13
Offsets and the development of the Brazilian arms industry

Sam Perlo-Freeman

Introduction

As from the 1960s, Brazil's governments pursued a concerted strategy to establish a domestic arms industry. It had two purposes. First, an indigenous arms industry was seen as essential for national security and to secure Brazil's ambitions for great power status. Second, the industry was to reduce dependence on United States arms. For a third-world producer and exporter, the industry achieved spectacular success in the 1980s, then experienced an equally dramatic collapse following the end of the Iran-Iraq war in 1988, but is now showing signs of revival.

A crucial element of the development strategy for the arms industry was, and continues to be, the acquisition of military technology from industrialized countries through licensed and coproduction, joint ventures, and other forms of what is now described as direct offsets, though formalized offset policies for procurement are of more recent origin. This strategy fits well with Brzoska's (1995) "5 easy steps" to developing an arms industry: assembly, component production, licensed production, domestic design and production, and independent production with few imported components.

While some countries have spoken for offsets in terms of job creation or favorable balance of trade effects, in Brazil the promise of technology transfer was central and frequently formed a key requirement for procurement. This is similar to the approach taken by countries such as South Korea and Taiwan (see, e.g., Cheng and Chinworth, 1996). This strategy enabled Brazil to produce a wide range of weaponry approaching the technological frontier. But it has required the investment of substantial economic resources and has produced mixed commercial results.

This chapter reviews the history of the development of the Brazilian arms industry and the role of various forms of technology transfer in this process, from the beginnings of the industry in the 1930s to the present day. The chapter also assesses the success and failure of the strategy in technological and in economic terms. Following an overview of the evolution of Brazil's arms industry, I discuss the role of offsets, especially as it relates to technology transfer, and their economic and technological successes and failures.

The evolution of the Brazilian armaments industry

Background and early efforts

Commanding one third of the region's population and GDP, Brazil is Latin America's largest state. It had and has the subcontinent's largest armed forces and highest level of military expenditure (Perry and Weiss, 1986; BVC, 2002).[1] As a result, Brazil is a dominant power in the region and has entertained ambitions to become a world power. Nonetheless, Brazil maintains peaceful relations with its neighbors and has not been involved in a war within the region since 1870.[2] Brazil has accordingly maintained a low level of military expenditure as a share of GDP, usually around 1 percent. Her desire for military power relates more to long-term ambitions as a regional and global power than to any immediate threat to its borders.

Independence of arms supply was seen as essential to fulfilling Brazil's potential. Former Air Force Minister Joelmir Campos Macedo declared that "it is a condition of security that each nation manufacture its own armaments" (Kapstein, 1991, p. 584). Military industrialization was also seen as central to general industrialization. This led to a concerted, long-term (and costly) government effort to establish a domestic armaments industry, based on a strong civilian industrial support base and a gradual ascent of the technology ladder through technology transfer.

The effort to lay a strong civilian industrial, technological, and manpower base for arms production began in the 1930s, when Brazilian military officers began to train in areas such as steel technology, telecommunications, and oil drilling (Barros, 1984). The government also sought to develop critical industries such as steel (Brigagao, 1986). To train engineers, government established an Aviation Technology Center (CTA) in 1945 and, in 1947, an Aeronautics Technological Institute (ITA). Based in Sao Jose dos Campos, these became the center of an aeronautics technology park, supported by a complex of peripheral civilian industries (Franko-Jones, 1988).

Rapid growth, 1969–1988

Brazil's modern arms industry came into being in 1969 with the foundation of the aircraft manufacturer Embraer. Receiving an astonishing level of government support, Embraer was able to recruit the entire research staff of the CTA's Institute of Research and Development (Cassiolato *et al.*, 2002) and was bequeathed CTA's design for the Bandeirante light transport/commuter plane. The government also gave tax breaks for companies buying Embraer shares (Franko-Jones, 1988). Around this time, civil engineering firms Engesa and Avibras commenced production of armored cars and missiles, respectively (Franko-Jones, 1988).

Under license from Aermacchi of Italy, Embraer began producing the Xavante armed trainer in 1971, to be followed by production of the Bandeirante. Engesa started production of the Urutu armored personnel carrier in 1972 (SIPRI Yearbook, 1978). Embraer also produced the indigenously designed Xingu transport and Seneca light planes produced under license from Piper of the US, and later the EMB-312

Figure 13.1: Brazilian exports of major conventional weapons, 1974–2001 ($1990 million)

Source: SIPRI.

Tucano trainer and the civilian Brasilia, successor to the Bandeirante. Helicopters were assembled in Brazil under license as from 1978. Engesa produced a wide range of armored vehicles, all popular export items. Avibras enjoyed great success in the 1980s with the Astros II series of multiple rocket launchers, based entirely on indigenous technology. In 1981, Embraer signed a co-design and production agreement with Aeritalia and Aermacchi of Italy for a new subsonic fighter, the AMX. Design, component production, and assembly were conducted in both Italy and Brazil. Brazil's naval production, centered at the Arsenal Marhina do Rio de Janeiro (AMRJ), advanced in the 1970s and 1980s in cooperation with British and German companies.[3]

Government support was essential. From the mid-1970s, government encouraged the setting up of joint ventures between overseas arms companies, mostly European, and local companies, bringing about technology transfer.[4] Financial support was extensive: funds were appropriated for military R&D, including through secret decrees and the granting of "extraordinary credits." Arms exports were subsidized (Brigagao, 1986).

Due to Brazil's relatively low own level of military expenditure, arms exports were crucial to the success of the industry. Brazil's largest arms market was the Middle East, and Iraq in particular during the 1981 -88 Iran-Iraq war, where Engesa's armored vehicles performed well. Brazilian aircraft were popular in South America, but the Embraer Tucano trainer was also sold to Britain[5] and France. During the early to mid-1980s, Brazil was frequently ranked as among the top-10 arms exporters and, among developing states, second only to Israel (SIPRI). Up to 90 percent of Engesa and Avibras's production, and 65 percent of Embraer's, was exported (Perry and Weiss, 1986; Franko-Jones, 1988). Figure 13.1, charting Brazil's exports of major weapons systems, illustrates the industry's rapid growth from the mid-1970s.

In the mid-to-late 1980s, then, the Brazilian arms industry was widely viewed as a success. Lock (1986) quotes a figure of 100,000 employees in 350 companies in the industry in 1984, while Brigagao (1986) claims 200,000. Domestic industry supplied 70 percent of the Brazilian air force's fleet (Perry and Weiss, 1986). Engesa likewise supplied most of the Brazilian army's armor requirements. Perry and Weiss (1986, p. 107) write that "with the assistance of foreign licenses for certain critical components, [Brazil] is now capable of producing the entire range of conventional armaments."

Collapse

In the late 1980s and early 1990s, Brazil's arms industry was adversely affected by a number of external factors. First, the end of the Iran-Iraq war in 1988 deprived Brazil of a lucrative weapons market, particularly affecting Engesa and Avibras. Second, the end of the cold war heralded a general decline in the global arms trade. And third, the 1991 Gulf war demonstrated the superiority of US technology, rendering Brazil's less sophisticated weapons much less attractive (Kapstein, 1991).

Engesa suffered a major disaster with the Osorno main battle tank, developed for the Saudi and Brazilian armed forces in the early 1980s. $100 million was spent on development,[6] and it was hoped that sales to Saudi Arabia would reach $4 billion but the deal stalled due to financing difficulties (Kapstein, 1991). The 1991 Gulf war, which tied Saudi Arabia more closely to Washington, effectively killed the deal.[7] In 1990, Engesa filed for bankruptcy, as did Avibras, which was also hit by the loss of the market in the Middle East. While Avibras survived, turning mostly to civilian production, Engesa was dismembered.[8]

Embraer was struck by a global aviation recession as well as by the national decline in support for technology. Embraer also pursued big new projects without proper financial backing (Cassiolato, *et al.*, 2002).[9] The AMX fighter failed to win any export orders. Between 1990 and 1995, Embraer cut its workforce from 12,700 to 3,600 (Goldstein, 2002), and the company was privatized in 1994 (Cassiolato, *et al.*, 2002). Embraer's fortunes improved in 1994 with the sale of 200 of its new EMB-145 regional jets at the Farnborough Air Show. The company subsequently thrived in this civil regional jet market, controlling around 40 percent of the market by 1999. The company was responsible for around 6.5 percent of Brazil's manufacturing exports. Military sales, however, had fallen to 7 percent of Embraer's total (Cassiolato, *et al.*, 2002).

Brazil's arms exports collapsed (see figure 13.1). From 1981 to 1988, they had never been below $100 million per year,[10] but slumped to $35 million in 1989, and have never since reached $100 million. From 1989 onward, no Brazilian company has been listed in SIPRI's list of the top-100 arms companies.

Recent developments

There are signs of recovery in Brazil's arms industry, especially in the aviation sector with recent export orders from Venezuela and the Dominican Republic. In addition, the Brazilian air force ordered 76 ALX Super Tucano trainers, adapted for patrolling the Amazon, as part of the $1.4 billion SIVAM (Sistema de Vigilância da Amazônia) monitoring and surveillance program for the region which is led by Raytheon of the United States.[11] Embraer also supplied five Airborne Early Warning and Control (AEW&C) and three Airborne Remote Sensing aircraft for the program which came online in summer 2002.[12] A planned purchase of 12 new advanced jet fighters may lead to substantial local production, though the purchase has been postponed.

There are signs as well of a new export drive in the arms industry, with Avibras sealing a $500 million contract with Malaysia for the supply of Astros II Multiple Rocket Launchers (MRLs).[13] Avibras is also developing a new Astros III MRL (Foss, 2002) and,

more ambitiously, a cruise missile.[14] However, there seems little prospect of Brazil returning to armored vehicle production (Rezende, 2002a). According to *Jane's Defence Weekly* (21 April 2000), the Rio Arsenal has started work on an indigenously designed submarine.

The role of offsets and technology transfer

Overview

Brazil's strategy for developing its arms industry was pragmatic and long-term, using what SIPRI described as an "appropriate level of technology" (SIPRI, 1986). One aspect of this was the strong foundation on research, technology, and educated personnel established through institutions such as the CTA. Another was the encouragement of a civilian industrial base. A third was the willingness to ascend the technological ladder gradually by pursuing links with foreign firms to obtain technology transfer, and specifically using overseas procurement to further the domestic industry through licensed and coproduction. At its best, this enabled Brazilian arms companies to obtain not just technology, but foreign capital, training, and practical know-how through interaction with foreign personnel.

The policy of seeking technology transfer as a requirement of procurement has been pursued fairly systematically. The *Financial Times* of 14 November 1980 wrote that "the armed forces are also important in the area of technology transfer. Whenever a part is imported, its technology is always transferred to the national industry." This strategy was pursued early on. The production of the Xavante trainer/ attack aircraft under license from Aermacchi of Italy was crucial to Embraer's early development, as were a number of other license deals. But Brazil's systematic courting of foreign (mostly European) firms started in the mid-1970s. The *Financial Times* article continues: "Between November 1974 and July 1975, 60 representatives of foreign arms manufacturers were in Brazil studying investment possibilities, either in technology transfer (via license) or formation of joint ventures with Brazilian companies." The advantages for European partners were numerous: cheap labor, abundant steel supply, political stability, proven industrial capacity, access to Latin American markets, and avoidance of domestic export controls (Rohter, 1978).

The use of licensed and coproduction continued in naval and aerospace procurement through the 1980s, but a formal offsets policy was not introduced until 1991 when the Aeronautics Ministry adopted a policy document for aerospace procurement. This was followed with an implementation document in 1992 (Brazil, 1991; 1992). In many ways, this formalized existing practice in promoting technology transfer through procurement. Significantly, the first objective of offsets listed in the documents is "promoting the increase of technological and quality levels of the national aerospace sector, with the modernisation of production methods and processes and the acquisition of new technologies." The implementation document specifies that compensation (offsets) shall apply to all purchases in the aerospace sector of over $1 million, but does not specify a minimum level of offset as a proportion of the contract. Instead, the document states that "the norms for the negotiation of Compensation Agreements must observe a degree of

flexibility…with a view toward technological capacity and the increase in labor charges in the… aerospace sector." The current competition to supply Brazil's air force with an advanced fighter is the first "big ticket" purchase by Brazil since the 1991 policy was introduced, and the first where offsets have been publicly discussed. Accordingly, the five bidders have competed intensively in terms of offsets offered. The technology transfer focus of the policy is reflected in this competition.[15] The industry magazine *Countertrade & Offset* reported in December 2002 that the Ministry of Defense was preparing a new offset policy whereby all three armed services would seek 100 percent offsets for purchases over $5 million.[16]

Offset arrangements, 1970–2002

I now discuss in detail some of the most significant offset and technology transfer deals that Brazil pursued as part of the development of its arms industry (see Perlo-Freeman, 2002). Some sectors of the industry have involved more by way of offsets and collaborative projects than others, especially fixed-wing aircraft and related systems, helicopters, and naval vessels. Armored vehicles and missile production was based overwhelmingly on indigenous design so that there are fewer major instances of offset arrangements in these sectors.[17]

AIRCRAFT

Embraer (Empresa Brasileira de Aeronautica) is at the center of Brazil's aeronautics efforts and is probably the clearest success story of Brazil's military industrialization effort. This sector has perhaps also been among the most effective at absorbing and developing foreign technology. It had the distinct advantages of the extremely strong technological and human resource base described earlier and, at a commercial level, a strong civil side to fall back upon when Brazil's export arms markets collapsed. In addition, Cassiolato, *et al.*, (2002) emphasize Embraer's well-thought out "learning strategy" within which relations with overseas companies played a vital part.

Early proiects: Although Embraer's first plane, the Bandeirante, was an indigenous design, their first specifically military plane, the EMB-326 Xavante trainer/tactical support aircraft was made under license from Aermacchi of Italy, a condition imposed by the Ministry of Aeronautics. This arrangement included Italian specialists coming to Brazil to help set up production, and Embraer engineers receiving training in Italy, accelerating and augmenting the process of technology transfer (Cassiolato, *et al.*, 2002). Between 1972 and 1981,200 of these planes were made and two dozen exported (Perry and Weiss, 1986). The 1978 SIPRI *Yearbook* notes that the Brazilian content of the planes was increasing.

The early 1970s also saw an open technology transfer agreement with Piper of the US to manufacture light planes, the Piper Seneca. This followed the imposition of a 50 percent tariff by the government on new planes entering Brazil (Franko-Jones, 1988).[18] In 1975, when Brazil bought 49 Northrop F-5E Tiger fighters, an offset arrangement involved Embraer manufacturing several components for the fuselage (Perry and Weiss, 1986). In addition, Embraer employees received technological training in engineering (Cassiolato, *et al.*, 2002).[19]

According to Cassiolato, *et al.* (2002, p. 16) these programs had the desired effect: "Learning through user/supplier interactions was intense and global. Embraer became known on the world market for being a user of extremely qualified equipment and software. It was not satisfied in simply knowing how to operate the services or the technology that it bought, but…to modify the technology to its requirements" (p. 16). However, Brazil cannot be said to have achieved fully independent production in this area. It remained heavily dependent on imported components. Lock (1986, pp. 86–87) paints a fairly negative picture: "It is commonly quoted that Embraer imports up to 60 percent of the components it uses to manufacture its aircraft. So far Brazil has not produced a single engine for its aircraft …There are no indications that the degree of nationalisation increased significantly during the period observed." Both Cassiolato, *et al.* (2002) and Goldstein (2002) describe this as a deliberate strategy: Embraer concentrated on "key technologies" such as fuselage and systems integration, gaining autonomy in its business, importing and integrating components as necessary. Pursuing rapid nationalization of components would have been more costly and may ultimately have led to a technological dead end.

The AMX: The indigenously designed Tucano trainer was Embraer's next step. Following that, it signed a coproduction agreement in 1981 with Aermacchi (now Alenia Aerospazia) and Aeritalia of Italy to produce the subsonic AMX flghter. Embraer's share in the project was 29.7 percent, with 23.8 percent for Aermacchi and 46.5 percent for Aeritalia. Brazil's air force ordered 56 aircraft, and the Italian air force 187.[20] Each company was involved in the design, development, testing, and manufacture of sections of the aircraft,[21] and the plane was assembled in both countries.[22] In addition, Brazilian companies made other subsystems under license or in coproduction deals (Perlo-Freeman, 2002), it being the government's policy to support suppliers in the aeronautics industry as well as Embraer, using subcontracting and technology transfer agreements (Franko-Jones, 1988). The aircraft entered service in 1989–90. The AMX project can be seen to have been a technological success for Embraer which became the lead partner for the new AMXT model of which 8 were sold to Venezuela in 2000.[23] However, that this was the first export order for any AMX illustrates the plane's commercial failure. Kapstein (1991) notes that the unit cost of the AMX doubled from its original $10 million.

SIVAM: Brazil's biggest-ever defense procurement deal, developed in the 1990s, is the $1.4 billion Sistema de Vigilância da Amazônia or SIVAM program, which came online in 2002. It is a collaborative project involving Raytheon of the United States, Embraer, and other Brazilian companies. SIVAM is a vast monitoring, surveillance, communications, and air-traffic-control system for Brazil's 5.2 million square kilometers Amazon region, "composed of a large quantity of ground-based and airborne platforms to include surveillance and remote sensing aircraft, radars, environmental and weather sensors, and remote user stations connected to three regional co-ordination centres by a vast encompassing telecommunications network."[24] SIVAM's goals include surveillance of illegal activities,[25] environmental protection, border patrols, air-traffic control, air-surveillance, and various other scientific, environmental, and economic purposes.[26]

Amid allegations of bribery and industrial espionage, the SIVAM prime contract was awarded to Raytheon in 1994 (e.g., Evers, 1996). Raytheon was to supply the ground and airborne radars and other sensors and communication systems. But the project was a

collaborative one with Embraer and ATECH, a Brazilian company set up for the purpose. Embraer supplied five AEW&C aircraft and three Remote Sensing Aircraft, both based on the ERJ-145 regional jet, to act as the airborne platforms for Raytheon and Swedish systems,[27] as well as a $380 million contract for 76 ALX Super Tucanos for SIVAM border patrols and training (Fricker, 2002). ATECH, was created for SIVAM in 1997, to ensure Brazilian autonomy in the operation, maintenance, and technological evolution of system intelligence, responsible for software development, technology absorption, and operational training of various governmental organizations.[28] This is indicative of the high level of technology transfer and training involved in the SIVAM program. Rodrigues (2001) argues that there is great potential for incorporating local commercial technologies into SIVAM and for development of Brazil's civil and military technological base through the program.

Formal offset requirements were attached to some aspects of the SIVAM program. Priority was given to direct offsets, with multipliers (allowing certain types of offset to be counted at a multiple of their value) rewarding technology transfer, training, coproduction and licensing, joint venture, and R&D in software.[29]

The F-X competition: The Brazilian air force has long sought to replace its ageing Mirage III fighters with an advanced supersonic multi-role fighter. A request for proposals for the F-X fighter was issued in August 2001, with final bids submitted in May 2002.[30] The contract is for around $700 million, with a 100 percent offset requirement. Air Force command stated that "companies should present trade compensation proposals, guaranteeing that the amount to be paid by Brazil in the aircraft purchases will be reinvested by those companies, in transferring technology that allows FAB [the Brazilian air force] to maintain the aircraft software on its own."[31] However according to Brigadier Cima of the Aeronautics Ministry, only 20 percent of the offsets were to be direct, the rest indirect, though with an emphasis on high technology items from Brazil's aerospace industry.[32] Initially the order was for 24 planes, but this had to be cut back to 12 to stay within budget, rendering full local assembly of the aircraft dubious.[33]

There are five planes in the competition: Dassault of France's Mirage 2000, Lockheed Martin's F-16, Saab/BAEs Gripen, and two Russian planes: Rosoboronexport's Su-35, and RAC-MiGs Mig-29 Fulcrum. Of these, Dassault, Rosoboronexport, and Gripen have already set up collaboration agreements with Brazilian companies: Dassault with Embraer, Rosoboronexport with Avibras, and

Table 13.1: Embraer aircraft production, 1980–1999

Model/year	*80*	*81*	*82*	*83*	*84*	*85*	*86*	*87*	*88*	*89*
Civil										
Bandeirante	73	67	32	10	23	2	4	7	10	2
Xingu	25	12	18	26	2	1	1	2	0	0
Brasilia	–	–	–	–	–	6	20	38	46	54
ERJ-145	–	–	–	–	–	–	–	–	–	–

ERJ-135	–	–	–	–	–	–	–	–	–	–
Light aircraft										
(Piper/Ipanema)	315	169	117	66	106	112	107	111	81	121
Military										
Xavante	5	15	0	0	0	0	0	0	0	0
Brasilia	–	–	–	–	–	0	0	0	0	0
Tucano	0	0	0	26	57	49	35	45	54	40
AMX	–	–	–	–	–	–	–	–	–	4
Model/year	*90*	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*
Civil										
Bandeirante	8	1	2	0	0	1	1	0	0	0
Xingu	0	0	0	0	0	0	0	0	0	0
Brasilia	55	35	15	10	7	20	17	8	12	7
ERJ-145	–	–	–	–	–	–	4	32	62	81
ERJ-135	–	–	–	–	–	–	–	–	–	16
Light aircraft										
(Piper/Ipanema)	67	51	33	49	43	28	24	24	26	17
Military										
Xavante	0	0	0	0	0	0	0	0	0	0
Brasilia	0	0	0	0	0	0	0	0	1	0
Tucano	5	0	1	5	8	18	15	–	6	–
AMX	5	8	7	6	1	4	3	5	10	3

*Source: Cassi*olato, et al. (2002).

Gripen International with the Brazilian airline VEM-Varig. The Dassault/Embraer and Rosobornexport/Avibras bids both envisage local production, while the Gripen bid promises local logistical support and software development. In all cases, the full transfer of software source code is key, a condition that puts the F-16 at a disadvantage as the United States is reluctant to transfer advanced technology to the region.[34]

The F-X purchase was postponed in early 2003 by incoming President Lula da Silva in favor of an anti-hunger program but has not been abandoned. The project may determine the extent of recovery in Brazil's arms industry: participation in production of such high-technology aircraft could potentially lead the industry to a new technological level. But the order is very small, so if a locally built plane does not win export orders local assembly could rapidly become unviable.

Overall, the examples show steady progression of technological capability in the aeronautics sector, with collaborative ventures playing crucial roles at many stages. But

this has not always led to commercial viability, with projects such as the AMX falling flat. Embraer was only able to survive and maintain Brazil's capability in the sector by diversifying into commercial aviation.

Illustrating the fluctuating fortunes of their military aircraft business, table 13.1 shows the number of each type of aircraft produced by Embraer from 1980 to 1999. Since then, military deliveries include continuing AMX production and the SIVAM planes.

Helicopters: Helicopter production in Brazil has been much less successful technologically than the fixed-wing sector. Production was established in 1978 through Helibras, a joint venture between Aerospatiale of France (now Eurocopter), which took a 45 percent stake, the Minas Gerais state government which also took a 45 percent stake, and the Brazilian company Aeroforto Cruzeiro do Sul which took the remaining 10 percent. The company assembles Aerospatiale/Eurocopter helicopters under license, with production of the Ecureuil and Lama models commencing in 1979.[35] Helibras now manufactures a wide range of civil and military helicopters, has around 300 employees, and has sold about 420 helicopters, with 15 percent exported to Latin America.[36] While the government hoped that Helibras would eventually design its own aircraft and produce or purchase components locally, the company never got much beyond the stage of assembling imported kits from France, producing no more than 5 percent of its components locally by 1986 (Bransford, 1986). The 1984 SIPRI *Yearbook* describes helicopter production in Brazil as only reaching the level of assembly and basic component production. Franko-Jones (1988) describes helicopter production in Brazil as an "acknowledged failure." Nonetheless, in contrast to other projects that have succeeded technologically but failed commercially, Helibras has remained commercially viable and continues to attract orders domestically and internationally (Perlo-Freeman, 2002). As to the reasons for Helibras's technological underachievement, one possible factor is that Helibras lacked the intense research and human resource development that lay behind, for example, Embraer's success.

NAVAL VESSELS AND EQUIPMENT

Brazil has produced warships since 1789 at the AMRJ arsenal (Mills, 1997). Production of modern major naval vessels began in the 1970s. For such vessels, Brazil was particularly dependent on foreign technology and collaboration, due to the advanced technologies and huge capital outlays involved (Perry and Weiss, 1986). The first major collaborative project was a contract with Vosper Thorneycroft of the UK, announced in 1970, for the construction of six frigates, the last two to be made at AMRJ. The deal was to include as many Brazilian-made components as possible. As with successful aerospace projects, exchange of personnel was important, with Brazilian engineers participating in the construction work and British specialists helping in Brazil. Despite this, the two Brazilian-built vessels took much longer to complete (Lock, 1986), and the total cost of the program was £200 million, twice the initial contract.[37] After the Niteroi, plans were initiated in 1977 to build locally-designed corvettes, the Inhauma, with assistance from a German company, Marin-Technik (Lock, 1986). The completed ships were commissioned from 1991–92 *(Jane's Fighting Ships)*. A fifth has now been started on (Mills, 1997). Originally 12 of these corvettes were planned, but lack of export orders made the ships an economic disaster (Kapstein, 1991).

Meanwhile in 1982, Brazil concluded an agreement with HDW of then-West Germany for the construction of four diesel-electric Tupi-class submarines. The first was built in Germany, the other three assembled by AMRJ. As with the Niteroi, technical assistance and training were part of the package. The aim was to increasingly incorporate Brazilian components and technology, with the goal of developing an indigenous submarine capability and eventually nuclear submarines (Meason, 1978). The submarines were commissioned from 1989–1996, and two more improved Tupi-class vessels are planned by AMRJ, with one under construction.[38] As with aircraft, a strong research base and a focus on active technology absorption through exchange of personnel has borne fruit in terms of developing capability. But the sheer size and complexity of major warship projects has given rise to serious cost inflation and delays, unmitigated by export orders, which raise the question of just how much resources the government is prepared to pour into this sector. Technological capability would seem to have been bought at a high price in this case.

Evaluation of Brazil's offset strategy

There are a number of levels at which the success or failure of the strategies and policies described in this chapter can be evaluated: the technological level, how well Brazil has been able to develop autonomous technological capability in armaments through the use of offsets; the commercial level, whether offsets have helped to create commercially viable arms production; and at the level of the effect on the economy as a whole.

General economic benefits have been tenuous at best, a pattern common to offset agreements in other countries. The first point to note is the added cost of such deals compared with off-the-shelf procurement. Numerous authors (e.g., Kapstein, 1991; Franko-Jones, 1988; Perry and Weiss, 1986) affirm that this was accepted by the government as a necessary price for obtaining technology. But clearly there is an economic burden. The vast subsidies poured into Embraer and into the industry generally through export support must also be considered.

Opinions differ as to the balance of trade effect. Brigagao (1986) quotes high figures for levels of exports and Franko-Jones (1992) claims that in 1982, Embraer earned two dollars of foreign exchange for every one they spent. But Väyrynen (1992) takes the opposite position with regard to Embraer, arguing that its imports of components exceeded their exports in the 1970s and early 1980s. Brauer argues that foreign exchange earnings from arms sales are often overstated and costs understated (for example the extra cost of procurement to obtain technology transfer), and that "no-one has provided conclusive evidence that the *net* effect is positive for the arms exporting country" (2002, p. 114). At any rate, arms exports are only a small proportion of total exports, so that any net positive effect is not likely to be large—a conclusion also reached by Barros (1984). As for jobs, even a high estimate of employment such as Brigagao's figure of 200,000 in 1984, at the height of the industry's success, is trivial for a country as huge as Brazil (Brigagao, 1986).

A stronger case can be made in terms of the development of the civilian industrial base, and Väyrynen (1992) argues that Brazil has gained economically from its arms industry in this respect. Certainly a project like SIVAM seems to offer the potential to diffuse a broad spectrum of technology through Brazilian government and society. And,

arguably, Embraer's success as a commercial aircraft manufacturer would never have come about had government support not been motivated by the desire to promote military production. Of course, this begs the question as to whether

Table 13.2: Assessment of Brazil's arms industry

Sector	*Use of offsets*	*Technological success*	*Commercial success*
Fixed-wing aircraft (Embraer)	High	High	Mixed; military production hit trouble, saved by strong civil side
Helicopters (Helibras)	High	Low	Fair
Missiles (Avibras)	Low	High	Ran into serious trouble, but diversified and survived
Land vehicles (Engesa)	Low	High	Went bankrupt
Major naval vessels (AMRJ; others)	High	Fair	Very costly, private companies withdrew

the same benefits for civil industry could have been achieved through direct civil investment.

Yet it was not primarily jobs or balance of trade that motivated offset deals, but technology transfer aimed at developing autonomous military capability. If we are to judge Brazil's strategy in its own terms, it must be at this level. From this point of view, it is important to consider both technological and commercial success together. If production cannot be made viable, as was the case for Engesa, the capability will practically be lost. The Brazilian case presents quite a mixed picture. Table 13.2 gives a broad overview, looking at the various sectors of Brazil's arms industry in terms of whether they used offsets, and the level of technological and commercial success. From this table it is not clear that there is any particular pattern. To the contrary: each sector appears to show a different pattern of development, depending on its particular circumstances. What is clear is that making a commercial success of design and manufacture of high-tech major weapons systems is difficult, whether or not offsets play a part in the strategy. Even with massive initial state support, it has only been possible to maintain viable operations by diversification into civil production as in the case of Embraer and Avibras, or by not being required to operate as a commercial entity, as is the case of the Navy-run AMRJ.

Embraer, and the associated aeronautics industry, perhaps represents the clearest success of the technology transfer strategy. They have gradually ascended the technological ladder, now apparently ready to participate actively in production of an advanced fighter aircraft. Their military and civil technologies have worked together effectively, producing a world-leader in the regional jet market. But this has all been achieved through massive government investment and subsidy, and at the end of the day Brazil is not anywhere near fully autonomous arms production in any sector. Even at the semi-autonomous, collaborative level that Brazil can reasonably aspire to, arms production is still operating at very low levels compared to the 1980s. It is hard not to ask what all the funds poured into the industry have actually bought.

Conclusions

Offset policy and practice in Brazil, involving licensed production, coproduction, and technology transfer has been pursued not so much for direct economic benefit but to develop Brazil's arms industry to fulfill a certain view of its place in the world. Indirectly, the arms industry has also been used to try to develop civilian industrial infrastructure. A strong research and development base in the post-war period, heavily supported by government, led to rapid development of the industry as from the 1970s, with technology transfer through procurement playing a crucial role, especially in the aeronautics sector. Collaborative arrangements of various kinds with foreign companies helped the industry to develop to higher technological levels. Domestically produced or licensed aeroplanes, armored vehicles, and missiles all enjoyed spectacular export success through the 1980s, rapidly turning to financial collapse following the end of the Iran-Iraq war. The armored vehicle sector vanished, while Embraer and Avibras only survived through success in civil manufacturing. Nonetheless, they maintained and developed their military production capabilities, enabling a tentative revival in the arms industry in recent years.

Overall, the arms industry in Brazil has proved costly, has been difficult to maintain as a commercially viable concern, and cannot realistically hope to attain full independence of arms supply in any case. Nonetheless, strategic use of offsets has brought technological benefits on both the military and civil sides, especially in the aeronautics sector.

Notes

1. In 1999, Brazil ranked 14th in the world in terms of military expenditure and 20th in terms of the size of its armed forces. The next-ranked Latin American countries were Argentina at rank 29 (military expenditure) and Colombia at rank 34 (armed forces).
2. Brazil sent troops to support allied forces in Italy in world war II.
3. These developments are discussed in more detail in Perry and Weiss (1986), Franko-Jones (1988), Franko-Jones (1992), and Perlo-Freeman (2002).
4. Links with the US were very limited as a result of the Carter administration's human rights restrictions on arms sales to Brazil.
5. Made under license by Shorts of Northern Ireland.
6. "EE-T1 Osório Main Battle Tank." http://www.fprado.com/armorsite/EE-TlOsorio.htm [accessed 20 August 2003]. Quotes source "Armas de Guerra do Brasil (Brazil's Weapons of War)" Editora Nova Cultural Ltda., Sao Paulo, Brasil, 1989 (in Portuguese).
7. http://www.fprado.com/, see note 6.
8. "Avibrás Aerospace Industry." http://www.globalsecurity.org/military/world/brazil/avibras.htm [last modified 15 July 2002, accessed 20 August 2003]; and http://www.fprado.com/, see note 6.
9. Cassiolato, *et al.* (2002) also blame an overemphasis on engineering, in neglect of market research.
10. SIPRI figures, constant US$1995.
11. See http://www.sivam.gov.br/ [accessed 20 August 2003].
12. "Embraer Presents Its Newest AEW&C Aircraft: Designated EMB-145 SA, the Aircraft will be used by the SIVAM (Amazon Surveillance System) Project." http://www.defense-aerospace.com//data/communiques/archives/1999May/data /1999May395/ [accessed 20 August 2003].

13. “Brazil to Raise Arms Exports.” *Gazeta Mercantil Online,* 26 October 2001, reproduced on *Arms Trade Newswire,* 26 October 2001, http://www.clw.org/atop/newswire/nwl02601.html#Brazil [accessed 20 August 2003].
14. “Cruise Missiles ‘Made in Brazil’.” *BBC News Online,* 4 September 2001. http://news.bbc.co.Uk/l/hi/business/1525374.stm [accessed 20 August 2003].
15. “Brazil: Firms Competing for $700 Million Air Force Contract Profiled.” *Folha de Sao Paolo* 14 August 2001, reproduced on *Arms Trade Newswire* 15 August 2001. http://www.clw.org/atop/newswire/nw081501.html#Brazil [accessed 20 August 2003].
16. “Brazil to Raise Threshold Level.” *Countertrade & Offset* Vol. 20, No. 24 (23 December 2002), p. 3.
17. Albeit that Engesa’s early models were modifications of foreign designs (see Turner, 1980).
18. As Embraer’s technology developed, it farmed production of the Seneca out to a subsidiary, Neiva. Franko-Jones (1988) notes that Embraer was trying to sell Neiva, but today Neiva is still part of Embraer, making the EMB-120 Brasilia and other commercial planes.
19. Cassiolato, *et al.* (2002) also note that Embraer manufactured complex components under subcontracts from Boeing and Douglas, although it is not clear if this was linked to a procurement.
20. According to airforce-technology.com, 192 were eventually delivered in total.
21. Embraer was responsible for the wings, air intakes, ordnance pylons, jettisonable fuel tanks, main landing gear, part of the electrical system, and reconnaissance pallets.
22. “Embraer—20 Years Old.” *Defence* (December 1989, p. 933); “AMX Fighter Bomber, Brazil/Italy” (undated) http://www.airforce-technology.com//projects/amx/ [accessed 20 August 2003].
23. “Historia da Forca Aerea Brasileira.” http://www.rudnei.cunha.nom.br/FAB/eng/a-l.html [accessed 20 August 2003].
24. www.raytheon.com/projects/sivam [accessed 21 August 2003].
25. Including drug smuggling, illegal logging and gold-digging, and rebel activity in neighboring civil war-affected states.
26. Raytheon web site, as in note 24. In many ways, though, SIVAM represents an assertion of sovereignty by Brazil over the poorly-controlled region. It was first announced at the Earth Summit in Rio in 1992 and was a way of demonstrating that Brazil could take care of the environmentally crucial region herself without outside interference. International environmental concerns had revived long-held fears in some military circles that outside powers coveted the Amazon’s vast natural resources (see Guedes da Costa, 2001).
27. http://www.embraer.com;www.raytheon.com//products/sivam. “Ericsson ERIEYE AEW&C System Selected for SIVAM." Ericsson press release http://www.ericsson.com/microwave/aewc/press/970317.shtml 17 March 1997 [accessed 21 August 2003]; “Brazil’s President Inaugurates Amazon Monitoring System,” *SpaceDaily Online* 12 August 2002, http://www.spacedaily.com/news/eo-02zb.html [accessed 21 August 2003].
28. http://www.atech.br/ [accessed 21 August 2003].
29. “Brazil to Raise Threshold Level,” *Countertrade & Offset* Vol. 20, No. 24 (23 December 2002), p. 3.
30. “Brazilian Air Force to Buy Fighter Jets from Whoever Transfers Technology.” *Sao Paulo Gazeta Mercantil* (23 July 2001), reproduced on *Arms Trade Newswire* (25 July 2003), http://www.clw.org/atop/newswire/nw072501.html#Brazilian [accessed 21 August 2003]; *Jane’s Defence Weekly* (29 May 2002).
31. See note 30.
32. See note 30. In fact, there seems to have been considerable confusion about the exact composition of the offsets requirement (Shanson, 2002).
33. “Brazil Seeks Revised Bids to Speed up F-X Fighter Buy.” *Flight International* (9–15 April 2002).

34. “Embraer, Dassault Aviation, Snecma Moteurs and Thales Airborne Systems Announce the ‘Mirage 2000 BR Consortium’.” Embraer press release, 4 April 2002, http://www.embraer.com/; “Avibras and Sukhoi in Production Alliance”, *Flight International* (22–28 January 2002); “Gripen and Varig’s Foster their Strategic Partnership,” Gripen International press release, 7 June 2002, http://www.gripen.com/pressindex_2.asp# [accessed 20 August 2003]; and Rezende (2002b). Also see Perlo-Freeman (2002).
35. Smith, 1978; and “France Guarantees Brazilian Deal,” *Flight International* (8 April 1978).
36. http://www.helibras.com/.br [accessed 20 August 2003].
37. “Brazil Accepts Final Missile-Armed Frigat.” *Flight International* (2 December 1978).
38. “SSK Tupi Class Attack Submarine, Brazil.” Naval-technology.com (undated), http://www.naval-technology.com//projects/tupi [accessed 20 August 2003].

References

Barros, A. de S.C. (1984) “Brazil” pp. 73–87 in J.E.Katz (ed.) *Arms Production in Developing Countries.* Lexington, MA: Lexington Books.

Bransford, S. (1986) “Brazil Announces Helicopter Venture.” *Flight International* (26 April 1986), p. 15.

Brauer, J. (2002) “The Arms Industry in Developing Nations: History and Post-Cold War Assessment,” pp. 101–127 in J.Brauer and J.P.Dunne (eds.) *Arming the South: The Economics of Military Expenditure, Arms Production and Arms Trade in Developing Countries.* New York: Palgrave.

[Brazil] (1991) Federative Republic of Brazil. Ministry of Defense. Aeronautics Command. *Policy of the Ministry of Defense for Commercial, Industrial and Technological Compensation.* 18 December 1991.

[Brazil] (1992) Federative Republic of Brazil. Ministry of Defense. Aeronautics Command. *Implementation of the Policy of the Ministry of Defense for Commercial, Industrial and Technological Compensation.* 21 September 1992.

Brigagao, C. (1986) “Brazilian Arms Industry.” *Journal of International Affairs* Vol. 40, No.1, pp. 101–114.

Brzoska, M. (1995) “Spread of Conventional Weapons Production Technology,” pp. 19–47 in S.Lodgaard and R.L.Pfaltzgraff (eds.) *Arms and Technology Transfers: Security and Economic Considerations Among Importing and Exporting States.* New York and Geneva: United Nations Institute for Disarmament Research (UNIDIR).

[BVC] US Department of State. Bureau of Verification and Compliance (2002). *World Military Expenditures and Arms Transfers 1999–2000.* Washington, DC: BVC.

Cassiolato, J.E., R.Bernardes, and H.Lasters (2002) “Transfer of Technology for Successful Integration into the Global Economy: A Case Study of Embraer in Brazil.” UNCTAD/UNDP Investment Policy and Capacity Building Branch (DITE), UNCTAD/ITE/IPC/Misc.20. New York/Geneva: United Nations.

Cheng, D. and M.W.Chinworth (1996) “The Teeth of the Little Tigers: Offsets, Defense Production and Economic Development in South Korea and Taiwan,” pp. 245–298 in S.Martin (ed.) *The Economics of Offsets: Defense Procurement and Countertrade.* Amsterdam: Harwood.

Evers, S. (1996) “Brazil to Give Priority to SIVAM Over F-5 Upgrade.” *Jane’s Defence Weekly* (20 March 1996).

Foss, C. (2002) “Avibras Develops Latest Artillery Rocket Systems.” *Jane’s Defence Weekly* (24 April 2002), p. 8.

Franko-Jones, P.M. (1988) “Public Private Partnership: Lessons From the Brazilian Armaments Industry.” *Journal of Interamerican Studies and World Affairs* [volume and no. unknown], pp. 41–69.

Franko-Jones, P.M. (1992) *The Brazilian Defense Industry.* Boulder, CO: Westview Press.
Fricker, J. (2002) "Region's Military Seeks to Modernise but Tight Funding Forces Ingenuity." *Shownews Online* report from Fidae air show, 11 September 2002 http://www.awgnet.com/shownews/02fidae/special.htm [accessed 21 August 2003].
Goldstein, A. (2002) "The Political Economy of High-tech Industries in Developing Countries: Aerospace in Brazil, Indonesia and South Africa." *Cambridge Journal of Economics* No. 26, pp. 521–538.
Guedes da Costa (2001) "Brazil's SIVAM: As it Monitors the Amazon, Will it Fulfil its Human Security Promise?" *Environmental Change & Security Project Report* No. 7, pp. 51–58.
Jane's Fighting Ships. Various editions.
Kapstein, E.B. (1991) "The Brazilian Defence Industry and the International System." *Political Science Quarterly.* Winter 1990–91, pp. 579–595.
Lock, P. (1986) "Brazil: Arms for Export." chapter 5 in M.Brzoska and T.Ohlson (eds.) *Arms Production in the Third World.* London: Taylor & Francis.
Meason, J. (1978) "Brazil's Plans to Build a Nuclear Submarine Industry." *Jane's Defence Weekly* (23 July 1978), p. 138.
Mills, G. (1997) "South African-Latin American Maritime Co-operation: Towards a South Atlantic RIM Community?" Monograph No. 9, Diplomats & Defenders, February 1997, http://www.iss.co.za/Pubs/Monographs/No9/Mills.html.
Perlo-Freeman, S. (2002) "Offsets and the Development of the Brazilian Armaments Industry." Paper prepared for the 2002 University of Cape Town Conference on Offsets and Economic Development, September 2002, available at http://www.ecaar.org/articles/offsets_abstracts.htm.
Perry, W and J.C.Weiss (1986) "Brazil" pp. 103–177 in J.E.Katz (ed.) *The Implications of Third World Militarisation.* Lexington, MA: Lexington Books, pp. 103–117.
Rezende, P. (2002a) "Brazilian Army Funding Package is Approved." *Jane's Defence Weekly* (15 May 2002), p. 11.
Rezende, P. (2002b) "Final Bids in for Brazil' s F-X Fighter." *Jans's Defence Weekly* (29 May 2002), p.3.
Rodrigues, V. (2001) "Dual-Use of Information System. The Fundaments of SIVAM: The Amazon Monitoring System as an Open and a Closed System." Centre for Hemispheric Defence Studies, REDES 2001. Research and Education in Defense and Security Studies, 22–25 May 2001. Washington, DC: Panel on Environmental Security.
Rohter, L. (1978) "Brazil Enters the Arms Deal Business." *Sunday Times* (16 July 1978).
Shanson, L. (2002) "Brazil: Internal Discord and Complexity of Benefits Causes Confusion and Delay." www.e-offsets.com/news/newsitem.Sp?IdArticle=2929 &section=3, 12 August 2002 [accessed 20 August 2003].
Smith, D. (1978) "Aerospatiale may Build Helicopters in America." *Financial Times* (1 March 1978).
Stockholm International Peace Research Institute. *Yearbook.* Various editions.
Turner, R. (1980) "Arms Manufacturers a Strong Force in World Markets." *Financial Times* (14 November 1980), p. 18.
Väyrynen, R. (1992) *Military Industrialization and Economic Development: Theory and Historical Case Studies.* Aldershot, UK: Dartmouth.