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EMBRAER and the trajectory of Brazil's aeronautics industry ecosystem

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Summary

Created as a State-owned company in the late 1960s, Embraer was privatized in the mid-1990s and became the main Brazilian company producing and exporting high-technology goods. The company diversified its operations within the aircraft business and added to its portfolio goods and services associated to its core activities.

EMBRAER and the trajectory of Brazil's aeronautics industry ecosystem

1. Introduction

Embraer was, in 2017, the world's third largest producer of commercial jet aircrafts, only outpaced – by far – by Boeing and Airbus. In the period between 2008 and 2016, its revenues were 56% above those of its main competitor, the Canadian Bombardier.

This paper departs from the description of the value chain model mobilized for the production and the use of commercial jet aircrafts, identifying the main economic, political and institutional factors that make for the structural features and the evolution of theses chains (Section 2). This description is essential to understand the case of Embraer, as the aircraft production is always internationalized and the relevant market for commercial jet aircraft is global. Section 3 presents Embraer's trajectory along its existence, shedding light on the factors – business-related and policy-related – that contribute to make sense of Embraer's success. Section 4 summarizes the main conclusions and policy lessons of the paper.

2. Aircraft production and its value chains

The commercial aircraft value chain is one of the chains that make for what is usually referred to as "aero spatial industry". This industry includes the production chains of spatial vehicles and equipment, aircrafts, other flying equipment, as helicopters or unmanned vehicles as well as ground equipment as radars. Within the aircraft production sector, two broad differentiated value chains exist: the one responsible for the production of military aircrafts, the other one for commercial aircraft.

From the technological and – to a lesser degree – the economic point of view, there exist intense interactions and synergies between the different chains that make for the aero-spatial industry, in such a way that some of the largest companies in the industry have activities in different stages of its value chains. Such interconnections, together with the high technological content of the goods produced by the aero-spatial industry, gives to the production of all these goods – included the commercial aircrafts – the status of strategic sectors, from the point of view of the national States and their public policies and goals.

For this reason, as will be discussed, the structural features and the main trends conditioning the evolution of the commercial jet aircraft value chain are impacted not only by economic factors, but also by political and regulatory initiatives at the national and international levels.

2.1. The value chain's economy

The value chain producing commercial jet aircrafts has, among its central features, the high level of investments in research and development (R&D) required before starting producing a new family of aircrafts. The activities developed at the different stages of the value chain are also highly intensive in capital, which implies the presence of high barriers to new entrants.

According to Gomes (2012), "in the aircraft industry in general, the high investments required during

the stage of project of a new aircraft – three to five years before the beginning of its serial production – will only be recovered after the selling of a certain number of unities, something between 200 and 250 aircrafts. Therefore (...) the sector's product cycle – the one that goes from the initial conception of a new commercial aircraft to the end of its production (followed by the continuity of after sales activities well beyond the suspension of production) – requires in general two or more decades".

The relevance of such structural features is paramount to explain why the production of commercial jet aircraft has been concentrated, during the last decades, on only four producers, as the result of a consolidation process through mergers, acquisitions and bankruptcies affecting many companies, in the 1970s and 1980s. Until the most recent episode of business consolidation in this sector in 2017 and 2018, four companies acted in the production of narrow body jets (Boeing, Airbus, Embraer and Bombardier), while only two of them (Boeing and Airbus) had the capabilities and resources to produce the largest commercial aircrafts (wide body), employed in transoceanic flights.

Two global duopolies were firmly established – as the relevant market for all of them is the global one. Strictly speaking, there was no direct competition between the companies acting in different segments of the global market, although the most recent Embraer's and Bombardier's aircraft families (with a carrying capacity between 70 to 120 passengers) tap a market niche that partially overlaps with some of Airbus' and Boeing's narrow bodies aircrafts.

The existence of such overlapping – more potential than actual – led, in 2017, Boeing to challenge, based on the WTO's agreements on antidumping and subsidies, a huge sale of Bombardier's new aircraft (C-Series) to an US air transport company. This dispute triggered the most recent cycle of consolidation in the sector, which eventually led to the acquisitions of the C-Series program by Airbus and of an Embraer's majority stake by Boeing[1].

Even before these recent shifts, business consolidation along the value chain hit the sectors and companies producing pieces and systems for the OEMs – the companies assembling and producing the final goods (aircrafts). This process was boosted by the OEMs, aiming at reducing the number of suppliers and to setting with the remaining ones a business model of "risk-sharing", encompassing the sharing of the costs related to the conception and production of components, subsystems and systems of the aircraft being developed.

The "risk-sharing" model concerns the producers of final goods and their "first-tier suppliers", whose production itself is in turn fed by second-tier and third-tier suppliers. In the risk-sharing model, "the terms of compensation for the first-tier suppliers involved are linked to the financial performance of the project as a whole and not only to the specific contribution of the supplier" (Sturgeon et alli, 2014).

In such a model, the value chain's leader companies (the OEMs) act as coordinators of the chain and they "concentrate on the systems integration, leaving to the suppliers the project and building of different subsystems and components" Sturgeon et alli (2014).

The integration of complex systems becomes the main mechanism of coordination and governance of the value chain. This pivotal function is performed by the producer of the final good, although it

1. More details in Section 3.1.

remains true that some of the first tier suppliers also develop such capability to be able to deliver its systems of very complex components. The value chain design resulting from these features points to a "network model", although hierarchy deriving from the scope of the goods produced by each participant is also a relevant component of the value chain model.

An implication of the model is "the disintegration of the innovative activities (...) through not only outsourcing them to key suppliers, but also through the contracting of companies specialized in technical services intensive in knowledge" (Montoro and Migon, 2009).

This is an important feature of the innovation dynamics taking place in the value chain, in the sense that innovation does not originate exclusively from the pressures and demands from the leader company. In many cases, innovation in supplier firms responds to dynamics shaped by the exchange of information and experience with the chains' leader firms and by a moving institutional setting, at the national and the international levels – in which economic, security and environmental concerns play a major role.

Many companies acting as first or second tier suppliers allocate the production of small components and pieces to developing countries to benefit from the lower labor costs. Some of these countries, e.g. Mexico, have been successful in attracting a relevant number of components and subsystems producers, which are integrated to the value chains under the leadership of Boeing, in the US, and Bombardier, in Canada. Bombardier has even transferred the production of some subsystems to its affiliate in Mexico. But the final assembling of the aircrafts takes place, in all the cases, in the originating countries of the value chains' leader companies: US (Boeing), EU countries (Airbus), Brazil (Embraer) and Canada (Bombardier).

A distinctive feature of the segment producing regional commercial jets (Embraer and Bombardier) points to the fact that some of its first-tier suppliers are larger firms than chain's leader companies. While Boeing and Airbus are the two largest companies within the whole aero-spatial industry, Bombardier and Embraer are positioned at a far lower position in this ranking, preceded by many companies that act as first tier suppliers in the value chains that they coordinate. Many of the first tier suppliers for Embraer and Bombardier also occupy this position in the value chains driven by Boeing and Airbus, reaching a production scale that can outpace the ones of the two producers of regional jets. By the same token, many air transport companies that are Embraer's and Bombardier's customers can have a business size that largely exceeds the ones of these two aircraft producers. These features, put together, imply a relative balance of power between the producers of aircrafts – especially regional ones – and other participants to the value chains that they coordinate.

2.2. The value chain's political and regulatory frameworks

The production of civil aircrafts takes place in an environment heavily conditioned by national industrial policies and by international regulations, applied to the sector's technical, environmental and trade-related dimensions.

As for national policies, the strategic value attributed to the aero-spatial industry – or to specific sectors of the industry – provides the rationale for public policies aimed at supporting the development of national producers, in the countries actually producing civil aircrafts as well as in those aiming to enter the market.

In the case of regional civil jet aircrafts – until recently dominated exclusively by Embraer and Bombardier – officially supported programs with high components of subsidies are been used by China, Russia and Japan to favor the development of national aircrafts targeting this sector and its markets[2]. The entry of new players in the production of jet aircrafts through this market's segment is explained by the fact that the barriers to entry of new producers are lower than in the case of the production of wide body aircrafts.

In broader terms, the industrial policies supporting the "national champions" in the sector cover a wide array of instruments, from public export financing to policies fostering research and development as well as other investments preceding the serial production of a new aircraft family.

The most relevant multilateral agreement for the sector is the WTO's Agreement on Subsidies and Countervailing Measures (ASCM), addressing industrial subsidies and identifying prohibited and actionable subsidies, among which exports subsidies (classified as prohibited). In paragraph k of its Annex 1 (Illustrative List of Export Subsidies), the ASCM refers to the conditions that define as a subsidy the public export credit as well as those that prevent such policy from being classified as a subsidy.

Subsidized export credit mechanisms practiced by Canada and Brazil in the Nineties were the subject of long bilateral disputes at the WTO. The difficulties to move forward the revision of the ASCM during the Doha Round led the discussions on the public export credits to the sector to the OECD.

The OECD had sheltered in 1986 the negotiation of the Sectoral Understanding on Officially Supported Export Credits to Civil Aircrafts – as an Annex to the Organization's Arrangement on Officially Supported Export Credits, in force since 1978, which constitutes itself the main institutional and legal reference for the provisions on export credits included in the WTO's ASCM.

In 2007, a new version of the Aircraft Sectoral Understanding (ASU) was negotiated with the participation of Brazil (as the only non OECD member). The countries having adhered to the instrument – among which were the four producers of civil jet aircraft – consider that the new agreement has been able to sharply restraining the ability of officially supported export credits to impact the decisions of the purchasers of such aircrafts. In 2011, the agreement was again updated, without major changes in its provisions.

An indirect effect of the enforcement of negotiated rules on the public support to export credits has been the "migration" of the governmental programs to the activities of research and development and to the activities related to the launching of a new aircrafts' family. These policies were the targets of two new panels taken to the WTO by the US and the EU, in 2014 and 2015 respectively, on behalf of Boeing's and Airbus' interests.

In addition, as recently as in 2018, a new WTO panel was installed, at the request of Brazil, targeting the set of Canada's and Quebec's public programs designed and enforced to support Bombardier's efforts to develop and launch its new aircrafts family: the C-Series.

The entry of new competitors in the market, especially those producing in countries under "State

2. The trade disputes in the WTO involving the incumbent players in the sector of commercial jet aircrafts – Boeing versus Airbus and Embraer versus Bombardier – had their focus put on export financing subsidies or "launch aids".

capitalism" regimes – e.g., China or Russia – make things more complex for the incumbent players, particularly Brazil and Canada, as their national producers are likely to be the more impacted by the newcomers to the market.

Another relevant multilateral agreement is the WTO's ATCA – Agreement on Trade in Civil Aircraft, in force since 1980. The main provisions of the ATCA address the withdrawal of import tariffs previously applied to aircrafts, as well as the parts, pieces and components needed for the assembling, repair and maintenance of civil aircrafts. ATCA is one of the few WTO's plurilateral agreements and Brazil has never adhered to it. However, as the commitments made through the ATCA by its signatories apply to all WTO member countries (the ATCA includes the clause of most favored nation as a binding commitment), the exports of non-signatory countries also benefit from the removal of import tariffs.

Technical standards are another regulation modality that plays a central role in the functioning of the whole aero-spatial industry, as a result of its technological complexity and its production process, which mobilizes a wide set of companies (suppliers) producing pieces, components and systems to be eventually assembled by the aircraft producer.

According to Sturgeon et alli (2014), "all the components of aircrafts have to be specified in detail and produced based on norms and patterns frequently higher than those required for other products. The suppliers of components may produce goods for other industries (...) but specialized certifications and long term commercial relationships imply that the highest level suppliers tend to concentrate in the aero-spatial and defense industry".

National certifications relating to safety and quality issued by different countries are required from the civil aircrafts producers, as aircrafts usually cross borders. In the case of civil aircrafts, to a great extent, the relevance of norms and standards relates to the fact that they are used for the transport of passengers of cargoes. The air transport itself is largely conditioned by certifications and other requirements related to the safety of passengers and cargoes, hence acting as a source of pressure on the aircraft producers as far as compliance with technical (and most recently environmental) standards for the production of aircrafts is concerned.

At the international level, those issues are managed through an intergovernmental agency, ICAO - International Civil Aviation Organization – which produces a large number of norms and standards that, being applied to the air transport sector, has relevant implications for the aircrafts producers. This is the case of environmental and climate-related concerns, which have growingly been a source of new norms and regulations. This trend will surely consolidate in the next years as a driving for technological change in the aircraft sector, again under the pressure of their clients.

3. The value chain in Brazil: Embraer and its suppliers

The civil aircraft value chain in Brazil is almost exclusively organized having Embraer at its center. Embraer is the only firm producing the final good – the aircraft – in Brazil. Embraer's value chain is composed by "first tier multinational suppliers (also known as global suppliers), first tier national suppliers and local SMEs supplying the first tier national and multinational suppliers" (Sturgeon et alli, 2014).

To a large extent, the activities developed in Brazil by the chain overlap with those undertaken within the borders of the leading company (Embraer). The majority of large suppliers are global suppliers to different companies having also global reach and they develop dedicated projects and products for Embraer at their countries of origin or at third countries. Some of these suppliers have established in Brazil units to produce components or to assemble systems, but the bulk of their relationship with Embraer is operationalized through exports to Brazil.

3.1. Embraer's trajectory: a stylized description

Embraer was created, in 1969, as a State-owned company, subordinated to the Ministry of Aeronautics, and geared at the production of turbo-propelled aircrafts to the Brazilian Air Force. The company is based in São José dos Campos, in the state of São Paulo, where the Technological Institute of Aeronautics – a prestigious center providing high-level education in aeronautics engineering – had been established in the Forties.

After having gone through heavy financial losses at the late Eighties, the company opened its capital in 1989 and was eventually privatized in 1994, acquired by a financial group and two State companies' pension funds[3]. As part of the privatization model, the Brazilian government retained a "golden share", keeping the power of vetoing strategic decisions taken by the company, as the transfer of the company's control, or decisions relating to defense programs involving the company.

First Embraer's civil aircraft geared at the market of regional air transport was Bandeirante, a non-pressurized aircraft for 19 passengers with two turboprop engines, developed originally to meet the needs of the Brazilian Air Force and certified for flying in 1973. Besides its military use, Bandeirante was well suited to operate in the regional aviation's domestic market, attending medium size cities. At the late Fifties, 335 Brazilian cities were serviced by airlines, most of which acting at the regional level. However, in the early Sixties, the sector went through a deep crisis, as a result of political and economic instability, high maintenance costs associated to an aging fleet and low profitability.

The policy response to the crisis was a set of measures creating legal barriers to the entry of firms and promoting the merger of the companies then in activity. The goal explicitly stated was to reduce the number of carriers in activity to no more than two in the international traffic and three in the domestic transport". (Malagutti, 2001).

The restructuring of civil aviation in the Sixties – with the reduction in the number of carriers and the increasing use of large planes – blocked the plans to boost regional aviation and closed the doors of the domestic market to Embraer's Bandeirante and to its followers: "since Brazil had a much smaller market than those of the United States and Europe, which were the focus of the leading aircraft manufacturers, the introduction of larger planes led to a substantial decline in the number of cities serviced: from 335 cities (roughly 4% of the total) in 1958, to 45 in 1965, before going up again until reaching 92 in 1975" (Bonelli and Castelar, 2007).

EMBRAER became an exporter as early as in 1975 and, in the following years, Bandeirante achieved positive results in the developed countries' markets. Forced to concentrate on exports – due to the unfavorable domestic circumstances referred to above – EMBRAER benefitted from the process of

3. Nowadays the company is publicly traded in the New York and São Paulo Stock Exchanges.

deregulation of the airlines' sector in the US market, enforced initially under President Carter's terms, in 1978.

Deregulation led to a strong and lasting restructuring of the US airline market, fostering the emergence and the consolidation of a business model that made room for the development of a dense network of regional air connections. This new business model – which became largely dominant – created a new demand for aircrafts suited for regional aviation, as Embraer's Bandeirante[4].

When other countries and regions followed the deregulation path inaugurated by the US in the late Seventies, EMBRAER was well positioned to reap the opportunities associated to the development of the regional aviation markets.

The success of Bandeirante in the foreign markets – especially in the US – pushed EMBRAER to develop a new generation of aircrafts. The next commercial aircraft produced by Embraer was Brasília (EMB 120), also a turboprop aircraft, certified in 1985, and carrying up to 30 passengers. Based on the Brasilia project and on the jet aircraft technology acquired during the development of AM-X – an aircraft for military use of the Brazilian Air Force developed through a joint venture with an Italian company – Embraer engaged, in the early Nineties, in the development of the ERJ 145 jet family designed for regional flights' markets, carrying between 37 and 50 passengers. This was the first civil jet aircraft developed and produced by Embraer.

In 1999, Embraer announced the development of a new jet Family, larger than the previous one, with a capacity going from 70 to 122 passengers – the E-Jet Family. According to Niosi and Zhegu (2010), "Embraer correctly forecasted that the market was moving toward larger regional jets and it was the first company to make the movement to the category of 100 – 120 seats, where it competes with the older Airbus 318 and Boeing 717". The new aircraft family was developed and produced through the mobilization of 16 risk-sharing partnerships and 22 first tier suppliers, some of them bigger than Embraer itself.

In addition, in 2001, Embraer entered the business jets' market, a segment that would lately gain relevance in the company's products portfolio and one that has already generated two families of aircrafts. At the same time, the production of aircrafts, equipment and services geared at the segment of defense also acquired relevance.

Actually, the defense segment is part of Embraer's history since the setting of the company. In the Eighties, Embraer began to produce aircrafts for military training – Tucano and Super-Tucano – sold not only to the Brazilian Air Force, but also to a large number of military clients in different countries and regions. The novelty, in this segment, has been the diversification of products and services undertaken in the current decade to meet the demand for defense-related goods and services. To develop such a portfolio of goods and services, Embraer was active in acquisitions and partnerships, setting a new company, named Embraer Sistemas.

Despite the diversification to other segments – within and outside the limits of the aircraft sector – civil aviation was responsible, in 2017, for 59% of the company's turnover, the remaining 41% being

4. "The United States experienced a shortage of planes with the appropriate size for traditional plane manufacturers were increasingly concentrated on expanding their typical airplane size, which reduced costs in dense air lines, but were too expensive and/or forced a low flight frequency in connecting small cities or one of them with a large one" (Bonelli and Castelar, 2007). .

shared by the business aviation segment (26%) and the defense segment (15%). More than 90% of the revenues accruing from the civil aircrafts sales correspond to exports, whose main market is North America (57% of the total, in 2017), followed by Europe and the Asia-Pacific region, each with a 13% share[5]. As for the imports of pieces and components, the main sources are the US and the EU, although imports from other sources have tended to increase their share in Embraer's imports in the last few years.

Highly internationalized through trade, EMBRAER's activities also contemplate foreign investments in productive activities in the US, the EU, China and Mexico. Its subsidiaries in these and other countries also act as commercial and logistic branches, giving technical assistance to foreign clients.

In China, Embraer has built a unit to produce the jet family ERJ 145 in a joint venture with a local firm. Actually this unit has been used to assembling business aircrafts, as the relationship with the local partner and government bodies in China has proven to be tough for the Brazilian firm. In the EU, Embraer has been producing, since 2012, in Portugal, some specific sophisticated equipment for its aircrafts. In the US, Embraer's base – in Florida – was recently expanded to receive an assembling chain for the production of business aircrafts, previously produced in Brazil, now exporting to the US unit pieces and components to be assembled. In Mexico, a joint venture with a local partner was established to produce parts to be used in the commercial aircrafts assembled in Brazil.

The other side of the high degree of internationalization reached by Embraer and its supply chain has been the limited development of domestic suppliers. Local suppliers act in specific segments producing engineering and industrial processes-related services and they are in general much smaller firms than Embraer's international suppliers. According to Montoro and Migon (2009), "the commercial flows undertaken with national suppliers are a small fraction of the value created in the relationships with the risk-sharing partners and other Embraer's international suppliers". However, the vast majority of local suppliers producing specialized services or pieces for Embraer are highly dependent on the demand generated by that firm.

Having conducted a field investigation on these local suppliers, the authors concluded that beyond their specificities as for the goods or services supplied or their insertion in the value chain – among others – they share a common trait: weaknesses at the technological, managerial and economic levels, hindering their growth in the domestic as well the international markets.

Some figures are useful to measure Embraer's size as a company and some of its main economic features (Table 1). In this respect, it is worth noticing that Embraer was, in 2017, the third largest manufacturer of commercial jet aircrafts, overcome (by far, it is true) only by Boeing and Airbus. Its turnover has been, between 2008 and 2016, 56% highest than the one recorded by its main competitor in the market of regional jets, the Canadian Bombardier.

5. Also in the case of business aircrafts, production is, to a large extent, exported, while the Brazilian government is the main client of the defense segment (62% of Embraer's revenues, in this segment, in 2017).

Table 1 : Some figures on Embraer's profile and performance

Total turnover in 2016 (US$ millions)	6,217
Total number of employees 2017	18,097
Employees in Brazil 2017	15,710
Employees in other countries 2017	2,387
Engineers / Employees (%) 2017	23%
Annual average net contribution of Embraer to Brazil's trade balance between 2007 and 2016 (US$ millions)	1,600
Position in the ranking of Brazil's top exporters – 2016 and 2017	2nd and 3rd.
Delivered aircrafts / Order portfolio 2016	244 /636, of which 108 / 450 for commercial aircrafts
Total order portfolio 2016 (US$ millions)	19,623

Source: Embraer

Embraer's trajectory would go through a significant shift, from 2017 on, when the acquisition, by Airbus, of the Bombardier's C-Series Program – the direct competitor for Embraer's E-Jets Family – acted as a game-changer in the commercial aviation market and inaugurated a new cycle of consolidation in this sector, having as its main players Boeing and Airbus – until then absent from the "regional" jet aircraft market[6].

The acquisition of Embraer's main competitor by Airbus represented a radical shift in the Brazilian company's business environment. In the new scenario, Embraer's competitor would be a company manifold larger than it. Besides, Airbus would be able to add the commercial jet competing with Embraer's E-Jets (the C-Series jets) to its large portfolio of products, gaining scope and flexibility to successfully face the competition of Embraer in a specific market segment (the regional jets one).

Therefore, those following the unfolding of such events were not surprised when two months after the movement made by Airbus, Boeing and Embraer announced their plans for a "potential combination". Even before these events, both companies have had a long lasting history of cooperation and partnerships in research and in after sales support to the military cargo aircraft developed by Embraer.

However, the announcement made in December 2017 signaled the beginning of a new phase of cooperation between the two companies, one that could trigger the merger between them or the acquisition of Embraer by Boeing. The negotiations between the two companies and between them and the Brazilian government – which holds a golden share in Embraer's capital – went through the entire year of 2018, concluding with the decision to set a new company exclusively dedicated to producing

6. The succession of initiatives leading to a new cycle of consolidation in the commercial jet aircraft market was triggered by the adoption, in September 2017, by the US Department of Commerce, of antidumping and compensatory duties 200% higher than the value of the C-Series aircrafts whose sale to Delta Airlines was concluded in 2016.The adoption of such measures – if confirmed by a definitive decision by the US International Trade Commission – would challenge the operation between Bombardier and Delta and put at risk the whole C-Series project. One month after the imposition of the US duties on aircraft import, Airbus acquired a majority stake in the company settling the C-Series project, without any financial disbursement. Paradoxically, on January 2018, the US ITC reversed the decision made by the DoC and the import duties were revoked. On the meantime, Bombardier had lost the control over the C-Series program.

commercial jets, in which Boeing will hold 80% of the shares and Embraer the remaining 20%. The agreement reached included the commitment to keep in Brazil the manufacturing of regional jets and to explore other potential market niches to be developed based on the capabilities and resources accumulated by Embraer in Brazil.

As far as the activities relating to the production of military aircrafts and defense equipment are concerned, a joint-venture between the companies was established, 51% of the shares accruing to Embraer and 49% to Boeing. Although it is true that Embraer's capital was, even before these movements, strongly pulverized and detained by non-Brazilian shareholders, from now on the company becomes largely controlled by a huge US firm and will have to adapt to its strategies and priorities.

From the point of view of the sectoral structure, at the global level, "the ongoing alignments (...) have the potential to reduce to a sole duopoly the two existing duopolies – at least until the producers from China, Russia and Japan reach the minimal threshold of relevance and reliability required to challenge the incumbents" (Gomes et alli, 2018).

3.2. Reasons for success

The success of Embraer owes to a set of factors, relating to the strategic options made at the company's level, as well as to public policies designed to support the company. The positive interactions between company-level decisions and public policies also largely contributed to Embraer's accomplishments.

As described, Embraer started its trajectory as a State-owned company, benefitting from the large significant public effort developed since the Forties to create a cluster of educational and R & D institutions focused on aeronautics technology: the Aero-Spatial Technological Center and, within it, the Technological Institute of Aeronautics – the first school of aeronautic engineering in Brazil – and the Institute of Research and Development. Embraer directly inherited from these institutions the results of their technological efforts, underwent during the Fifties and the Sixties, which eventually led to the development of the Bandeirante aircraft. Beyond financing the initial technological investment, government support also showed up through military procurement, a mechanism that supported Embraer's efforts to produce more sophisticated planes.

Therefore, the success of Embraer cannot be understood if its origin as a State-owned company is ignored. This status allowed the company to enter the market of commercial turboprop aircrafts overcoming huge technological and economic barriers.

On the other side, the privatization of the company in the mid-Nineties also appears as an event essential to explain its sustainable and long-lasting success. As explained by Bonelli and Pinheiro (2007), "while a state-owned enterprise , it had focused on technology and technical matters, with comparatively less stress being put on management practices, especially as administrative restrictions and political interference expanded in the 1980s". The authors add: "starting in the mid-1980s, government ownership went from being a plus into becoming a major drag for Embraer's competitiveness. For one, public controls on the company's management activities became much more cumbersome: all important decisions had to go through various instances in Brasilia, often in both the executive and the legislative branches of government. For another, the government forced the company to enter into unprofitable projects such as (...) a joint-venture with Argentina (...) which

although technologically sophisticated was commercially nonviable. A decline in exports and domestic sales reduced the total number of planes sold from 211 in 1989 to 81 in 1992 (...).In 1990-1992 Embraer accumulated net losses of US$ 775.7 million, out of a total of US$ 1,060.2 million in net revenues".

Embraer benefited tremendously from privatization: "privatization led to a complete turnaround in the company's management practices and finances, accounting for a significant part of its later success. In particular, it enhanced its profit orientation and freed it from a myriad of restrictions and controls to which all Brazilian SOEs have to abide".

Hence, the sequencing of events strongly favored Embraer: it largely benefited from being set as a State-owned company and from being privatized as part of a public policy of divestment in productive activities in the mid-Nineties.

In-company reasons for success

Although it is almost impossible to disentangle specific features that can be deemed responsible for the success of a company, it seems possible, in the case of Embraer, to identify a non-exhaustive list of factors that concurred for its accomplishments. The following ones are surely factors having played a major role in Embraer's successful trajectory:

a) A strong focus on exports, almost since the early years of Embraer's existence[7]. Focus on exports allowed for "longer production runs, stimulated customers to bring new ideas for technical change, and demanded exacting performance standards" (Goldstein, 2002). As commented, exports represent nowadays more than 90% of Embraer's revenues.

b) The decision to continually generating new technologies directed to commercial use, despite the risks involved in this option. The alternative would be to license foreign technology, but, as Bonelli and Castelar (2007) put it, "in this case it would not have been able to export, at least to the main markets. Without exporting it would have to operate with a low scale and high costs, and thus depend on a continued inflow of public subsidies and/or trade protection to remain competitive".

Therefore a) and b) above are strictly interrelated: the export orientation would not be possible without the decision to develop the technology needed to keep the pace of innovations that characterize this sector. On the other hand, the export drive of the company create the conditions for a continuous technological upgrading of its aircrafts and for the enforcement of a productive strategy based on reducing aircraft weight – hence its fuel consumption – and achieving low manufacturing costs when producing aircrafts with a high level of reliability.

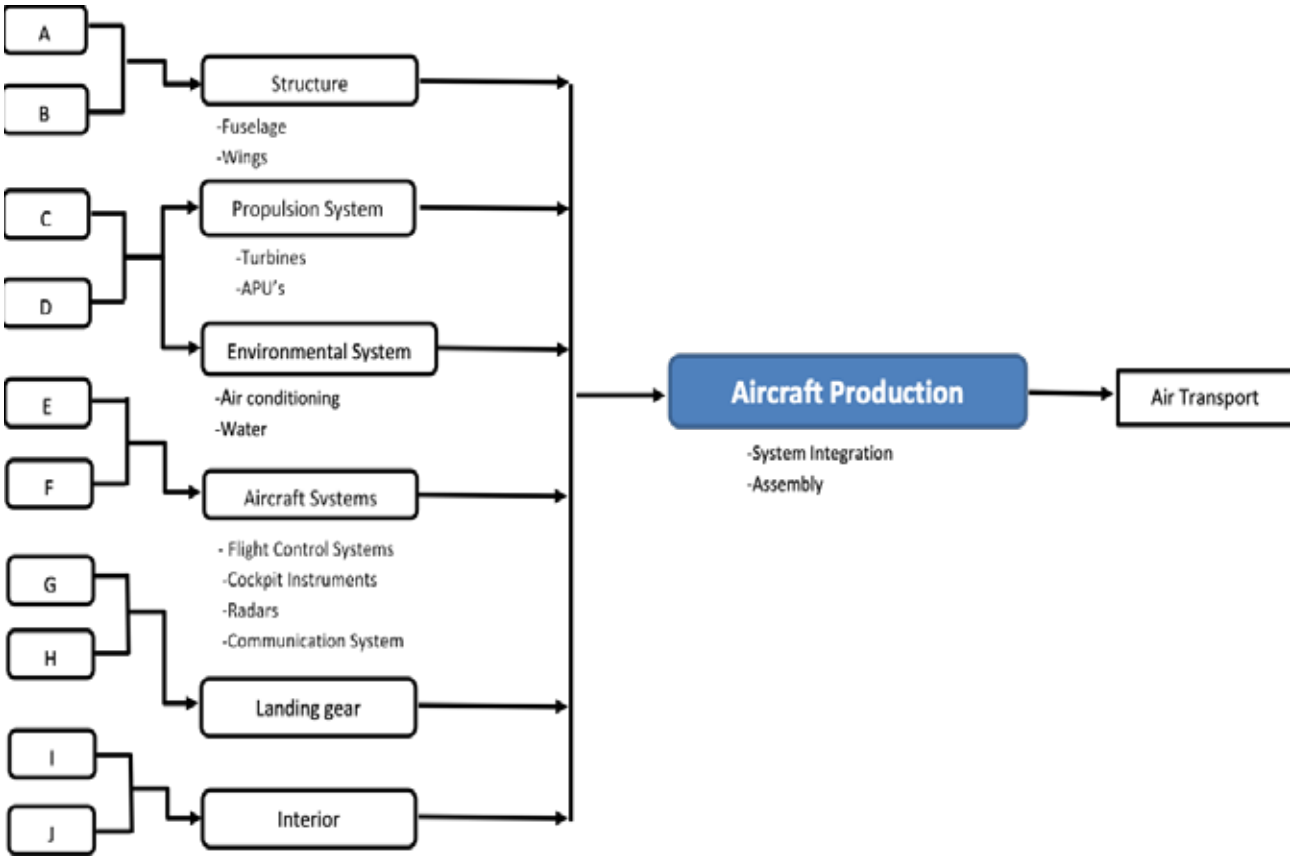
c) The decision to focus the efforts of the company in specific profitable and high value added functions of the chain value geared at the production of commercial aircrafts. In fact, Embraer focused on highly valued value chain's functions: the conception and development of the product, its assembling, commercialization and the supplying of after sales services. Although the few commercial aircrafts producers have different degrees of vertical integration, they control the same components of the value chain as Embraer and let to a wide network of suppliers the production of equipment and parts lately integrated to the final product.

7. As stressed by Bonelli and Castelar (2007), "exporting was totally dissociated from the original government program, which foresaw Embraer focused on the domestic market and as a supplier of military planes".

d) The setting of stable cooperation relationships with suppliers of aircraft's parts and equipment, a mechanism which brought two very relevant benefits to Embraer: avoiding an excessive vertical integration and absorbing technology from these suppliers, many of which operate at global scale.

The commercial aircrafts' supply chains are structured as a pyramid, with a wide set of suppliers at its basis and, above them, another one or two layers of suppliers that integrate into systems and subsystems the parts and components produced by the firms at the basis of the pyramidal structure (Figure 1)

Figure 1: The commercial jet aircraft value chain: a stylized representation with two suppliers' layers



Embraer's trajectory, especially after its privatization, followed a path geared at consolidating and coordinating this pattern of industrial organization. Until the early 1990s – before privatization – Embraer adopted a vertical development system, outsourcing production, but not the development of aircraft parts.

The decision to outsource part of the project development process was forced on Embraer, for it lacked the funds to proceed with its traditional model, which also explains why its then new family of aircrafts - EMB-145 - took so long to develop. The first risk-sharing partnerships were established during the EMB-145 family's development, but at that time they involved only a small number of suppliers, most of them acting in the segment of structural components

The risk-sharing strategy was significantly expanded and deepened through the E-Jets family's project. Many suppliers have then participated to the project development and, according to Montoro and Migon (2009), the new program produced a "deep change in Embraer's value chain organization and in its governance model"[8]. Beyond, the development of the E-Jets family provided the opportunity for Embraer to consolidate its profile as a firm whose central competences rely on the integration of complex systems in aeronautics and subsequently in other areas as defense equipment.

Of course, c) and d) are also strongly correlated: the decision to target some functions of the value chain would not be possible without the establishment of stable cooperation relationships with competitive and reliable suppliers spread all around the world.

It is worth noticing that, beyond the setting of long-lasting cooperation relationship with its main suppliers, Embraer was also able to consolidate a group of "key customers" that have repeatedly made the option for its aircrafts. This is perceived by the company as one of the reasons for its success, as it assured the continuity and the stability of the demand, acting as a relevant mitigating factor of the commercial risks incurred by the company. IN the commercial segment, at the end of 2016, more than 85% of the so-called firm orders for the E-Jets family originated in less than ten key customers from different countries and continents.

e) The ability to anticipate market trends and the focus on a dynamic and promising market niche. In the commercial aircraft segment, Embraer targeted, from the beginning, the market of regional routes, which was not supplied by the large aircraft producers. This market niche was supplied by different manufacturers producing turboprop aircrafts and Embraer followed the same track with its Bandeirante aircraft. However, the market for regional aircrafts expanded rapidly from the Eighties on, as a consequence of regulatory changes in the civil aviation sector in the developed countries. These changes opened new opportunities for the regional aircrafts manufacturers and for the introduction of jet-propelled aircraft in this market niche, in competition with the traditional turboprop aircrafts. Embraer seized these opportunities and moved to the manufacturing of jet aircrafts, a move that only the Brazilian company and Bombardier were able to accomplish, thus producing a new segmentation of the market, between regional jets (a new market niche) and regional turboprop aircraft.

Public policy-related reasons for success

Set as a State-owned company, Embraer was by definition a product of public policies. The company's privatization in the Nineties – which played a central role in the consolidation of the company as a major global player in its markets – also derives from a policy decision taken as part of a broader liberalization shift that marked Brazil's public policies at that time.

As argued, as a State-owned company, Embraer strongly benefitted from the significant public effort developed since the Forties to create an eco-system of educational and R & D institutions focused on aeronautics technology: the Aero-Spatial Technological Center and, within it, the Technological

8. In a risk-sharing partnership, the supplier firm is responsible for the project, the development and the manufacturing of the main aircraft's components or systems. The goods produced by the risk-sharing partners correspond to the main components of the aircraft structure: propulsion, avionic systems etc. With the adoption of the risk-sharing model, the number of companies supplying directly to Embraer was substantially reduced.

Institute of Aeronautics. The initial steps made by the company and its entry in the commercial aircraft segment owes a lot to these previous efforts and it is hard to imagine such accomplishments should this eco-system not exist.

After the company's privatization, the main mechanism used for public support was export financing, through direct credit or interest rates equalization to compensate for the higher rates practiced in Brazil in comparison to the OECD countries.

According to Embraer's official information, between 2004 and 2016, "around 27% of the commercial aviation deliveries were subject to public export credit. In 2015 and 2016, 43% and 57% of our commercial aviation deliveries, respectively, were supported by the Brazilian Export Financing Program"[9].

BNDES – The National Bank for Development – was responsible for direct financing, Banco do Brasil – a publicly held commercial bank – for the interest rate equalization (using Treasury funds) and FINEP –a public agency acting in the financing of innovation – for the support to R & D investments. Although public funds have played a relevant role in the support to Embraer's activities, the repeated economic crises that Brazil has gone through in the last four decades have constrained the availability of funds use to such end.

Besides the financial support to Embraer exports and R & D investments, the State played a relevant role defending the company's interests in the dispute settlement that have opposed (and still oppose) Embraer to Bombardier at the WTO and in the negotiations of the ASU at the OECD.

In the case of the WTO, the disputes relate to the officially supported credit programs put in place by Brazil's and Canada's governments to support the national companies competing in the commercial jet aircrafts market. Two panels were installed at the WTO, each one at the demand of one country, and both panels concluded that, in the two countries' programs, there were elements incompatible with the WTO rules. In the case of Brazil, these elements were revised following the Appellate Body decision.

As the Brazil-Canada and US – EU disputes at the WTO made evident at the beginning of the Century, export financing in the commercial aircraft sector had become a highly controversial issue, negatively affecting the market as a whole. As a consequence, the countries representing the main players in the sector sought to reach an agreement at the OECD setting criteria and parameters to avoid "predatory" competition through subsidized officially supported export credits.

Although not a member of the OECD, Brazil took part integrally to the negotiations and signed the resulting instrument – the Aircraft Sectoral Understanding (ASU), which constitutes the Annex II of the OECD's Arrangement on Officially Supported Export Credits. The ASU was signed in 2007, reviewed in 2011, and it is regularly updated by the signatory countries.

After the entry in force of the ASU, the national officially supported export financing programs had to adapt to the new rules and the subsidized public support to the national manufacturers of commercial aircrafts shifted to the investments in R & D and the so-called "launch aid". The growing

9. Embraer, SEC, Form 20 F, 2017.

relevance of this kind of subsidies has led to the opening of two new dispute settlement episodes at the WTO between the US and the EU and, more recently to a new panel opened at the demand of Brazil against Canada's public policies in support of the C-Series[10].

A third dimension of public policies' support to Embraer was made concrete through measures that created a "tailor-made" trade regime for the company, mainly through the withdrawal of import tariffs and taxes extended to all the components, equipment and systems needed for the production of aircrafts in Brazil. As a consequence, Embraer enjoys a free trade regime for all its imports, sparing the company from the burden to its costs that would arise from the collection of taxes and tariffs on its imports.

Tariffs applied by Brazil to the imports of parts and components for commercial aircrafts are subject to the Tax Rules applied to the Aeronautical Sector, a regulation that reduce to 0% the import duties on these goods. In fact, the Brazilian rules reproduce the ATCA's Annex listing the items whose import tariffs are zeroed by the signatory countries (although Brazil is not one of them). Besides, Embraer's imports benefit from RECOF – a special and computerized customs regime adopted in 1979 that guarantees a quick process of custom clearance for the companies using it. In the industrial policy front, BNDES has loosened, in the case of Embraer, the minimum level of national content required from the goods benefited by its funds.

The "exception" status granted to Embraer by Brazil's traditionally protectionist trade and industrial policies is also reflected in the low effectiveness and policy implication of the criticism addressed to the company for the high percentage of import added to the final product. In fact, despite the shifts in the political and policy preferences of successive federal governments, they have resisted to adopt lasting measures aimed at "forcing" the company to internalize (in Brazil) additional upstream linkages of the value chain. Contrarily to what has happened in the management of public policies addressing the industrial sector as a whole, in the case of Embraer the export competitiveness and outward-oriented strategies have prevailed over the import substitution logic and goals.

4. Main conclusions and policy lessons

This paper has sought to trace back the unique trajectory of Embraer, a company born in a developing country that was able to enter different segments of a high-tech industry and to occupy the global top position among the producers in one of such segments (the regional commercial jet aircrafts one).

The success of Embraer owes to a set of factors, relating to the strategic options made at the company's level, as well as to public policies designed to support the company. Especially relevant for Embraer's accomplishments have been the positive interactions between company-level decisions and public policies. The sequencing of events, under the impacts of different public policies orientations, strongly favored Embraer: it largely benefited from being established as a State-owned company, between 1969 and the Eighties, but also from being privatized as part of a public policy of divestment in productive activities in the mid-Nineties.

10. On February 2017, the Brazilian governed asked for consultations with Canada at the WTO, targeting the programs set by the Canadian and Quebec's provincial governments to support the development and the launching of the C-Series program, including a substantial injection of public capital in the special purpose company established to manage the program. The consultations were not considered conclusive by the Brazilian government and, in August, Brazil asked the establishment of a new panel.

In-company reasons for success are manifold and they point to a long-lasting outward orientation, the ability to anticipate trends in the international markets and to set a network of partnerships based on risk-sharing arrangements with large suppliers as well as on the consolidation of a group of key-customers.

Outward orientation owes, from the outset, to an unfavorable domestic evolution in the Sixties which led to the reduction in the number of air carriers and the increasing use of large airplanes connecting a declining number of large cities. Regional aviation never prospered in Brazil and as recently as in 2014, a Program for the Development of the Regional Aviation (PDRA) was launched and enthusiastically received by Embraer, only to be abandoned in 2016 in the middle of Brazil's fiscal crisis[11].

At the same time, deregulation of the airlines services in the US and later on, in other countries and regions fostered the demand for regional aircrafts, which had become, at that time, the main Embraer's business. Some years later, Brazil developed financial instruments to support the exports of manufactured goods, among which airplanes, and this trend helped to consolidate the outward orientation of the company.

Besides these circumstantial factors that explain the sharp contrast between Embraer's performance in foreign and domestic markets, exporting is a vital necessity for aircraft manufacturers: "without exporting, it (Embraer) would have to operate with a low scale and high costs, and thus depend on a continued inflow of public subsidies and/or trade protection to remain competitive (…) Lack of scale was a critical limitation to the ability to compete, internally and abroad, with incumbent manufacturers" (Bonelli and Castelar, 2007).

Partnerships are another essential component of Embraer's strategy and success. As stated, the company has established long-lasting relationships with the main suppliers of systems and sub-systems to its aircrafts, adopting the model of risk-sharing partnership with some of them. Broadly speaking, these arrangements have been quite successful.

On one hand, they substantially reduce the uncertainties arising from ad hoc relationships between suppliers and consumers, while at the same time distributing the burden of the development and manufacturing of significant and costly components of the aircrafts. As a consequence, Embraer could concentrate its efforts on some specific activities of the value chain, as the design, the assembling and the provision of post-sales services

On the other, in political economy terms, the setting of such partnerships was relevant to consolidate alliances between Embraer and suppliers based on its main foreign markets, thus mitigating the risks of protectionist reactions against the company's exports to such markets.

Less successful has been Embraer's partnership established in China to assemble its regional jets and to complement the local assembling with exports of aircrafts from Brazil. In this case, Embraer's performance was frustrating, as the company's plans seem to have collided with the Chinese governmental program to develop its own national aircraft targeting the same market as Embraer's.

11. The PDRA aimed at promoting the setting of a regaional aviation netwaork through the granting of subsidies to the airlines committing to establish regular connections between regional airports.

Public policies were functional to Embraer's strategies first and foremost by creating – in the decades preceding the setting of the company - a whole technological eco-system favorable to the development of aircraft design and manufacturing. After the company's privatization, official support was particularly relevant in export financing and in the support to the company's interests through multilateral diplomacy (WTO dispute-settlement).

In a country whose industry is historically protected from import competition by tariffs and non-tariff barriers, Embraer was granted a free trade status as far as its imports are concerned. Besides, Brazilian successive governments have refrained from actively "inducing", through industrial policies, the import substitution of parts and components bought by Embraer from its foreign suppliers.

Implicitly at least, the public policies have acknowledged the fact that the value chain coordinated by Embraer should necessarily be global and that, at least in this case, the value chain's logic should prevail over import-substitution oriented policies.

This is the first of the three main policy lessons to be derived from Embraer's experience. Competitiveness goals – especially when import of large amount of goods is required for exporting (as happens in many international value chains) – conflict with industrial and trade policies shaped by the logic of import substitution or by the objective of promoting the development of an indigenous group of suppliers[12]. The level of conflict between these objectives is high in the case of Embraer, whose manufacturing activities concentrate on the assembling of complex systems and subsystems produced by world-class suppliers and whose production is almost entirely exported.

If they are to be successful, public policies targeting sectors which forcefully operate according to the logics of international value chains have to adapt to these logics, avoiding any temptation of imposing requirements of domestic contents and other discriminatory tools. As high-technology sectors, in industry as well as services, tend to be international by nature, this lesson extends beyond the specific sector of aircrafts production, encompassing a wide range of high-tech activities.

One relevant implication of this lesson points to the fact that the spill-overs traditionally expected to take place in the industrial sector – through the local development of suppliers and the "nationalization" of segments of the value chain – tend to be limited, as was the case on Embraer's experience. Driven from the outset by international competitiveness's concerns, the consolidation of Embraer as a global player relied strongly on the connections between the company and its foreign suppliers and clients, a configuration which did not favor the development of a wide set of local industrial suppliers.

A second lesson refers to the relevance of State policies in setting a technological infrastructure (the Aero-Spatial Technological Center and, within it, the Technological Institute of Aeronautics) dedicated to aviation. The operationalization of such lesson can vary according to the countries, but the Brazilian experience evidences the relevance of the State initiatives taken as early as the Forties, to build, in São José dos Campos, such an infrastructure.

The third lesson is not exclusively related to Embraer's experience or to the aeronautical sector one, pointing to the role of the State in defending the company's interests through economic diplomacy, at the WTO, in the OECD and in bilateral instances. This is a dimension of public policy which can

12. These can be legitimate goals for trade and industrial policies but governments can be obliged to choose between achieving them and keeping the exporting companies competitive.

be underestimated, especially when contrasted to policies based on the transfer of public financial resources to private companies.

However, this policy has played a major role for Embraer in contributing to level the playing field in international competition through the public financing of aircraft sales. Brazil is a developing country, less fiscally endowed than its developed competitor (Canada) to subsidize its industry. As a consequence, a "subsidization race" in this sector would certainly harm Embraer's competitiveness as compared to its competitors. Therefore, leveling the playing field for public financing through dispute-settlement at the WTO and the negotiation of a specific agreement at the OECD has been highly functional to company's interests.

Embraer and the federal government have worked closely alongside the whole first WTO process[13] and this pattern of relationship was replicated in the following dispute-settlement episodes, as well as in the ASU's OECD negotiations. As the trade political environment goes worse, as it is currently the case, the relevance of public-private partnerships to foster the interest of the national companies in the global markets tend to become even more relevant than before.

13. The first bilateral dispute between Brazil and Canada focusing on the aeronautical sector, initiated by Brazil, in the Nineties, was also the first governmental experience with the multilateral dispute settlement mechanism as applied to anindustrial sector.

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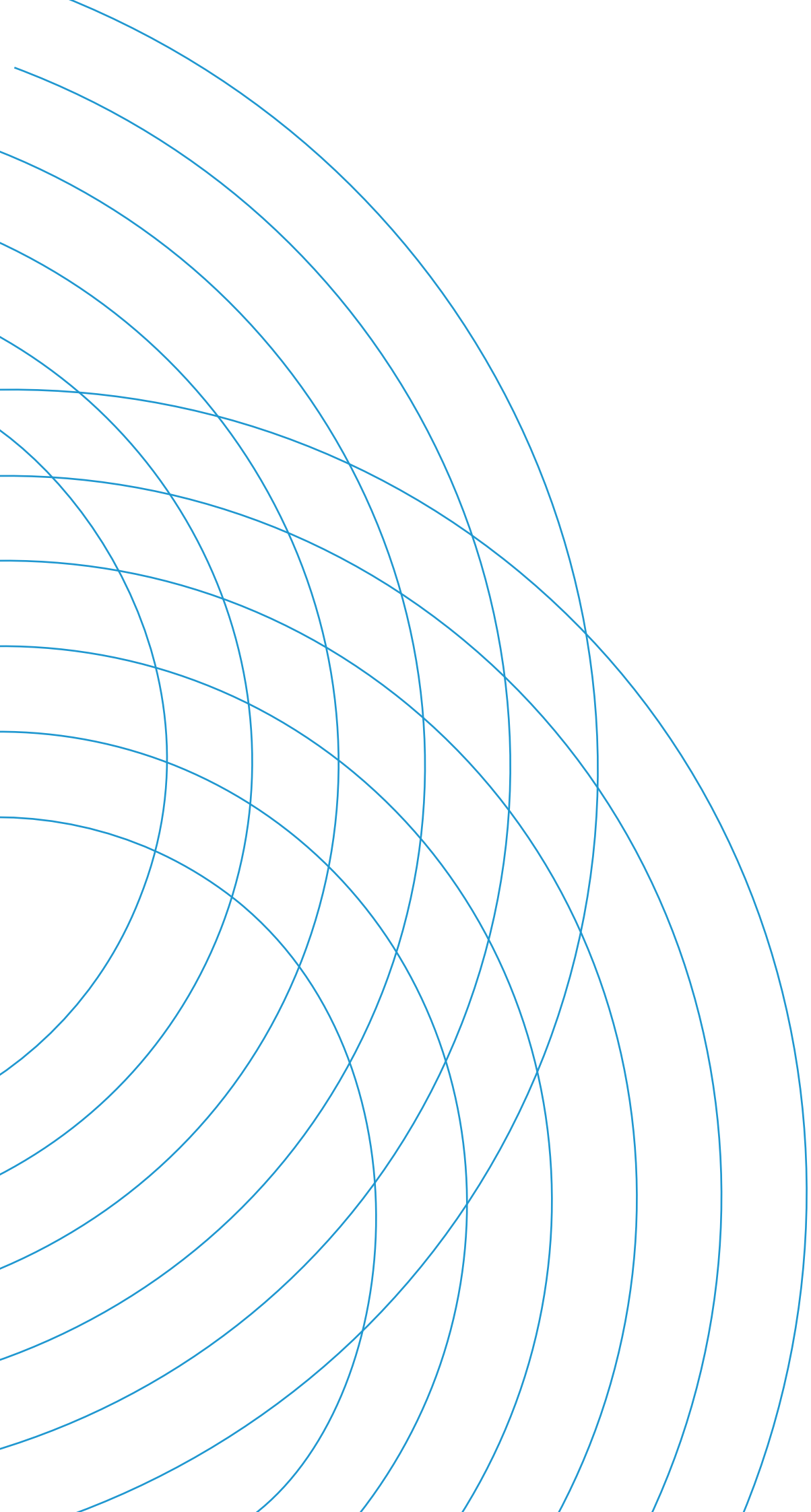

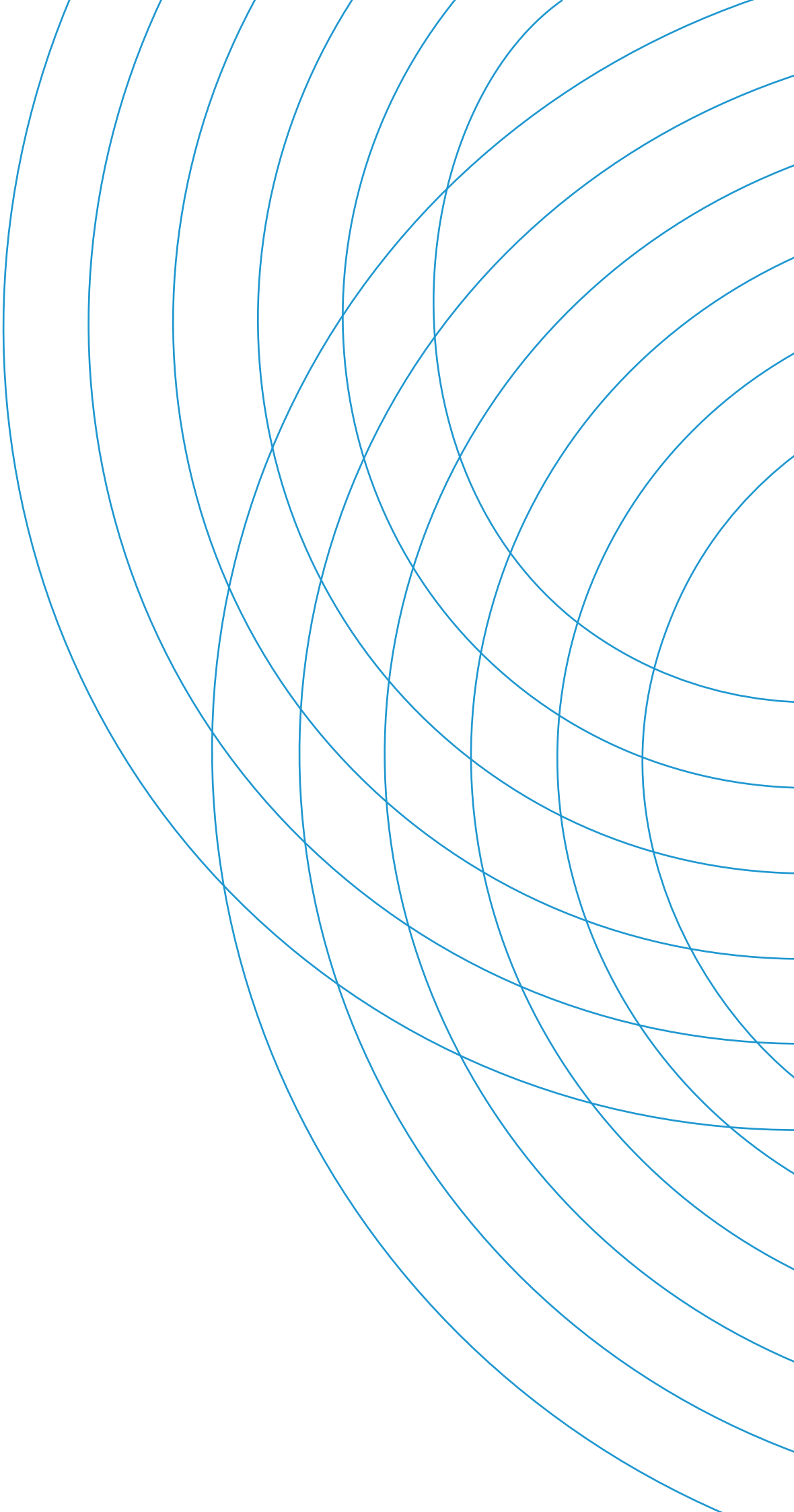

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