

The Interplay Between International Relations and Science, Technology and Innovation: An Analysis of Embraer's International Partnerships



A Interface entre Relações Internacionais, Ciência, Tecnologia e Inovação: Uma Análise das Parcerias Internacionais da Embraer

La interacción entre las relaciones internacionales Capes la ciencia, la tecnología Capes la innovación: Un análisis de las asociaciones internacionales de Embraer

Maurílio Daros²
Iara Costa Leite³
Vitelio Marcos Brustolin⁴

DOI: 10.5752/P.2317-773X.2022v10n4p55-71.

Recebido em: 09/02/2022
Aprovado em: 17/10/2023

ABSTRACT

International partnerships have been fundamental to Embraer's technological advancement. The very creation of the company was only possible due to prior support received from specialized institutions in countries such as the United States, with governmental support. Even so, academic works on Embraer focus very little on its international agreements. This article maps and systematizes literature on international partnerships involving Embraer retrieved by Scopus, Scielo and the CAPES Thesis and Dissertation Catalog. In addition to presenting quantitative data that corroborates the finding on low participation of specific literature on international partnerships involving Embraer, this article demonstrates that almost none of the articles retrieved by the search are from the field of International Relations. In general, concepts and theories on which the mapped literature relies assume a purely transnational component in the partnerships without taking into account, for instance, the role of states in supervising international knowledge flows. Contributions made by the literature, while relevant to understanding business partnerships involving knowledge flows, do not necessarily consider the uniqueness of such flows when they cross national borders. Furthermore, it is demonstrated that the mapped literature does not take the partnership axis (North-South or South-South) as a relevant variable for effectiveness.

Keywords: Embraer; Brazil; Airplane manufacturers; Science, technology and innovation; International partnerships.

1. We thank the National Council for Scientific and Technological Development - CNPQ (Universal Public Notice 2016), the Visiting Professors Abroad Program 2019-2020 of the Coordination for the Improvement of Higher Education Personnel - CAPES and the Support Fund for the Maintenance and Development of Education Superior of Santa Catarina State for the financial resources destined to the authors of this article.

2. Maurílio Eduardo Daros holds a Master's degree in International Relations at Federal University of Santa Catarina. Received his Bachelor's in International Relations from the same university. His research focuses on international cooperation in Science, Technology, and Innovation (STI). Email: maurilio.daross@gmail.com.

3. Iara Costa Leite is Associate Professor of the Department of Economics and International Relations of the Federal University of Santa Catarina (UFSC) and leader of the CNPq research group Relações Internacionais e Ciência, Tecnologia e Inovação (RICTI – International Relations and Science, Technology and Innovation). PhD in Political Science (IESP/UERJ), Master's in International Relations (PUC-Rio), Bachelor's in International Relations (PUC-Minas). Emails: iara.leite@ufsc.br | iaracleite@hotmail.com | Academic websites: ricti.ufsc.br.

4. Vitelio Brustolin is a Research Scientist at Harvard Law School, a Visiting Professor at the Harvard Department of the History of Science, an Adjunct Professor at Columbia University in the School of International and Public Affairs, and a University Professor at the Institute of Strategic Studies and International Relations (INEST) of the Fluminense Federal University (UFF). PhD and MSc in Public Policy, Strategy, and Development (UFRJ and Harvard). Bachelor's of Legal Sciences (JD) and Social Sciences (BA) from URI. Emails: Brustolin@g.harvard.edu | viteliobrustolin@id.uff.br Academic websites: https://scholar.harvard.edu/brustolin | www.professores.uff.br/brustolin.

RESUMO

As parceiras internacionais foram fundamentais para o avanço tecnológico da Embraer. A própria criação da empresa só foi possível graças ao apoio prévio recebido de instituições especializadas de países como os Estados Unidos, com o apoio governamental. Ainda assim, os trabalhos acadêmicos sobre a Embraer se debruçam muito pouco sobre os acordos internacionais da empresa. Este artigo mapeia e sistematiza a literatura sobre as parcerias internacionais envolvendo a Embraer por meio de consultas à Scopus, à Scielo e ao Catálogo de Teses e Dissertações da CAPES. Além de apresentar dados quantitativos que corroboram a constatação acerca da baixa participação da literatura específica sobre as parcerias internacionais envolvendo a Embraer, demonstra-se que quase nenhum dos artigos retornados pela busca é da área de Relações Internacionais. Em geral, os conceitos e as teorias em que a literatura mapeada se baseia presumem um componente de caráter puramente transnacional nas parcerias, sem levar em conta, por exemplo, o papel dos Estados na supervisão do fluxo internacional de conhecimentos. Os aportes realizados pela literatura mapeada, ainda que relevantes para a compreensão de parcerias empresariais que envolvam fluxos de conhecimentos, não levam necessariamente em consideração a singularidade de tais fluxos quando perpassam as fronteiras nacionais. Além disso, demonstra-se que a literatura mapeada não toma o eixo das parcerias (Norte-Sul ou Sul-Sul) como variável relevante para sua efetividade.

Palavras-chave: Embraer; Brasil; Fabricantes de aeronaves; Ciência, tecnologia e inovação; Parcerias internacionais.

RESUMEN

Las asociaciones internacionales han sido fundamentales para el avance tecnológico de Embraer. La propia creación de la empresa sólo fue posible gracias al apoyo previo recibido de instituciones especializadas de países como Estados Unidos, con apoyo gubernamental. Aun así, los trabajos académicos sobre Embraer se centran muy poco en sus acuerdos internacionales. Este artículo mapea Capes sistematiza la literatura sobre asociaciones internacionales que involucran a Embraer, recuperada por Scopus, Scielo Capes el Catálogo de Tesis Capes Dissertaciones de CAPES. Además de presentar datos cuantitativos que corroboran la constatación de la baja participación de la literatura específica sobre asociaciones internacionales que involucran a Embraer, este artículo demuestra que casi ninguno de los artículos recuperados por la búsqueda es del campo de las Relaciones Internacionales. En general, los conceptos y las teorías que respaldan la literatura mapeada asumen un componente puramente transnacional en las asociaciones sin tener en cuenta, por ejemplo, el papel de los Estados en la supervisión de los flujos internacionales de conocimiento. Las aportaciones de la bibliografía, si bien son relevantes para comprender las asociaciones empresariales que implican flujos de conocimiento, no consideran necesariamente la singularidad de dichos flujos cuando atraviesan las fronteras nacionales. Además, se demuestra que la literatura mapeada no toma el eje de la asociación (Norte-Sur o Sur-Sur) como una variable relevante para la eficacia.

Palabras clave: Embraer; Brasil; Fabricantes de aviones; Ciencia, tecnología e innovación; Asociaciones internacionales.

INTRODUCTION

The interplay between international relations and science, technology and innovation (STI) is increasingly important in the contemporary world, permeating dynamics of cooperation and conflict in areas such as defense, development, and the environment. To grasp such interplay satisfactorily, it is necessary to investigate not only transnational interac-

tions established between knowledge repository actors, such as companies and universities, but also the role of states in overseeing international knowledge flows - either promoting or restricting them.

Although liberal-inspired perspectives have predicted, and even celebrated, diminishing state control over international knowledge flows after the end of the Cold War (Wagner, 2008), in the current moment, marked by the technological competition between China and the US, few question the validity of understanding the relevance of states in defining “policies and instruments that help draw the line between what kind of knowledge will be shared with (or denied to) whom” (Krige, 2019, p. 13).

Although reference studies on the subject, such as those produced by historians of science and technology, focus on the analysis of dynamics related to the Cold War, particularly in the nuclear field, they pose relevant implications for studies of more recent phenomena and in other sectors. One of them comes from the demonstration that, contrary to what liberal theories on international cooperation, inspired by game theory, advocate, cooperation and competition are not opposite dynamics (Leite; Gayard, 2019). The promotion of collaboration among scientists in the nuclear field, for example, was used by the US as a tool to access crucial knowledge produced in countries with which it cooperated in order to monitor the development of nuclear technology and prevent proliferation.

In many cases, while restricting access to nuclear strategic technologies, knowledge flows have been promoted in areas that might pose little threat to the security of the United States, under a strategy known as “positive disarmament”. Such strategy was applied, for instance, in the promotion of space cooperation with Germany in the 1960s, diverting the latter's nuclear efforts (Krige, 2014). At the North-South level, the same happened in the case of US-India collaboration during the Johnson administration, which promoted knowledge flows in agricultural and meteorological technologies in an attempt to confer a symbolic status to Indian scientific-technological capabilities in areas that would not endanger US security (Doel; Harper, 2006).

Likewise, the early years of the Cold War saw the emergence of the American government's concern about Brazilian interests in the possession and trade of fissile materials as a bargaining tool in the search for the accumulation of knowledge necessary for the development of nuclear technology (Conselho de Segurança Nacional, 1947). In that context, seemingly at an attempt to balancing moves by Washington to hinder Brazilian access to nuclear know-how not only in the United States but also in other countries (see, for example, US Department of State, 1947), US aid initiatives started sponsoring knowledge flows from the US to Brazil in other areas. We believe such flows have been crucial to laying the grounds for Brazilian technological advance in areas such as aeronautics, culminating with the creation of EMBRAER in 1969.

With those considerations as background, this article aims to undertake a meta-analysis of the academic production on the interplay between international relations and STI in the case of Embraer. Throughout its history, the company has entered partnerships with competing firms, promoting knowledge sharing of aircraft production. However,

even though the international element integrates the entire trajectory of Embraer, it is still a topic that is poorly reflected upon, as will be demonstrated in this article. When academic literature examines the subject, in general it is backed by concepts and theories that focus on company-company relations, and not on the role of states in supervising international knowledge flows in aeronautics.

This article is divided in three sections: the first one addresses the research method and presents its statistical results. The second section synthesizes the trajectory of Embraer, highlighting its main international partnerships, including the ones that laid the ground for its creation. The third section focuses on a qualitative discussion of the retrieved literature on the interplay between STI, international relations, and the case of Embraer. At its conclusion, this article's findings are summarized and future research avenues are pointed out.

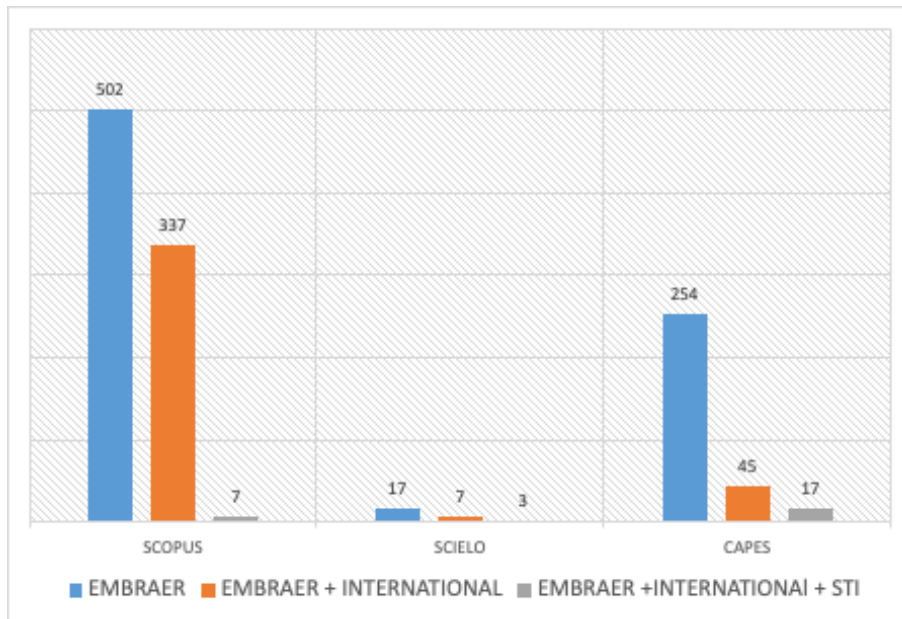
METHODOLOGY AND STATISTICAL RESULTS OF THE SURVEY

The first methodological step of this study was to map out literature on the interplay between international relations and STI in the case of Embraer. To this end, the word "Embraer" was first searched for in the abstracts of articles registered with Scopus and Scielo, as well as in the CAPES Thesis and Dissertation Catalog.⁵ Second, the literature was screened by reading the abstracts of the retrieved papers, selecting those in which the international element was present. Thereafter, those articles with abstracts containing words such as "international," "world," "global," "foreign," "overseas," any variants thereof, or mention of specific countries or foreign companies or suppliers, such as Boeing and Airbus, were selected. Finally, through a second reading of the abstracts, publications that incorporated the element of STI were identified.

The chart below illustrates the number of publications selected in each step described above. Although the number of publications varied greatly among the databases, in all cases there was a significant decrease in the number of publications when the searches for the international element, and subsequently for STI, were introduced.

5. The CAPES Catalog is a database of theses and dissertations defended in Brazil.

Chart 1 – Number of publications selected in each research step



Source: Produced by the authors

Once we mapped out publications in which the interplay between international relations and STI was present, we proceeded to the systematization phase. The first statistical result of this analysis pertains to the type of material surveyed (Table 1), pointing to a prevalence of master's theses among the selected publications.

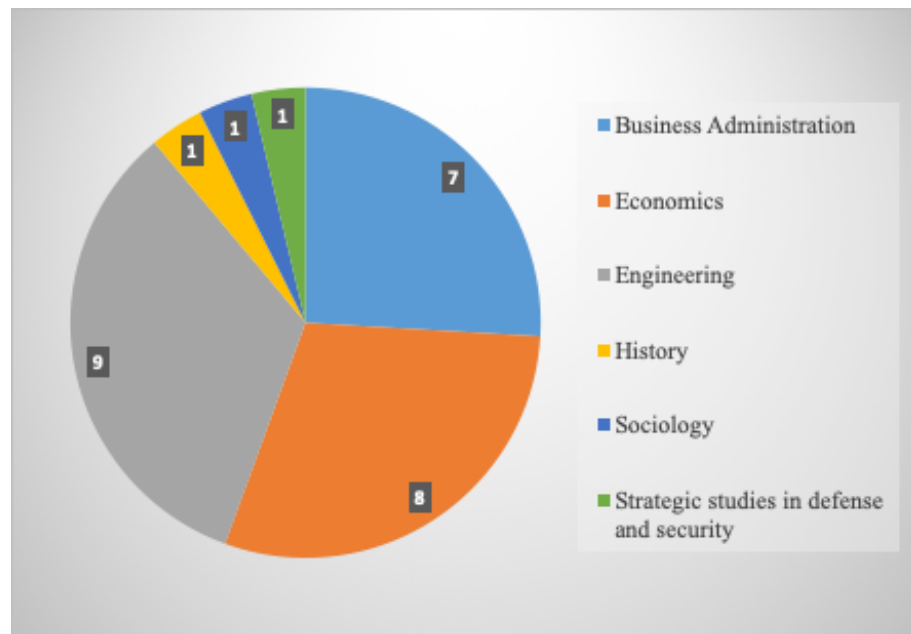
Table 1 – Selected literature classification by type of material

Material Type	Number of selected works
Conference Paper	1
Journal Article	8
Thesis	16
Dissertation	1
Book chapter	1

Source: Produced by the authors

Regarding the areas of origin of the authors, the chart below shows that professionals in engineering (aeronautical, production, or naval) are the most frequent authors, followed by economists and business administration professionals.

Chart 2 – Selected literature classification according to authors' area



Source: Produced by the authors

The fact that only one paper has been written by an International Relations scholar (more precisely, from the area of Strategic Defense and Security Studies) reinforces, for the case studied, assertions made by authors such as Mayer, Carpes and Knöblich (2014), Skolnikoff (1993), and Weiss (2005), considering that the area of International Relations has not yet incorporated STI as a crucial element in its studies and approaches.

According to Susan Strange (1994), part of the puzzle of grasping the centrality of knowledge in international political economy dynamics relates to the fact that the structural power emanating from the knowledge structure relies not only on the ability to provide knowledge, but also to deny it. As stressed in this article's introduction, international knowledge flows can indeed be hindered or encouraged by government policies, depending on the objective pursued. The Point IV Program, initiated during the Truman administration in 1949, may have represented not only a milestone in US attempts to share its scientific advances and industrial progress with Third World countries as a means to secure allies in the containment of communism (Lancaster, 2000), but also in the promotion of knowledge flows that could help push developing countries' scientific and technological efforts away from nuclear proliferation.

As will be shown in the next section the Point IV Program, and later the Alliance for Progress, sponsored knowledge flows from the US to Brazil that supported the accumulation of the capacities necessary for the creation of Embraer. What follows is an illustration of the centrality of international relations in Embraer's trajectory, a topic not yet adequately reflected in the literature, as previously indicated.

THE INTERNATIONAL TRAJECTORY OF EMBRAER

The trajectory of the development of the aeronautical industry in Brazil, initially led by the state, is marked by a sequence of international cooperation agreements aimed at bringing to the country technologies that would accelerate local industry development. In June 1941, the initial cornerstone for this development was laid when Brazil and the United States signed an agreement based on the Lend-Lease Act, which regulated military loans to allied countries. Besides providing more than 400 aircrafts to Brazil, that agreement allowed Brazilian Air Force officers to take a training course in the United States in exchange for the installation of American military bases in Brazil (Forjaz, 2005). The military staff responsible for the creation of the Ministry of Aeronautics and the Brazilian Air Force aimed to promote a national aeronautics industry and access the required technology. This group, led by Salgado Filho, shared the belief that the best option to achieve such goals was to support rapprochement with the US and, therefore, intensify negotiations with the country to equip the Air Force and train its personnel (Moura, 1996).

After the Second World War, a group of aeronautical officers,⁶ led by Casimiro Montenegro Filho, began planning the creation of an institution focused on the development of the aeronautical industry in Brazil (Forjaz, 2005).⁷ Aimed at establishing organizations that combined teaching, technological research, and training of engineers, an agreement to receive a mission of professors from the Massachusetts Institute of Technology (MIT) supported the creation of an aeronautical engineering school, which would later become the Brazilian Aeronautical Institute of Technology (ITA) (Forjaz, 2005; Martinez, 2007).

At the end of the 1950s, ITA began to earn support from official US development assistance programs, initially through the Point IV Program and later the Alliance for Progress (Forjaz, 2005). The initiative that counted with the largest amount of resources was perhaps the agreement between the US Agency for International Development (USAID) and the University of Michigan, signed in 1962 and implemented between 1964 and 1967. USAID earmarked \$1.4 million that allowed 14 University of Michigan professors, for instance, to create a mechanical engineering graduate program at ITA, equip its laboratories, and promote contacts between ITA and other institutions, including the industry (Mouzon, 1967).

ITA and the Aeronautical Technical Center (CTA), created in 1947,⁸ were key institutions for the establishment of aeronautical companies in Brazil, the most important being Embraer, which was established in 1969 as a mixed economy society, controlled by the federal government and linked to the Ministry of Aeronautics. The company's primary objective was to meet the demand for production of the aircraft *Bandeirante*,⁹ designed by CTA for the Brazilian Air Force (Drumond, 2004).

In 1971, Embraer established a partnership with the Italian Aermacchi to manufacture the *EMB 326 Xavante*,¹⁰ allowing the Brazilian company to accumulate know-how, for instance, in technical material development, integration technology, jet engine testing, and improved techniques for large-scale production (Mattos, 2005). Two years later, an agreement

6. Most of this group of military personnel had international aviation expertise and had studied at the Massachusetts Institute of Technology (MIT).

7. Montenegro Filho was responsible for bringing the North American physicist Richard Smith, head of the Aerodynamics Department at Massachusetts Institute of Technology (MIT), who played a key role in the creation of ITA (Forjaz, 2005).

8. Centro Tecnológico de Aeronáutica was created in parallel with ITA, with the main goal of supporting the nascent aeronautical industry through scientific research and technical surveys, leading and promoting the scientific and technological advancement of Brazilian aviation (Forjaz, 2005).

9. *Bandeirante* was the result of two successful prototypes created by the CTA team. It not only met FAB's demands, but was also very well accepted internationally for having the best cost-benefit ratio in the market at the time (EMBRAER, 2021).

10. The EMB 326 *Xavante* is a military training jet designed by the two Italian companies and assembled in Brazil through a license agreement signed in 1970. Embraer produced a total of 182 units of the model, of which 167 went to FAB, 9 to Paraguay and 6 to Togo (EMBRAER, 2021).

was signed with American Northrop for the production of F-5 components, enhancing Embraer's knowledge on technologies of advanced aluminum-magnesium alloy production, welding between metals, and manufacturing of aluminum cores using numerical control machines (Coelho Netto, 2005). Then, in 1974, Embraer signed a contract with American Piper for the development, production, and marketing of light aircraft, allowing it to access knowledge on aircraft marketing and sales, after-sales support and technical assistance, and technological know-how for the manufacture of acrylic and fiberglass parts (Bernardes, 2005).

In 1979, expanding its global activities beyond the modalities listed above, Embraer Aircraft Company (EAC) was created in Dania, Florida, and in 1983 Embraer Aviation International (EAI) was founded in Paris, with the goal of promoting sales and providing support to customers in Europe, the Middle East, and Africa (Embraer, 2021).

In 1980, a new agreement was signed with AerMACchi to manufacture Embraer's first fighter jet, the AMX,¹¹ bringing to the latter's technological knowledge on composite material, anionic systems, and software for military aviation. Furthermore, this partnership facilitated the incorporation of know-how on project management, systems integration, and technical industrial cooperation agreements on wing conformation and manufacturing of machined parts in five axes (Cavagnari, 1993).

In 1990, going beyond the partnerships restricted to developed countries, Embraer partnered with *Fábrica Argentina de Material Aeroespacial* (FAMA) to manufacture an innovative project, the CBA,¹² which did not have the expected adherence in the market, but allowed Embraer to accumulate knowledge in project risk sharing (Silva, 1998). South-South partnerships continued to advance in the 2000s, with the opening of Embraer offices in China and Singapore (2000).

In 2004, an unprecedented step in Embraer's international affairs was taken with the purchase of *Indústria Aeronáutica de Portugal* (OGMA), intensifying its presence in Europe, besides benefiting the former with the latter's experience in numerous aerospace operations (Embraer, 2021).

Partnerships with Embraer's traditional partner, the US, have also continued and diversified. In 2011, Embraer's first aircraft assembly plant was founded at Melbourne International Airport in Florida, while in 2013 assembly facilities were opened at Jacksonville International Airport (also in Florida). In 2017 an Embraer innovation team was set up in Silicon Valley and Boston, which, in partnership with startups, investors, academia, and corporations, aims to work on opportunities for the air transport business (Embraer, 2021).

The second half of the 21st century was also marked by greater media exposure of international negotiations involving Embraer, particularly those conducted under the Ministry of Defense's FX-2 Program (Reim, 2021), which, in 2013, resulted in a partnership with the Swedish company SAAB (Brustolin, Pedone, and Martins, 2018).

In February 2019, a joint venture was established between Boeing and Embraer. Under the terms of this joint venture, Boeing would purchase an 80% stake in Embraer's commercial aircraft division. The deal was approved by Embraer's shareholders and the Brazilian government

11. Designed to meet the demands of the Italian Air Force, the manufacture of the first fighter jet in Embraer's history was the result of an association between AerMACchi and Embraer. The Brazilian company contributed 1/3 of the costs and was responsible for sections of the wings, empennage, and the fatigue tests of the structure. AerMACchi, on the other hand, bore 2/3 of the costs, contributing to the fuselage, the onboard systems, and the static and armament tests (Embraer, 2021).

12. Jet-performance turboprop for regional flights (Embraer, 2021).

(which owns a golden share of Embraer). However, in April 2020, Boeing terminated the joint venture. Embraer claims that the financial impact of the temporary flight ban of the Boeing 737 MAX contributed to Boeing's withdrawal. For its part, Boeing claims that Embraer has not complied with the Master Transaction Agreement (MTA). The crisis caused by Covid-19 may also have made it difficult to conclude the joint venture. Currently the case is going through an arbitration dispute and may even be sent to a New York court (Brustolin, 2020).

International partnerships involving Embraer, which, as seen above, began even before the company was created and laid the foundations for much of its development, have undoubtedly contributed to the technological level achieved by Embraer. Knowledge flows in multiple levels and modalities allowed Embraer to become a major worldwide competitor in the sector. Today, the company has 18,000 employees, has delivered more than 8,000 aircrafts, is the world's third largest manufacturer of commercial jets and the world leader in the up-to-130-seat category, and counts with industrial plants, distribution centers, and offices in the Americas, Africa, Asia and Europe (Embraer, 2021).

We believe it is not possible to adequately understand the trajectory of the technological level reached by Embraer, including its achievements and challenges, without understanding the role played by states in international knowledge flows. The role of state actors is not only restricted to the fact that some of the partners involved are public organizations, but also relates to state incentives to partnerships, either by placing them as priorities for national development and allocating the necessary resources to realize them, or by overseeing the type of knowledge that would be shared in view of security or economic interests. Therefore, literature that emphasizes the role of the Brazilian state, particularly within the scope of military partnerships in international negotiations designed to aid technological acquisition, as in the case of the FX Program and offsets (Brustolin, Oliveira, and Senna, 2016), can be complemented with reflections on the role of the states that host Embraer's partner companies.

In the literature of International Relations there are important debates that could shed light on this question. For example, on the one hand we have the work of Mastanduno (1991), who highlights the predominance of security interests in knowledge flows from the US to Japan during the Cold War in the case of the FSX Agreement. Such flows would have been supported by the American government, to the detriment of the preference of American companies (which opposed it), in a context marked by the salience of the Soviet threat. Moravcsik (1992), on the other hand, concludes that the interests of companies were crucial in defining the implementation of military technology transfer agreements among Europeans between 1975 and 1985. If a company is already a reference in the export of a certain technology, it will not get involved or support state initiatives that encourage technology transfer in the field. On the contrary, if it is not yet a reference, companies may support such transfer in the expectation that it can provide access to knowledge accumulated by other companies operating in the same sector. One may also wonder to what extent a reference company would also agree to share a certain

technology with partners that do not accumulate the specific demanded tacit knowledge to really learn from it, as a means to fulfill other purposes, economic or political.

Contributions as the ones mentioned above are aligned with mainstream perspectives on International Political Economy, according to which “international politics could not be fully understood or analyzed without paying attention to international business, and conversely, that international business and management could not be fully understood without paying attention to international and domestic politics” (Strange, 1996). Nevertheless, as we will see in the next section, the few studies mapped in our search for literature on international STI partnerships involving Embraer (following the criteria specified in the former section) are backed by concepts and theories that tend to focus only on one of the vertices of triangular diplomacy that affect the political economy of countries, namely, business-company relations, failing to consider business-state and state-state relations.

QUALITATIVE ANALYSIS

As seen in the previous section, Embraer’s international interactions throughout its trajectory have impacted its technological development. Nevertheless, as was shown in the first section, very few works on Embraer consider the international aspect and, of the few that do, a small number addresses the interplay between international relations and STI.

This section aims at analyzing a couple of qualitative features of the retrieved material, starting with recurring concepts that back analysis on international knowledge flows involving Embraer (Box 1).

Box 1 – Recurrent concepts mobilized by the retrieved literature

Concept	Author	Area	Definition
Strategic Alliance	Bedaque Junior (2006)	Administration	“Gulati (1998) presents a broad and generic definition of alliance when considering that they are voluntary agreements between companies that involve exchange, sharing or co-development of products, technologies and services... (...). According to Hitt et alii (2003:362) ‘strategic alliances are partnerships between firms at which their essential resources, capacities and competencies are combined to pursue mutual interests when projecting, manufacturing and distributing goods and services.’” (p. 44-45)
	Ferreira (2010)	Engineering	“A strategic alliance is formed, according to Lorange and Roos (1996), when partners form a new venture, and exhibits, as a main feature, the intention to move each participant toward a common long-term strategic goal, resulting in strengthening partners’ competitive positions.” (p. 39-40)

Strategic Alliance	Coelho Netto (2005)	Administration	"(...) Pinho (1998) argues [that] some authors tend to agree on some aspects and characteristics that an alliance must possess (...) 1. it is an agreement, arrangement, association, coalition or union with specific aims, which gathers specific aspects of two or more companies (...); 2. that union's foundation is a business partnership, which allows each of the partners to create and maintain competitive advantage through mutual benefit of technology, product, skill or any other type of resource exchange; 3. Strategic alliances have four attributes, necessarily and sufficiently: (...) companies remain independent after the alliance formation; partners share control over the performance of tasks associated with the partnership and the benefits resulting from them; partners contribute continuously to the alliance; and partners generate a mutual dependence relationship, that is, projects are indivisible." (p. 24-25)
	Vital (2010)	Engineering	"Fusco and Sacomano (2009) state that strategic alliances between partner companies are a viable way out of a volatile environment of business concentration. They define strategic alliances as a means for companies from the same industrial sector to compete on a global scale, while preserving their independence." (p. 36-37)
Open Innovation	Bedaque Junior (2006)	Administration	"a new paradigm, which emerged in the 1990s, determining a new logic, moving from a closed model of innovation (proprietary, internal and vertically integrated) to an open, dynamic and systemic one, which interacts with the external environment and enables sustained innovation." (p. 84)
	Cedalon; Sbragia (2020)	Administration	"OI is based on the ability to recognize externally available knowledge that can be assimilated and applied commercially." (p. 71)

Source: Produced by the authors

The box above shows that recurring concepts in the retrieved literature that focus on international knowledge flows involving Embraer are concentrated in business analysis. International dynamics are not addressed specifically, but as part of alliances, networks and other processes that can characterize partnerships involving companies located in the same country or not. Furthermore, in general conceptual frameworks do not incorporate dynamics that are not related to the business logic per se. For instance, the role of states in facilitating or hindering transnational knowledge flows in the aeronautic sector is usually not conceptually accounted for,¹³ though such role is mentioned when authors describe how international partnerships involving Embraer happened – for instance, in negotiating offset agreements (Coelho Netto, 2005). It should be noted that our findings do not represent a criticism to the analyzed authors, who naturally work with concepts from their respective fields. What is striking, as already noted, is the lack of studies from International Relations on international STI partnerships involving Embraer, which could potentially complement the retrieved literature by also focusing on business-state and state-state analysis.

A second aspect that has been observed during the qualitative analysis of the retrieved literature on Embraer was the evaluation of international partnerships involving knowledge flows according to their axis (South-South or North-South). Do authors consider that South-South partnerships are more effective from the point of view of Embraer or the opposite? Box 2 summarizes the reviewed literature views on the impact of international partnerships in granting Embraer access to new knowledge.

13. It must be noted that exceptions include works that rely in innovation system approaches (Luz; Minari; Santos, 2010; Marques, 2011), where the role of of all innovation system actors, including the government, is accounted for.

Box 2 – Evaluation of Embraer’s international partnerships

Initiative (year)	Knowledge accessed or developed by Embraer (Coelho Netto, 2005)	Partner Country	Evaluation of partnership in terms of knowledge benefits to Embraer
EMB-326 Xavante project with Aermacchi – license acquisition for MB-326 manufacturing (1971)	Technical improvement for large scale production (mainly project and fixture confection and manufacturing solutions); experience in technical guide elaboration; know-how in integration technology and jet engine testing.	Italy	Positive (Coelho Netto, 2005; Marques, 2011; Vital, 2010)
Agreement with Northrop for production of F-5 military aircraft components (including vertical warp) (1973)	Know-how composite material technology; know-how in aluminium-magnesium advanced alloy cutting technology; know-how in using numerical control machines; know-how in metal-metal welding technology; know-how in aluminium honeycomb manufacturing.	US	Positive (Coelho Netto, 2005; Vital, 2010)
License agreement with Piper to manufacture six types of light aircraft in Brazil: EMB 710 Carioca, EMB 711 Corisco, EMB 720 Minuano, EMB 721 Sertanejo, EMB 810 Seneca II e EMB 820 Navajo (1974)	Know-how in aircraft trade (marketing and sales); know-how in after-sales support and technical assistance; technological know-how to manufacture acrylic pieces and glass fiber.	US	Positive (Coelho Netto, 2005; Lima, 2017; Marques, 2011)
Offset agreement with Sikorsky Aircraft for chemical machining technology transfer (1970s)	Know-how in chemical machining technology.	US	Positive (Coelho Netto, 2005)
AMX project with Aeritalia and Aermacchi (1985)	Know-how in composite material technology; know-how in avionics systems and military aircraft softwares; know-how in project management, system integration and industrial cooperation agreements; know-how in wing shaping techniques; know-how in manufacturing five-axis machined parts.	Italy	Positive (Coelho Netto, 2005; Lima, 2017; Vital, 2010)
Project CBA-123 Vector, with FMA (1988)	Know-how in risk-sharing project.	Argentina	Positive (Coelho Netto, 2005; Marques, 2011)
Agreement with McDonnell Douglas for production of carbon fiber flaps for the MD-11 aircraft (1992)	Know-how in composite material technology; know-how in production norms and procedures; know-how in project management, system integration and industrial cooperation agreements; know-how in risk-sharing project.	US	Positive (Coelho Netto, 2005)
Contract with Boeing for production of parts requiring fine mechanics for the Boeing 747 and 767 aircrafts (1990)	Know-how in fine mechanics technology; know-how in production norms and procedures.	US	Positive (Coelho Netto, 2005)
Contract with Boeing to supply wing tips and dorsal fins assemblies to Boeing 777 aircraft (1991)	Know-how in production norms and procedures.	US	Positive (Coelho Netto, 2005)
Risk-sharing agreement for the development of ERJ-145 family project, with Gamesa, Sonaca, ENAer and C&D Interiors (1993)	Know-how in risk-sharing project management; know-how in virtual project development (use of CATIA software).	Spain, Belgium, Chile, US	Positive (Coelho Netto, 2005; Bedaque Junior, 2006; Ferreira, 2010)

Production of the fuel system and landing gear for the Sikorsky S-92 Helibus helicopter as part of a risk-sharing project that also involved Mitsubishi Heavy Industries, Gamesa and Jingdezhen Helicopter Group (1995)	Know-how in advanced materials (Invar alloy); know-how in project virtual development (use of CATIA software).	US, Japan, Spain, China	Positive (Coelho Netto, 2005)
ERJ-170/190 family project, with Parker Aerospace, Hamilton Sundstrand, General Electric Aircraft Engines, Latécoère, Gamesa, Liebherr, Sonaca, C&D Aerospace, Kawasaki Heavy Industries, Honeywell, and Parker Hannifin (1999)	Know-how in risk-sharing project management; execution of technical harmonization during the aircraft project (through the Virtual Reality Center – CRV); execution of production following the just-in-time model.	US, France, Spain, Germany, Belgium, Japan,	Positive (Bedaque Junior, 2006; Coelho Netto, 2005; OLIVEIRA, 2009)
Offset agreement with Elbit for the remodeling of FAB F-5 military aircraft (2000)	It is likely that Embraer is acquiring some know-how in avionics development, but that information was not confirmed as that agreement was confidential.	Israel	No evaluation made since it was an ongoing partnership when author published his work (Coelho Netto, 2005)
Contract for the production of ERJ-145 in China, with AVIC II (2002)	Not identified.	China	Uncertain - no learning to Embraer related to technology development has been identified by the author, but partnership was still ongoing when his work was published (Coelho Netto, 2005)
Gripen project with SAAB AB (2013)	N/A	Sweden	Positive (Cedalon; Sbragia, 2020)

Source: Produced by the authors

The obvious point that can be made after going over the box above is that there is no correlation between the axis of international partnerships involving Embraer (North-South or South-South) and the evaluations in terms of knowledge benefits to Embraer. In fact, most of international partnerships Embraer has taken part of are seen as having brought direct or indirect knowledge gains to the company. Although many emphasize that South-South STI partnerships would be more effective due to a greater similarity between partners (Troyjo, 2003), a partnership with China, a Southern country, has not been identified as having produced knowledge gains to Embraer. Though the latter were not part of Embraer's aims with that partnership, which targeted access to the Chinese market (something that has also been negatively evaluated), Coelho Netto (2005) expresses some concern with "the risk that the Chinese company absorbs Brazilian technology, becoming a potential competitor in the future...". However, concerns with knowledge transfers to competitors as a risk involved in international partnerships can also be found in analysis on North-South partnerships. For instance, Bedaque Junior (2006) quotes Bernardes (1998) on the ERJ 145 risk-partnership program, at which "Embraer has transferred technology, and will possibly suffer those firms' competitiveness in the future...".

Still, an eventual correlation between international partnerships and knowledge loss is not part of the central concerns found in the retrieved literature. Instead, most of it adopts a positive stance towards international partnerships involving Embraer throughout its history. Ac-

cess to knowledge produced outside the company is seen as positive from the point of view of Embraer's technological progress, converging with the whole literature on the factors that influence innovation (Cassiolato; Lastres, 2005). Even projects that failed from the commercial point of view, such as the AMX (with Italy) and CBA 123 (with Argentina), both "imposed" to Embraer by the Brazilian government (Coelho Netto, 2005), are evaluated as positive in terms of knowledge accumulated to future well-succeed projects from the point of view of sales, implemented after Embraer's privatization. Nevertheless, Araújo (2017) and Lima (2017) calibrate such optimistic views when pointing to Embraer's growing technological dependency in that context, whereas Marques (2011) shows that dependency has been part of the whole trajectory of Embrapa, as the majority of higher value added parts suppliers have continuously been foreign ones.

CONCLUSION

This article undertook a meta-analysis on the interplay between STI and international relations in the case of Embraer. Our major finding was that international STI partnerships involving Embraer are analyzed by business management, economics and engineering professionals. For this reason, analysis of the international element is based on theoretical concepts that do not take into account specificities that characterize international knowledge flows. The retrieved literature conceptual background tends to focus on firm-to-firm relations, and not the international economic political context in which partnerships involving Embraer were designed and implemented.

International knowledge flows involving societal actors (such as companies and laboratories) can be promoted or hindered by states, and therefore political domestic, bilateral, and structural aspects should be accounted for. For instance, one cannot ignore that the US government directly supported knowledge flows from the US to Brazil during the Cold War, as it did in the case of the partnership between ITA and the University of Michigan in the 1960s. At that time, Brazilian efforts to develop nuclear technology already concerned US authorities, in a context marked by the latter's support of knowledge flows in areas that would not endanger US security, but that would still confer a symbolic status to other countries' technological capacities. This was the case, for instance, of Germany (Krige, 2014), India (Doel; Harper, 2006), and, likely, Brazil. As such, supporting knowledge flows that later contributed to the development of the aeronautic industry in Brazil might have been part of the US positive disarmament strategy.

Therefore, for future work we recommend that knowledge flows involving Embraer are analyzed considering the role that might have been played by the states of origin of its partner companies. In doing so, one should bear in mind that states can also play a central role in withholding knowledge, something that may have prevented Embraer from addressing key technological challenges.

REFERENCES

.....

- ARAÚJO, Vera Lucia de Toledo. **Morte Social de um Grupo Profissional de Elite: Os Engenheiros da Embraer no Processo de Reestruturação da Empresa**. 2017. Tese (Doutorado em Sociologia) – Universidade de São Paulo, São Paulo, 2017.
- BEDAQUE JÚNIOR, Alípio. **Alianças Estratégicas e Inovação de Valor: Estudo de Caso dos Jatos Regionais 170/190 da Embraer**. 2006. Dissertação (Mestrado em Administração) – Pontifícia Universidade Católica de São Paulo, São Paulo, 2006.
- BERNARDES, Carlos Roberto. **Os Limites do modelo autárquico de competitividade: os fatores sistêmicos da competitividade a partir do estudo de caso da indústria aeronáutica brasileira**. 1998. Tese (doutoramento) - Faculdade de Filosofia, Letras e Ciências Humanas da USP, São Paulo, 1998.
- BERNARDES, R. **Redes de Inovação e Cadeias Produtivas Globais: Impactos da Estratégia de Competição da Embraer no Arranjo Aeronáutico da Região de Desenvolvimento Industrial e Tecnológico**. Estudos Empíricos, nota técnica 23, descrevendo o histórico da Embraer, p. 13-16, 2005. Available at: <http://redesist.ie.ufrj.br/sinal/dados/nt.php?projeto=nt2>. Accessed on: October 27, 2023
- BRUSTOLIN, Vitelio. **Contencioso entre Boeing e Embraer na Justiça Deverá ser Demorado**. BizBrazil Magazine, May 1, 2020. Available at: <https://bizbrazilmagazine.com/contencioso-entre-boeing-e-embraer-na-justica-devera-ser-demorado>. Accessed on: December 19, 2021.
- BRUSTOLIN, Vitelio; OLIVEIRA, Cleber Almeida de; SENNA, Claudio José D'Alberto. Análise das Práticas de Offset nos Contratos de Defesa no Brasil. **Journal of the Naval War College**, v. 22, n. 1, p. 169-196, January/April, 2016. DOI: 10.21544/1809-3191/reg.v22n1p169-196.
- BRUSTOLIN, Vitelio; PEDONE, Luiz; MARTINS, Cesar. Military Malthusianism and the Strategic Partnership in the FX-2 Program. **Journal of the Naval War College**, v. 24, n. 2, p. 276-300, May/August, 2018. DOI: 10.22491/1809-3191.v24n2.p276-300.
- CASSIOLATO, José Eduardo; LASTRES, Helena Maria Martins. **Sistemas de inovação e desenvolvimento: as implicações de política**. São Paulo em Perspectiva [online], v. 19, n. 1, p.34-45. Available at: <https://doi.org/10.1590/S0102-88392005000100003>. Accessed on: February, 07, 2022.
- CAVAGNARI, G. P & D Militar: Situação, Avaliação e Perspectivas. **Programa de Apoio ao Desenvolvimento Científico e Tecnológico**. (PADCT II), p. 34, 1993.
- CELADON, K. L.; SBRAGIA, R. Open Innovation: The Challenges of Knowledge Integration in Bi-National Projects. **World Review of Science, Technology and Sustainable Development**, v.16, n.1, p. 64-86, 2020. DOI:10.1504/WRSTSD.2020.105585.
- COELHO NETTO, Luis Eduardo Santos. **Alianças Estratégicas como Fontes Geradoras de Vantagens Competitivas Sustentáveis: O Caso Embraer**. 2005. Dissertação (Mestrado em Administração) - Universidade Federal do Rio de Janeiro, Rio de Janeiro, 2005.
- CONSELHO DE SEGURANÇA NACIONAL. **Minutes of the Tenth Session of the Brazilian National Security Council, Alvaro Alberto's proposal to establish a Brazilian Atomic Energy Program**. August 27, 1947, History and Public Policy Program Digital Archive, National Archive (Brasília). Obtained and translated by Fundação Getúlio Vargas. Available at: <http://digitalarchive.wilsoncenter.org/document/116912>. Accessed on: December 18, 2021.
- DRUMOND, C.D. **Asas do Brasil: Uma história que voa pelo mundo**. São Paulo: Miriam Paglia Editora de Cultura, 2004.
- DOEL, R.; HARPER, K. Prometheus Unleashed: Science as a Diplomatic Weapon in the Lyndon B. Johnson Administration. **Osiris**: Chicago, v.21, n.1, p. 66-85, 2006.
- EMBRAER. 2021. **Centro Histórico da Embraer**. Available at: <http://institutoembraer.org.br/centrohistoricoembraer>. Accessed on: December 18, 2021.
- FERREIRA, Vanessa de Lima. **A estratégia na relação com os fornecedores na indústria aeronáutica brasileira: o caso da Embraer**. 2010. Dissertação (Mestrado em Engenharia de Produção) – Universidade de São Paulo, São Paulo, 2010.
- FORJAZ, Maria Cecília Spina. As origens da Embraer. **Tempo Social**: São Paulo, v. 17, n. 1, p. 281-298, 2005. DOI: <https://doi.org/10.1590/S0103-20702005000100012>.
- FUSCO, J. P. A.; SARCOMANO, J. B. **Alianças em redes de empresas**. 2009. São Paulo: Arte & Ciência.
- KRIGE, John. Introduction: Writing the Transnational History of Science and Technology. In:

KRIGE, John (ed.). **How knowledge moves: Writing the Transnational History of Science and Technology**. Chicago: The University of Chicago Press, 2019, p. 1-31.

KRIGE, John. **Technological Collaboration and Nuclear Proliferation: a transnational approach**. 2014. In: M. Mayer, M. Carpes and R. Knoblich (eds.). *The Global Politics of Science and Technology*. London: Springer, p. 227-241.

LANCASTER, Carol. **Transforming Foreign Aid: United States Assistance in the 21st Century**. 2000.

LEITE, I. C.; GAYARD, N. A. Quatro abordagens sobre a interação entre cientistas e estados nas relações internacionais. *Relações Internacionais*: n.62, p.85-101, 2019.

LIMA, Antonio Carlos. **O Papel da Internacionalização na Inovação das Indústrias de Alta Tecnologia em Países Emergentes: o Caso da Embraer**. 2015. Dissertação (Mestrado em Administração) – Escola Superior de Propaganda e Marketing, São Paulo, 2015.

LIMA, Roberta Pereira de. **Abertura econômica brasileira a partir dos anos 1990 e seus impactos no setor aeronáutico**. 2017. Dissertação (Mestrado em Economia) – Universidade Federal da Bahia, Salvador, 2017.

LUZ, Márcio da Silveira; MINARI, Gustavo Matheus; SANTOS, Isabel Cristina dos. Aglomerações industriais no setor aeroespacial e automobilístico no Vale do Paraíba Paulista: uma comparação de trajetórias de formação. *J. Aerosp. Technol. Manag.*, v.2, n.1, p.71-82, Abr 2010. ISSN 2175-9146.

MARTINEZ, Maria Regina Estevez. **A Globalização da Indústria Aeronáutica: O Caso da Embraer**. Tese (Doutorado em Relações Internacionais) – Universidade de Brasília, Brasília, 2007.

MARQUES, Rosane Argou. **O desenvolvimento da capacidade para inovação: as pequenas e médias empresas do setor aeronáutico brasileiro**. 2011. Tese (Doutorado em Administração) - Universidade Federal da Bahia, Salvador, 2011.

MASTANDUNO, M. Do relative gains matter? America's response to Japanese industrial policy. *International Security*, v.16, n.1, p.73-113, 1991.

MATTOS, Bento. **Embraer: 1969-1976, o choque do futuro**. 2005. Available at <<https://www.aereo.jor.br/2018/03/04/embraer-1969-1976-o-choque-do-futuro/>>. Accessed on: December 19, 2021.

MAYER, M.; CARPES, M.; KNÖBLICH, R. (2014) The global politics of science and technology: an introduction. In: MAYER, M; CARPES; KNÖBLICH, R (eds.). **The Global Politics of Science and Technology**. London: Springer International, 2014.

MORAVCSIK, A. **Armaments among allies: European weapons collaboration, 1975-1985**. In: P. B. Evans, CAPES. K. Jacobson, R. D. Putnam (eds) *Double-Edged Diplomacy: international bargaining and domestic politics*. Berkeley, Los Angeles, London: University of California Press, 1992.

MOUZON, J. C. **Final report: The University of Michigan-AID Brazilian Program at the Instituto Tecnológico de Aeronáutica**. Contract AID/LA-81 (Brazil). Ann Harbor: Bentley Historical Library, University of Michigan, 1967.

MOURA, Nero. **Um voo na história**. Rio de Janeiro: Fundação Getúlio Vargas, 1996.

OLIVEIRA, Luiz Guilherme de. **O desenvolvimento de projetos de sistemas complexos na indústria aeronáutica: o caso de gestão integrada aplicada ao programa Embraer 170**. Cad. EBAPE.BR, Rio de Janeiro, v. 7, n. 1, p. 19-33, Mar. 2009. DOI: <https://doi.org/10.1590/S1679-39512009000100003>.

REIM, Garrett. Brazilian air force to nearly double Saab Gripen order cut KC-390 order in half: reports. *Flight Global*, June 3, 2021. Available at: <https://www.flightglobal.com/flightglobal/brazilian-air-force-to-nearly-double-saab-gripen-order-cut-kc-390-order-in-half-reports/144019>. article. Accessed on: December 19, 2021.

SILVA, O. **A Decolagem de um Sonho: a História da Criação da Embraer**. São Paulo: Lemos Editorial, 1998.

SKOLNIKOFF, E. **The elusive transformation: Science, technology, and the evolution of international politics**. Princeton: Princeton University Press, 1993.

STRANGE, Susan. **States and Markets**. Continuum 2nd ed. The Royal Society (2010) *New Frontiers in Science Diplomacy: Navigating the Changing Balance of Power*. Policy document 01/10, 1994.

STRANGE, Susan. **The retreat of the state: the diffusion of power in the world economy.** Cambridge: Cambridge University Press, 1996.

US Department of State. **Memorandum by Mr. Edmund A. Gullion to the Under Secretary of State (Acheson).** Washington DC, March 3, 1947. FRUS, General; The United Nations, v. 1. Available at: <https://history.state.gov/historicaldocuments/frus1947v01/d408>. Accessed on: December 18, 2021.

TROYJO, Marcos Prado. 2003. **Tecnologia & Diplomacia: Desafios da Cooperação Internacional no campo Científico-Tecnológico.** São Paulo: Aduaneiras.

VITAL, Luiz Carlos Cordeiro. **A Evolução de Indústria de Alta Tecnologia com o Uso de Parcerias: Estudo de Caso na Indústria Aeronáutica Brasileira.** 2010. Dissertação (Mestrado em Engenharia de Produção) – Universidade Paulista, São Paulo, 2010.

WAGNER, C. **The new invisible college.** Washington: Brookings Press, 2008.

WEISS, C. Science, technology and international relations. **Technology in Society:** v.27, n.3, p.295-313, 2005.