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PRIORITIZATION OF MULTILATERAL AGREEMENTS ON EXPORT CONTROL OF DEFENSE PRODUCTS AND SENSITIVE TECHNOLOGIES BY HIERARCHICAL ANALYSIS PROCESS

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Introduction

The Brazilian intention to project itself internationally and to assume a role compatible with its territorial, population and economic magnitudes, necessarily obliges the country to take part in multilateral organizations and inter-regional mechanisms that enable participation in international decision-making processes (Miyamoto 2000, 122; Sardenberg 2005, 347). Another important attitude to gain prestige and achieve that goal is the careful adherence to international agreements, in order to gain visibility and credibility, in order to be able to use this position as an advantage in any bilateral and multilateral negotiations (Silva and Guimarães 2020, 23).

Several of these international agreements are intended to control the sale and transfer of arms, supplies and related technologies, in order to prevent terrorist organizations or even countries that do not commit to peace and regional and international balance from doing wrongful use of that material. Possessing modern weapons, materials and technology to build them, they could potentialize the outbreak of violent conflicts, with the possible occur-

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rence of actions of mass destruction, crimes against humanity and/or war crimes (Nayan, Nayan, and Ghosh 2019; Casarini and Tsuruoka 2021, 95).

Consistently, countries that undertake not to supply such equipment and technologies, voluntarily limiting their commercial possibilities, also undertake to refrain from taking part in the reprehensible actions that such agreements seek to avoid.

The adherence to Multilateral Export Control Regimes (MECR), by increasing the adherent country's credibility with the international community, can also facilitate access to these same products and technologies that are controlled by the agreements in question (Gahlaut 2017).

Then a window of opportunity opens in which our country can acquire supplies from the international war industry that, until then, were denied to us, forcing us into a long and costly process of development, as well as representing an opening of new markets and new customers to our Defense Industrial Base (DIB). In short: paradoxically, increasing export controls on sensitive products, rather than weakening our position as a war material supplier, can strengthen it (Khokhar 2018, 27).

Brazil has a substantial peaceful tradition, being recognized for actively participating, through diplomacy, in several global initiatives to mitigate conflicts and maintain balance between nations. Moreover, the art. 4 of the Federal Constitution presents the principles that guide our international relations. Among others, the following stand out: the defense of peace, the peaceful solution of conflicts and cooperation among peoples for the progress of mankind (Brasil 2016, 11).

Themes such as arms control, non-proliferation of weapons of mass destruction, renouncing the development and use of nuclear devices, demonstrate that Brazil respects the norms of International Law, investing in transparency, submission to international control agencies and in multilateralism. This posture constitutes a basis for building mutual trust between international actors (Oliveira and Onuki 2000, 111).

In this sense, several actions are aligned with the National Defense Policy (NDP) and the National Defense Strategy (NDS), as they contribute to the country's projection in the concert of Nations. The eighth National Defense Objective (NDO) encourages the country to assume a leading role in more international organizations, as long as the benefits outweigh the costs for adhering to the agreements considered (Brasil 2020). For the achievement of the NDO, the NDS details Strategic Defense Actions (SDA). Here we highlight the SDAs directly related to the research problem:

> SDA-45 - Promote exports from the Defense Industrial Base.
> SDA-79 - Intensify foster measures in order to promote mutual trust and

> international security.
> SDA-80 - Intensify exchanges and agreements in the defense area with other countries.
> SDA-82 - Intensify action in multilateral forums and inter-regional mechanisms.
> SDA-86 Intensify the performance of the Defense Sector in international organizations (Brasil 2020).

According to the Defense Ministry, Brazil is a signatory to the following Treaties and Regimes with reflections on Defense (Brasil 2021):

- Convention on Certain Conventional Weapons (CCW);
- The Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction (BTWC);
- Chemical Weapons Convention (CWC);
- OTTAWA Treaty;
- Arms Trade Treaty (ATT);
- Tlatelolco Treaty;
- Treaty on the Non-Proliferation of Nuclear Weapons (NPT); and
- Treaty on the Prohibition of Nuclear Weapons (TPNW).

The major Multilateral Export Control Regimes (MECR) in the world today are (Beck and Jones 2019; Gahlaut 2017):

- Wassenaar Arrangement (WA);
- Missile Technology Control Regime (MTCR);
- Australia Group (AG);
- Nuclear Suppliers Group (NSG); and
- Zangger Committee (ZC).

Among the five current MECR, Brazil is a signatory to only two: the MTCR and the NSG (Pecequilo and Bertolucci 2019, 168). Thus, the country's adhesion to the WA, the AG and the ZC can be seen as a natural step for Brazil, as it is coherent with its aspirations for regional protagonism, international projection and its peaceful tradition. However, it is necessary to think about the burden involved in adhering to each of these Agreements, as well as the possible resulting benefits, for later comparison and establishment of a priority for adhesion, rationally supporting strategic decision-making.

The Research Design

Given the context presented, the following question guided the research: among the three agreements within the scope of the MECR in which Brazil does not participate (WA, AG and ZC), which one presents the greatest feasibility of being implemented, indicating a priority for Brazil's adhesion? This "feasibility" translates into advantages in adhesion from different points of view, of a political, legal, economic, military, industrial and even cultural nature, in a way that adheres to the expressions of National Power (Spiller 2013, 180).

This problem can be solved through the development of a decision support model capable of analyzing the cost-benefit ratio of complying with the WA, AG and ZC clauses, serving as an advisory instrument for the Brazilian political and strategic levels. To achieve this general objective, intermediate objectives were selected, which contribute to the general achievement:

- Describe WA provisions on export controls on conventional arms and dual-use goods and technologies (dual employment);
- Describe the AG clauses on export controls for chemical and biological elements;
- Describe ZC provisions on export controls on nuclear products and radioactive elements;
- Develop a decision support model that allows solving the research problem;
- Apply the model based on expert assessments on the topic.

Establishing a priority of choice for a set of alternatives is a subject studied and analyzed in depth in the Operational Research (OP) through multicriteria decision support models (Sant'Anna 2015; Almeida 2013). These models seek satisfactory solutions for the choice or classification of alternatives evaluated under multiple criteria. They also make it possible to reduce the subjectivity of the processes of choice or classification of alternatives for a problem, proposing solutions that avoid biased or arbitrary decisions which do not reflect institutional or corporate interests.

Among several possible models of application to the problem of this research, the Analytic Hierarchy Process (AHP) was chosen for its simplicity, its suitability to the need to present a final priority to the Agreements, its internal validation instrument that assesses coherence logic of the experts' opinions and for not requiring the quantification of measures to the selected criteria for the evaluation (Saaty 1990; 1980; Saaty and Vargas 2012; Bhushan

and Rai 2004). The AHP is widely applied in decision support problems in the most varied areas of human knowledge, including applications in decision-making problems at the political-strategic level (Hassan and Lee 2019; Elezaj et al. 2021; Duleba 2019; Chen, Hayat , and Alsaedi 2017).

In general, the signing of an international agreement involves different interest groups. In the case of agreements under the MECR, the Defense Ministry (DM) stands out as the main stakeholder due to the nature of the content of those Agreements, including formally designating the Department of Defense Products (DDP) to monitor the negotiations related to the subject. Thus, the research established this design for the application of the model, seeking DM specialists to identify the priority among the three selected Agreements.

Arms Control Agreements

Arms control is not a new issue,societies have been dealing with it since industrial processes have lowered production costs to the point where such "tools" could be within the reach of individuals, companies and governments (Lafer 1998; Croft 1996 ; Gillespie 2011, 8).

Perhaps the most famous international agreements on limiting the use of weapons in a situation of war are the Hague conventions on means and methods of combat, which, together with the Geneva conventions on the protection of victims, constitute the International Law of Armed Conflicts (ILAC) also known as International Humanitarian Law (IHL) (Gillespie 2011, 21). Both conventions were promoted by the International Committee of the Red Cross (ICRC), a Swiss private body, founded in 1863, whose purpose is notably humanitarian (Gillespie 2011, 50).

Although several other agreements of this nature have been signed throughout history, it was not until 1945 that their true need was verified. The use of nuclear devices in World War II and the subsequent arms race that began with the so-called "Cold War" alerted the world to the need for rules, agreements, treaties, resolutions, regimes and any other pacts that could control weapons and ammunition, including its inputs and storage (Gillespie 2011, 124). That is why the Charter of the United Nations highlighted the purpose of "preserving future generations from the scourge of war" (UN 1945, 3).

The most significant UN resolutions are usually issued by its Security Council (SC/UN). However, the Security Council's veto power often hinders the UN's internal decision-making process, considering that its permanent members have divergent interests and that unanimity is needed between them for the resolutions to be signed (Silva and Tavares Filho 2020, 18). In

this context, this lack of consensus on resolutions dealing with arms control led to the emergence of other forums capable of promoting this activity. The WA, for example, has its origins in the Coordinating Committee for Multilateral Export Controls (CoCom), a pact of countries aligned with the US that aimed to restrict the export of sensitive military material to communist countries (Li et al. 2019; NTI 2021).

The Wassenaar Arrangement

Wassenaar Arrangement is the shortened name of the Wassenaar Arrangement on Export Control for Conventional Arms and Dual-Use Goods and Technologies (WA 1996). Usually, the available literature on the subject refers to it in a simplified way as Wassenaar Arrangement or even WA, notation adopted hereinafter.

The WA was established in 1995 with the participation of 28 countries: Germany, Australia, Austria, Belgium, Canada, Denmark, Slovakia, Spain, United States of America, Finland, France, Greece, Netherlands, Hungary, Ireland, Italy, Japan, Luxembourg, New Zealand, Norway, Poland, Portugal, United Kingdom, Czech Republic, Russia, Sweden, Switzerland and Turkey. Over time, 14 more countries joined: South Africa, Argentina, Bulgaria, South Korea, Croatia, Slovenia, Estonia, India, Latvia, Lithuania, Malta, Mexico, Romania and Ukraine. The European Union is considered an observer of the WA (WA 1996).

Its purpose is to contribute to regional and international security and stability, preventing destabilizing accumulations of military material through transparency and increasing accountability in transfers of conventional weapons and dual-use technologies and equipment (civil and military). Through national policies, member countries seek to ensure that transfers (sale, resale, donation, among others) of these materials do not contribute to the development or improvement of destabilizing military capabilities, and that they are not diverted for use by terrorist organizations (WA 1996).

To achieve this goal, member countries undertake to inform each other every six months about transfers of materials under control to non-WA countries, or even refusals to transfer, which must also be reported.

There is an eight-category list that lists the materials and technologies to be monitored through export control. The categories are as follows:

1. Battle Tanks;
2. Armoured Combat Vehicles;
3. Large Caliber Artillery Systems;

4. Military Aircraft / Unmanned Aerial Vehicles;
5. Military and Attack Helicopters;
6. Warships;
7. Missiles and Missiles Systems); and
8. Small Arms and Light Weapons - Man-portable Weapons made or modified to military specifications for use as lethal instruments of war.

In turn, the Lists of Dual-use Goods and Technology lists dual-use materials and technologies, with the following categories:

- Category 1 - Special Materials and Related Equipment);
- Category 2 – Material Processing;
- Category 3 – Electronics;
- Category 4 – Computers;
- Category 5 – Part 1 – Telecommunications;
- Category 6 – Part 2 – Information Security;
- Category 7 – Sensors and Lasers;
- Category 8 – Navigation and Avionics;
- Category 9 – Marine;
- Category 10 – Aerospace and Propulsion;
- Sensitive List [SL];
- Very Sensitive List [VSL]; and
- Munition List.

It should be noted that this commitment to report on material transfers does not imply an obligation on the member country to transfer or deny transfer of such materials. This is a sovereign decision, under the sole responsibility of the member country.

Nevertheless, it is necessary for the member country to establish, at a national level, an effective control of exports through a legal framework, a regulatory system for international trade and a licensing system for products controlled by the WA. It is not an easy task as it involves, mainly in the regulatory and licensing systems, the active participation of international trade regulatory agencies and defense product certification agencies, the Armed Forces, the Public Security Forces, Customs, companies in the Defense sector, export companies, brokers and even charter companies, especially those of the maritime modal (WA 1996).

Since the legal and regulatory issues are specific to each country and there is a myriad of conditions that shape them, the WA cannot dictate the

rules to be adopted by each member. However, in an attempt to homogenize these issues, the WA also functions as a forum for exchanging experiences among member countries, making available a series of documents that report on good practices that have been positively tested, divided by thematic areas (WA 1996).

One of the most interesting recommendations of this forum concerns the transfer of dual-use material, even if not formally listed by the WA, to countries that are subject to an arms embargo by the SC/UN and/or some other relevant embargo at regional reach. The WA recommends establishing the regulation so that the exporting company is obliged to request authorization from the Government to proceed with the transfer of these materials when there is a suspicion that they could be used, in whole or in part, for military purposes. The WA defines the term "military purposes" as the use of unlisted material in conjunction with any listed material, but the final definition and classification criteria remain at the discretion of each member country. This type of regulation is commonly known as Catch-all (WA 1996).

Another very effective recommendation concerns the control of chartering companies. There are members of the WA that are not among the main producers of military material, but they are headquarters of large transport logistics companies. In this case, good practice recommends that the member country exercise effective control over the products that are transported by the ships and/or planes of these companies, even if such cargoes do not even transit through its territory. And there are also cases in which the member country functions as a true logistical hub, that is, it has important port/airport facilities, through which a good part of international trade transits. In this case, good practice recommends that the member country exercise effective control of what leaves or enters these facilities, including through electronic detection means, also covering what only transits through these places, even if they are considered free zones or free trade areas (WA 1996).

One of the provisions of the Agreement concerns refusals to transfer listed materials to countries that do not participate in the WA. The refusal of a transfer made by a member country does not oblige the other members to also refuse to carry out similar transfers, but obliges them to communicate to the other members any license or authorization of identical transfer (same materials and same recipients) that have been denied in the last three years by another member country (WA 1996).

The WA is headquartered in Vienna, Austria, where a small secretariat is maintained, and member country representatives meet annually, usually in December, forming what is known as the "WA Plenary". During these meetings, issues related to the functioning of the WA are discussed, the control

policies to be proposed are studied and reviewed, and the lists of controlled materials are updated. The most current discussions going on at WA concern the inclusion of cyberwarfare-related materials and technologies on checklists. In these plenary sessions, the membership proposals of new members are also evaluated. All decisions are taken by consensus. (WA 1996).

Candidate countries for WA membership are evaluated on the following criteria:

- Whether the country is a producer/exporter of arms or related industrial material;
- Whether the country uses the WA lists as a reference for its national export controls;
- Its non-proliferation policies, including adoption of the NSG, ZC, MTCR and AG policies, checklists and rules;
- Whether the country has adhere to the NPT, the Biological and Toxicological Weapons Convention, the Chemical Weapons Convention and the Strategic Weapons Reduction Treaty, if applicable; and
- Whether the country effectively controls its exports.

The Australia Group

The Australia Group, also known by the abbreviation AG, is an informal forum of countries that seeks to minimize, through effective export control, the risk of proliferation of chemical and biological weapons. (AG 2007).

After the UN found in 1984 that Iraq had used chemical weapons during the Iran-Iraq war, in violation of the 1925 Geneva Protocol, several countries implemented export controls on certain chemicals products that could be used to produce chemical weapons (Torres and Colasso 2018, 38). At the time, it was found that part of the chemical precursors used by Iraq were acquired through conventional channels of international trade (Walker 2017; Foroutan and Tu 2017). As there was no uniformity in the export control rules, which still allowed the acquisition of dangerous chemical inputs by belligerent countries, Australia proposed a meeting with the purpose of standardizing the control rules through cooperation between the countries that adopted them. The initial participants of this meeting, which took place in Brussels - Belgium in June 1985, formed what was later known as the Australia Group. Currently, the AG holds an annual meeting in Paris - France and its decisions are taken by consensus, that is, unanimously. (AG 2007).

Originally, 17 countries plus the European Union formed the GA: Germany, Australia, Belgium, Canada, Denmark, Spain, United States of America, France, Greece, Netherlands, Ireland, Italy, Japan, Luxembourg, New Zealand, Portugal and United Kingdom. Currently, the AG has 42 members plus the European Union, having joined over time: Argentina, Austria, Bulgaria, Cyprus, South Korea, Croatia, Slovakia, Slovenia, Estonia, Finland, Hungary, India, Iceland, Latvia, Lithuania, Malta, Mexico, Norway, Poland, Czech Republic, Romania, Sweden, Switzerland, Turkey and Ukraine (AG 2007).

The purpose of the AG is achieved through the harmonization of export controls among member countries, so that everyone can meet the minimum control requirements, preventing countries or terrorist organizations willing to build chemical and biological warfare capabilities from achieving their intent. To guide export controls, the AG draws up lists of chemical and biological products that must be under the constant attention of States (AG 2007).

All member countries are committed to establishing licensing procedures for 89 chemical weapons precursors, in addition to requiring specific licensing for: facilities, equipment and technologies related to dual-use chemical and/or biological manufacturing; animal and plant pathogens and biological agents. By adopting such licensing procedures, member countries serve as an example to the international community, encouraging other countries to do the same within the international effort to comply with the provisions of CS/UN Resolution No. 1540/2004 on non-proliferation of weapons of mass destruction (Stewart 2018).

Naturally, the AG member countries are signatories to the International Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on the Destruction of the World's Existing Chemical Weapons (known as the Chemical Weapons Convention) and the Convention on the Prohibition on the Development, Production and Storage of Bacteriological (Biological) and Toxin-Based Weapons and their Destruction (known as the Biological Weapons Convention). In order to fulfill their obligations under these two Conventions, member countries exchange information on export control measures and are not obliged under the Agreement to restrict international transfers of the listed materials. The decision to transfer or not is a sovereign decision of the participating State, based mainly on the judgment it makes about the non-proliferation practices of the destination country (AG 2007).

The laws, regulations and standards that each member country adopts must prevent the production of chemical and biological weapons, must be easy to implement and must not impede the normal trade of materials and

equipment intended for legitimate use (AG 2007).

The AG recommends that when exporting controlled materials to countries not participating in the AG, the member country should ensure that the products will not be re-exported; and that, if re-exported, the products will continue to be controlled by the country of destination and, in this case, the country of destination will obtain the consent of the member country where the transaction originated in order to carry out the re-export. Among the non-proliferation measures of chemical and biological weapons that the member country adopts, the AG recommends the inclusion of sanctions for potential violators (AG 2007).

Member countries should be careful to also maintain control over items which, although not controlled by the AG, contain one or more controlled components and which are subject to removal for use for other purposes. For this purpose, the effective quantity of the controlled product must be taken into account and whether the country of destination dominates the technology necessary to extract the controlled element.

The AG recommends that member countries also adopt Catch-All type legislation, also sharing information with other member countries about transfer refusals (Seevaratnam 2006). It should be noted that it is the obligation of member countries, in cases where the sale of an identical item has been denied by another member, to consult it before authorizing the licensing for export (AG 2007).

Export controls involve several actors, which obliges the member country to establish pertinent legislation, regulatory frameworks and licensing agencies that can effectively bring the chemical, biological and pharmaceutical industries, as well as the brokers specialized in the sector, under the state's attention. (AG 2007).

Countries interested in becoming AG members must fully meet the following requirements:

- Be a party to the Chemical Weapons Convention and the Biological Weapons Convention;
- Be a producer, exporter or logistical intermediary of items controlled by the AG;
- Adopt and implement the AG rules on the transfer of sensitive chemical or biological material;
- Have an effective export control system that allows the country to inspect and control all items listed by the AG through a licensing system;

- Have a legal system that provides for punishment for actors who do not comply with the rules being able to apply it;
- Create channels for exchanging information that are capable of providing confidentiality, establishing links between specialists and providing a transfer refusal system that protects commercial secrecy; and
- Agree to participate in the AG in order to strengthen its effectiveness in preventing the proliferation of chemical and biological weapons.

The Zangger Committee

The Zangger Committee was formed after the establishment of the NPT to serve as the "faithful interpreter" of paragraph 2 of Article III of that Treaty, in order to harmonize the interpretation of nuclear material export control policies among NPT member countries . In this sense, the Zangger Committee is a complement to the NPT, in addition to having an informal character (ZC 2021).

Its denomination derives from the name of its first President, Professor Claude Zangger. Initially, a group of 15 countries held informal meetings between 1971 and 1974, in Vienna – Austria, with the purpose of reaching a common understanding on the meaning of "equipment or material specially designed or prepared for the processing, use or production of special fissile material", since such expression appears in the text of the NPT, but is not defined in that Treaty. Another point on which common understanding was sought was: "the conditions and procedures that would regulate the exports of that equipment or materials in order to meet the obligations of paragraph 2 of Article III of the NPT, based on fair commercial competition" (ZC 2021; Schmidt 2000, 144).

The ZC currently has 39 members: South Africa, Germany, Argentina, Australia, Austria, Belgium, Belarus, Bulgaria, Canada, Kazakhstan, China, South Korea, Croatia, Denmark, Slovakia, Slovenia, Spain, United States of America, Finland, France, Greece, Netherlands, Hungary, Ireland, Italy, Japan, Luxembourg, Norway, New Zealand, Poland, Portugal, United Kingdom, Czech Republic, Romania, Russia, Sweden, Switzerland, Turkey and Ukraine, plus the European Union as a permanent observer (ZC 2021).

Decisions are taken in the ZC by consensus, that is, unanimously, and do not constitute legal obligations for member countries. The first ZC consensus was reached in 1972, when two Memoranda containing the "basic understandings" were issued. These two Memoranda form the ZC guidelines to this date and each describes the procedures for the export of materials and

equipment described in paragraph 2 of Article III of the NPT. The first Memorandum deals with supplies and fissile material, while the second deals with equipment dealing with fissile material (ZC 2021).

These two Memoranda became known as the Trigger List as the export of listed items triggers International Atomic Energy Agency (IAEA) safeguards. Due to the constant development of nuclear technology, the Trigger List is constantly updated by member states, including an annex that specifies and details the equipment that handles fissile material (Sevini and Janssens 2020).

From the detailed study of the ZC guidelines, a qualification emerges that separates States into two categories: States that have nuclear weapons and those that haven't. For the sake of simplification, in order to provide greater fluidity to the text, we will name the former as "Nuclear States", and the latter as "Non-Nuclear States". That is, even if a country uses nuclear equipment for peaceful purposes, such as power generation or propulsion, even if applied to equipment for military use, it will be called a Non-Nuclear State (ZC 2021).

The ZC interprets that there are three supply conditions:

- Fissile material exported to Non-Nuclear States cannot be diverted for use in nuclear weapons or nuclear explosives;
- Fissile material exported to Non-Nuclear States, as well as transferred equipment and non-nuclear material, will be subject to safeguards as established by the IAEA; and
- Fissile material, equipment and non-nuclear material may not be re-exported to Non-Nuclear States unless the receiver State accepts the safeguards on the re-exported item.

In this regard, clarification is needed on the meaning of the safeguards applied by the IAEA. Safeguards are activities carried out by the IAEA to ensure that a State is not violating the international agreements it has signed and through which it has pledged not to develop nuclear weapons programs. Thus, the safeguards are intended to prevent the diversion for hidden purposes of nuclear material that allegedly would be used for peaceful purposes. They usually comprise surveillance and inspections, scheduled or unannounced (Carlson 2021; IAEA 2021).

Unlike the WA and the AG, the ZC does not impose rules aimed at increasing control over exports, nor does it make objective recommendations on legislation, licensing systems or sanctions. These functions are already the responsibility of the IAEA, which emerged before the ZC, in 1957, and with which Brazil already has signed agreements. Nor does the ZC establish the policies and strategies necessary to prevent the proliferation of nuclear wea-

pons devices and to allow the peaceful use of nuclear energy. This prerogative belongs to the NPT, to which Brazil is already a signatory. The ZC only interprets the NPT in a technical way and publishes the Trigger List in order to allow for a more comprehensive understanding of the Articles of the NPT and to enable the triggering of safeguards by the IAEA. In short, membership of the ZC does not impose additional obligations that a member of the NPT and the IAEA has not previously accepted, which is the case of Brazil.(ZC 2021).

The ZC meets twice a year, in May and October, in Austria. Their work schedule typically involves updating the Trigger List and other administrative measures, such as reviewing the membership of a new member (Schmidt 1994, 41). To join the ZC, the country must first be part of the NPT. Furthermore, "any country that is a supplier of nuclear material, current or potential, and that is prepared to implement the Committee's understandings, is eligible" (Assembly 2015, 5). The decision to admit a new member to the ZC is taken by consensus (ZC 2021).

Development of the decision support model

The research was carried out in four stages. The 1st Stage consisted of outlining the hierarchical structure of the problem, based on the objective to be solved, the research problem, the evaluation criteria and the alternatives capable of solving it. This framework follows the AHP problem-solving model (Wind and Saaty 1980; Saaty 1980; 1990).

Figure 1 illustrates the hierarchical tree created for the research. The top of the structure is composed by the general objective of prioritizing the Agreements, from the DM's point of view. The 1st level consists of criteria selected from the attributes observed in international agreements. Criteria 1 to 5 were taken from (Nayan 2019) research, which looked at a similar problem in India, and criteria 6 and 7 were added based on the experience of the experts consulted. Table 1 describes the meaning of the criteria considered for the assessment of the three Agreements, indicated in the 2nd level

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Figure 1: Hierarchical structure of the problem

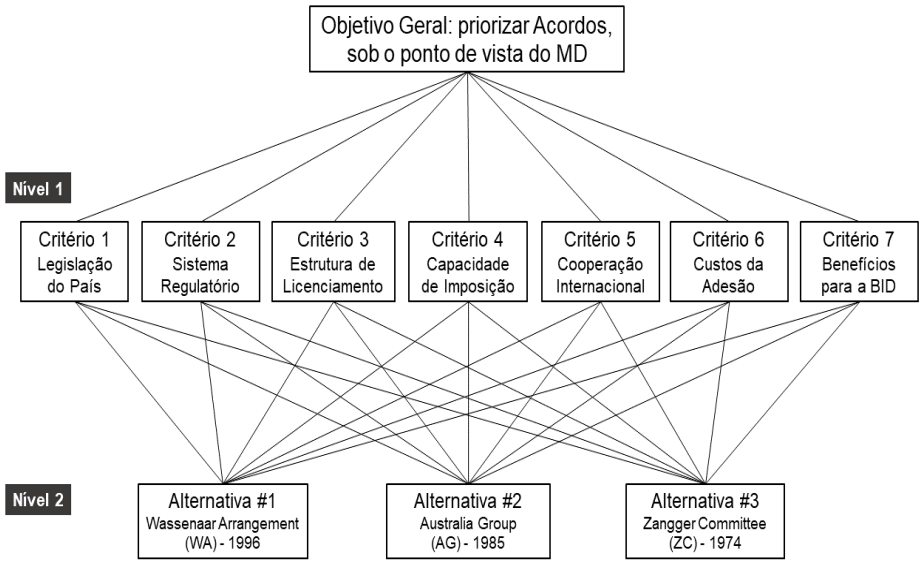


Table 1: Description of criteria

CRITERIA	DESCRIPTION
1. Country Legislation	Existence of a legal framework already in place that favors the adherence of the country to the agreements considered.
2. Regulatory System	Bureaucratic facilities for international trade and/or control of the products related to the Agreements considered.
3. Licensing Structure	Existence of bodies and agencies that favor the licensing of products related to the Agreements considered.
4. Enforceability	Existence of infrastructure capable of preventing the illicit transaction of products related to the Agreements considered.
5. International Cooperation	Existence of cooperation from the signatory countries to encourage and comply with the considered Agreements.
6. Membership Costs	Costs considered for formal adhesion to the agreement's managing committee, including the eventual need for creating and maintaining permanent committees in the country and/or abroad, committee travel, among other costs involved.
7. Benefits for the Defense Industrial Base (DIB)	Stimuli and benefits that joining one Agreement can bring to the Defense Industrial Base (DIB), favoring joining one over the other by comparison.

The 2nd stage of the research consisted of the elaboration of questionnaires, which collected information on the qualification of specialists and their evaluations regarding the selected criteria and alternatives. Subsequently, this information was added for modeling, following the steps of the decision support method chosen for the solution.

The 3rd stage consisted of choosing DM specialists, with academic background and professional experience capable of properly evaluating the requested information. Table 2 presents the demography of the experts consulted.

Table 2: Expert Demographics

Exp	Graduation	Post-graduation	Current occupation	Professional Experience	Experience in Agreements and Treaties
Exp.1	Naval Sciences	Senior Policy and Strategy Studies	Director of the Department of Science, Technology and Innovation of the Defense Ministry - Representative at the Interministerial Commission for the Control of Exports of Sensitive Goods (CIBES)	38 years	Over 1 year
Exp.2	Chemical Engineering	Master in Nuclear Technology	Advisor in the nuclear area - Defense Products Department of the Defense Ministry	28 years	Over 9 years
Exp.3	Chemical Engineering	Master in Military Science	Manager of the Department of Science and Technology of the Secretariat of Defense Products of the Defense Ministry	30 years	Over 5 years

Exp.4	Pharmacy	Biochemistry and hospital pharmacy	Coordinator of the Department of Health and Social Assistance of the Defense Ministry	20 years	Over 5 years
Exp.5	Aeronautical Engineer	Specialization in Flight Test Engineering	Coordinator for Missile, Aerospace and Space Technologies at the Defense Ministry	45 years	Over 15 years
Exp.6	Aeronautical Sciences	Aerospace Sciences	Coordinator of the Department of Commercial Promotion of the Ministry of Defense	38 years	Over 7 years
Exp.7	Marketing	MBA in Commercial and People Management	Manager of the Department of Commercial Promotion of the Defense Ministry	20 years	Over 2 years
Exp.8	Naval Sciences	Advanced Studies in Maritime Strategy and Business Management	Advisor to the Secretary of Defense Products of the Defense Ministry	29 years	Over 1 year
Exp.9	Naval Sciences	Advanced Studies in Maritime Strategy and Business	Coordinator of the Department of Science, Technology and Innovation of the Secretariat of Defense Products of the Defense Ministry	32 years	2 years

The 4th stage consisted of modeling the assessments with the AHP. This process is composed of a sequence of procedures and calculations to produce the final weights of the alternatives, the highest value of which indicates the Agreement deemed preferential for the group of consulted experts.

Initially, the experts' assessments need to be standardized, as each respondent chooses his reference for the assessment of the others. This standardization follows the principle of additive transitivity, as presented in Alonso et al. (2008), Alonso et al. (2009), Li et al. (2019) and Gavião, Lima, and

Garcia (2021). In this way, the number of joint evaluations required from each specialist is considerably reduced, reducing the response time and possibly guaranteeing greater reliability in the results.

Assessments are carried out based on the nine-point scale proposed by Saaty (1980). For the peer-to-peer evaluations of the criteria and alternatives, the linguistic variables of the scales presented in Figures 2(a) and 2(b), respectively, were adapted.

Figure 2: 9-Point scales

Source: adapted from Saaty (1980).

After completing the matrix of peer evaluations, described in Equation (1), the sequence of Equations (2) to (6) are applied in the AHP to calculate the weights of the alternatives and the Consistency Ratio (CR) of the evaluations. The literature registers some techniques for calculating the weights of the AHP, with the original proposal deriving from linear algebra, also called the eigenvalue model. Thus, the equations listed were detailed in Liu and Lin (2016). The cutoff value considered for the CR is 10%, below which the expert's judgments are considered logically consistent.

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix}$$

$$w_i = \frac{\left(\prod_{j=1}^{n} a_{ij} \right)^{1/n}}{\sum_{i=1}^{n} \left(\prod_{j=1}^{n} a_{ij} \right)^{1/n}}$$

$$A^s = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \times \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} = \begin{bmatrix} w_1' \\ w_2' \\ \vdots \\ w_n' \end{bmatrix}$$

$$\lambda_{\max} = (1/n) \times (w_1'/w_1 + w_2'/w_2 \cdots + w_n'/w_n)$$

$$IC = \frac{\lambda_{max} - n}{n - 1}$$

$$RC = \frac{IC}{IR}$$

In which:

A: Matrix of Peer Assessments by an Expert

aij: value of the peer evaluation corresponding to the Saaty scale

wi: eigenvector of alternatives (criteria weights or Agreements)

λmax: maximum eigenvalue of the reciprocal matrix

IC: Consistency Index

RC: Consistency Ratio

RI: Random Index, calculated based on the reference table with the matrix ratio

Table 3: AHP Random Index Values

Matrix reason (number of variables)	1	2	3	4	5	6	7	8	9
Random Index (RI)	0	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45

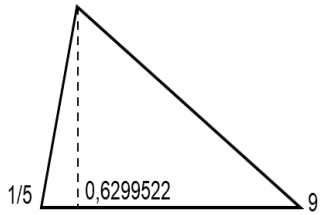
Since it involves a group of experts, in a process of independent collection of judgments, it is difficult for peer assessments to converge. Thus, it is possible that an expert judges that criterion "A" is more important than "B", for example, while another expert judges it differently, evaluating that "A" is less important than "B". These different assessments can be aggregated into single values (example: averages) or they can be fitted to probability distributions to simulate a significant amount of values with the same profile as the data sample.

The use of averages with small samples, usually less than 30, can cause distortions, as they try to reduce a series of few data to a single value. Considering the sample of nine experts in this research, the use of the averages of the initial assessments could distort the results and reflect an unreliable order of preference to the Agreements. For example, if nine people usually consume a liter of water a day and one only drinks ten liters of water a day, the average [(9x1)+(1x10)]/10 = 1.9 liters/day is different from reality, since it represent almost twice the per capita water consumption of the majority of individuals considered. Therefore, we opted for the simulation approach instead of computing the averages of the initial evaluations.

The simulation procedure is performed based on a probability distribution that allows adjusting the collected data. Each assessment of a sample has a different associated probability. For example, if in a sample of ten evaluations most of them focus on the value 1/5 of the Saaty scale, it is possible to assume that in a simulation of ten thousand random values, more values appear close to 1/5 than the extreme values.

In this research, the triangular distribution was used to adjust the experts' assessments. The function that defines this type of distribution requires three parameters from the dataset: the minimum sample value, the most likely value (mode), and the maximum value. The minimum and maximum of the samples are easily identifiable. The mode of each sample needs to be estimated, being calculated with the aid of the modeest application, of the R statistical software (Poncet 2019). Each evaluation simulation was submitted to the AHP equations, with its result being maintained if the CR < 0.1 and discarded if the CR > 0.1. Figure 3 illustrates the procedure for fitting the data set, referring to the peer assessments of Criterion 1 in relation to Criterion 5 in a triangular distribution.

Figure 3: Data adjustment procedure

Avaliações Paritárias dos Especialistas (Critério 1 x Critério 5)									Mínimo	Moda Estimada	Máximo	Distribuição Triangular
E1	E2	E3	E4	E5	E6	E7	E8	E9	1/5	0,6299522	9	
7	9	1	3	4	1	1/3	1/3	1/5				

Collection of data from experts

Table 4 shows the data collected (already standardized for common reference) from the Specialists through the questionnaires. This need to standardize the data derived from the option in the questionnaire for the specialist to choose the reference that gave them more confidence to compare with the others. For example, considering the peer assessments of Level 1, Expert 2 could have chosen a different benchmark than the other experts. Applying these results, with different references, directly in the AHP equations would distort the results.

The standardization procedure followed the logical principle of additive transitivity proposed by Gavião, Lima and Garcia (2021). In this procedure, it is possible that compliance with this principle requires the extrapolation of the nine-point Saaty scale, to extreme values of up to 17 or 1/17. For this reason, it is possible to justify the existence of values above 9 in Table 4.

Table 4: Collected data (standardized)

Lev.	Ref.	Exp.1	Exp.2	Exp.3	Exp.4	Exp.5	Exp.6	Exp.7	Exp.8	Exp.9	Goal
1	Criterion 1	1	1	1	1	1	1	1	1	1	Criterion 1
		4	5	7	1/3	1	1	3	1	1/3	Criterion 2
		7	3	1	1	1	1/7	1/7	1/9	3	Criterion 3
		8	1/3	1	1/3	2	1/5	1/5	1/5	1/5	Criterion 4
		7	9	1	3	4	1	1/3	1/3	1/5	Criterion 5
		10	11	1/3	9	3	1/7	1/7	1/9	3	Criterion 6
		2	5	3	5	1	1	1	1/3	1/5	Criterion 7
2 – C1	Wassenaar Arrangement	1	1	1	1	1	1	1	1	1	Wassenaar Arrangement
		1/7	1	5	XXX	1	1	3	5	1	Australia Group
		4	5	5	XXX	1	3	1	5	1/5	Zangger Committee
2 – C2	Wassenaar Arrangement	1	1	1	1	1	1	1	1	1	Wassenaar Arrangement
		6	1	1	XXX	1	3	5	3	1	Australia Group
		6	5	1	XXX	1/2	3	1/3	3	1/7	Zangger Committee
2 – C3	Wassenaar Arrangement	1	1	1	1	1	1	1	1	1	Wassenaar Arrangement
		5	1/3	1	XXX	1	3	1	3	1	Australia Group
		1/5	1/5	1	XXX	1	3	1/3	3	1/7	Zangger Committee
2 – C4	Wassenaar Arrangement	1	1	1	1	1	1	1	1	1	Wassenaar Arrangement
		3	1/5	1	XXX	2	1/3	1/5	7	1	Australia Group
		1/7	1/7	1/3	XXX	2	1/5	1/7	7	1/9	Zangger Committee

2 – C5	Wassenaar Arrangement	1	1	1	1	1	1	1	1	1	Wassenaar Arrangement
		5	1/5	7	XXX	2	1	1/3	5	1/3	Australia Group
		1/7	1/7	7	XXX	3	1	1/7	5	1/3	Zangger Committee
2 – C6	Wassenaar Arrangement	1	1	1	1	1	1	1	1	1	Wassenaar Arrangement
		1/3	1	1	XXX	1	3	1	1	1/3	Australia Group
		1/2	5	1	XXX	1	1/3	1	1	1	Zangger Committee
2 – C7	Wassenaar Arrangement	1	1	1	1	1	1	1	1	1	Wassenaar Arrangement
		8	1	9	XXX	7	5	1/3	7	1	Australia Group
		4	7	9	XXX	5	3	1/7	7	1	Zangger Committee

Table 5 shows the parameters of the triangular distributions used to simulate ten thousand assessments of each sample. The columns show the minimum, maximum and estimated mode values for the scores obtained when comparing each criterion with the others, according to the data obtained in the questionnaires.

Table 5: Triangular distributions parameters

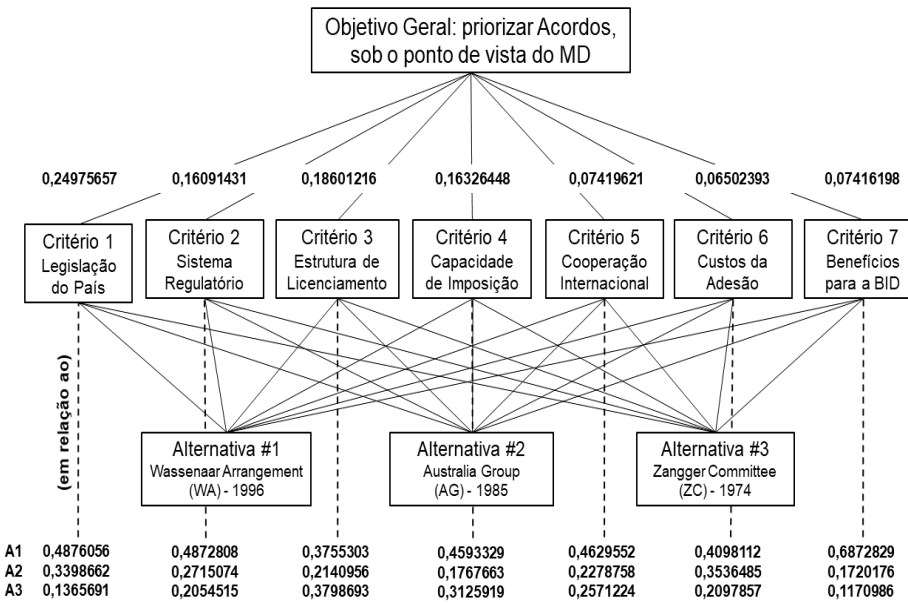
Level	Reference	Minimum	Estimated Mode	Maximum	Goal
1	Criterion 1	1	1	1	Criterion 1
		1/3	0,7410264	7	Criterion 2
		1/9	0,7116237	7	Criterion 3
		1/5	0,3195537	8	Criterion 4
		1/5	0,6299522	9	Criterion 5
		1/9	1,207711	11	Criterion 6
		1/5	0,9390724	5	Criterion 7

2 – C1	Wassenaar Arrangement	1	1	1	Wassenaar Arrangement
		1/7	0,8457952	5	Australia Group
		1/5	4,663565	5	Zangger Committee
2 – C2	Wassenaar Arrangement	1	1	1	Wassenaar Arrangement
		1	1,007513	6	Australia Group
		1/7	0,5344237	6	Zangger Committee
2 – C3	Wassenaar Arrangement	1	1	1	Wassenaar Arrangement
		1/3	0,9286321	5	Australia Group
		1/7	0,3291595	3	Zangger Committee
2 – C4	Wassenaar Arrangement	1	1	1	Wassenaar Arrangement
		1/5	0,4877779	7	Australia Group
		1/9	0,178056	7	Zangger Committee
2 – C5	Wassenaar Arrangement	1	1	1	Wassenaar Arrangement
		1/5	0,453637	7	Australia Group
		1/7	0,1961331	5	Zangger Committee
2 – C6	Wassenaar Arrangement	1	1	1	Wassenaar Arrangement
		1/3	0,8734841	3	Australia Group
		1/3	0,8472322	5	Zangger Committee
2 – C7	Wassenaar Arrangement	1	1	1	Wassenaar Arrangement
		1/3	7,852908	9	Australia Group
		1/7	5,651251	9	Zangger Committee

AHP Results

Equations (1) to (6) were applied to each evaluation simulation, generating ten thousand results. However, some simulations generated inconsistency coefficients above the 10% threshold, which were then discarded. Of the consistent results, the geometric average indicated the preferences shown in Figure 4.

Figure 4: Partial results



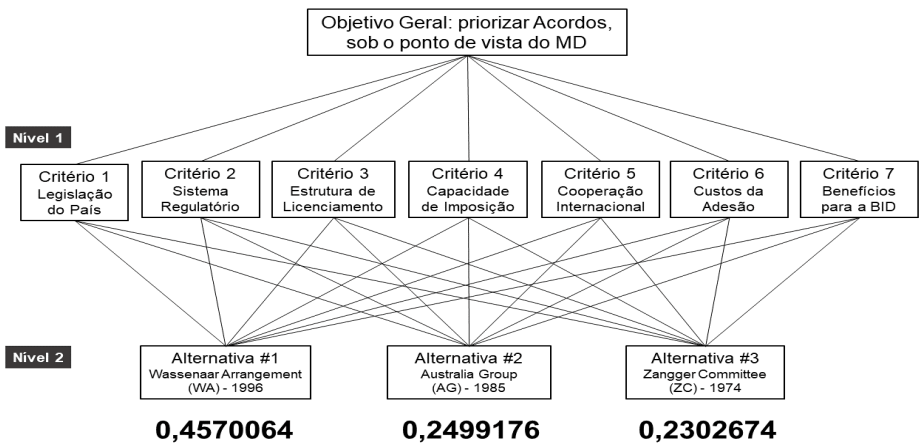
The partial results indicated above the criteria show the average preferences of the group of experts for that level. For example, it is possible to verify that Criterion 1 was considered the most important, as it obtained an overall assessment of 0.24975657, a value higher than the others. Experts considered that the existence of a legal framework already in force, which favors the country's adherence to the considered Agreements, is the most important attribute to assess their priority. This view is reinforced by the fact that the next three Criteria considered the most important - 3, 4 and 2, respectively - are also directly related to regulatory issues, as well as the existence of an adequate government structure capable of imposing the necessary sanctions.

On the other hand, the costs of adherence to the Agreement indicated

the least important criterion for decision making, with a weight of 0.06502393, probably because they consider that any costs arising from the creation and maintenance of permanent committees in the country and/or abroad, travel of delegations, among other costs involved, are less representative due to the benefits that the Agreement generates for the country. The weights of the last lines of Figure 4 indicate the results of the global assessments of the Agreements in relation to each criterion.

Finally, the final results in Figure 5 reflect the clear preference for the WA, with 45.7% of the preference, indicating the priority for adherence to this Agreement, from the point of view of Defense specialists. These final weights were obtained by the weighted sum of the evaluations of each Agreement for each criterion. Thus, this weight of 45.7% results from the sum (0.24975657 x 0.4876056) + (0.16091431 x 0.4872808) + ... + (0.07416198 x 0.6872829).

Figure 5: Final results



The results in Figure 5 also show a "technical tie"[4] between AG and

4 The research presents an exploratory bias, in the sense of presenting a decision support methodology for the prioritization of alternatives, being desirable to deepen with samples of respondents from other sectors of interest (IDB/private sector, Academia, or Itamaraty civil servants, for example). Results with samples from different groups may indicate a more significant difference in score than obtained, or even an inversion favorable to the ZC. Regarding the sample size, it is worth noting that the simulation procedure of ten thousand values, implemented based on information collected from the sample of nine experts, tends to considerably reduce the distortions caused by small samples.

ZC preferences. The AG obtained better scores than the ZC in criteria 1, 2, 6 and 7. In addition to representing the majority, it is possible to verify that the AG involves lower costs and brings more benefits to the DIB, when compared to the ZC. Thus, between these two Agreements, it would be interesting for the MD to prioritize joining the AG, leaving the ZC to the last option.

Final Remarks

The careful adherence to international agreements can enable the country to participate more actively in international decision-making processes, projecting itself into the concert of nations as a relevant actor, providing more visibility and credibility.

Specifically, the Brazilian tradition of opting for the peaceful resolution of disputes, as well as its recognized diplomatic capacity, makes it natural to adhere to agreements that have the purpose of controlling the sale and transfer of arms, supplies and related technologies, known as Multilateral Export Control Regimes (MECR).

Among the five MECR in vogue in the world, Brazil is not a signatory to three of them: the Wassenaar Arrangement (WA), the Australia Group (AG), and the Zangger Committee (ZC).

Having in mind the interest of the Department of Defense Products (SEPROD) of the Defense Ministry (DM) in this topic, which can be used to prioritize a possible decision to join the WA, the AG and the ZC, this research sought to develop a model decision support capable of analyzing the cost-benefit ratio of complying with the clauses of the WA, the AG and the ZC, from the point of view of an expression of the National Power, in order to serve as an advisory instrument for the Brazilians Political and Strategic levels.

The methodology used to meet this goal was the Analytic Hierarchy Process (AHP), a current method in the field of Operational Research, which is adequate to support decision processes in which judgment and human perceptions are involved or when the problem is expressed in uncertain, fuzzy and/or confused terms.

The research consisted of outlining the hierarchical structure of the problem, based on the objective to be solved, the research problem, the evaluation criteria and the alternatives capable of solving it. Then, questionnaires were created for data collection and specialists with recognized experience and academic training were selected to answer them. The focus on specialists from the Defense Ministry was due to the relationship between the object of study and the Defense Industrial Base, which establishes a specific Secretariat

for the study and monitoring of the topic. Finally, the answered questionnaires were analyzed, and the necessary data for modeling the assessments with the AHP were extracted.

After modeling the assessments, the method indicated the priority for adherence to the Wassenaar Arrangement, from the point of view of the consulted Defense specialists. The decision support model clearly identified that the WA was superior to the other Agreements in all criteria, with the exception of the negligible difference for the ZC in Criterion 3. It was also possible to verify a small difference between the importance of the WA and of the ZC, according to Criterion 3 (Licensing Structure), probably because Brazil is a signatory of the NPT, due to mastering the uranium beneficiation cycle and for having a nuclear program for peaceful purposes. As the ZC is closely linked to the NPT, it is to be assumed that experts considered that, according to Criterion 3, Brazil is as well prepared to join the WA as it is to join the ZC.

It is also noteworthy the great preference that the WA had over the other agreements when considering Criterion 7 (Benefits for the DIB). The result shows that there is a consensus among experts as to the possible benefits of joining the WA, since, by increasing Brazil's credibility with the international community, such adhesion will also open the doors of a very restricted market, where only the members of this group have the possibility of accessing strictly controlled technological components, which has great potential to boost Brazilian defense products.

It is also important to add that the AHP method is based on the opinion of experts, through judgments that can take into account their professional experiences, their interests in the proposed subject and their academic background. In this sense, the present result expresses the opinion of a group of specialists who are professionally linked to the MD's assistance in the process of joining the MECR, whose methodology reduces the subjectivity and arbitrariness of a direct choice for an Agreement.

Thus, it is recommended that this decision support model, validated in this study, be deepened with samples of experts from other expressions of National Power, with different views on the subject, such as components of the Ministry of Foreign Affairs, the Ministry of Economy, from the National Nuclear Energy Commission, from the Defense Industrial Base and from the Academy, providing greater robustness to the results achieved.

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ABSTRACT

This paper proposes a model to support the decision to choose which multilateral export control regime of defense products and sensitive technologies in which Brazil does not yet participate, namely, Wassenaar Arrangement, Australia Group and Zangger Committee, should be prioritized for adhesion. For the development of this model, the Analytic Hierarchy Process (AHP) method was used, considered adequate for solving problems where criteria are qualitative and decisions tend to be based on personal experiences. The hierarchical structure of the problem used seven criteria (Country Legislation, Regulatory System, Licensing Structure, Enforcement Capacity, International Cooperation, Costs of Adhesion and Benefits for the Defense Industrial Base) to compare the three mentioned agreements. A questionnaire was set up and specialists related to National Defense were selected to answer them, after which their answers were collected, standardized, processed and analyzed. At the end, the agreements were ordered by preference to support decision making, illustrating the application of the proposed model.

KEY WORDS

National Defense Industrial Base; National Security; Defense; Trade Treaties; International Economic Relations.

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