by farmers, for 2 inputs (K and L).*

There exists "upward mobility" among TLs, which is made possible by the adoption of AVAILABLE techniques and inputs, together with the capacity to use them efficiently. This "inter-level mobility" (ILM) rate is defined as the percentage of the area[11] of a given TL that gets "promoted" each year to the next TL, in terms of productivity[12]. This process is represented by a linear function. This mobility is unidirectional, that is, promoted areas cannot be "demoted". The National Agricultural Research System, has the capacity to generate NEW technology. Its (future) adoption by farmers is represented by a non-linear function (sigmoid), its parameters given by the nature of the innovation and the socio-economic profile of the target audience (see Fig. 2).

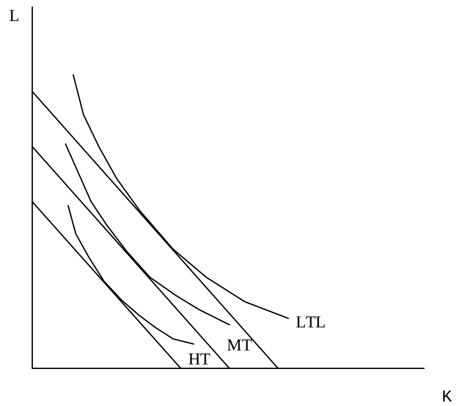

Figure 2. *Cumulative adoption percentage for an adoption ceiling (K) of 0.99 and an adoption half-time (ƒ) of 4 years.*

[11] Or any other unit of measurement that would be suitable as an indicator of scale of production (i.e., "bee hives" for honey production).

[12] The rate of mobility, such as it has been defined, can be conceived as an indicator of the RATE OF ACCUMULATION OF HUMAN CAPITAL in the agricultural subsector which is being considered. This is so since, to have access to inputs and information on its optimal use is a necessary but not sufficient condition to attain the productivity levels associated with the top TL. To the acquisition of the needed KNOW-HOW (which is not the same thing as having access to the information), we must add an enhanced entrepreneurial ability (including the means to evaluate both downside risks and upside potential together with the willingness to take the risks). This implies a process which is unavoidably slow and accumulative, clearly linked to one of the least studied components of any economic system, which Hayami and Ruttan (1985) call "**cultural endowment**". This cycle of human capital accumulation adds credibility and support to the assumption of the unidirectionality of the phenomenon of inter-level mobility. Although it is acknowledged that micro (i.e., erroneous business decisions) or macroeconomic circumstances (i.e., changes in the price ratios) can lead to a drop in productivity due to the suboptimal utilization of inputs, that does not necessarily imply an involution in the process of human capital accumulation: if the environment returns to its *ex-ante* status, productivity would probably pick up after a brief lag. A parallel could be drawn between this situation and the unutilized capacity of an industry, augmented as a consequence of business cycle-related causes and its incidence on fixed costs.

The model key component consists of a reconstruction of the process of adoption by farmers of technological innovations that shift the isoquant that represents them (as a combination of inputs and factors), achieving a more efficient use of resources, which implies a reduction of production costs. The most significant **implicit** assumption that SAT makes is that the coexistence of the three isoquants or TLs, cannot be satisfactorily explained resorting to analytical tools provided by the neoclassical economic theory, since according to it, if farmers are profit-maximizers, they would all move to the isoquant nearest to the origin (the chosen point on that isoquant would depend on price ratios). This does not imply that the rationality of farmers is being questioned. Instead, it recognizes the existence of barriers associated with incomplete and/or non-existent markets, as well as of restrictions to the adoption of available technology and its optimum utilization, caused by the undersupply of public goods (like infrastructure) or pure private ones (like refrigeration or storage capacity) or mixed ones, like entrepreneurial skills or level of training of farmers.

The **SAT** model is not to be thought of as an alternative to the other ones proposed in the literature, but as a contribution that improves them. It tries to identify and explain the dynamics of two processes that take place at the same time. According to previous studies (Byerlee, D. and Hesse de Polanco, E., 1982), the adoption of a specific innovation occurs at a rate which is considerably higher than the values found for the inter-level mobility (Cap *et al*, 1993). There is another significant difference between these two processes: its mathematical representation (linear for the ILM and non-linear (sigmoid) for the adoption of a single innovation).

The **SAT** model treats the surplus produced in excess of the current output, as a function with the following general expression:

$$E_t = f \| \; x_t^d \; [w\,[\,R\,(Bp)]]\,,\; x_t^p \; [Y^p(tec^p),$$

$$p_t \; ((f(tec^p), K,\; a\,(Bp))], S(tec^d \; e\, D,\; tec^p)\,, z \;\|$$

where:

E_t: surplus attained at time **t**.

x_t^d: increase in productivity (yield) at time **t** by tapping into the stock of technology available at time $\mathbf{t_0}$.

w: annual rate of inter-level mobility.

R: restrictions to ILM.

B_p: supply of public goods (extension, infrastructure, macroeconomic policy, etc.).

x_t^p: increase in productivity (yield) at time **t** attributable to the adoption of new technology ($x_t^p > 0$ if $\mathbf{t} >= \mathbf{t_d}$, where $\mathbf{t_d}$ is the time of availability of the technology; $x_t^p = 0$ if $\mathbf{t} < \mathbf{t_d}$).

Y^p: potential productivity of the new technology.

tec^p: non-available technology (to be developed).

tec^d: available technology.

D: stock of available technology.

p_t: level of adoption of tec^p at time **t** ($p_t > 0$ if $\mathbf{t_d} \geq \mathbf{t}$).

f: parameter that measures the time it takes for 50% of farmers to adopt a specific new technology.

K: adoption ceiling, $K \in (0,1]$

a: restrictions to the adoption of a specific technology.

S_{TL}: correction factor for sustainability of the set of technologies used at TL, $S \in (0,1]$

z: vector of random variables.

The problem (**P**) that policy-makers face, can be formulated as follows:

(**P**) *max* E_t *(choosing* B_p, tec^p*)*

subject to restrictions, i.e., budgetary[13]

For this theoretical model, as $\mathbf{E_t}$ approaches its maximum from the left, its partial derivatives are associated with a sign (+ or -), which is consistent with explicit or implicit hypotheses of the model.

$$1.\ \frac{\partial E_t}{\partial x^d} - \frac{\partial x^d}{\partial w} x \frac{\partial w}{\partial R} x \frac{\partial R}{\partial Bp} > 0$$

$$2.\ \frac{\partial E_t}{\partial x^p} x \frac{\partial x^p}{\partial y^p} > 0$$

$$3.\ \frac{\partial E_t}{\partial x^p} - \frac{\partial x^p}{\partial p} x \frac{\partial p}{\partial f} < 0$$

$$4.\ \frac{\partial E_t}{\partial x^p} - \frac{\partial x^p}{\partial p} x \frac{\partial p}{\partial K} > 0$$

$$5.\ \frac{\partial E_t}{\partial x^p} - \frac{\partial x^p}{\partial p} x \frac{\partial p}{\partial a} x \frac{\partial a}{\partial Bp} > 0$$

$$6.\ \frac{\partial E_t}{\partial S} \geq 0 \ \ if\ \ S = 1;$$

$$> 0 \ \ if \ \ S < 1$$

2.1 EMPIRICAL MODEL

The empirical formulation of the **SAT** model is as follows:

$$VE_T = \sum_{t=0}^{T} \sum_{k=1}^{K} \sum_{i=1}^{3} (\| S_{ik} \ x \ [\ b_{ik}^{d} \ x ((w_{ik} \ ) x \ A_{(i-1)kt})]$$

$$+ [\ b_{ik}^{p} \ x (K / (1 \ + \ e^{-a(t-f_i)} \ x \ A_{ikt})] \ \| x \ p_k^{FOB})$$

13 This optimization problem should be analyzed using a piecemeal/second best approach, since neoclassical economics cannot be used due to the violation of its fundamental assumptions. A viable alternative would be to use benefit/cost ratio (B/C) indicators or internal rates of return (IRR) PER RESTRICTION to the inter-level mobility for the available stock of technology and PER SUBJECT MATTER for technologies that are still in the development process.

where:

VE_T: value in US dollars of the additional output at time **T** (simulation horizon). Applying the discount rate to the sequence $\{VE_t\}_0^T$, the Net Present Value (NPV) can be calculated.

t: time period (year).
k: crop or productive activity (K: total # of items).
i: technological level, **i** $\in$ [1,2,3], where 1=L, 2=M and 3=H.
S: correction factor for sustainability, **S** $\in$ (0,1]
$\mathbf{b}^d$: productivity gap between actual and attainable yields using AVAILABLE TECHNOLOGY, per TL.
A: area dedicated to produce **k**.
$\mathbf{b}^p$: productivity gap between actual and attainable yields using TECHNOLOGY NOT YET AVAILABLE, per TL.
K: adoption ceiling. **K** in (0,1].
e: base of natural logarithms.
a: parameter of the sigmoid function, associated with restrictions to adoption of technology.
f: adoption half-time: number of years elapsed between availability of technology and its adoption by 50% of the farmers.
p^{FOB}: FOB price of item **k**.

NOTE: the first term of the equation allows the estimation of the increase in output, at time **T**, attributable to the adoption of available technology and its optimal use. The second term quantifies the pure effect of NEW TECHNOLOGY (net social benefit).

2.2 REQUIRED INFORMATION

The **SAT** model requires descriptive and prospective input data, as follows:

GENERAL (descriptive)

Yield per **TL**.
Area per **TL**.
Annual inter-level mobility rates (ILMR).
Price elasticity of supply (whenever possible, it should be discriminated by **TL**).

SPECIFIC (prospective)

Importance of the problem to solve or the technical innovation to produce, *i.e.*, yield losses in kg/ha due to a pest or disease (in these cases, information on frequency of occurrence is also required).
Geographical area affected by the problem or to benefit from the new technology.
New state-of-the-art of production technology, should the research be successful, measured in productivity or quality.
Year of availability of the new technology.
Research costs (direct, indirect and labor).

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ANEXO 2

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"Opportunities for growth in the Pacific Food System".
Mr. CHU Hon Fai. Dah chong Hong, Ltd. Hong Kong.
"Food security and market reform".
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"Meeting´s Asia´s changing food requirements".
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"Food and agriculture outlook for mainland China".
Prof. KE Bingsheng. Beijing Agricultural University. P.R. of China.
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