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The agricultural machinery industry in Argentina: from restructuring to internationalization?

Graciela M. C. García

This paper sets out to show that, having undergone restructuring at a microeconomic and sectoral level, the agricultural machinery industry in Argentina depends for growth on higher exports and further progress towards internationalization, which are strategic goals for the largest firms. Given the dynamism of global demand for this type of machinery, the conclusion is that the sector can increase its sales in export markets, where some of its products are competing well. The behaviour of domestic demand will be critical, and this largely depends on the profitability of Argentine agriculture. To internationalize further, the sector will have to overcome certain limitations, largely technological in nature, while receiving support from government programmes and assistance from employers' associations and science and technology institutions.

Graciela M. C. García
Researcher with the Research Council,
Professor of Microeconomics II at the Faculty of Economic Sciences and Statistics,
National University of Rosario
gragarci@fcecon.unr.edu.ar

I
Introduction

The agricultural machinery sector in Argentina developed in the import substitution industrialization period. It consisted of subsidiaries of transnational enterprises and locally-owned firms whose growth was oriented towards the domestic market, which they supplied without external competition until the late 1970s. The last three decades have been a time of increasing competitive pressure and technological change in the metallurgical industry and pampas agriculture, and this has exposed the sector's lack of competitiveness in an open, globalized domestic market. The result has been a process of restructuring in the sector, its industries and its individual firms. Firms have also rethought their own growth strategies and improved their techno-productive capabilities.

These changes have left the sector with a domestic market share of 35%, barely higher than in the early decades of the twentieth century. In this first decade of the twenty-first century, however, after building up experience and maturing technologically over six decades, locally-owned firms are active participants in the market. Some of them have increased their exports and begun to internationalize. Has this happened because of favourable economic trends, or because international expansion is among their strategic goals? Does the techno-productive development they have achieved fit them to continue operating in global markets? What are the factors underlying the Argentine agricultural machinery sector's internationalization? This article will try to find answers to these questions and others like them.

The present study posits that, following its restructuring at the microeconomic and sectoral level, the long-term expansion of the agricultural machinery sector in Argentina will depend on its ability to operate in globalized markets, increase exports and internationalize, and that this process is possible given certain macroeconomic and industrial policy conditions. To undertake this exploration, the findings of a number of studies carried out over recent years will be used to examine, first of all, the performance of the sector in 1980-2007, along with changes in the incentive regime and the macroeconomic situation of Argentina.

Second, it will analyse fundamental macro/micro links, describe the main features of the successive bouts of sectoral restructuring and analyse the roles and activities of supporting institutions.

The behaviour of firms will be examined by employing a neo-Schumpeterian approach and dynamic capabilities theory to construct their "evolutionary pathways" and review three different but interrelated features of each firm: its strategy, its structure and its basic capabilities. Restructuring in the sector and markets will be studied from an industrial organization standpoint, and the roles and activities of supporting institutions from a National Innovation System (NIS) perspective.

Third, the sector's internationalization potential and limitations will be explored and a number of case studies drawn upon to show that since the 1990s the goal of larger firms' strategies has been to increase exports and operate in external markets. Lastly, the sector's situation as it faces the challenge of expanding exports and pursuing further internationalization will be briefly described.

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II

The incentive regime and competitiveness

1. Market opening and technological change

In Argentina, growing competitive pressures, the shifting technology frontier in the metallurgical industry and the spread of direct seeding techniques have all influenced the performance and organization of the agricultural machinery sector in the last three decades.

Competitive pressures gradually increased as the process of domestic market opening and "globalization" proceeded. Market opening began in the late 1970s;[1] it gathered pace in 1988 with the signing of the Integration, Cooperation and Development Treaty between Argentina and Brazil and was consolidated from 1991 with a new reform of the tariff system[2] and progress with the formation of MERCOSUR. At the same time, the increasing globalization of transnational enterprises' techno-productive activities and of global markets for agricultural machinery increased intra-firm trade, imports of such machinery and, ultimately, the globalization of the domestic market.

Meanwhile, the shifting technology frontier of the metallurgical industry resulted in machine tools that were more complex and productive than conventional ones. The best-known are numerically controlled machine tools (NCMT) and computer numerical control machine tools (CNCMT).[3] These NC/CNCMT, and new technologies generally, have advantages over the conventional variety. They provide flexibility and allow for smaller batches and production runs without loss of efficiency. They are capable of turning out particular shapes and precisely engineered, standardized products. They also offer savings in working capital, energy, labour and quality controls and they use less space because one machine can replace several (Soifer, 1986).

Both globally and locally, transnational enterprises were the first to introduce the new machine-tool, design and industrial organization technologies. In Argentina they began to do so in the late 1980s. The process accelerated in the 1990s because of the increasing globalization of these firms' techno-productive activities and the spread of information and communication technologies (ICTs). Locally-owned firms began to incorporate NC/CNCMT and design technologies in the 1990s, and this trend accelerated in the 2000s.

Another technological change that has had major effects on the agricultural machinery sector is the spread of direct seeding techniques in Argentina,[4] owing to their economic advantages and technological viability. Direct seeding makes intensive use of agrochemicals, resistant seed strains and equipment specially designed to seed without tilling the soil. Its general adoption was made possible by a "technology package": advances in chemistry, which provided the agrochemicals; in biotechnology, which developed genetically improved, agrochemical-resistant seeds; and in the agricultural machinery industry, which designed the seeding equipment.

From the economic standpoint, average costs are lower for direct seeding than for conventional seeding. The reduction in tractor use means lower fuel consumption per hectare, while better management of soil humidity and nutrients raises yields per

[1] In 1978, agricultural equipment import tariffs were cut and the tractor industry regime began to be liberalized. That regime established which tractor parts and components could be imported, what percentages of foreign-made components were allowed and what customs tariffs and duties had to be paid. Around 1990, the requirement for Argentine components to be used in tractor production was dropped.

[2] In 1991, import tariffs on agricultural machinery were set at 22% for final goods, 11% for intermediate goods and 5% for tractors of more than 140 h.p. Since 1995 the tariff has been zero for imports of agricultural equipment (and the corresponding parts and components) from MERCOSUR member countries. Since 2001, there has also been a 14% tariff on imports of final goods from outside MERCOSUR.

[3] There are also robots that integrate different devices into flexible production "cells", "islands" or "lines", as well as simple or complex graphical systems –computer-aided design (CAD), computer-aided engineering (CAE), computer-aided manufacturing (CAM), computer-integrated manufacturing (CIM)– and computer software for business and organizational purposes. It is also possible to replace a set of tools with a laser system.

[4] Conventional tilling exposes soils to wind and water erosion and reduces their water retention capacity, thereby exhausting them and destroying their agricultural potential. By contrast, direct seeding (no-till) on existing crop residues reduces the need for ploughing and mechanical weed control, contains erosion, increases the amount of organic material and allows soils and their agricultural conditions to be managed more sustainably. Direct seeding began to be used in Argentina in the 1980s, and in 2005/2007 the area sown in this way stabilized at 19 million hectares, or about 70% of the total area under cultivation.

hectare. In consequence, total direct seeding costs are lower than (or similar to) those of conventional agriculture, while revenues are greater because of higher yields (García, Ambroggio and Trucco, 2000; Hybel, 2006).

Changes in pampas farming techniques made it necessary to devise and incorporate innovations in a range of agricultural implements (Bisang and Kosacoff, 2006). Direct seeding requires seed drills for plots with stubble, treated with agrochemicals. Some locally-owned firms began to manufacture this type of equipment in the early 1980s, improved their products in the 1990s and have begun to export them in the last few years. Direct seeding also makes it necessary to design and manufacture large self-propelled sprayers, increase cutting width and improve both the productivity of combine harvesters and the use of electronic global positioning systems (GPS).

Changes in technology and in the incentive regime have strongly affected the techno-productive behaviour of firms, as well as the organization of the agricultural machinery sector in Argentina. They have likewise influenced the results of market opening and the strategies of transnational enterprises.

2. Performance of the sector in an open economy (1980-2007)

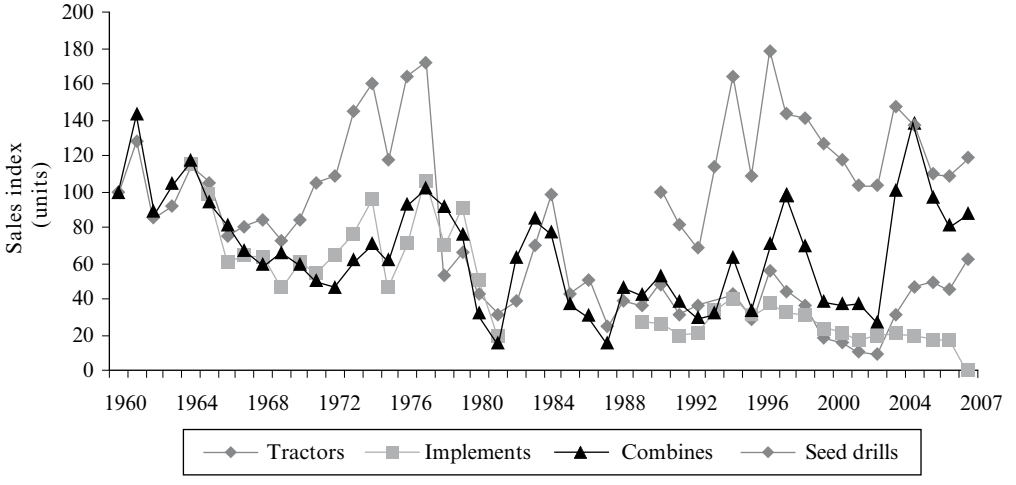
The Argentine State encouraged the development of the agricultural machinery sector to meet the mechanization needs of pampas farming. From the 1950s until the late 1970s, the sector was protected from external competition by quotas and high import tariffs, so that activity levels reflected the behaviour of domestic demand.

(a) Small market size and cyclical demand

Since the 1960s, the demand for agricultural machinery from pampas farmers has behaved cyclically, with large annual fluctuations (figure 1). The evidence suggests that the determining factors in this behaviour are technological and economic in nature and operate over both the short and long terms. The hypothesis of the present paper is that demand levels are basically related to the areas under cultivation and the profitability of agriculture, which depends both on company size and on technological, economic and climatic variables. Among the technological variables to be

FIGURE 1

Argentina: domestic demand for agricultural machinery, 1960-2007
(Units)



Source: Prepared by the author on the basis of information from AFAT, CAFMA and INDEC, Huici (1988) and Fontanals and Lavergne (1988).

considered are elements contributing to improved agricultural productivity (seeds, agrochemicals, agronomic techniques) and the degree of equipment obsolescence. Among those of an economic nature are the relative prices of cereals and inputs, interest rates, the availability of financing and tax policy for the agricultural sector.

The cyclical behaviour of demand leads to changes in the size of the domestic market for agricultural machinery. If the size of this market is compared with average annual sales in a particular period (table 1), it is observed that the Argentine market for combine harvesters and tractors was greater in the 2002-2007 period than in the 1990s, while for seed drills it was unchanged and for ploughing equipment it was smaller. This pattern is connected with the increasing prevalence of direct seeding and the high returns on pampas agriculture in recent years.

In money terms, the Argentine agricultural machinery market is worth about a billion dollars a year. Even in its expansionary phase, it is smaller than the Brazilian and United States markets. The Brazilian market for such machinery is five to seven times as large as that of Argentina, while the United States market for combine harvesters is about 15 times as large as the Argentine market.

In Argentina, market size and the cyclical behaviour of demand have influenced the techno-productive behaviour and performance of firms, especially locally-owned ones that started out in the import substitution industrialization period. The small size of the market has constrained growth in supplier numbers and the exploitation of economies of scale and specialization. The cyclical behaviour of demand has also discouraged firms from planning for long-term investment and expansion.

(b) New market participants and the problem of competitiveness

The change in the incentive regime and the arrival of new participants in the market put the competitiveness of the sector in Argentina to the test. Imports increased in the 1980s, particularly for combine harvesters and tractors. Then between 1992 and 1998, which was a period of economic liberalization, progress with the creation of MERCOSUR and dynamic demand, imports trebled in value and, with the exception of seed drills, their share of sales in the domestic market rose. In 1998, about half of all tractors and combine harvesters sold were imported. Conversely, the share of imports in seed drill sales fell from 6% in 1992 to 1% in 1998.

Between 2002 and 2007, in a context of dynamic demand and installed capacity constraints in the Argentine agricultural machinery sector, imports sextupled in value and their share of total sales rose. In 2006/2007, about 80% of tractor and combine harvester sales by value, and 27% of implement sales, were of imported equipment.

In Argentina, transnationals were responsible for most imports of combine harvesters, tractors and agricultural implements. In the 1990s they imported from their subsidiaries in Brazil, Germany and the

TABLE 1

Argentina: size of the agricultural machinery market, 1980-2007

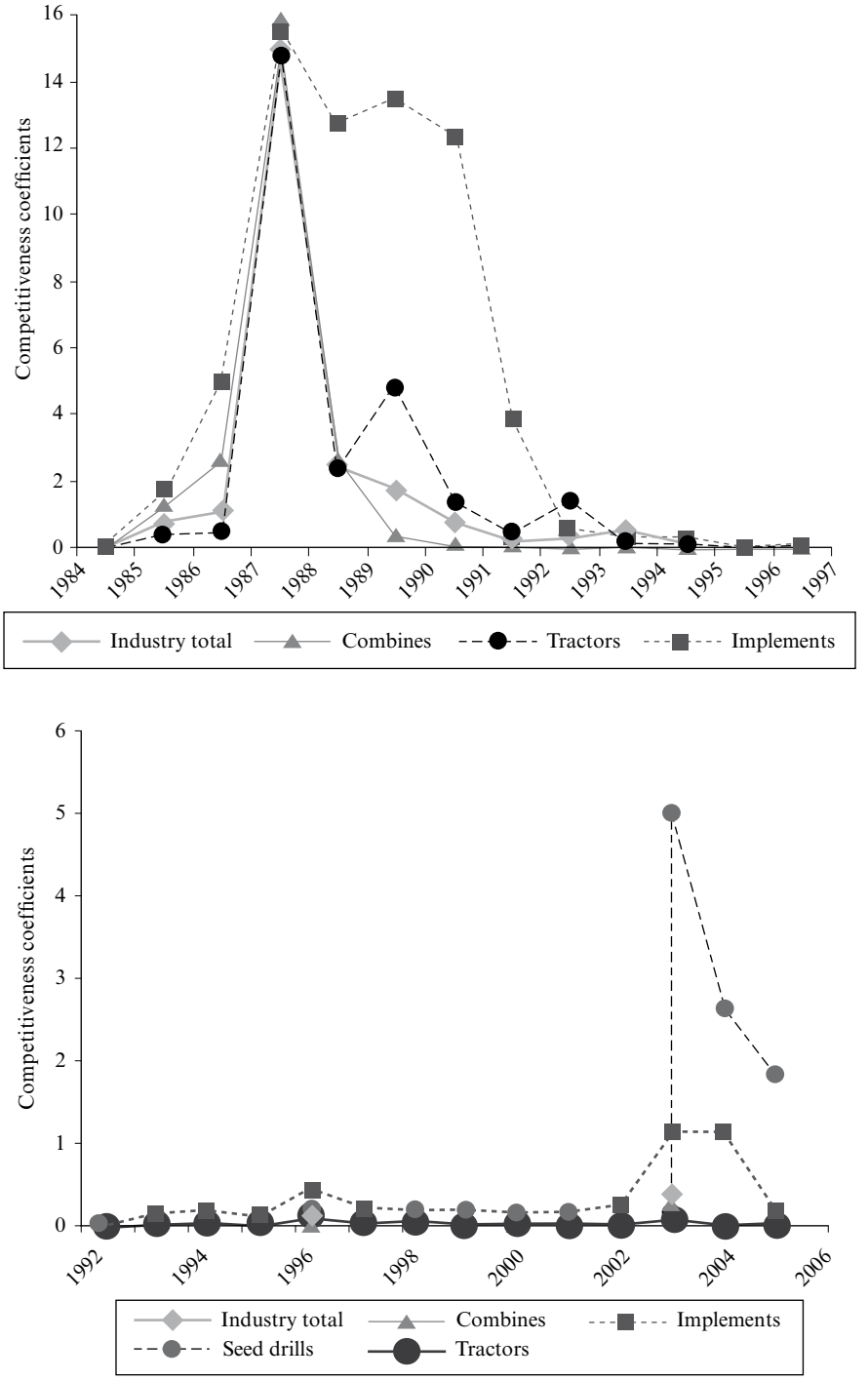
Period \ Total sales in the domestic market	Size of the tractor market (average annual sales, units)	Size of the combine harvester market (average annual sales, units)	Size of the ploughing and seeding implements[a] market (average annual sales, units)	Size of the seed drill market (average annual sales, units)
1979-1984	7 437	1 351	23 058	3 828
1985-1989	5 079	803	10 110	3 280
1980s	6 172	1 036	19 821	3 691
1990-1996	5 188	1 063	10 776	3 840
1997-2001	3 259	1 307	9 258	4 174
1990s (1990/1999)	4 163	1 224	10 772	4 040
2002-2007	5 349	2 052	6 923	3 992

Source: prepared by the author on the basis of information from AFAT, CAFMA and INDEC, Huici (1988) and Fontanals and Lavergne (1988).

[a] Includes ploughs, harrows, seed drills and tillers.

FIGURE 2

Argentina: competitiveness coefficientsa in the agricultural machinery sector, 1984- 2004



Source: prepared by the author using information from INDEC for 1984-1995, Chudnovsky and Castaño (2003) for 1992-2001 and Documentos de PROARGENTINA, Serie Estudios Sectoriales, Maquinaria Agrícola (2005) for 2002-2004. The export and import series in both documents were prepared using INDEC data.

[a] The competitiveness coefficients measure the value of exports per dollar imported each year.

United States; in the 2000s, 80% to 90% of tractors and combine harvesters and most agricultural implements were imported from Brazil.

In the import substitution industrialization stage, Argentine agricultural machinery firms had only a small presence in external markets. In the 1980s they barely exported at all, except in the 1986-1988 period. In the 1990s, which were a time of intense competitive pressure, the exports of the sector rose, especially for agricultural implements and seed drills. This exporting trend has gathered force in recent years. As a result, the share of exports in sectoral gross domestic product (GDP) rose from 3% in 2001 to 30% in 2006/2007. The products displaying the greatest dynamism were seed drills, agricultural implements (including sprayers) and tractors. Although the Argentine sector still makes 86% of its sales in the domestic market, the steady rise in the value of its exports suggests that some firms are selling regularly in external markets.

Competitiveness coefficients, defined as annual exports by value as a proportion of annual imports by value, give a broader view of the competitiveness of the sector and its leading industries (figure 2). They suggest that after 1991, when the formation of MERCOSUR began and the economic liberalization process gathered pace, the competitiveness of the sector and each of its industries declined. They also suggest that in the 1990s the implements industry was the most competitive and the combine harvester industry the least.

According to the competitiveness coefficients, the competitiveness of the sector and its industries (except tractors) was greater in the 2000s than in earlier decades. Continuing with the trend begun in the 1990s, the seed drill industry was the most competitive, followed by the implements industry; the tractor and combine harvester industries were the least competitive.

To sum up, as competitive pressures have growth over the last three decades, the Argentine agricultural machinery sector has lost 80% of the domestic market for tractors and combine harvesters. This has been due to the strategic reorganization of transnationals operating in Argentina and to the local industry's lack of competitiveness. In the 2000s, however, some locally-owned firms making combine harvesters and tractors have competed well in external markets. Exports of seed drills and agricultural implements have also grown. Even so, the sector as a whole is not very competitive either in the domestic market or abroad.

III

The restructuring of firms and of the sector: new actors

Over the last three decades, amidst changes in the incentive regime and the Argentine macroeconomic situation, the agricultural machinery sector and the firms in it have undergone restructuring (Katz, 1996). In addition, new supporting institutions have been created and existing ones have taken on new roles.

1. Firms and macro/micro links

The macroeconomic situation in Argentina from 1976 to 1982 was one of "stabilizing liberalization": the tractor industry regime was liberalized, import tariffs were cut and subsidized-interest credits for agricultural machinery purchases were discontinued. Demand fell dramatically, imports rose and firms in the sector lost profitability.

In those years, major transnational firms restructured both their production and their commercial arrangements with a view to cutting costs. To lower their costs in this corporate environment, their Argentine subsidiaries cut their research and development (R&D) spending, dismantled whole departments and restructured to adapt to lower levels of activity and new product mixes. They reorganized to produce and trade within the transnational enterprise, specializing in products they could make at a lower cost than other subsidiaries and importing others. They standardized tractor design, specialized in the production of particular models, increased their use of imported inputs and began making parts and components for subsidiaries in Brazil. They also began to import tractors made outside

Argentina and Brazilian combine harvesters, which they finished assembling in their local plants.

The "dislocation" of the 1983-1990 period was characterized by profound macroeconomic imbalances, high and variable inflation rates and a dearth of financing. In this context, the challenge facing firms was to restore their profitability and improve their techno-productive capabilities, operating as they were with a great deal of idle capacity (50% to 70%).

Larger firms sought to reduce costs by expanding their product ranges and improving production processes. Although falling demand and high real interest rates discouraged investment in equipment, the subsidiaries of transnational enterprises and some locally-owned firms adopted new technologies and incorporated NC/CNCMT. For their part, most small and medium-sized enterprises (SMEs) that manufactured combine harvesters expanded their production and trading platforms and increased their degree of vertical integration to reduce idle capacity and market risks. Irrespective of size and production type, locally-owned firms also set out to lower their unit costs by forging production and commercial partnerships (García, 2005 and 2006).

To narrow the product technology gap, manufacturers of combine harvesters also brought in innovations to increase the productivity of these machines. Producers of agricultural implements, meanwhile, increased the size and traction power of their devices and incorporated hydraulic mechanisms into them.

In 1991-2001, a time of stability, the economy was opened up further, progress was made with the formation of MERCOSUR and the environment became more favourable to the success of industrial activities. Domestic demand for agricultural machinery recovered and import growth increased. In the area of taxation, tax rebates were introduced for the domestic sales of firms in the sector.[5] The corollary of this was a rise in the relative prices of goods and services that were not tradable internationally, particularly privatized public services.

Some locally-owned agricultural machinery firms modified their growth strategies, others restructured and most invested in greater production capacity. More dynamic demand and lower prices for imported capital goods allowed them to build or expand factories and equip them with NC/CNCMT and lasers. Most of them increased R&D spending, expanded their engineering departments, improved their techno-productive capabilities and reduced their unit production costs. In addition, some firms reduced their degree of vertical integration as the labour market was deregulated.[6]

In SMEs that manufactured combine harvesters, the technological modernization process of the 1990s was constrained by the small size of plants, the type of equipment used and the difficulty of reorganizing production processes. As a result, some firms left the industry and some went into partnership with other companies in the sector or diversified their output to capitalize on the capabilities they had acquired. Only one combine harvester firm expanded during the decade. At the subsidiaries of transnational enterprises, meanwhile, techno-productive activities diminished and the commercialization of imported agricultural equipment (most of it from Brazil) increased.

In the mid-1990s, transnationals once again redefined their global strategies and centralized their decision-making. They sited the production of tractors for MERCOSUR in Brazil and stopped making them in Argentina. Some Argentine subsidiaries invested in refitting their plants to produce tractor and other agricultural machinery parts, components and engines for other subsidiaries, particularly those in Brazil. They also increased their imports of tractors, combine harvesters and other agricultural equipment and started importing earth-moving, road-building and construction equipment.

In the late 1990s, growth in the Argentine economy slowed down and it became harder to hold the exchange rate at the level set by the Convertibility Act. From 2002, following suspension of payments on the external debt and the devaluation of the peso, the growth rate recovered. From 2005 onward, rapidly rising inflation eroded the real exchange rate and the competitiveness of firms.

Under these circumstances, the expansion and creation of techno-productive capabilities in agricultural machinery firms that had begun in the 1990s gathered pace. One locally-owned firm, the

[5] In 1993, the national State established a regime that gave capital goods manufacturers a tax rebate of 15% on sales in the domestic market. In 1995 the rebate fell to 10%, and in 1996 the regime was abolished altogether. One with similar characteristics has applied since 1999 exclusively to manufacturers of agricultural machinery.

[6] The mechanism worked as follows: the firm would dismiss workers, provide them with financing to buy equipment and then purchase the parts or components they manufactured.

largest manufacturer of combine harvesters, increased its production capacity tenfold between 1990 and 2004 while lowering its unit costs and commencing export operations. New tractor and combine harvester firms also entered the sector, all of them SMEs. In this situation of industrial dynamism, the participation of science and technology institutions in the quest for new markets and in corporate innovation processes increased, especially in the case of firms making seed drills and direct seeding implements.

In summary, over the last decade the subsidiaries of transnational enterprises have stopped making tractors in Argentina, increased their imports and consolidated their strategy of specialization and complementation with other subsidiaries of the parent company. Some locally-owned firms that make combine harvesters and tractors have built up new techno-productive capabilities and begun exporting. The largest manufacturers of seed drills and agricultural implements, spurred by the spread of direct seeding, have created new products and begun exporting, either on their own or in partnership with other firms. They have also developed products in other countries, for other agricultural environments. In most cases, however, production scales are still small and conventional equipment still predominates.

2. Reorganizing the agricultural machinery sector: industries and markets

In the late 1970s, this sector was characterized in the industrialized countries by the presence of large enterprises, some of them transnational, that manufactured several different lines of agricultural equipment. In Argentina, on the other hand, what prevailed in the sector were SMEs specializing in the manufacture of one main product line, and four industries could be identified: tractors, combine harvesters, agricultural implements and auxiliary agricultural equipment.

Since 1978, the sector has gone through four episodes of restructuring (table 2). The first episode, in 1978-1981, took place amidst changes in the incentive regime, falling domestic demand and an abrupt decline in sectoral production indices. Many locally-owned SMEs left the business and the subsidiaries of transnational enterprises that made tractors reduced the scale of production. There were massive lay-offs, particularly in the tractor industry.

Between 1988 and 1994, Argentina saw its second episode of restructuring, driven by the loss of competitiveness among locally-owned firms.[7] Many manufacturers of agricultural implements and auxiliary equipment left the business and the combine harvester industry broke up (García, 1999). The tractor industry accounted for the largest share of sectoral output by value, while the implements industry was the most considerable in terms of the number of firms and the level of employment.

The main features of the third episode, which took place between 1995 and 2000, were the departure of subsidiaries of transnational enterprises from the Argentine tractor industry and the arrival of new locally-owned firms in the seed drill industry. Since then the sector's organization has been dominated by locally-owned firms, most of them SMEs. The global strategy shift among transnationals and the spread of direct seeding in Argentina were what triggered this episode.

Between 2002 and 2006, the fourth and latest restructuring episode took place. The increased profitability of agriculture and the newly dynamic demand for agricultural machinery[8] attracted new locally-owned firms into the business; the combine harvester and tractor industries were reorganized; the seed drill and agricultural implements industries came to account for the largest shares of sectoral GDP; and firms with two or more principal product lines also emerged.

To sum up, between 1980 and 2007 the structure of the agricultural machinery sector in Argentina changed and the value of its output fell by 50%. Following successive bouts of restructuring: (i) the tractor industry and market are now dominated by locally-owned firms, most of them SMEs; (ii) transnational firms have ceased to manufacture agricultural equipment in Argentina and have raised their market share for combine harvesters to 80%; (iii) the leader in the sector is no longer the tractor industry but the seed drill industry, while the share of the combine harvester industry, at 17%, is now just above its 1980s level; and (iv) the seed drill, agricultural implements and agricultural accessories industries are now the most dynamic in the sector (led by manufacturers of direct seeding implements).

[7] According to information from the National Industry Register (RIN), the value of the agricultural machinery sector's output doubled between 1990 and 1993 while direct employment fell by 36%.

[8] Data from the National Institute of Statistics and Censuses (INDEC) show the sector's output increasing by 60% in value between 2002 and 2006.

TABLE 2

Argentina: restructuring episodes in the agricultural machinery sector, 1980-2007

Key episodes	First episode (1978-1981)	Second episode (1988-1994)	Third episode (1995-2000)	Fourth episode (2002-2006)
Incentive regime, impact on the sector	Market opening. The State and public banks discontinue incentives to the sector. Abrupt fall-off in demand and exporting difficulties. Decline in production indices and loss of profitability.	Economic liberalization and faster import growth. Loss of competitiveness for locally-owned firms. Tax rebates on sales of agricultural machinery from 1993.	Liberalization and MERCOSUR. Dynamic demand due to growth of direct seeding and tax rebates on agricultural machinery sales. Transnationals relocate tractor production to Brazil and discontinue it in Argentina.	Demand increases 400% between 2002 and 2006 because of high profits in agriculture and the growth of direct seeding techniques. Tax rebates on sales of agricultural machinery. Increased profitability for agricultural machinery firms.
Role of employers' associations and science and technology institutions	Locally-owned firms join forces in the Argentine Chamber of Agricultural Machinery Manufacturers (CAFMA). Technology Advisory and Services Department (DAT) created in Santa Fe Province to provide technical assistance.	INTA steps up its programme to reduce harvesting losses and spreads direct seeding techniques. CAFMA forges ties with science and technology institutions to support the development of firms' techno-productive capabilities.	The CIDETER Foundation is created as a public-private initiative. It offers technical assistance. Firms increasingly link up with science and technology organizations to implement innovation processes and find markets.	Employers' associations and science and technology organizations implement programmes to enhance technological capabilities and increase exports. Ties between firms and sectoral institutions strengthen.
Tractor industry and market	Four or five subsidiaries of transnational firms. Loss of production capacity, break-up of the supplier network and decline in R&D spending. Mass lay-offs. Joined in the 1980s by three locally-owned firms. Highly oligopolistic supply, more asymmetrical than in previous decades. Competition is on product type rather than price.	Seven firms in the industry. Industry share of sectoral GDP by value rises from 43% in 1984-1986 (Huici, 1988) to 65% in 1993. Independent importers enter the market and transnationals increase imports.	Break-up of the industry as subsidiaries of transnationals depart. Locally-owned firms remain. These contribute 7% of sectoral GDP in 2001 (Hybel, 2006). In 1990-1998, the number of manufacturers rises from seven to nine; they include five independent importers. Globalization of supply, change of leadership and reduced concentration. Oligopolistic and asymmetrical supply. Four firms have a combined market share of 75%, the share of the two largest is 40%.	Industry built around locally-owned firms. Five SMEs enter the market. There are 12 market participants; eight are locally-owned firms (two large and six SMEs). Globalization of supply. Two transnationals have a combined market share of 70% (Hybel, 2006). Oligopolistic and asymmetrical supply.
Combine harvester industry and market	Higher imports. There are 12 to 15 locally-owned firms. No changes in the industry. Oligopolistic supply, with one dominant firm whose market share is 40%. The other firms position their prices and technology around it. SMEs compete among themselves in peripheral markets.	Break-up of the industry. Between 1990 and 1994, the number of locally-owned firms falls from 10 to two while the number of imported machinery suppliers rises from two to six. There are eight to 10 suppliers in the market. Leadership has shifted from a locally-owned firm to a transnational with market share of 40%.	Industry broken up. One or two firms active. Share of the industry in sectoral output by value: 14% in 1984 (Huici, 1988) and 15% in 2001 (Hybel, 2006). In the 1990s there are eight to 10 participants. The market share of the four largest ranges from 77% to 82%. Oligopolistic and asymmetrical supply. There is one dominant firm with a market share of 38% to 48%. The others position themselves around it.	Entry of three locally-owned firms and reorganization of the industry. Ten to 12 participants in the market. Oligopolistic, asymmetrical supply. One dominant firm with a market share of 40%. The market share of the two largest, both transnationals, is 60%. That of five locally-owned firms is 18% (Hybel, 2006).
Agricultural implement and seed drill industry and market	Exit of firms. In 1984-1986: 400 locally-owned firms in agricultural implement and auxiliary equipment industries, most of them SMEs. They account for 43% of sectoral output (Huici, 1988).	Import growth speeds up in 1990-1994. Between 1984 and 1993 an estimated 100 to 150 SMEs leave the industry. In the 1980s, manufacturers of seed drills for direct seeding also enter the market. In the ploughing and seeding implements industry and market, there is great dispersion in company size. Two or three leading firms each have a 10% market share.	Number of firms in the seed drill industry and market: rises from 40 to 50, all locally-owned. Oligopolistic and asymmetrical supply. Supply is diversified but not internationalized. In 2001, seed drills account for 45% of sectoral output by value and sprayers for 16% (Hybel, 2006).	Dynamism in the seed drill, self-propelled sprayer and grain platform industries. Lower output of ploughing implements owing to spread of direct seeding techniques. In 2005/06, seed drills account for 42% of sectoral output by value. Seven or eight large seed drill manufacturers have a market share of 50% to 60%, and the two largest have a 10% share apiece. Competition is on product, price and financing.

Source: Prepared by the author.

3. New actors and new roles in the sector

In the import substitution industrialization years, the main actors in the agricultural machinery sector were locally-owned firms, subsidiaries of transnationals, suppliers and a variety of public and private institutions. The national State, besides protecting the domestic market, promoted the sector's development by means of programmes implemented through the Department of Industry, the public banking system and international financial organizations. For their part, science and technology institutions provided technical assistance under various programmes. As for private-sector institutions, those years saw the creation of the Association of Argentine Tractor Manufacturers (AFAT), whose membership consisted of tractor-making subsidiaries of transnational enterprises. These firms contributed to the industrial fabric of the sector by training engineers and technicians who disseminated cost-reducing technological practices not hitherto used by local firms.

In the 1980s, the national State and the public banking system abolished incentives for the sector, and competitive pressures accordingly increased. In response to the changes in the incentive regime, locally-owned firms joined forces in the Argentine Chamber of Agricultural Machinery Manufacturers (CAFMA).[9] The Technology Advisory and Services Department (DAT) of Santa Fe Province was also set up to provide technical assistance to industrial companies in the province (García, 2004).

In those years, locally-owned firms forged more contacts with science and technology organizations with a view to improving their own techno-productive capabilities. With centres in the provinces of Buenos Aires, Córdoba and Santa Fe, the National Institute of Industrial Technology (INTI) offered a variety of services to firms in the sector, with a particular focus on new materials, the design and production of devices and improvements to production processes.

Meanwhile, the National Institute for Agricultural Technology (INTA) stepped up its R&D, assistance and advisory activities aimed at improving the technology, utilization and safety of agricultural equipment. With the participation of locally-owned agricultural machinery firms, it also began to implement programmes to improve seeding technologies and reduce harvesting losses. The programmes and activities of INTA were critical to the spread of direct seeding and the improvement of the technological capabilities of seed drill firms. Other important actors were the Argentine Association of Direct Seeding Producers (AAPRESID) and the stock exchanges of Buenos Aires, Córdoba and Rosario.

In the last decade, spurred by rising domestic demand, employers' associations and science and technology organizations involved themselves further in companies' innovation processes and in the search for new markets. In this respect, the 1990s seem to have marked a clear departure from earlier decades. The two employers' associations (AFAT and CAFMA) took on new roles. At AFAT, subsidiaries of transnational enterprises were joined by locally-owned tractor manufacturers and independent importers. Since the main business of most of these firms is the import and export of agricultural equipment rather than manufacturing, AFAT activities are oriented mainly towards the regulatory framework for the external trade in agricultural machinery.

CAFMA, meanwhile, represents locally-owned firms and has struck up relationships with science and technology institutions to implement programmes and activities aimed at enhancing the innovation and commercial capabilities of firms. With a view to promoting exports and internationalization in the sector, in 2007 it formed the Argentine Agricultural Machinery Research and Business Development Centre (CIDEMA).

In response to growing demand for particular technology services, the CIDETER Foundation was created in Santa Fe Province in the 1990s. This is a regional technology centre involving firms from Santa Fe and Córdoba provinces. Its objective is to encourage the formation of an agricultural machinery production cluster and respond to companies' need for outside assistance with their technological, production and commercial activities. In recent years, Argentine universities have also begun to provide technology services to firms in the sector through their agricultural machinery departments, as have research institutes and colleges.

As for firms, in the last decade the subsidiaries of transnationals have reduced their presence in the sector's industrial fabric. This has been detrimental to the transmission of their technology practices to

[9] CAFMA is a member of the Association of Metallurgical Industrialists of Argentina (ADIMRA), which in turn is part of the Argentine Industrial Association (UIA).

locally-owned firms. Meanwhile, a group of locally-owned SMEs, the most dynamic in the sector, have stepped up R&D activities oriented towards product innovation and process improvement to raise their productivity and lower production costs: they have expanded their engineering departments, worked regularly with science and technology professionals and organizations and, in some cases, carried out joint activities with INTA and INTI.

This whole process has intensified in the last few years because of the need to resolve the problems created by the growing technological complexity of products and processes. However, only a small group of firms in the sector have created ties with science and technology organizations to implement innovation processes.

Firms, science and technology institutions, employers' associations, Argentine and international financial organizations and different departments of the national State and the provincial states of Santa Fe, Córdoba and Buenos Aires[10] are the main stakeholders in the National Innovation System for Agricultural Machinery (SNIMA). On the whole, their activities are not well coordinated and they do not offer specialist services. However, growing competitive pressures and rising domestic demand have given rise to activities and programmes oriented mainly towards techno-productive capacity-building, exporting and the internationalization of SMEs in the sector. Against this background, trade associations and science and technology institutions are now participating more in locally-owned companies' innovation activities.

IV

Global markets, corporate strategies and internationalization

Following successive bouts of restructuring, the agricultural machinery sector in Argentina now consists of locally-owned firms, most of them SMEs oriented towards the domestic market. Manufacturers of agricultural implements in general, and seed drills in particular, are the most dynamic and contribute most to the sector's GDP. The small size of the domestic market and the cyclical behaviour of demand there continue to limit the long-term growth prospects of the sector. To expand, firms will have to export more and become more international.

Agricultural machinery markets are global, as are the main participants in them. A group of large transnational enterprises, which are also leaders in technology, account for the bulk of global output of this type of machinery.[11] Meanwhile, global demand for this is rising thanks to the dynamism of world agricultural commodity markets. In this context of global markets and rising demand, Argentine firms could be suppliers of combine harvesters, tractors and particularly seed drills and implements for direct seeding, a practice in which European and Latin American countries are showing an increasing interest. This means developing the techno-productive capabilities and commercial skills needed to operate in globalized markets.

1. Industrial development and the ability to compete

Even though global and local demand for agricultural machinery is dynamic, the sector in Argentina is uncompetitive. Imports have risen and Argentine production has declined in value over the last decade, revealing the limitations of the installed production capacity in the sector. At the same time, exports have grown[12] and certain indicators of competitiveness have improved. As well as increasing their exports,

[10] In Argentina, agricultural machinery firms are distributed around small towns in the pampas region, especially the provinces of Santa Fe and Córdoba (70%) and Buenos Aires (20%).

[11] According to information from PROARGENTINA (2005), the two largest transnationals in the industry, John Deere and CNH, account for 44% of world output, and the six largest for 54%. As global actors, they design products for different markets while also operating locally.

[12] Some 82% of Argentine agricultural machinery exports go to neighbouring countries, particularly Uruguay (51%). Other destinations are Australia, Mexico, Spain, the United States and Ukraine, according to information from PROARGENTINA (2005).

producers of seed drills, sprayers and agricultural implements have expanded their activities to other countries, focusing on developing products that are specially suited to their soils.

The dynamism of external sales can be attributed to large firms, specialized production clusters and link-ups between innovative SMEs and a range of sectoral institutions. Both employers' associations and science and technology organizations and institutes have reorganized their activities to meet the needs of firms. They have increased their participation in innovation activities, in the search for new markets and in the internationalization of SMEs in the industry. Technology upgrade financing from international organizations, the dynamism of domestic demand and the State incentives available to the sector have also been favourable to external sales growth.

The growth in exports suggests that firms have gone through techno-productive learning and development processes that have prepared them to compete in globalized external markets. With tractors and combine harvesters, progress is still based on adaptive imitation and innovations are mainly associated with the practices of the metallurgical and electronics industries. By contrast, the innovations being incorporated into seed drills, sprayers and other agricultural implements go beyond metallurgy and electronics to take in practices in the fields of agriculture, genetics and biology. Argentine seed drill manufacturers usually innovate in response to specific agronomic requirements. However, some firms have introduced innovations of their own that are original and unlike those found in products at the technology frontier (Bragachini, 2005).

To operate in global markets, Argentine agricultural machinery firms would have to attain a certain level of development in their techno-productive capabilities and be able to adapt continuously to technological change. However, the evidence suggests that a number of constraints need to be overcome first. One of them is the small scale of production (250 to 500 seed drills and 400 to 600 combine harvesters a year) even at plants considered large (García, 2005 and 2006). The production plant of the largest combine harvester manufacturer in Argentina is only 10% to 20% as large as its counterparts in Brazil and the industrialized countries.[13] Because plants are small, there is a great deal of vertical integration and few opportunities for cost-cutting. Generally speaking, the small size of plants and the lack of suppliers mean there is little scope to increase production, lower product prices and break into new markets.

Another constraint on efforts to raise the sector's international competitiveness is the way businesses are managed: although some firms have professional management, most of the others are family-owned, family-run SMEs with non-specialized executive (and sometimes technical) staff. Their products usually do not have international quality certification and their R&D spending, ranging from US$ 100,000 to US$ 200,000 a year, is well below that of foreign firms. They usually have trouble designing and improving products because of financial constraints and the lack of suppliers. Because they are situated in small towns in the pampas region, furthermore, they generally find it hard to recruit and retain skilled labour.

In summary, global demand for agricultural equipment is increasing. This suggests there are opportunities for Argentine firms in the industry to increase their exports and operate regularly in globalized, dynamic external markets. The ability to increase exports and internationalize depends both on companies' level of techno-productive development and on the macroeconomic environment and incentive regime. The process of acquiring new techno-productive capabilities involves both the firms and institutions supporting the sector and the industrial and technological policy of the Argentine State.

Irrespective of the incentive regime and macroeconomic context, however, it is firms themselves that set their strategic goals. These goals may or may not include increasing their exports and expanding their techno-productive activities to other markets. Corporate decisions are a necessary but not sufficient condition for export growth and further internationalization of the Argentine agricultural machinery sector.

2. Strategy and the search for new markets

At the import substitution stage, increasing exports was not a strategic goal of firms in the sector. In most of them, sales to external markets (usually neighbouring countries) served to offset cyclical variations in the small domestic market. One question must be whether the rise in exports over recent years

13 When domestic demand is in a contractionary phase, furthermore, Argentine companies operate with idle capacity of 40% to 60%.

has been the result of favourable economic conditions or of changes in corporate strategy. Another is whether firms that have begun to export aim to set up operations in other countries. In an attempt to answer these questions, the growth strategies of one subsidiary of a transnational enterprise and six locally-owned firms will now be examined.

By a company's strategy is meant a set of broad measures that include identifying and rationalizing goals and the methods to be used to attain them. The measures in a strategy may not be optimum; indeed, they could be self-destructive. From an evolutionary perspective, it makes no sense to assume that a firm can determine its "best" strategy. However, some strategies will be profitable and others will not; firms that systematically lose money will have to change their strategies and structures and create new capabilities or use those they already have to better effect if they wish to survive in the marketplace. To be successful in an innovative and changing world, firms need to delineate a strategy that enables them to decide which new avenues they should follow and which they should not. It must be assumed that firms are diverse and will choose slightly different strategies that lead them to different structures, to different basic capabilities and, inevitably, to different pathways to maturity (Nelson, 1991).

Firms' strategies are influenced by the macroeconomic situation and the incentive regime. In the Argentina of the 1980s, agricultural machinery firms lost competitiveness: they needed to restructure to adapt to the new incentive regime. However, falling demand, relative price volatility, high and variable inflation rates and high real interest rates discouraged investment in capital goods and in some cases helped to swell firms' debts.

In this macroeconomic context, SMEs in the sector expanded their product range to reduce their high levels of idle capacity and keep annual revenues more or less stable. Large firms, meanwhile, not only altered or expanded their product mix, but sought to restore profitability by entering into techno-productive and commercial partnerships with other agricultural machinery manufacturers to cut costs and break into new markets. Subsidiaries of transnational enterprises, meanwhile, diversified production, increased their commercial activities and began to trade with subsidiaries in Brazil. In some locally-owned firms and in subsidiaries of transnational enterprises, there were changes in ownership and organization structures.

As indicated earlier, in the 1980s the Argentine subsidiaries of transnationals, operating within the global strategies of their parent companies, initiated specialization and production and trade complementation processes with other subsidiaries. Meanwhile, locally-owned firms that had started out in a context of substitution industrialization carried on with "defensive" growth strategies that had proved profitable in earlier decades. They looked towards the domestic market not only because they were uncompetitive abroad, but essentially because they believed that the market opening process in Argentina would not be extended and indeed would not be permanent.

By contrast, locally-owned firms that entered the sector in the 1980s pursued "offensive" strategies appropriate to an open economy and competitive markets. For them, increasing exports was a strategic goal right from the start: they designed products to compete with foreign firms and operate in other markets, such as Brazil, Chile and European countries (Spain, the United Kingdom and eastern Europe).

By the 1990s, most of the firms that redefined their growth strategies had lost competitiveness as manufacturers of combine harvesters or tractors, but retained the ability to design, manufacture and market less technologically complex equipment. This group included both subsidiaries of transnational enterprises and locally-owned SMEs.

Two SMEs that made combine harvesters set up a techno-productive and commercial partnership with other firms in the industry, reallocated their accumulated production capacity and modified their product and commercial mix to make better use of installed capacity and economies of scale. The Argentine subsidiaries of transnationals, meanwhile, reacted to a new wave of global strategy shifts by discontinuing tractor production in the late 1990s. Since then they have made engines, parts and components, i.e., less technologically complex products than tractors. In general, commercial and financial activities have grown in Argentina while manufacturing activities have declined.

Although imports have increased, the leading seed drill manufacturers have not lost their competitiveness in the domestic market. Those that started out in the substitution industrialization stage and wished to carry on expanding have included higher exports and greater internationalization of their techno-productive activities among their strategic goals. Some firms have also decided to go

into techno-productive and commercial partnerships with others to operate in the domestic market and abroad. These changes of strategic direction, associated with the growing use of direct seeding and the dynamism of demand, have been consolidated in the 2000s.

Generally speaking, firms manufacturing seed drills have built up their techno-productive capabilities with the domestic market and certain external markets in view. The largest have forged ties with science and technology organizations to innovate and increase their exports. In some cases, these activities are supported by government agencies. Some firms manufacture seed drills adapted to the soils of neighbouring countries, others design them for European countries (the United Kingdom, Spain, eastern Europe) or New Zealand.

In summary, Argentine subsidiaries of transnational enterprises have used specialization and intra-firm techno-productive complementation to go further along the road they started down in the 1980s, and now operate in global markets. For larger locally-owned firms, increasing exports and trading in globalized external markets have been strategic objectives since the 1990s. For firms that are leaders in the seed drill and agricultural implements industry, in particular, higher exports and internationalization of their activities are strategic goals associated with the spread of direct seeding techniques. The factors helping to consolidate these goals have been ties with science and technology organizations, the formation of export consortia and techno-productive and commercial partnerships between firms in the sector.

V

Concluding remarks

In a more competitive environment, the Argentine agricultural machinery sector has struggled to compete in both the domestic and external markets. In the 1980s, to narrow the product and process technology gap, locally-owned firms began to restructure in a context of low domestic demand, high levels of uncertainty and relative prices that were a disincentive to production. Even so, locally-owned tractor manufacturers began to expand in those years, as did small firms that began to produce seed drills for direct seeding.

Spurred by the liberalization and globalization of the domestic market for agricultural equipment and by progress with the formation of MERCOSUR, large and medium-sized locally-owned firms included higher exports and greater internationalization of their activities among their strategic goals. The dynamism of domestic demand, the increasing use of direct seeding and the actions of organizations and institutions in the sector helped to consolidate these goals and have underpinned firms' expansion in recent years.

Until the 1990s, generally speaking, agricultural machinery firms in Argentina were subjected to successive bouts of techno-productive restructuring and changes in growth strategy. Since then, subsidiaries of transnational enterprises have operated at a global level. Locally-owned firms have increased their exports and some have begun to internationalize. These processes have been driven equally by the macroeconomic environment in Argentina, including the incentive regime applied to the sector, and by the strategic decisions of firms and support from governmental and science and technology bodies.

For a number of reasons, the agricultural machinery sector in Argentina has scope to increase exports and internationalize further. First, the dynamism of agricultural commodity markets is expanding the local and global agricultural frontier and Argentine firms are in a position to design and manufacture equipment tailored to different farming models. Given that from a global perspective the level of agricultural development in Argentina is considered to be comparable with that of Europe and the United States (PROARGENTINA, 2005), there seems to be no reason why the country should not develop equipment for sophisticated markets.

Second, agricultural implement markets are dynamic, largely because of the diversity of sources contributing to product innovation. These sources include technological changes in agronomic practices (direct seeding, for example), in the metallurgical industry (new types of engines, new designs), in

biotechnology (new seeds) and in the chemical industry (agrochemicals). This implies that barriers to entry are low and that locally-owned SMEs could enter the market and compete as well as or better than established firms, including transnationals.

Third, the sophistication of demand and the internationalization of the domestic market are pitting locally-owned firms, especially those making tractors and combine harvesters, against large manufacturers of products at the global technology frontier. This situation offers a challenge to the design capabilities of local firms, while providing them with models to live up to and incentives for learning: products that compete successfully in the domestic market can do so in other markets as well.

In recent years, firms making seed drills and agricultural implements have been the most competitive. Some that have forged ties with science and technology institutions to pursue their innovation processes are also undertaking research and development to design and manufacture equipment suited to other countries' soils and spread the practice of direct seeding (for example, in New Zealand, Chile and Spain). To consolidate this incipient internationalization and the rise in SME exports, support from government activities and programmes, employers' associations and science and technology institutions is just as important as firms' own strategic goals.

Export growth and progress with internationalization in the Argentine agricultural machinery sector also depend on its ability to overcome its own limitations, particularly where technology is concerned. This being so, the macroeconomic and institutional environment needs to be one that is favourable to long-term decision-making. The incentive regime should also promote and facilitate access to external markets, larger plant sizes, the creation of a supplier network and the manufacture of safer, quality-certified products.

Lastly, it needs to be borne in mind that the profitability of Argentine SMEs in the industry depends on their performance in the domestic market and that firms need to mature and consolidate in that market before starting to export. Consequently, one of the factors that have contributed most to export growth and greater internationalization in the sector is the behaviour of domestic demand for agricultural machinery, which basically depends on the profitability of Argentine agriculture.

(Original: Spanish)

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