

## HIGH TECHNOLOGY EXPORTS BY STATE ENTERPRISES IN LDCs: THE BRAZILIAN AIRCRAFT INDUSTRY

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### I. INTRODUCTION

LDCs are under constant pressure to diversify their exports away from traditional, primary goods towards nontraditional, manufactured products in order to increase and stabilize export earnings as well as improve their terms of trade. However, several obstacles hinder the achievement of this goal. This paper examines the particularly successful experience of one LDC (Brazil) in promoting exports of a sophisticated manufactured product (light aircraft or "general aviation") using a state-owned enterprise (Empresa Brasileira de Aeronáutica S.A. or Embraer). The objective of this paper is to identify the country-specific, industry-specific, and firm-specific factors that brought about Embraer's results, and to derive policy conclusions for other LDCs seeking to implement state-owned enterprises (SOEs) to develop internationally competitive high-technology industries within their national boundaries. It must be added from the outset that this paper focuses only on economic, institutional, and managerial factors accounting for Embraer's *effectiveness* and not on its *efficiency* (in social cost-benefit terms); although the latter is clearly also important from a policy standpoint.

The paper concludes with speculations on whether SOEs like Embraer are likely to appear with increasing or decreasing frequency in LDCs in the future.

#### *Barriers to Export of Manufactured Goods by LDCs*

Among the several problems confronting LDCs as they try to export manufactured goods is the fact that manufacturing, in general, is more capital-intensive than agriculture; and therefore, puts capital-short LDCs at a comparative dis-

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advantage vis-à-vis industrialized nations in international markets.<sup>1</sup> To the extent that high-technology industries may be more capital-intensive than the average manufacturing industry (especially if one includes the investment in R & D and the development of human capital), the comparative disadvantage of LDCs would presumably be even greater in this area.<sup>2</sup> Manufactured goods also require access to technology and modern manufacturing methods that LDCs may not possess or must obtain—at great cost, and with some time lag—from industrialized countries.<sup>3</sup> If economies of scale are high in a particular industry, then LDCs may suffer a further handicap because their home markets are typically smaller than those of industrialized nations. Finally, the export of manufactured goods poses a variety of marketing barriers that LDC firms may be unable to surmount, especially in the case of high-technology or differentiated products.<sup>4</sup>

The actual record shows that, despite the above barriers, a few LDCs—the so-called newly industrializing countries (NICs)—have registered impressive growth rates in the export of manufactured goods in the last ten–fifteen years, with much of those exports going to the industrialized countries.<sup>5</sup> However, almost 40–50 per cent of those exports have their origin either in LDC-based subsidiaries of MNCs,<sup>6</sup> or in local private firms manufacturing under contract for multinational buying groups;<sup>7</sup> with the former being relatively more important in NICs that have followed the import-substitution-industrialization route, and the latter being more important in LDCs following the export-oriented industrialization route. There is also evidence that the involvement of MNCs, whether as buyers from or investors in LDCs, is greater in those manufactures characterized by product differentiation or other marketing barriers.<sup>8</sup> LDC exports of manufactures that do not depend on MNC involvement consist largely of traditional goods or standardized products such as handicrafts, leather products, processed foods, steel, cement, rayon, etc. Links with MNCs seem to be essential for LDCs to overcome technology, scale, or marketing barriers.

When the firms involved in LDCs happen to be government-owned, the entry barriers discussed above may become compounded with even more restrictions specific to state-owned enterprises. Jones and Wortzel [17] see the typical SOE

<sup>1</sup> This conclusion emerges from the work of authors like E. F. Heckscher and B. Ohlin in international trade theory. For a review of traditional trade theory and some of its limiting assumptions, see [33, pp. 19–21].

<sup>2</sup> Technology-intensive industries may not also be capital-intensive. In fact, W. H. Gruber, D. Mehta, and R. Vernon observed a negative correlation between these two variables in [12, pp. 124–25]. However, the measures of capital-intensity used in this study did not include investments in R & D and development of skilled labor.

<sup>3</sup> For a comprehensive review of the problems LDCs face in this regard, see [25].

<sup>4</sup> See, for instance, [27].

<sup>5</sup> Exports of manufactured goods by LDCs totalled U.S.\$44 billion in 1976, according to a study by D. Keesing and Phi Auh Plesch, "Recent Trends in Manufactured and Total Exports from Developing Countries," unpublished working paper, International Bank for Reconstruction and Development, June 1977, which is reported in [34, p. 51].

<sup>6</sup> See [21].

<sup>7</sup> See [14].

<sup>8</sup> See [27], for a study involving Colombian, Mexican, and Nicaraguan enterprises.

as being unable to stay on top of events in the international market place, unable to respond to those events quickly and flexibly or stick to commitments on delivery and quality, and unable to follow a consistent, long-term strategy; although they may have a comparative institutional advantage over private firms in raising capital. All these problems, according to them, would be more severe for SOEs trying to export differentiated products as opposed to standardized products, and for sales to MNCs as opposed to sales to other SOEs, foreign governments, or East European enterprises. Vernon sees a further institutional problem for SOEs trying to export non-standardized manufactures inasmuch as governments may hold them back from investing abroad in subsidiaries that are usually necessary to support sales of such products [32].

The overall conclusion emerging from the above discussion is that LDCs can expect several barriers to successful export of manufactured goods, especially if those efforts do not involve MNCs, and that the export marketing barriers would be more severe for non-standardized goods than for standardized goods, and more severe for SOEs than for private firms (especially when the foreign customers are not other governments or SOEs).

In light of the above conclusions, Embraer of Brazil stands out as both an exceptional LDC-firm and an exceptional SOE. Its business is fairly capital-intensive, its products technologically complex, and its industry highly concentrated globally; yet it has exported 40–50 per cent of its output in recent years, its principal foreign markets have been the industrialized countries (the United States, France, and Britain) which are being served by two wholly-owned foreign subsidiaries, and it has relied very little or not at all on MNCs for technology and assistance in international marketing. What is more, in 1984, Embraer was just a fifteen-year-old organization. How did these results come about?

Data for research on this question was collected from trade journals, company documents, annual reports, etc. and through extensive, on-site interviews with officials belonging to Embraer, the Brazilian government, and some of Embraer's American competitors.

## II. EMBRAER'S NATIONAL AND INTERNATIONAL POSITION

In 1983, Embraer's product-mix was comprised of seven product lines, of which the following five had been developed locally (see Table I): a non-pressurized nineteen-seater turboprop (Bandeirante); an agricultural aircraft (Ipanema); a pressurized turboprop (Xingu); a military trainer (T-27); and, under advanced stages of development in 1983, a pressurized thirty-seater turboprop (Brasília) aimed primarily at the foreign commuter airline market. Planes manufactured to foreign design included a military attack aircraft (Xavante), and seven varieties of recreational and business aircraft produced since 1974 under license from the Piper Aircraft Company of the United States. Except for the Xavante, all of Embraer's aircraft fit into what is usually described as "general aviation."<sup>9</sup>

<sup>9</sup> The average price of such planes varied from as low as U.S.\$20,000–40,000 to U.S.\$1.5 million in the United States, according to [26, pp.184–85].

TABLE I  
EMBRAER'S PRODUCTS AND MARKETS

Product Line / Model	Year First Manufactured	Use	Main Target Market	Total No. of Units Manufactured, 1969-80
I. Indigenously designed aircraft				
A. Bandeirante				
1. EMB-110	1972	Military liaison transport (12 passengers)	Air force	60
2. EMB-110C	1973	Commercial transport (15 passengers)	Domestic airlines	37
3. EMB-110E/J	1975	Executive transport (7-8 passengers)	Local companies	16
4. EMB-110P	1975	Passenger feederliner (18 passengers)	Domestic airline	20
5. EMB-110S1	1976	Geophysical survey (2 passengers)	Air force	1
6. EMB-110B1	1976	Convertible pass-cum-aerial photography (14 passengers)	Private operator	3
7. EMB-110B	1977	Aerial photogrammetric (5 passengers)	Air force	6
8. EMB-110K1	1977	Cargo-paratrooper	Air force	20
9. EMB-110P2	1977	Passenger feederliner (18-19 passengers)	Foreign airlines	34
10. EMB-111	1977	Maritime patrol aircraft	Air force	18
11. EMB-110P1	1978	Mixed passenger-cargo transport	Foreign airlines	109
			Total Bandeirante	324
B. Ipanemas				
1. EMB-200	1972	Agricultural spraying aircraft	Domestic farmers & private sprayers	49
2. EMB-200A	1974	Improved version of EMB-200	Domestic farmers & private sprayers	56
3. EMB-201	1974	More Payload and power than EMB-200A	Domestic farmers & private sprayers	203
4. EMB-201A	1976	Improved version of EMB-201	Domestic farmers & private sprayers	112
			Total Ipanemas	420
C. Xingu				
1. EMB-121	1976	Executive transport (pressurized) (6-7 passengers)	Domestic private sector and air force	66
D. T-27 <sup>a</sup>				
E. Brasilia <sup>b</sup>				
	1983	Military trainer (turboprop)	Air force	
	1983	Commuter aircraft	U.S. commuter airline market	

TABLE I (Continued)

Product Line / Model	Year First Manufactured	Use	Main Target Market	Total No. of Units Manufactured, 1969-80
<b>II. Manufactured under license</b>				
<b>A. Xavante</b>				
1. EMB-326GB	1971	Military trainer and ground attack aircraft	Air force	167
<b>B. Piper-model aircraft</b>				
1. "Carioca" EMB-710	1975	Piper's Dakota (1+3 passengers)	Domestic private sector	272
2. "Corisco" EMB-711	1975	Piper's Arrow (1+3 passengers)	Domestic private sector	338
3. "Tupi" EMB-712	1978	Piper's Archer (1+3 passengers)	Domestic private sector	80
4. "Minuano" EMB-720	1975	Piper's Saratoga (1+5 or 6 passengers)	Domestic private sector	145
5. "Sertanejo" EMB-721	1976	Piper's Saratoga S.P. (1+5 or 6 passengers)	Domestic private sector	169
6. "Seneca" EMB-810	1975	Piper's Chieftain (1+7 or 9 passengers)	Domestic private sector	395
7. "Navajo" EMB-820	1975	Piper's Seneca III (1+5 or 6 passengers)	Domestic private sector	124
			Total Piper-type aircraft	1,523

Source: Compiled from company records.

Note: All Bandeirante, Xingu, and Brasilia models have twin-turboprop engines, all Ipanemas and Piper models have single-piston engines, and Xavantes have twin-turbojet engines.

<sup>a</sup> Deliveries began in 1983.

<sup>b</sup> Prototype flown. No commercial production before 1985.

Embraer's domination of the protected Brazilian market for general aviation is not entirely surprising. It has been practically the only supplier since 1972 of agricultural aircraft and light transport planes, and since 1975, of recreational and business planes. It has also supplied 65 per cent of the Brazilian Air Force's requirement for military aircraft (measured in numbers, not value).<sup>10</sup> Two private companies in the industry, NEIVA and AEROTEC, accounted for 13 per cent of the national production of aircraft between 1969 and 1979, selling almost entirely to the Brazilian Air Force.<sup>11</sup> By 1980, however, NEIVA had run into financial difficulties and been acquired by Embraer, while AEROTEC had become an important subcontractor to the emerging "national champion," whose planes

<sup>10</sup> Reported in [10, 1981 edition, p. 5].

<sup>11</sup> Reported in [9, 1980 edition, p. 21].

TABLE II  
EMBRAER'S EXPORTS, 1973-82

A. Total Sales and Exports, 1973-82	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Sales (U.S.\$ million)	36.3	53.6	79.2	112.3	102.8	115.0	171.6	171.3	237.3	205.7
Exports (U.S.\$ million)	—	—	5.0	20.7	12.1	38.0	70.0	85.0	102.7	95.0
Share of Exports (%)	—	—	6.0	18.7	11.7	33.0	40.8	49.6	43.4	46.2

Source: Compiled from company records.

Note: For details on exchange rates used to convert Brazilian cruzeiros into U.S.\$, see note to Table V.

B. Product-wise Direction of Embraer's Exports, 1975-82

Type of Aircraft	Less Developed Countries (LDCs)			Developed Countries (DCs)				Grand Total	% for LDCs	% for DCs
	Latin America	Africa	Other	Total	U.S.A.	France	Others			
Bandeirante	30	7	13	50	76	10	47	133	183	73
Xingu	1	2	—	3	—	41	7	48	51	94
Ipanema	13	—	—	13	—	—	—	—	13	0
Xavante <sup>a</sup>	10	6	—	16	—	—	—	—	16	0
T-27	—	—	—	—	—	—	3	3	3	100
Total	54	15	13	82	76	51	57	184	266	69

Source: Compiled from company records.

<sup>a</sup> This is the only type of aircraft exported by Embraer that is manufactured under license.

TABLE III  
BACKGROUND INFORMATION ON LEADING U.S. COMPANIES IN GENERAL  
AVIATION INDUSTRY RELATIVE TO EMBRAER

Description	Top Three U.S. Companies			Embraer
	Beech	Cessna	Piper	
Age in 1983 (Year)	51	56	53	14
Sales in 1981 (U.S.\$ million)	619.7	895.7	368.8	237.3
Planes manufactured in 1981 (No.)	1,242	4,680	2,495	265
Cumulative production: inception to 1982 (No.)	46,000	173,191	125,000	2,748
Exports as a percentage of total sales in 1981 (%)	30.6	26.2	23.5	43
Worldwide dealer network in 1983 (No.)	138	612	350	19

Sources: All data on Embraer obtained from annual reports and other company records. Data on U.S. companies obtained from their annual reports and/or concerned corporate staffs.

accounted for 89 per cent of all new aircraft registered in Brazil in 1979.<sup>12</sup>

Embraer's growing involvement in foreign markets is what is truly surprising (see Table II), especially because the international general aviation industry has traditionally been concentrated in the United States, where about a dozen firms have accounted for almost 90 per cent of the "free world's" production.<sup>13</sup> In 1981, 65 per cent of the U.S. production was accounted for by just three firms—Beech, Cessna, and Piper. These long-established firms (see Table III), with R & D expenditures running typically at 4–6 per cent of sales,<sup>14</sup> are the only full-line producers of general aviation aircraft in the United States; the other firms in the United States typically concentrate on one or two of the general aviation lines: for example, Gates primarily manufactures business jets, while Swearingen (a subsidiary of Fairchild Industries) concentrates on turboprops. The dominant trio in the United States has also largely avoided foreign investment all these years even though foreign sales have accounted for 30 per cent of their production. Only in recent years have Cessna and Piper (but not Beech) commenced local manufacturing or assembly operations in some foreign markets. The U.S. general aviation market with estimated sales of U.S.\$2.9 billion in 1981 is by far the largest in the world.<sup>15</sup>

<sup>12</sup> According to communication received from Embraer in 1980, the Brazilian Aeronautics Register shows that 322 of the 362 new planes registered in 1979 were manufactured by Embraer. However, only 1,632 out of the total 6,490 planes on the register in 1979 were of Embraer origin (i.e., 25 per cent).

<sup>13</sup> Reported in [13, pp. 1–2].

<sup>14</sup> Beech and Piper would not divulge the magnitude of their R & D outlays. But Cessna's outlay in 1982 was U.S.\$52 million on sales of U.S.\$831 million (6 per cent), according to a speech made by the company's chairman in April 1983. This estimate is also consistent with data reported in *Business Week's* annual survey of R & D expenditures in American industry (July 2, 1979 issue, pp. 52–72).

<sup>15</sup> According to [30, p. 5].

Comparative data on Embraer and the industry giants set out in Table III indicate that the latter are about 4 times as old as Embraer, 1.5–4 times as big in sales volume, manufacture 5–17 times as many aircraft annually, have cumulative experience in the industry that is even more disparate, and have well-established international dealer networks. Altogether, these facts indicate that the capital, technological, and marketing barriers to entry are high in this industry. It must be added, however, that Embraer's size and experience are less disparate in relation to some of the smaller U.S. firms: for instance, Swearingen-Fairchild is only ten years older than Embraer and had manufactured only 500 turboprops from inception to 1982 as opposed to Embraer's tally of 423.<sup>16</sup>

Outside the United States, there are prominent manufacturers of general aviation in countries such as Canada (de Havilland, Canadair), France (Aerospatiale), Britain (British Aerospace), Germany (Dornier, VFW-Fokker), and Spain (Construcciones Aeronáuticas S.A.). Among the developing countries, the only ones with an aircraft industry of any significance are Argentina, Brazil, India, Indonesia, and Taiwan. Of these countries, only Brazil has achieved significant results in exports.

Exports as a percentage of Embraer's sales have shown a secular increase between 1973 and 1982, rising to well over 40 per cent in recent years (see Table II). Apart from a few Xavantes, the rest of Embraer's exports have been comprised of three indigenously designed planes, the Bandeirante, the Ipanema, and the Xingu. Further, developed country markets have accounted for 69 per cent of total exports, with 41 per cent of that going to the United States alone. One analyst makes the interesting observation that there were more Americans flying daily in the Bandeirante in 1981 than there were Brazilians flying in the same aircraft.<sup>17</sup> Company officials estimate Bandeirante's share in the U.S. commuter airline market as being 17 per cent of passenger-seats flown in 1982, while its share in the addition to the U.S. commuter aircraft fleet in 1981 was 46 per cent.<sup>18</sup> The Bandeirante's main competitors in foreign markets have been the Beech B-99 and C-99, Swearingen's Metroliner (a larger, pressurized, more expensive turboprop) and de Havilland of Canada's Twin Otter (an older turboprop well-suited for short takeoff and landing operations).

Embraer's new line, the Brasília, is scheduled to be sold by 1985, and will compete with new turboprops being designed for the same market segment (thirty-seater, commuter aircraft) by de Havilland of Canada and by a joint venture between Saab-Scania of Sweden and Fairchild-Swearingen of the United States. The first prototype of the Brasília was flown in July 1983, by which time the

<sup>16</sup> According to [15, Vol. 36, No. 4 (April 1982)], Swearingen produced its 500th turboprop in mid-March 1982. Embraer's tally was obtained from company documents.

<sup>17</sup> Reported in [6, p. 1].

<sup>18</sup> The number of turboprops in use by commuter airlines in the United States increased from 333 in 1980 to 415 in 1981, and 38 of the 82 additional turboprops acquired in 1981 were supplied by Embraer, according to information compiled by the U.S. International Trade Commission. This material was brought to my attention by my colleague, R. Sarathy.



company had already signed over 100 options for the aircraft, with nearly 75 per cent coming from foreign customers.<sup>19</sup> The United States is expected to provide a market for 200–250 Brasílias by the turn of this century. If all existing options mature into orders, Embraer aircraft could continue to account for over 40 per cent of all new planes acquired by U.S. commuter operators in the next few years.<sup>20</sup>

These facts show that by 1982 Embraer had emerged as a prominent, independent actor in the international general aviation industry. If success is measured by how *effectively* an SOE becomes a “national champion” in its industry (and not necessarily by how *efficiently* it does so), then it would seem that Embraer must be regarded as quite a success.

### III. EXPLAINING EMBRAER'S PERFORMANCE

As might be expected, a combination of factors have contributed to Embraer's performance. These are discussed in the rest of this section, keeping in mind the various barriers to entry and export discussed in the introduction to the paper.

#### A. *Development of Human Capital and Institutional Infrastructure*

Long before Embraer was created, several steps were taken by the Brazilian government to develop the human capital and institutional infrastructure required for a national aircraft industry. Further, Brazil, as a country, has sought and obtained technical assistance from abroad in the field of aeronautics in unusual ways in the course of last three decades, although Embraer has only limited dependence on foreign technology today. Once these two facts are recognized, the growth of Brazil's aircraft industry looks much less like an overnight miracle than it otherwise might.

In 1978, Brazil had nearly 25,000 scientists and engineers engaged in research and development in various sectors, a pool that was second only to India's among LDCs (excluding China) and several times that of the typical LDC [29, pp. 755–61]. In the field of aeronautics, Brazil's involvement also has a long history. For instance, in 1906, soon after the maiden flight by the Wright brothers in the United States, a Brazilian flew the first self-propelled, heavier-than-air craft in Paris. As early as 1910, a simple monoplane was built in Brazil for the first time, followed by a military trainer biplane built in 1918, and a twin-engine airplane built in 1922. Series production of planes (trainers for flying clubs) was started for the first time in 1936.<sup>21</sup> A chronicler of Brazil's aircraft industry estimates that some 700 prototypes in all have been built since 1910, mostly by foreign-

<sup>19</sup> Reported in [9, 1982 edition, pp. 41–42].

<sup>20</sup> Based on data from U.S. commuter operators' outstanding orders as reported in [2, pp. 64–67].

<sup>21</sup> Extracted from tables in Embraer document referred to earlier; see tables entitled “The Pre-Embraer Phase of Brazilian Aeronautics” and “The Pioneering Phase of Brazilian Aeronautics” [9, 1980 edition, pp. 28–29].

educated Brazilians who did it simply because they enjoyed it. Only a handful were ever commercially exploited [3]. A French government study conducted in the 1960s is reported to have observed that Brazilians were the single largest group of foreigners studying aeronautical engineering in French universities.<sup>22</sup> In short, there was a certain scattered but significant human capital available in Brazil for developing a national aircraft industry long before Embraer was created.

Active state involvement in aeronautics began in 1941, when a Ministry of Aeronautics was created to assume control of both civil aeronautics and the Brazilian Air Force. Five years later, this ministry created the Aeronautics Technical Center, now called the Aerospace Technical Center (CTA), to sponsor and undertake projects in the aircraft sector. Simultaneously within the CTA, the Instituto Tecnológico de Aeronáutica (ITA) was created and staffed by specialists from the Massachusetts Institute of Technology to train aeronautical engineers for Brazil.

In 1950, some fifty German specialists, rendered unemployed after the war, were brought by the aeronautics ministry to the CTA to help develop a revolutionary helicopter and a combat aircraft. A new research center called the Instituto de Pesquisa e Desenvolvimento (IPD) was specially created for this group. Although four years and several million dollars later, this project was declared a failure and abandoned for a number of reasons, the Brazilians involved in it reportedly gained valuable technical expertise in the process.

Prior to Embraer's birth, the aeronautics ministry and the air force also tried to develop an aircraft industry in the private sector through a combination of financial and marketing assistance. One private firm, CAP, survived from 1942 to 1948, while NEIVA (founded 1953) and AEROTEC (founded 1962) manufactured several hundred single-piston engine trainers for the air force. Neither of these companies, however, was ever financially very strong or willing to risk the development of larger, more sophisticated planes than the simple trainers they were producing all along. Nevertheless, these companies were able to become important suppliers and subcontractors for Embraer in later years.

It was only in 1965, seven years after the unsuccessful experiment involving the Germans had been abandoned, that project "IPD-6504" was started in the aircraft design group of CTA's research center (IPD) with the objective of developing the prototype of a Brazilian transport plane that could replace an aging fleet of Beech 18s for the air force. This project was headed by a French designer, Max Holste, who provided both expertise and credibility to the endeavor, although the real impetus came from Ozires Silva, head of the aircraft design group of IPD and a captain in the Brazilian Air Force. Following the unexpected success of this project in 1968, when the first prototype was successfully flown, the government created Embraer to establish series production of the plane, known thereafter as the Bandeirante. At the same time, the aeronautics ministry seems to have decided to make Embraer the "national champion" in the aircraft

<sup>22</sup> According to Mr. Ozires Silva, President, Embraer.

industry: about 150 engineers and technicians from the CTA (including Ozires Silva) who had worked on project IPD-6504 were transferred to Embraer; another IPD project to design an agricultural aircraft (funded by the agriculture ministry) was also shifted to Embraer; and the air force decided to route through Embraer its purchases of a new military attack aircraft (known in Brazil as the Xavante) from Aeromacchi of Italy. The latter enabled Embraer to obtain the know-how for establishing series production of the Xavantes, a skill that was then applied to the production of the Bandeirantes.<sup>23</sup> As part of the agreement with Aeromacchi, about twenty Brazilians received training in Italy and a handful of Italian experts spent extended periods at Embraer's plant in São José dos Campos, where the CTA and the ITA were also located.

Thus, before Embraer was created in 1969, the Brazilian government had invested considerable resources in building a technical and institutional infrastructure and a reservoir of human capital that made possible the development of the Bandeirante in the late 1960s and facilitated Embraer's rapid growth thereafter. It is interesting to note how technology was "unbundled" by the aeronautics ministry and obtained very selectively over a long period of time—sometimes to help start a training institution, sometimes to build local R & D skills in association with foreign designers, and sometimes to obtain a missing element in the portfolio of skills required for series production of aircraft.

#### B. *Size of the Home Market*

Even though Brazil is classified as an LDC, its national fleet of civilian aircraft is among the fourth or fifth largest in the world (excluding China and the Soviet Union) and one of the top two in its rate of growth (see Table IV), thanks to a land area greater than that of the continental United States, a difficult terrain, and rising per capita incomes in the late 1960s and 1970s. In fact, the Brazilian market is significantly smaller only than the U.S. and Canadian markets, and about the same size as the Australian, British, French, and German markets; and significantly larger than the Japanese, Swedish, and Swiss markets. These general patterns hold for other indicators of market size, such as the number of general aviation aircraft registered, number of valid civilian aircraft licenses at year-end, and the volume of scheduled and nonscheduled airline traffic.<sup>24</sup> In short, the home markets has been a source of strength rather than weakness for Brazil insofar as the aircraft industry is concerned.

The figures in Table IV do not include military aircraft, which is an important line for most aircraft manufacturers (including general aviation manufacturers). Here again, Brazil has been able to provide a fairly big market for Embraer, with the Brazilian Air Force being both an important and a cooperative customer.

<sup>23</sup> Although the production of Xavantes contributed positively to Embraer's financial results in the early years, the most important benefit it provided, according to Mr. Pessotti, Embraer's technical director, was know-how in areas like tracing technology, technical documentation, production planning, quality control, tooling, etc.

<sup>24</sup> See [16, 1981 edition, Tables 2-1 and 2-4].

TABLE IV  
CIVILIAN AVIATION MARKET IN SELECTED COUNTRIES

Country	Civil Aircraft on Register <sup>a</sup> (No.)						General Aviation <sup>b</sup> 1981	
	1971	1976	1981	Rank in 1976	Growth Rate 1971-81 (%)	Rank	No. of Air- craft	Rank
Brazil	3,316	5,371	6,896	5	7.60	2	5,970	4
Canada	11,851	19,186	23,663	2	7.16	4	13,666	2
France	5,140	6,238	6,464	3	2.32	9	6,193	3
India	n.a.	n.a.	612	n.a.	n.a.	n.a.	n.a.	n.a.
Japan	983	1,174	1,486	8	4.22	7	637	9
Mexico	n.a.	n.a.	4,482	n.a.	n.a.	n.a.	3,602	6
Sweden	1,035	1,146	1,329	9	2.53	8	1,200	8
Switzerland	1,091	1,363	1,745	7	4.81	5	1,607	7
U.K.	2,858	4,493	n.a.	6	9.47 <sup>c</sup>	1	5,891	5
U.S.A.	164,510	203,034	n.a.	1	4.30 <sup>c</sup>	6	n.a.	1
West Germany	4,338	6,218	n.a.	4	7.47 <sup>c</sup>	3	n.a.	n.a.

Sources: [16, 1976 edition, Table 2-1] [16, 1981 edition, Tables 2-1 and 2-4].

<sup>a</sup> Includes all commercial and non-commercial aircraft in civilian operation. The bulk of this (90 per cent) is accounted for by general aviation aircraft with maximum takeoff weight less than 9,000 kilograms. Data for some countries for some years are missing in original source.

<sup>b</sup> For International Civil Aviation Organization purposes, general aviation activities are classified into instruction flying, business and pleasure flying, aerial work, and other flying.

<sup>c</sup> Relate to the period 1971-76 only.

### C. Government Orchestration of the Home Market

The Brazilian market for general aviation—both civil and military—has not only been large but also effectively manipulated to Embraer's advantage by the ministry of aeronautics.

First, the ministry itself provided a large market for Embraer's products through the air force, which is the single most important customer in the home market, accounting for about 75 per cent of Embraer's domestic sales since inception. All Xavantes and about half of all Bandeirantes sold in the home market have gone to the air force.

Second, the air force was a most cooperative buyer, placing large orders upfront for new types of planes in addition to paying for their development: 80 planes in the case of the original Bandeirante; 112 planes in the case of the Xavante; 20 planes and 11 planes, respectively, in the case of the cargo-trooper and maritime versions of the Bandeirante; and 118 planes in the case of the T-27 trainer. In addition, the air force permitted Embraer to take advantage of unexpected market opportunities for the Bandeirante by diverting planes meant for the air force to private customers.

Third, the aeronautics ministry effectively blocked imports of products equivalent to those manufactured by Embraer, especially after the oil crisis of 1974

led to an overall tightening of imports by Brazil and empowered the ministry to carefully scrutinize individual import applications. Import procedures were made cumbersome, and duties varying from 0 per cent for aircraft not manufactured in Brazil to 50 per cent for general aviation of the Piper variety were imposed. Before Embraer started producing the Piper-type of aircraft under license, import duty on such aircraft had been only 7 per cent.<sup>25</sup>

Finally, the aeronautics ministry used its regulatory power to increase local demand for Embraer's products, the most important example of which was the rapid growth of regional airlines in Brazil after 1973. This was the weakest tier in Brazil's three-tier airline network and was also a good target market for the Bandeirante, which until then had been sold only to the air force. The government imposed a 3 per cent levy on all long-distance air travellers, and used the proceeds to provide subsidized loans to regional airlines for buying Bandeirantes and then also subsidized their operations.<sup>26</sup> The air force accepted an arrangement whereby every other Bandeirante meant for its use could be diverted to the regional airlines. By 1977, Embraer had sold the regional airlines over thirty-seven Bandeirantes [31, p. 233].

The aeronautics ministry's ability to create a supportive environment for Embraer's growth was undoubtedly aided by the fact that it was not only responsible for supervising Embraer, but also had authority over the air force, the CTA, the ITA, the airline industry, and the aircraft industry (NEIVA, AEROTEC, etc.) from the very beginning. This enabled it to provide technical, financial, marketing, and regulatory support to Embraer in a potent and coordinated way, and eliminated inter-ministerial wranglings that might have occurred if responsibility had been more fragmented within government.

#### D. "Venture Capital" for Embraer

The special ability of SOEs to raise large amounts of capital at relatively low cost is well recognized in the literature.<sup>27</sup> But in the case of Embraer, venture capital was generated using a scheme that was unusual even for SOEs, and reflected the Brazilian government's unsuccessful efforts to induce private firms to take a leadership role in this sector. In 1968, soon after the successful flight of the first Bandeirante prototype, the Brazilian government offered the design for this aircraft free of charge to any private firm willing to commercialize it and also offered an up-front order for eighty Bandeirantes. However, no private party, including NEIVA and AEROTEC, was willing or able to make what was regarded as a risky investment and one tied too closely to the government. Besides, in the late 1960s, Brazil offered more attractive opportunities to a private investor.<sup>28</sup> According to a historical overview prepared by Embraer:

Considering the relative scarcity of capital in Brazil and the abundant opportunities for profiting from that available, it is not surprising that no sources of private capital

<sup>25</sup> According to [5, p. 35].

<sup>26</sup> See [7, p. 66].

<sup>27</sup> See, for instance, [11, pp. 257-80].

<sup>28</sup> For a review of the economic boom in Brazil around the time Embraer was created, see [4].

could be found for such a "risk scheme." To solve this problem, the Federal Government decided to undertake sponsorship of a company to be financed by a tax allocation system and make that company an instrument for other new aircraft programs also needed by the country. [9, 1983 edition, p. 8]

Multinationals, too, showed little interest in starting aircraft manufacture in Brazil, least of all to an unproven indigenous design. Among them was Fokker Aircraft of Holland, which was reportedly approached because it had worked in Brazil for the air force between 1941 and 1947. When all these options were exhausted, the Brazilian government decided to create an SOE. Wishing perhaps to maintain at least the semblance of private enterprise, however, the government created Embraer as a "mixed enterprise."

Technically, only 7 per cent of the equity in Embraer in 1981 belonged to the government (see Table V); in fact, all of it should be regarded as government equity. The so-called private equity in Embraer's share capital (U.S.\$179 million in 1982) was provided over the years by 223,687 Brazilian public and private companies under a tax incentive scheme, which allowed Brazilian corporations to invest up to 1 per cent of the income tax owed by them to the federal government each year in Embraer stock and to offset income tax payments to the same extent. The scheme was voluntary, but few companies preferred the alternative of paying taxes to that of investing in Embraer, which at least held the possibility of yielding a return. The Presidential decree creating Embraer envisaged that the company would enjoy this privileged financing only up to 1975,<sup>29</sup> but it has been extended twice and is now due to run out in 1985. In exchange for these funds, corporate investors were provided *nonvoting* stock, which was not listed in the stock exchange, while the government, through the aeronautics ministry, controlled 51 per cent or more of the voting stock, as required by the decree creating Embraer. In fact, between 1970 and 1981, the government's share of voting stock increased marginally from 51.0 per cent to 54.4 per cent, while its share in *total* equity fell from 82 per cent to only 7 per cent (see Table V).

The fiscal incentive scheme provided growing amounts of funds to Embraer over the years, totalling U.S.\$251.8 million up to 1982, which permitted Embraer to finance the development of the Xingu (estimated cost: U.S.\$80 million at 1981 prices) and the Brasilia (estimated cost up to mid-1983: U.S.\$250 million), without running into the red, and, until 1981, almost totally free of long-term debt (see Table V). The cost of capital raised through the incentive scheme (measured as the ratio of dividends to total shareholders' funds) never exceeded 2.8 per cent, as shown in Table V. The token dividend paid since 1974, one year before the fiscal incentive scheme first ran out, was more likely meant to be a *reminder* to shareholders to keep sending in their annual contributions rather than to provide them a *return* at market rates, which have been much higher in Brazil even for less risky investment. The real interest rates paid by Embraer on government-guaranteed, long-term debt raised after 1981 (U.S.\$100 million) ranged from 7.2 per cent to 22.2 per cent [8].

The other principal source of capital for Embraer has been the air force,

<sup>29</sup> Decreto Lei No. 770 of August 19, 1969, Article No. 7.

TABLE V  
FINANCIAL STATISTICS ON EMBRAER

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Sales (U.S.\$ million)	6.7	5.9	29.1	36.3	53.6	79.2	112.3	102.8	115.0	171.6	171.3	237.3	205.7
Government share of total equity (%)	81.9	50.7	31.3	21.7	16.3	16.0	16.0	12.7	10.8	9.2	8.0	7.1	n.a.
Government share of voting stock (%)	51.0	51.0	51.0	51.0	51.0	51.0	51.0	54.4	54.4	54.4	54.4	54.6	54.4
Fiscal incentive receipts (U.S.\$ million)	0.3	5.1	7.7	10.3	15.9	21.1	21.4	28.7	29.4	26.3	24.8	29.8	31.0
Profit (Loss) (U.S.\$ million)	(0.2)	0.4	1.4	3.5	7.3	7.5	5.2	0.002	3.5	9.4	(4.9)	14.3	1.8
Long-term loan / total asset (%)	0	0	0	0	0	0.05	2.0	4.0	3.0	2.0	0.09	27.0	26.0
Dividends (U.S.\$ million)	—	—	—	—	1.7	2.3	2.7	2.2	0.9	2.4	0	3.6	0.5
Dividends / sharehold funds (%)	—	—	—	—	2.8	2.5	2.4	2.2	0.7	1.5	0	2.1	0.08

Source: Company annual reports and internal records.

Note: Brazilian cruzeiros have been converted to U.S.\$ at the following rates: U.S.\$1=4.593 (1970), 5.287 (1971), 5.934 (1972), 6.125 (1973), 6.790 (1975), 8.129 (1974), 10.674 (1976), 12.144 (1977), 18.070 (1978), 26.945 (1979), 52.714 (1980), 93.125 (1981), 179.51 (1982).

which paid for the development of the original Bandeirante (a substantial but unknown amount), five of the ten variants of the Bandeirante developed thereafter, the Xavante (U.S.\$65 million), and the T-27 trainer (estimated cost: U.S.\$6.5 million).<sup>30</sup>

We turn next to the two main reasons why Embraer was able to overcome the "institutional barriers" that many SOEs face because of their links to government. First, the formal institutional design adopted for Embraer avoided from the outset some of the institutional problems encountered typically by SOEs. Second, Embraer's managers were able to neutralize most of the residual problems by skillfully handling relations with external groups (including government). These two factors, as we shall see, were not entirely unconnected, because Embraer's only chief executive since inception (Ozires Silva) also had a hand in shaping the institutional context within which he was to operate later on.

#### E. *Institutional Design Adopted for Embraer*

The formal institutional relationships designed for Embraer gave its managers a fair amount of discretion and relatively clear goals—both qualities that are generally lacking in SOEs.

The fiscal incentive scheme was perhaps the single most important structural source of autonomy for Embraer's managers, since it provided them with steadily increasing amounts of low-cost, long-term, *intervention-free* capital. At the same time, it transformed Embraer into a mixed enterprise by supplying the so-called private equity in the company, and avoided cumbersome legal procedures and controls that might have been necessary if Embraer had been created as a wholly government-owned company like Petrobrás or Eletrobrás. Instead, Embraer is governed by private company law, which provides for the usual board of directors, annual shareholder meetings, and so on. Embraer's board is controlled by the government through appointment of four out of the six directors, who are technically nominated by the President of Brazil in consultation with the ministers for aeronautics, planning, finance, and commerce and industry.<sup>31</sup> Private shareholders elect two directors to the board. At shareholders' meetings, however, the entire voting power on behalf of the government is exercised by a representative of the ministry of aeronautics.<sup>32</sup> In effect, therefore, the company's affairs, including decisions on how to spend resources raised under the fiscal incentive scheme, have been substantially under the control of the aeronautics ministry.

Embraer's legal status as a mixed enterprise has probably also created some pressure on the enterprise to pay attention to financial results, even though private shareholders have been quite dormant in the running of the enterprise. The presidential decree leading to the creation of Embraer hinted at this when it

<sup>30</sup> Figures supplied by Embraer were expressed in cruzeiros and were converted by the author to U.S. dollars at the exchange rate prevailing between 1970 and 1974 in the case of the Xavante and at 1980 rates in the case of the T-27 trainer.

<sup>31</sup> Empresa Brasileira de Aeronáutica S.A., Bylaws, Article 15, Sections 1 and 2.

<sup>32</sup> *Ibid.*, Article 14.



said that, as the company grew, it "must observe rational economic criteria, including the need to ensure minimum scale for efficient production."<sup>33</sup> By and large, this criterion has been observed by Embraer. In dealings with the air force, for instance, the latter has invariably paid for any special work done for it by Embraer, thereby preventing any blurring of financial accountability between the air force and Embraer. For similar reasons, Embraer has been able to turn down requests to produce certain kinds of aircraft (e.g., helicopters) for which the home market was not considered large enough by Embraer, and for which no one else was willing to subsidize or underwrite the costs involved.

It is not entirely clear whether the managerial implications of these aspects of Embraer's institutional design were fully recognized when they were adopted by the Brazilian government in 1969; rather, the design seems to have resulted from a desire to camouflage a government-owned company as a private company, since the latter was the preferred mode of industrial development in Brazil at that time.

#### F. *Role of Embraer's Leadership*

Embraer's success cannot be fully explained without attributing an important role to its top management, particularly Mr. Ozires Silva, who has headed the enterprise since inception. In a sense, Silva is the entrepreneur, or more precisely the "public entrepreneur,"<sup>34</sup> who founded Embraer. While a captain in the air force and head of the aircraft design group of the CTA, he obtained approval for the project to develop the Bandeirante prototype in the air force labs against considerable resistance and skepticism.<sup>35</sup> He then successfully implemented the project, later worked to create an SOE to commercialize that design, and finally, as chief executive, provided a coherent strategy to make that SOE a "national champion." SOEs often suffer from the lack of managerial autonomy and motivation; but at Embraer it was quite the opposite. Silva and his team were highly motivated, enjoyed considerable autonomy, and enjoyed continuity in office that is quite unusual for SOEs, whether in Brazil or elsewhere. In 1983, five out of Embraer's six internal directors (including Silva) had been in their positions since the company's inception, and until shortly before, so had the sixth. What is more, three of those directors were part of the original air force team that worked on the Bandeirante project between 1965 and 1969.

The relatively high autonomy and continuity enjoyed by Silva and his team was probably influenced by a number of factors. First, there was a measure of financial and institutional autonomy built into the formal structure of the enterprise, as discussed in the previous section. Silva himself had a hand in designing this structure, including the idea of using the fiscal incentive scheme, when he

<sup>33</sup> Translated from original Decreto Lei No. 770, Article 2, Section 2.

<sup>34</sup> For an elaboration of this concept, see [24].

<sup>35</sup> The proposal was rejected at least twice by the air minister before Ozires Silva got it approved. Apparently, the minister was reluctant to allocate money for aircraft projects after the fiasco involving the German specialists between 1954 and 1958. Finally, Silva offered to execute the project without any formal budgetary allocation, whereupon it was approved. Silva then persuaded different parts of the air force and the CTA to pick up the material and personnel costs of the project.

represented the air force, an inter-ministerial task force set up in 1968 to decide how to commercialize the Bandeirante design. Second, Embraer's relations with the air force have been very positive; partly because of Silva's own background, partly because both organizations have been under the same ministry, and partly because Embraer is still viewed as an extension or a "child" of the air force.<sup>36</sup> Given the concentration of power in the hands of the aeronautics ministry and the influence of the air force within that ministry, this must have been a big help. Third, the complex nature of the enterprise's technology and the steady stream of new products flowing out of Embraer (see Table I) have meant that the company could never afford to lose the Silva team. Finally, under Silva, the enterprise has produced one wave of success after another, thereby strengthening the position of the existing team. As one manager put it: "There is a saying in Brazil that if the football team is winning, why change the composition?"<sup>37</sup> Strong support for Embraer in the external environment is reflected in the fact that the fiscal incentive scheme, which should have run out in 1975, has been extended twice—first in 1975, and then in 1980. It is not beyond the realm of possibility that it will be extended again in 1985.

#### G. *Embraer's Business Strategy*

The high level of managerial autonomy and long tenure of its top management allowed Embraer to follow a fairly consistent business strategy. Four aspects of that strategy are particularly important.

First, Embraer consistently focused on turboprop aircraft, not by accident but by a conscious decision to try to become one of the best turboprop manufacturers in the world, a goal that Embraer officials regard as being at once ambitious and achievable given their resources and competence. Thus, Embraer seems to have stayed away from developing small single- and twin-piston engine planes until it was urged strongly by government to include this line within the context of acute foreign exchange crisis in 1974 (Brazil's imports of such aircraft, mostly from U.S. suppliers like Beech, Cessna, and Piper, amounted to 508 and 540 planes in 1973 and 1974, respectively<sup>38</sup>). Although the technology involved in the production of such aircraft was not beyond Embraer's reach, the company preferred to borrow foreign technology for these lines from Piper and focus its own R & D efforts on turboprops.<sup>39</sup>

Second, Embraer consistently focused on the *design* of aircraft, the manufacture of the fuselage, and the final assembly operations, staying away from the manufacture of high-value, high-technology inputs such as engines, landing gear,

<sup>36</sup> Interview notes, conducted at São José dos Campos, Brazil, in June 1981.

<sup>37</sup> Interviews conducted at Embraer offices, June 1981.

<sup>38</sup> [10, 1981 edition, p. 17] which was compiled, in turn, from national civil aeronautics statistics.

<sup>39</sup> The only non-turboprop aircraft currently being developed by Embraer is the AM-X, a state-of-the-art tactical fighter, and involves a joint effort with two Italian firms Aer-macchi and Aeritalia. The Brazilian share (one-third) of the development cost (U.S.\$600 million) is being paid for in full by the air force.

and avionics. As a result, imported components account for a high proportion of the value of Embraer's products: 38 per cent in the case of the Bandeirante, 41 per cent in the case of the Xavante, 27 per cent in the case of the Ipanema, and between 47 and 71 per cent in the case of various models of the Piper aircraft.<sup>40</sup> This approach to manufacturing is, of course, fairly common in the aircraft industry; but somewhat surprising for an SOE, which could easily have strayed in other directions. At any rate, this approach conserved capital for Embraer for use in research and new product development, reduced risks, facilitated penetration of foreign markets (by increasing the value of equipment in Embraer aircraft that was supplied by reputed foreign manufacturers), and, for the same reason, also made it easier to meet foreign certification standards.

Third, Embraer continually upgraded or modified existing products to exploit or create new market opportunities. As shown in Table I, the company had developed eleven variants of the original Bandeirante and four variants of the original Ipanema by 1978. Further, the Xingu can be viewed, in some ways, as just a pressurized version of the Bandeirante, and the Brasília can be viewed as a stretched version of the Xingu.

The fourth aspect of Embraer's strategy, which is related to the point made in the earlier paragraph, is the systematic way in which it took up products of increasing technological and marketing complexity over the years. In the first phase (1969-73), Embraer concentrated on producing the Bandeirante in series, selling to a customer who posed the least marketing problems, namely the air force. In the second phase (1973-75), Embraer introduced the Bandeirante into a market segment that was somewhat more difficult to serve, namely the domestic private airline industry. In the third phase (1974-78), Embraer introduced the Xingu, a product that was technologically more complex than the Bandeirante (because it has a pressurized fuselage) and was primarily aimed not at the air force but at the local corporate sector. In the fourth phase (1975 onwards), Embraer went overseas with the Bandeirante, an aircraft that had established its quality and reliability in the home market, selling it first in developing countries and then in developed countries. In the fifth phase (1980 onwards), Embraer moved on to an even more complex product (the thirty-seater, pressurized Brasília), and is aiming it at an extremely difficult market, namely the developed nations. And in so doing, it is capitalizing on the demonstrated success of the Bandeirante in foreign markets. One thus finds Embraer "crawling" up the ladder of technological and marketing complexity in a planned way. Embraer's top management appears to have been instrumental in maintaining this kind of consistency in the enterprise's growth.

#### IV. EMBRAER'S INTERNATIONAL COMPETITIVENESS

Much of the previous discussion deals with factors that enabled Embraer to overcome technology, capital, and institutional barriers, and dominate the home

<sup>40</sup> According to information supplied to author by Embraer.

market. These were necessary but by no means sufficient conditions to penetrate foreign markets.

Although Embraer was a full-line general aviation manufacturer at home, its main product for foreign markets was the Bandeirante, which was portrayed as an efficient and reliable eighteen- to twenty-seater turboprop that was specially well suited for commuter operations. Therefore, most of the discussion in this section will pertain to exports of the Bandeirante, although it is true that Embraer exported a few agricultural and military aircraft and obtained one large order for forty-one Xingus from the French navy in 1981<sup>41</sup> (see Table II). Furthermore, the discussion will focus on Bandeirante sales to private buyers in developed nations as opposed to the relatively smaller volume of sales to foreign governments and government-owned airlines that was characteristic of Embraer's initial export successes in Latin America and Africa. In the United States, which was Embraer's biggest export market, the Bandeirante was quite competitive in terms of product characteristics, price, financing, and quality of after-sales-service.

The demand for a eighteen- to twenty-seater turboprop aircraft grew rapidly in the United States in the late 1970s for two important but unconnected reasons: first, the oil crisis increased the attractiveness of the noisy but fuel-efficient turboprop over the quieter but fuel-guzzling jet; second, the deregulation of the airline industry in the United States in 1978 led to spurt in the number of commuter operators who demanded small, efficient, and rugged aircraft for their businesses (sales of turboprops almost quadrupled in the United States between 1974 and 1981 [30, 1983 edition, p. 6]. The Bandeirante was well positioned to exploit these opportunities because it was one of the most recently designed turboprops available in the world. Both the seventeen-seater Beech B-99 and the nineteen-seater de Havilland Twin Otter (which had a fixed landing gear) were much older designs, while Piper flew its first prototype of an eleven-seater turboprop (the T-1040) only in 1981 [15, March 1982, pp. 268-69] [15, August 1982, pp. 757-58] and Cessna sold its first turboprop (the eight- to thirteen-seater Conquest) only in 1977. Fairchild-Swearingen, which for two decades produced mainly turboprops, offered a nineteen-seater turboprop that used a trouble-prone engine and was also more expensive because it was pressurized. Beech was the leader in the turboprop market in the United States but its popular King Air was aimed primarily at the business market [26, p. 183]. It was only in 1982 that Beech introduced an improved version of the B-99 turboprop (called the C-99) for the commuter market. In short, the Bandeirante served a "niche" that was largely neglected by the leading U.S. general aviation manufacturers.

The Bandeirante was also quite competitive in terms of price with its principal competitors, the Beech B-99 and the Fairchild-Swearingen Metro III. Embraer

<sup>41</sup> The French order for forty-one Xingus came mainly because the Xingu's landing and takeoff characteristics closely resembled those of jet aircraft used by the French navy. The Xingu had a big enough cockpit to accommodate most of the avionic equipment fitted in those jets, but its operating costs were lower because it was a turboprop. Therefore, it could serve as an efficient aircraft for training jet pilots. For similar reasons, the Belgian airline Sabena purchased three Xingus from Embraer.

did not suffer any cost disadvantage on account of the import content in the Bandeirante because it was exempt by presidential decree from Brazilian import duties on components. Neither did it suffer any disadvantage due to tariffs in Western Europe (where the Bandeirante escaped duties because it had a sufficiently high EEC content) and in the United States (where the import duty on general aviation was zero). Moreover, although the production of aircraft was fairly capital-intensive,<sup>42</sup> the average cost of capital to Embraer (though not to the country) was so low that capital-intensity may actually have been competitive advantage for Embraer vis-à-vis foreign competitors.

Even more important than price was Embraer's ability to provide foreign customers attractive financing through the Bank of Brazil, a source that was available to all Brazilian exporters of large projects and systems, public or private. Under such a financing package, Embraer could typically provide seven-year credit at interest rates as low as 7.5 per cent to 8.5 per cent per annum for up to 85 per cent of the price of a plane. In contrast, Fairchild-Swearingen reportedly demanded a down payment of 30–40 per cent of the price, and like Beech or Cessna, charged market rates of interest on outstanding balances (which in 1981 and 1982 were reportedly as high as 18–22 per cent [1, p. 96]. In 1982, Fairchild-Swearingen filed (and lost) a complaint with the U.S. Department of Commerce and the International Trade Commission demanding a countervailing duty of 39–44 per cent on the Bandeirante to offset the effective price advantage enjoyed by Embraer [1, p. 96]. In general, the terms of financing offered by U.S. companies to their foreign customers have been more stringent than those provided by Embraer to its foreign customers. Beech, for instance, traditionally expected non-U.S. buyers to pay the entire price of a plane in U.S. dollars before delivery [26, p. 186].

These advantages were offset by several weaknesses. Principal among these were Embraer's lack of experience in selling abroad, lack of a reputation or brand identification among foreign customers, problems in obtaining certification in each country, problems in translating manuals and technical documentation into foreign languages, problems in finding good agents and in providing reliable after-sales-service to customers.

Of these problems, the one that Embraer's managers regarded as most severe was not bureaucratic checks at home (arising out of state-ownership) but the process of obtaining certification in the United States from the Federal Aviation Administration (FAA). Between 1973, when Embraer first applied for certification from the FAA, and 1978, when it was finally granted, Embraer had to set in motion an inter-governmental process that led to the signing of a U.S.-Brazil bilateral agreement on aircraft certification. Then, the FAA refused to consider an application from Embraer directly since its services could only be provided

<sup>42</sup> Embraer's capital to labor ratio in 1976 (measured in 1970 prices) was 176,000 cruzeiros per man year, while the corresponding ratios for public enterprises in other sectors were 283,000 (mining), 227,000 (steel), and 169,000 (communications), according to T. J. Trebat [28, p. 180]. Trebat's data suggests that Embraer's capital-intensity is below the average for public enterprises and probably above average for all industry.

to U.S. taxpayers. So Embraer had to find a U.S. commuter operator willing to apply on its behalf. Embraer officials attributed delays in the processing of that application by the FAA to efforts by Cessna and some other U.S. manufacturers to block or delay Embraer's entry into the United States in retaliation for the high import duties on general aviation imposed by Brazil after the oil crisis.<sup>43</sup>

Once certification was obtained, Embraer did not face severe problems in finding foreign customers, possibly because of the several advantages it enjoyed. In France, Britain, and the United States, the first customer was also appointed agent for Embraer in that country and/or neighboring areas. A few years later, however, Embraer created two wholly-owned subsidiaries to sell and service its products in the United States (1980) and Europe (1983). Embraer was aggressive in marketing its products, and has participated so far in air shows at Paris (four times), Farnborough (thrice), Singapore (once), and Brazil (once). In 1979, soon after obtaining certification in the United States, Embraer took the Bandeirante on a fifty-one tour of the United States. In 1980, Embraer reportedly had one of the most impressive displays (a full-size mock-up of its new plane, the Brasilia) at the annual meeting of the Commuter Airlines Association of America. Embraer also systematically courted journalists from abroad and featured in a number of special reports in industry journals.

In general, Embraer seems to have been quite responsive to the needs of its foreign customers. In fact, in 1976, Embraer specially developed a stretched version of the Bandeirante with an additional rear door in response to an enquiry from the Federal Express Company of the United States. Although no orders eventually came from Federal Express, the effort involved led to the development of the stretched versions of the Bandeirante (EMB-110P1 and EMB-110P2) that later became Embraer's best-sellers abroad. Customer satisfaction with Embraer's after-sales service seems also to have been quite high. In 1982, when Fairchild-Swearingen filed its complaint with the U.S. International Trade Commission, several U.S. commuter operators reportedly testified in support of Embraer's products and service. The determination of Embraer's manager to provide such service is reflected in the fact that foreign subsidiaries were created for this purpose even though each time it called for a special decree signed by the President of Brazil. The equity investment in the U.S. subsidiary located at Miami, which is equipped with a simulator for pilot training and stocks critical spare parts, was U.S.\$11 million [8]. Since 1980, Embraer has also been organizing annual meetings in Brazil of international Bandeirante operators and international representatives (of whom there were altogether nineteen in 1983) with a view to obtaining feedback on the product's performance. Overall, therefore, Embraer does not seem to have suffered any special institutional handicaps in marketing or servicing its products abroad because it was state-owned although its managers may have had to work harder to implement what they did because of a somewhat more tedious decision-making process.

<sup>43</sup> See [22].

## V. CONCLUSIONS

From a policy standpoint, the Embraer case study suggests that SOEs *can* be used by LDCs—and sometimes *only* SOEs can be used by LDCs—to promote internationally competitive high-technology industries, although the odds of succeeding in such an endeavor are limited by the requirement that a number of necessary conditions—each one with a relatively low probability of occurring—must be simultaneously satisfied. These necessary conditions include: availability of human capital commensurate with the technological ambitions of the state venture; a large home market by international standards; an institutional design for the SOE that provides a measure of managerial autonomy and goal clarity; and the type of manager (“public entrepreneur”) who has the combination of motivations and skills that make one effective at the helm of SOEs.

Where technological learning is viewed as a main product rather than a by-product by government, as in the Embraer case, state participation in industrialization seems inevitable, even in a country like Brazil where the ideological preference was to employ private enterprise rather than an SOE. Brazil had a similar experience in the computer field where a government-controlled SOE became necessary after a *tri-pé*<sup>44</sup> arrangement collapsed in its very first year of existence. Besides the riskiness of the venture, an additional factor of some significance that seemed to discourage private investment in an aircraft company in Brazil was the relatively high dependence such a firm would have on government markets for survival.

The Embraer case also suggests that the state not only has special motivations for creating high-technology industries (due to their externalities), but also has special strengths in overcoming some of the entry barriers. Capital barriers are overcome with particularly great ease by the state, followed by marketing barriers in the home market, which are overcome using the state’s regulatory and purchasing powers. Technological barriers take the greatest time to overcome in the LDC context, even if the LDC (like Brazil) has a relatively large base of technical manpower. Brazil’s success in mastering aircraft technology looks *deceptively* simple and quick because of Embraer’s young age. Further, the greater the extent to which an LDC tries to unbundle the technical inputs it requires from abroad to launch a national industry, the longer (and riskier) the learning process is likely to be. LDCs must be careful not to underestimate this problem, which could offset the state’s enormous power in overcoming some other entry barriers.

The state’s ability to manage demand in the home market does not mean, of course, that it can indefinitely increase demand for an SOE’s products through artificial means. Therefore, the “natural” size of the home market—as well as the importance of the government as a customer in that market—are important determinants of a high-technology SOE’s chances of success. Brazil was fortunate, thanks to some unique national factors, to have a home market for aircraft that

<sup>44</sup> The *tri-pé* is a three-way joint venture in which a local private firm, a local state-owned enterprise, and a multinational enterprise are equal partners.

was very large even by international standards. This is an important advantage because a large home market allows the national firm to move up the learning curve, establish a track record, improve product design and manufacturing methods, and enjoy scale economies—in short, to use the home market as a springboard for entering foreign markets. Most LDCs cannot expect to enjoy this home market advantage in most high-technology industries.

Penetration of foreign markets also requires an SOE to be persistent, to be agile, and to follow a consistent long-term strategy, all of which are more likely if the institutional design used for the SOE involved provides greater autonomy and clearer goals than most SOEs enjoy. This aspect does not always receive the attention from government that it deserves, whereas governments typically spend considerably more time on selecting an SOE's product-mix, location, source of technology, etc. The idea of funding risky SOEs through something like the fiscal incentive system (which provides both capital and a measure of managerial autonomy) deserves more study for its wider applicability and potential costs and benefits.

Even with a supportive institutional design, SOEs are likely to face some organizational barriers to successful export marketing. For instance, they may not provide formal incentives for managers to make the determined and persistent efforts required for selling abroad; or political and bureaucratic controls may discourage managers from taking risks, adopting a long-term view, responding quickly to market requirements, or investing abroad in sales and service facilities. These residual barriers are certainly not insurmountable, as the Embraer case shows; but to neutralize those barriers an SOE requires that rare breed of managers—referred to here as “public entrepreneurs”—for whom *formal* incentives (including economic incentives) are less important than the *intrinsic* incentives SOEs can offer—such as the ability to create a new enterprise, and who are skilled at managing *both* business and political relationships.<sup>45</sup> Unfortunately, such individuals are rare; the chief executive of Embraer just happened to be such a person.

It is important to note, however, that when SOEs are “captured” by public entrepreneurs, they can turn into highly entrepreneurial and potent organizations because they combine the strengths of private enterprises (high managerial autonomy and flexibility) with the strengths of SOEs (preferential access to markets, capital, and other scarce resources). Although actual experience with SOEs suggests that this combination occurs only rarely, when it does the consequences are far-reaching (e.g., ENI of Italy under Enrico Mattei; Renault of France under Dreyfus; Finsider of Italy under Sinigaglia; BHEL of India under Krishna-murthy; etc.).

From the standpoint of corporate strategy, the Embraer experience highlights the importance of identifying a “niche” in international markets that LDC-SOEs could hope to dominate (e.g., turboprops for commuter airline operators) as opposed to competing across the board with established foreign firms. Ideally,

<sup>45</sup> In this context, see [19] [24] [35].



the niche selected should build on special strengths and skills gained by the SOE in tackling problems peculiar to its home market. Another lesson from the Embraer experience is that vertical integration in production must be made very carefully and cautiously because a higher use of imported components (e.g., engines, avionics, etc.) can reduce resistance to the product in foreign markets. A greater degree of vertical integration may be appropriate after the upcoming LDC-SOE has gained a foothold abroad. Of course, this approach may conflict with the LDC government's desire to use the SOE to maximize technological learning by substituting imports and continually integrating backwards, as has happened in the Indian state-owned aircraft company.

An important consideration that has not been addressed in the above discussion is the social cost at which a company like Embraer achieved the technological and market results it did. This would require a detailed social cost-benefit analysis, which is beyond the scope of this paper. Nonetheless, the insights provided by this paper could be of use to governments that have decided, regardless of cost-benefit calculations, to create a domestic high-technology industry using an SOE.

The Embraer case also has implications for MNCs, especially for the large number that rely on a technological lead as a source of bargaining power vis-à-vis LDCs. Obviously, MNCs should not dismiss all high technology SOEs as minor competitive threats. Occasionally, an SOE like Embraer cannot only shut out MNCs from foreign markets but even threaten the home markets of MNCs. The success factors discussed in this paper provide some clues as to the circumstances under which this might happen. MNCs may have to show greater flexibility in dealing with such SOEs on the principle that half a loaf is better than no loaf at all. Cessna's experience in Brazil illustrates the point. Up to 1974, Brazil was Cessna's most important foreign market and Cessna was Brazil's most important supplier of single- and twin-piston engine planes (with nearly a 60 per cent share of the market). In that year, the Brazilian government invited the three leading U.S. companies to submit proposals for joint manufacture of such aircraft in Brazil, with Embraer acting as the Brazilian partner, and under conditions that were quite demanding of the foreign partner. Cessna was reportedly so inflexible in meeting Brazilian demands that Embraer went ahead and signed an agreement with Piper even though Piper had only 19 per cent of the Brazilian market at that time [5, pp. 35-39]. In 1976, Cessna sold only five planes in Brazil while Piper exported 352 kits to the same market for assembly by Embraer.

From a positive standpoint, the Embraer case does not bring into serious question any of the dominant themes in the literature except for what seems like a misplaced emphasis on the effect of capital intensity on the ability of LDCs to compete in international markets *when the LDC firm happens to be an SOE*. The cost of capital to some SOEs may be so low—and Embraer provides an extreme illustration of this—that capital-intensity could even be a source of competitive advantage for them relative to foreign, private firms in developed countries, although from a social cost-benefit viewpoint, this might be undesirable.

Successful penetration of foreign markets with sophisticated manufactures by SOEs like Embraer is likely to remain an exception to the rule in LDCs for a long

time, but less so in the future than in the past. For one thing, the home markets of some SOEs in some NICs have been amongst the fastest growing in some industries (e.g., steel, fertilizers, oil refining, petrochemicals, etc.) and have, therefore, become large even in comparison to those of some developed nations (such as Italy, Spain, Sweden, United Kingdom, etc.). SOEs operating in such industries or selling engineering services/capital goods to such industries can be expected to enjoy a home market advantage in the international market. Second, the passage of time is likely to increase the number of import-substituting SOEs in NICs that turn to export markets for growth opportunities. Finally, a variety of factors—all correlated with time and organizational age—may increase the autonomy of SOE managers and thereby help them overcome some institutional barriers to exports.<sup>46</sup> Collectively, these factors may make SOEs more important exporters of manufactured goods in the future than in the past, and their share in the export of manufactured goods could become higher than it has been so far. This subject requires more study than it has received so far and the works of authors like Jones and Wortzel [17], Katz and Ablin [18], and Lall [20] need to be built upon in the future.

<sup>46</sup> For one view of the dynamic changes in behavior of SOEs, see [23, pp.352–55].

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