

# Meeting Global Challenges Through International Science And Technology Cooperation - A Glance At United Nations' Multilateral Treaties

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**Abstract:** The paper focuses on United Nations' multilateral treaties adopted for the purpose of international cooperation in science and technology (S&T) to provide a detailed and up-close grainy picture of how the world cooperates to address a vast area of global issues. On one hand, the paper measures the degree of global joint-commitment by the international community for major S&T agreements. On the other hand, it suggests quantitative measure to analyze the policy making attitude of states as actors negotiated in these agreements. More precisely, it measures how quick a national response to the global call in solving the new and emerging threats. Moreover, the state's readiness in policy making towards these cross-border challenges is also represented in comparative with its level of national human development. By providing the closer and combining look at these two aspects which are both immensely important to achieve global governance progress, the paper makes a number of important recommendations to increase the likelihood and the scope that states will act collectively at global level in addressing major crises. Based on that, widespread coordination and cooperation among states and international institutions can be strengthened and extended to ensure cohesiveness in global governance of S&T.

**Index Terms:** Science and Technology Cooperation, United Nations' Multilateral Treaties, Global Challenges, Policy Making, Global Governance of Science and Technology, Human Development

## 1 INTRODUCTION

### 1.1 INTERNATIONAL S&T COOPERATION TO ADDRESS GLOBAL CHALLENGES

Our increasingly interdependent world nowadays confronts a daunting array of threats that transcend national boundaries, such as nuclear catastrophes, ozone depletion, climate change or loss of biodiversity. Most countries have acknowledged that national policy measures essentially cannot cope with such international issues because their impact may not be within a particular state's jurisdiction. As national governments alone cannot ensure adequate and effective solutions, international cooperation and collective action in the form of global commitment to multilateral agreements are required to solve shared global concerns and to promote sustainable development. Noticeably, the international community now recognizes international cooperation in science and technology (S&T) as an urgent necessity for addressing a host of global issues, from the global peace and security, to environment protection, public health and safety. Indeed, multinational S&T cooperation have played a vital role in devising the solutions that are necessary to overcome the awful problems arising from these global threats.

The rapid growth in S&T research capability around the world provides a strong foundation for facilitating an effective response to global challenges over the long-term, such as finding and using renewable energy sources to mitigate the environmental consequences associated with climate change. Being convinced that S&T innovation will spur strong economic growth and contribute to global sustainability, more and more countries are currently committing substantial priority for international S&T cooperation and collaboration. States has built formal S&T relationships and partnerships around the world. With this strong international partnership network, the last decades have seen incredible breakthroughs and significant innovations in S&T that have become the essential catalysts for the increased productivity and social wealth of the world.

### 1.2 International S&T Cooperation and the Creation of Multilateral Treaties

Advances in S&T during the past few decades have accelerated the growth of international law as a creative force in organizing and regulating cooperative programs among nations. International law can serve as an organizational mechanism to implement the desires of nations to cooperate [1]. Specifically, multilateral efforts to facilitate cooperation among states are increasingly materialized in the form of multilateral treaties which are binding at international law. Treaty processes and declarations of international institutions enable nations to have a common commitment—national and global—towards the trans-border threats and to react quickly to meet new situation. States are expected to ratify international conventions as way to endorse and express a public and legally binding commitment to a universally concern [2]. This suggests that ratification decision to any international treaty represents the interest in a certain international policy area, and then reflects the willingness on the part of the ratifying country to comply with international law and thus, to cooperate with other partners. International treaties to promote cooperation in scientific research and development can be bilateral or multilateral. They provide the privileged and strategic forum to identify common interests, priorities, policy

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dialogue, and the necessary tools for S&T collaboration [3]. These agreements also serve as the guidelines for member states to facilitate the exchange of scientific data and results, protect intellectual property rights, and establish effectively partnerships and work with counterpart institutions abroad to increase international S&T capacity [4]. An ever more interconnected world demand more cooperation among nations which leads the number of multilateral treaties negotiated under the United Nations (UN) systems is increasing year by year. To the initial goals of safeguarding peace, establishing a framework for international trade and promoting economic and social progress, their domain nowadays encompass various subject areas of international concern, ranging from environment to intellectual property, from occupational health to food and drug safety. The significant growth in the number of international conventions that had been deposited in UN system shows the effort by the international community towards trans-boundary issues. However, international relation scholars have pointed that while the cross-border challenges are likely to continue in coming decades, the current global governance architectures still short on capacity to cope with them. Policy makers and leaders may find themselves unprepared for the sheer speed and scale of these global threats [5]. The call for collective action in the form of a global commitment to international agreements is raised for a more-effective and better international governance to urgently respond to these global challenges. Therefore, more attention should be paid more on the behavior of the international community in these joint commitments, particularly the attitude of states towards the international agreements. Though such overall analysis should be particularly interesting to international relation scholars, this is still a rarely examined in the context of international regime study. This absence of this empirical analysis suggests the overall analysis of how international community commit, accept and denies global objectives towards S&T embodied in the most important conventions in current international regimes.

### 1.3 Study Aims

The paper focuses on UN's multilateral treaty system adopted for international S&T cooperation, simply referred here as S&T agreements, to provide a detailed and up-close grainy picture of how the world cooperates in S&T to address a vast area of global issues. The aim is to describe two aspects of international S&T agreements. On one hand, it measures the degree of global joint-commitment by the international community for major S&T agreements. On the other hand, it suggests quantitative measure to analyze the policy attitude of states as actors negotiated in these agreements. More precisely, it measures how quick a national response to the global call in solving the new and emerging threats. Moreover, the state's readiness in policy making towards these cross-border challenges is also represented in comparative with its level of national human development. By providing the closer and combining look at these two aspects which are both immensely important to achieve global governance progress, the paper makes a number of important recommendations to increase the likelihood and the scope that states will act collectively at global level in addressing major crises. Based on that, widespread coordination and cooperation among states and international institutions can be strengthened and extended to ensure cohesiveness in global governance of

S&T. For this purpose, the collection of multilateral treaties deposited in UN System which contains the ratification status of nearly hundred major international agreements and covering a range of S&T subject matters has been developed. The records of ratification year that cover participation by nearly 200 nations in the four major international agreement categories, from security, environment, technical competitiveness to safety and health will be examined in explaining the policy behavior of nation-states. Based on that, the research gives a striking portrait of international commitment on an array of global issues; whilst at the same time give an overview of the most important international treaties. In addition, it pays particular attention to disparities between groups of countries' behavior towards trans-boundary problems and the priority in cooperating with other partners that they are showing to the world. The rest of the paper is structured as follows: The collection of UN multilateral S&T agreements on a wide range of arenas is first introduced. The third section then describes the level of global commitment in creating and implementing the regulations and norms of different domains of global S&T governance. The paper continues by explaining the states' policy quantitative measurement and analysis. The obtained results are then used to observe the states' behavior in policy decision making towards international S&T issues. Based on that, we proposed some recommendations to achieve the efficacy of the international cooperation in S&T from the international treaties perspective. Finally, some conclusions are offered in the last part of the paper.

## 2 INTERNATIONAL S&T COOPERATION IN THE FORM OF UN SYSTEM'S MULTILATERAL TREATIES

Our collection of multilateral treaties is a resource containing information on the ratification status of nearly hundred major international agreements deposited in the United Nations system and covers a range of subject matters of international S&T cooperation. Basically, the collection provides information about "when, who, what" stating that which country ratified which treaty and when. The first version of the collection was created in 1999 and covered the treaties that are mainly related to the issues such as the management of dual technology to govern the global peace and security issues, the management of hazardous substances that harm to the environment, intellectual property protection and technical standards to regulate the global trading system, or the matters of transportation and telecommunication [6]. The database had indexed by Japan National Diet Library (NDL) and became accessible on-line since 2001 through NDL's Japan Database Navigation Service (Dnavi) [7]. As new treaties and agreements are continually being deposited with the Secretary-General of the United Nations, since then, several updating efforts were routinely made to keep the database up-to-date with such new content. The current version covers around one hundred of multilateral treaties. The coverage of conventions is greatly improved especially in the specific concern of safety and health issues, including nuclear safety, food and drug safety, occupational health and safety regulations of International Labour Organization. The records about these treaties are mainly based on physical collection with a lot of labour from various reliable resources, amongst which are the UN Treaty Collection, the annual reports from well-known international organizations, such as Organization for the Prohibition of Chemical Weapons (OPCW),

International Atomic Energy Agency (IAEA) or World Trade Organization (WTO) among others. Specifically, our collection of UN multilateral treaties can be categorized as four major groups representing four major domains of concern in the international S&T cooperation nowadays. These include: Security, Environment, Technical Competitiveness, Safety and Health. Each is further classified in different related subgroups. Fig. 1 shows the institutional infrastructure of global governance of S&T in the forms of multilateral treaties covered in our collection listed by groups, by subgroups and by their short names. The full listing of conventions is given in the Appendix.

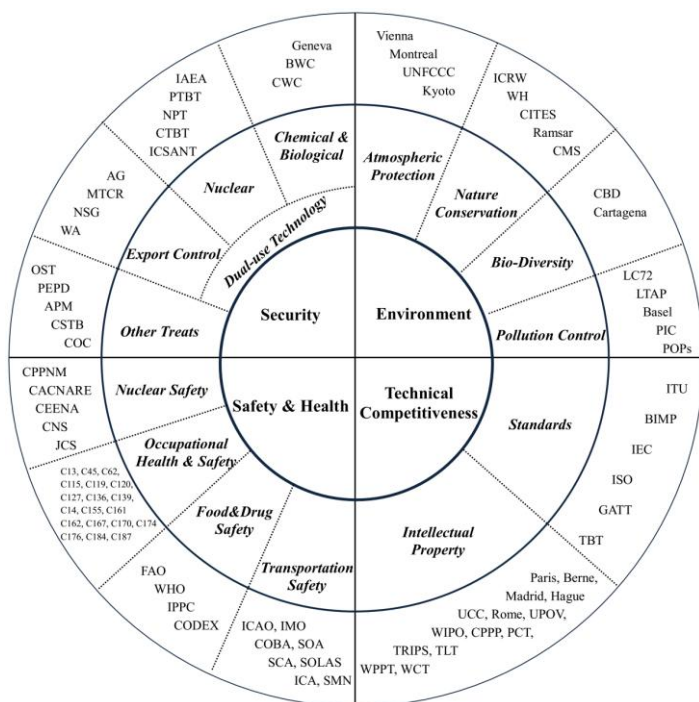


Fig. 1. The Classification of International S&T Cooperation by Multilateral Treaties

### 3 GLOBAL COMMITMENT TO DIFFERENT DOMAINS OF INTERNATIONAL S&T COOPERATION

In this section, the degree of global support by the international community for S&T agreements is reviewed by considering their ratified world population coverage. We have not only collected member countries' ratification data but also combined with their yearly population data from 1960 to 2011 recorded in the Statistic Collection of World Bank [8]. The degree to which a given S&T agreement is supported or has spread globally through a time-series base is then defined by the percentage of world population covered by this agreement. Based on that, a more detailed and up-close grainy picture of how the world supports different international S&T agreements according to the global issues is provided. Through the analysis of changes in treaty participation by the world population coverage across a broad time pattern, what important to note is that, there is clearly a surge of global commitments for the list of the most important international agreements deposited to the UN system, especially from the mid-twentieth century onwards. The community support networks has been extended and empowered for better international governance towards critical global issues. Moreover, the noteworthy difference in the level of global

support for different agreements in various subject areas of international concern suggests useful information about how well the international S&T cooperation operated can be extracted. The following sections of this paper detail, category by category, changes in global commitment level while also briefly introducing the formation and goal of each agreement.

#### 3.1 Security

The control of export, transit and brokering of dual-use technology are steadily becoming one of the specific concerns for sustainable global peace and security and thus needs the strategic partnerships among nations. The term dual-use refers to any technology that has both vital legitimate uses and potent military applications [9]. Beside peaceful civilian purposes such as the specific uses of biological and chemical substances within government funded research laboratories, or the uses of nuclear energy for the production of electricity, these technologies came along with the possibility of offensive military applications and may contribute to the manufacture and proliferation of weapons of mass destruction (WMD). Therefore the consideration about undesirable dangerous consequences which could make harm to human beings from acquiring and spreading of these technologies become a key instrument in the governance of global peace and security. A regulatory framework of international treaties has been created for the purpose of controlling and monitoring these sensitive dual-use goods and technologies, including chemical, biological and nuclear weapons. The World War I first saw large-scale deployment of chemical weapons. Thousands of people were infected by the horrific use of poison in warfare and died from scarring of the lungs, skin damage, and cerebral damage in the years after the conflict ended. The Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or other Gases, and of Bacteriological Methods of Warfare, usually called as Geneva Protocol, was adopted in 1925 as the first treaty prohibiting the use of chemical and biological technologies for military aims. What is important to note is that the Geneva Protocol was only explicitly prohibited the use, but not the production, storage, or transfer of these agents. As the results, the creation and stockpiling of chemical and biological weapons have been continuously deployed in some countries despite the existence of the treaty. Later, the 1972 Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction (BWC) and the 1993 Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction (CWC) were created to include the regulation of development and possession, other than use of biological and chemical weapons. Significant challenges to controlling the bad side-effects of these dual-use technologies still remain, however. The UN's effort to develop these conventions has faltered because of the dual-use technology dilemma [9]. Some countries resist cooperation from a concern that many legitimate uses of the technologies are still needed, such as the applications for purely medical purpose; thus this convention was not ratified by many states for decades. In spite of this fact, BWC has been currently ratified by 165 states and CWC nowadays received the multilateral consensus from 188 states in the world. Other type of WMD—nuclear weapons entered the bloodstream of world politics during the World War II after the atomic bombings of the cities



of Hiroshima and Nagasaki in Japan in August 1945. The debate about the control of nuclear materials and technology has formed one of the most important dimensions of the politics of international security. The 1963 Partial Test Ban Treaty (PTBT) which banned nuclear tests in the atmosphere, in outer space and under water, was the first systematic international regulation of the nuclear age. The treaty arose out of concerns about the negative effects of nuclear testing and the resulting radioactive fallout, on health and the environment, as well as a desire to limit the arms race. Despite early plans to call for a ban on all explosive nuclear weapons testing, in the end the treaty did not cover underground explosions. As a result, hundreds of such tests were conducted over the following decades. A major step towards peace came with the signing of the key agreement, the Non-Proliferation Treaty in 1968 (NPT) with extended arms control to other areas of the world. A total of 190 parties have joined the treaty, with five states being recognized as nuclear-weapon states: the United States, Russia, the United Kingdom, France, and China (also the five permanent members of the United Nations Security Council). Under the NPT, non-nuclear weapon states were prohibited from, among other things, possessing, manufacturing or acquiring nuclear weapons or other nuclear explosive devices. The CTBT marks an historic milestone in the efforts of international community to reduce the nuclear threat and build a safer world. Later, the CTBT will prohibit any nuclear explosion, whether for weapons or other purposes. Because halting all nuclear explosions will constrain the development of more sophisticated and destructive nuclear weapons, the CTBT will thus help to prevent the spread of nuclear weapons, promote nuclear disarmament and enhance global security. Since the concept of "international security" is no longer confined to traditional issues of war and peace, but now also covers topics such as terrorism and criminal law [10]. To deal with one of the most threatening kinds of terrorism offences, the International Convention on the Suppression of Acts of Nuclear Terrorism (ICSANT) is established to criminalize the planning, threatening, or carrying out acts of nuclear terrorism. ICSANT is entered into force in 2007 and covers a broad range of acts and possible targets, including nuclear power plants and nuclear reactors. To verify the correctness and the completeness of the declarations made by states about their nuclear material and activities, IAEA and its safeguard agreement adopted from 1962 have increasingly become an essential component in regulating the international security system. At the forefront of managing strategic goods and dual-use technology to prevent the threats from the proliferation of weapons of mass destruction, export controls, more than ever, become a critical security-related trade instrument. Most industrial countries thus have controls on the export, transit and brokering of certain types of designated defense material and dual use items that are subject to legislation. These efforts are carried out by concluding international agreements and exercising multilateral cooperation related to export control. There are several international arrangements among countries which seek to harmonize lists of dual-use technologies to control. These include the Nuclear Suppliers Group (NSG) which focuses on stemming the proliferation of nuclear weapons, the Australia Group (AG) which looks at chemical and biological technologies, the Missile Technology Control Regime (MTCR), which covers delivery systems for weapons of mass destruction, and the Wassenaar Arrangement (WA),

which covers conventional arms and dual-use technologies. Fig. 2 is the degree of global joint-commitment for the most important treaties related to global security issue measured by their percentage of ratified world population coverage. It can be seen clearly that some treaties seem to attract more particular attention from international community than others and then quickly reached to the high degree of global consensus and commitment from majority number of states.

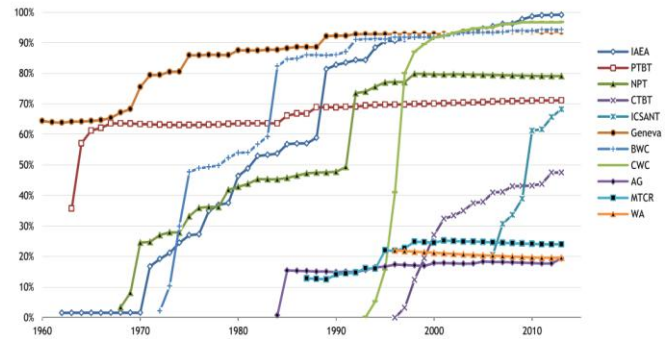


Fig. 2 Global Commitment Measure for Global Security related Treaties

### 3.2 Environment

The environmental protection movement might be said to have begun centuries ago as a response to industrialization. However, it is not until the aftermath of the World War II that the truly awareness of environmental problems and the concern about the sustainable use of the planet's resources began to dawn on the collective international environmental agreements (IEAs). Global environmental problems, such as ozone depletion, climate change, and loss of biodiversity across borders, endanger the entire globe and also pose a long-term obstacle for all of humanity. The international community's recognition about the importance of working together to solve these trans-boundary issues continued to grow and assembled formally in the 1972 United Nations Conference on the Human Environment in Stockholm. This landmark event addresses the need "to defend and improve the human environment for present and future generations" [11] and laid the groundwork for the new environmental agenda of the United Nations system. Later, another blueprint for the protection of our planet and its sustainable development is recognized on the meeting in Rio de Janeiro in 1992, the "Earth Summit," which is well-known by its "Agenda 21" action plan. Its priority for action emphasizes on the conservation and management of resources for development which includes different issue-areas, amongst which are: 1) protection of the atmosphere; 2) nature conservation and protection of terrestrial resources and all kinds of seas; 3) conservation of biological diversity and environmentally sound management of biotechnology; 4) promotion of the safe management of toxic wastes to prevent air and water pollution. These environment movements provided the catalyst that shape and strengthen the system of IEAs until today. The action towards protecting the atmosphere represents one of the most important groups of multilateral conventions and includes: The 1985 Vienna Convention for the Protection of the Ozone Layer (Vienna), the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal), the 1992 Framework Convention on Climate Change (FCCC), and the 1997 Kyoto Protocol (Kyoto). To deal with nature conservation and protection of terrestrial resources and all

kinds of seas, a list of IEAs have been adopted to form another important regulatory framework for environmental protection. Among them is the International Convention for the Regulation of Whaling (ICRW) which has the longest history and aims to regulate commercial whaling and conservation of the remaining whale populations. Other IEAs, including the 1971 Ramsar Convention on the Conservation of Wetlands (Ramsar), the 1972 World Heritage Convention concerning the Protection of the World Cultural and Natural Heritage (WH), the 1973 Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), the 1979 Convention on the Conservation of Migratory Species of Wild Animals (CMS), all are linked to the regulatory area of nature conservation. Environmentally sound management of toxic wastes for preventing air and water pollution is another target of IEAs. These include: the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (LC72), the 1979 Convention on Long-range Transboundary Air Pollution (LTAP), the 1989 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (Basel), the 1998 Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (PIC) and the 2001 Stockholm Convention on Persistent Organic Pollutants (POPs). Another critical issue, despite mounting efforts over the past 20 years, the loss of the world's biological diversity, mainly from habitat destruction, over-harvesting, pollution and the inappropriate introduction of foreign plants and animals, has continued [12]. To address this issue, the 1992 Convention on Biological Diversity (CBD) was finalized and adopted in Montreal in 2000. It provides a comprehensive and holistic approach to the conservation of biological diversity, the sustainable use of natural resources and the fair and equitable sharing of benefits deriving from the use of genetic resources [13]. Biosafety is one of the main topics addressed by the convention. As twin aspects of biotechnology, besides great potential for food, agriculture and health care, this modern technology can also pose the potential threats to human health and the environment. With a view to the sustainable management and use of biological resources, the 2000 Cartagena Protocol on Biosafety seeks to protect biological diversity from the potential risks posed by genetically modified organisms resulting from modern biotechnology [14]. Fig. 3 is the measure of global joint-commitment for the most important treaties of "Agenda 21" action plan. It depicts clearly that since the early 1970s, environmental protection wage has received the noble support from states and keeps increasing until today.

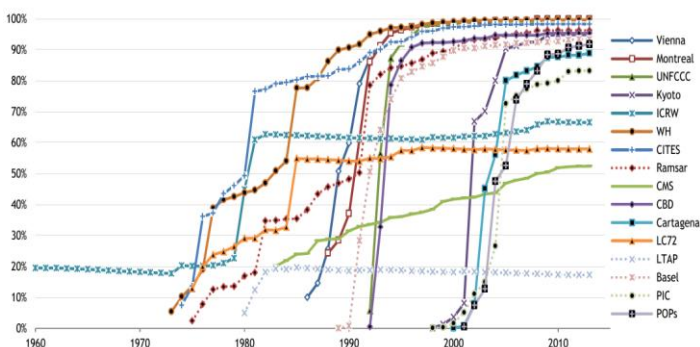


Fig. 3 Global Commitment Measure for "Agenda 21" Action Plan

### 3.3 Technological Competitiveness

The growth of cross-border trade of products and service is a driving force behind the creation of a global system of tariffs and technical standards. Standards facilitate international trade, by ensuring the compatibility and interoperability in different markets. Standards also have an important role to play in supporting the competitiveness of each country in global market, by helping to improve the products and services. They help to harmonize technical specifications of products and services making industry more efficient and breaking down barriers to international trade [15]. Many existing global standards are developed and regularly revised and updated to ensure that they remain fit for purpose as new materials, technologies and processes become available [16]. The first ever globally uniform measurement convention was established in 1875 based on the Metric System. As a central organ to implement the Convention, the International Bureau of Weights and Measures (French acronym BIPM is commonly used to denote this organ) was established in Paris at the same time to ensure world-wide uniformity of measurements and their traceability to the International System of Units (SI). Other well-known standards setting organizations, the International Telecommunications Union (ITU), the International Electrotechnical Commission (IEC) and the International Organization for Standardization (ISO) stand as three principal standards bodies involved in the development and adoption of international standards. Being one of the oldest international organizations, ITU is a specialized agency of the United Nations which is specifically responsible for coordinating standards for shared global use of the telecommunication infrastructure and for assisting in the development and coordination of worldwide technical standards. IEC is a non-governmental organization that plays as the principal body coordinating the development and promulgation of international standards for electrical, electronic and related technologies. It publishes 300 to 500 international standards each year, covering a wide range of technologies from power generation, transmission and distribution to home appliances and office equipment [16]. ISO is the principal body coordinating the development and promulgation of formal international standards. ISO standards are developed in almost all industry sectors, with the exception of electrotechnical and telecommunications standards (developed by IEC and ITU respectively) [16]. In the increasingly globalized 'informational' economy, many countries have recognized competitive advantages from intellectual property by licensing a new technology or generating revenue from a useful patent. When valuable technology is transferred through trade, it is therefore likely to be copied or imitated. Therefore, intellectual property rights which regulate legal protection for investors from outside use or implementation without consent, has increasingly become an important issue in multilateral trade negotiations. They provide encouragement for developing and exploiting subsequent innovations by granting successful inventors temporary monopoly power over their innovations. By this mechanism, intellectual property rights can foster creativity in high technology, thus strengthening its protection has been a priority for many nations and has increasingly been the focus of attention of policymakers [17]. There is an extensive international system for defining, protecting, and enforcing intellectual property rights, comprising both multilateral treaty schemes and international organizations [18]. Examples of

such treaties and bodies include the most important international governmental organizations to promote the protection for intellectual property is the World Intellectual Property Organization (WIPO)—a specialized UN agency, established in 1967 in Geneva, Switzerland. WIPO currently has 187 member states and manages 26 international treaties. Amongst are the 1883 Paris Convention for the Protection of Industrial Property (Paris), the 1886 Berne Convention for the Protection of Literary and Artistic Works (Berne), the 1891 Madrid Agreement Concerning the International Registration of Marks (Madrid), the 1925 Hague Agreement Concerning the International Deposit of Industrial Designs (Hague), the 1961 Rome Convention for the Protection of Performers, Producers of Phonograms, and Broadcasting Organizations (Rome), the 1970 Patent Cooperation Treaty (PCT), the 1971 Convention for the Protection of Producers of Phonograms against Unauthorized Duplication of Their Phonograms (Phonograms), the 1994 Trademark Law Treaty, the 1996 WIPO Performances and Phonograms Treaty (WPPT) and the 1996 WIPO Copyright Treaty (WCT). Notably, the 1994 Agreement on Trade Related Intellectual Property Issues (TRIPS) administered by World Trade Organization (WTO) achieved further progress in this field by creating a framework of uniform standards of protection for a wide range of intellectual property on a near-universal basis. TRIPS Agreement is obligatory for all states that wish to join the WTO, and is part of the WTO's common institutional framework. The Agreement covers all intellectual rights, patents, trademarks, copyrights and trade secrets, including relatively new ones such as semiconductor chip rights [19]. Other instruments in the field of protecting copyrights include the well-known 1952 Universal Copyright Convention (UCC) hosted by United Nations Educational, Scientific and Cultural Organization (UNESCO) and the 1961 International Convention for the Protection of New Varieties of Plants (UPOV) organized by International Union for the Protection of New Varieties of Plants. Fig. 4 is the measure of global commitment degree for the well-known treaties regulating the intellectual property protection of the global trade system nowadays.

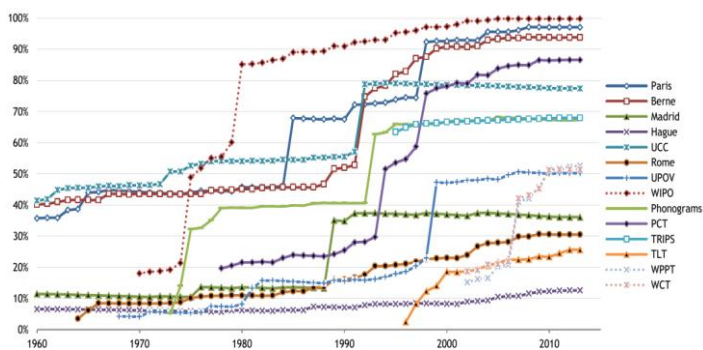


Fig. 4 Global Commitment Measure for Intellectual Property Protection Treaties

### 3.4 Safety and Health

Most of the increased productivity and social wealth in the world over the recent decades can be traced largely to the advances in technology. However, along with great benefits it can bring to mankind, technological advances are frequently accompanied by undesirable social consequences, such as health or safety hazards. It is a characteristic trend nowadays that, the magnitude of the consequences of each individual incident, whether it be air, train or shipping disaster, a

chemical or nuclear plant, is growing considerably [20]. For preventing these kinds of tragic accident, the governments as overseers and protectors of the public interest must play a very direct role in controlling such undesirable effects, via planning, controls and regulations. Last decades of the twentieth century has seen the multinational cooperation in finding a regulatory framework in the form of international treaties to tackle different safety issues of the humankind. The Chernobyl disaster in 1986 brought attention to the importance of safety culture and the impact of managerial and human factors on the outcome of safety performance [21]. As the response, the international legal framework for nuclear energy safety, was developed relatively recently. Promotion of nuclear safety is achieved mainly through adoption of legally binding agreements focusing on two basic aspects of nuclear energy: 1) prevention of accidents and 2) communication and management of their effects. Currently, there are five key international conventions are in force regulating these aspects and the IAEA is the depositary of these legal agreements. Adopted in 1986, the Conventions on Early Notification of Nuclear Accident (CEENA) and Convention on Cooperation and Assistance in Cases of Radiological Emergencies (CACNARE) deal with responses to communication and management of nuclear accidents or radiological emergencies. Later, the other critical conventions are issued cover the aspects of prevention of accidents. The Convention on Nuclear Safety (CNS) which was adopted in 1994, is an incentive-based instrument that commits states operating nuclear power plants to establish and maintain a regulatory framework to govern the safety of nuclear installations. Entered into in 2001, the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (JCS) is the first international instrument to focus on minimizing the effects of hazardous radiological materials and developing best practices to promote an effective nuclear safety culture. Another critical convention which deals with international legally binding undertaking in the area of physical protection of peaceful use nuclear materials is the Convention on the Physical Protection of Nuclear Material (CPPNM). It establishes measures related to the prevention, detection and punishment of offenses relating to nuclear material. Over the years, another safety issue that has received a lot of attention from the international community is occupational health and safety (OHS) which encompasses the social, mental and physical well-being of workers in the workplace environment [22]. Most countries and industries scarcely recognize occupational health and safety practices as a crucial determinant of national development. The protection of the worker against sickness, disease and injury arising from employment and the achievement of strong preventive safety cultures are among the main tasks assigned to the International Labour Organization (ILO) through its set of international OSH conventions. In our database, the data of nearly twenty conventions that regulate the fundamental principles to guide national policies for OSH promotion, action and management, is collected. Recently, a series of bad rumor involving contaminated baby formula milk, toxic fruits and vegetables demonstrated the threat that unsafe food and drug imports pose to public health and international trade. The expanding importation and exportation of food products among countries has raised the importance of global food safety-related regulatory systems. Ensuring safety in the global trade in food and drugs has introduced many challenges to UN



System, especially to specialized agencies such as Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO). The International Plant Protection Convention (IPPC) is an international plant health agreement, established in 1952 by FAO that aims to prevent the introduction and spread of pests to protect not only cultivated plants but also natural flora and plant products. The Convention makes provision for the application of measures by governments to protect their plant resources from harmful pests (phytosanitary measures) which may be introduced through international trade [23]. Another critical joint FAO/WHO Food Standards Programme that works towards setting international food standards is the Codex Alimentarius Commission, established in 1963. Its target is to develop harmonized international food standards, guidelines and codes of practice to protect the health of the consumers and ensure fair practices in the food trade [24]. Fig. 5 is the measure of global commitment degree for the selected treaties regulating the food and drug safety.

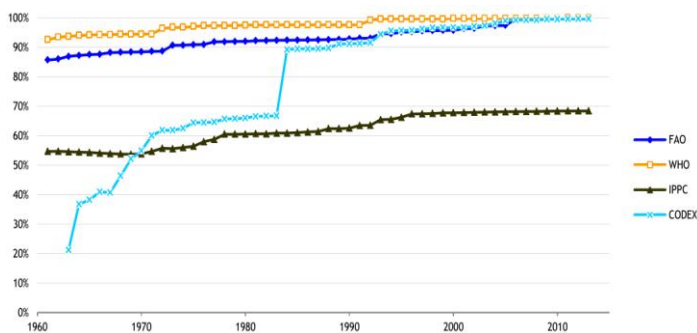


Fig. 5 Global Commitment Measure for Food and Drug Safety Treaties

A connected world always requires international coordination efforts to establish and maintain connectivity through a safe transportation system. The International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO) are two important specialized agencies in UN system that constitute in the law-making process for international transport by air, sea, and other international waterways. During the second half of the twentieth century the international community, the world is facing the terrorist phenomenon by the means of transportation system. Even a cursory review of the numerous hijacking, train and bus bombings can establish beyond doubt that transport systems are particularly vulnerable targets of terrorist attack [25]. Among the types of terrorist attacks on public transportation, commercial aviation has been increasingly worried that hijacked commercial airliners can be used as weapons of mass destruction. To confront and seek remedies for this problem, states have cooperated to issue a list of international conventions to deal the transportation safety against terrorism. The 1963 Convention on Offences and Certain Other Acts Committed On Board Aircraft (COBA), the 1970 Convention for the Suppression of Unlawful Seizure of Aircraft (SOA), the 1971 Convention for the Suppression of Unlawful Acts against the Safety of Civil Aviation (SCA) and the 1988 Protocol for the Suppression of Unlawful Acts of Violence at Airports Serving International Civil Aviation (ICA) are those conventions that aims to that purpose. To deal with the safety of maritime, the Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation (SMN) was adopted since 1988.

## 4 STATE POLICY MAKING TOWARDS INTERNATIONAL S&T COOPERATION

### 4.1 Cycle Time of S&T Policy Making

The expected rules for the international S&T cooperation and the state's policy making behavior to comply with these rules are increasingly materialized in the way states ratify to the multilateral treaties. The decision to ratify any UN treaties represents the national interest in a certain international policy area, and then reflects the willingness on the part of the ratifying country to comply with international law and thus, to cooperate with other partners. By analyzing our data of treaty ratification, we found that, some treaties, after its declaration, seem to attract more particular attention from international community than others and then quickly reached to the global consensus and commitment of majority number of states. Therefore, they can achieve their peak in the number of membership in merely a couple of years, whereas others were still gradually changing. The global effort for a given multilateral treaty to reach to multilateral consensus from a great number of countries strongly depends on the quickness or reluctance of national policy in response to a global calling. In other words, the speed for achieving highly international consensus of a multilateral treaty can be used to reflect the cycle time of policy making process from member countries towards different issue-areas of S&T cooperation. In this study, we have analyzed our data to find out the year when a treaty received the ratification from 50% of its current number of country members. Based on that, how many years it takes for a multilateral treaty to attract ratification from 50% of its membership can be produced. By that way, the cycle time of policy making for states to take part in a multilateral consensus for a shared global challenge can be measured and compared among various global issue-areas. How long international cooperation towards different S&T fields can be consolidated among countries becomes visibly observed. Fig. 6 shows the difference in time cycles of policy making for various key domains of international S&T cooperation. It can be seen clearly that environmental movements in the form of multilateral treaties quickly have received boost of support from international community. Biological diversity and atmospheric protection are among the top global issues draw attention of more than one hundred of states in merely first 4 years after their promulgation. Indeed, the issues such as climate change and global warming, ozone layer depletion or biodiversity loss are among the most serious dangers that threat human beings worldwide. The need for an effective and efficient international regime that regulates the global action to mitigate these threats is in urgent and highly recognized by majority of nations around the world. That explain why an enormous number of countries have taken initiatives by committing themselves very quickly to those agreements in a short period of time. The same fact can also be observed for the issue of pollution control. Nearly 70 states, which account for 50% of current membership, has make national policy decision during the first 4 years to adopt the regulation of treaties of pollution control issue. Out of environment domain, the issue of export control for dual-use technology and goods also gain the consensus from 50% first members in around first 3 years. As this issue only attract regional attention from a group of members, the member parties is yet still in a limited number.

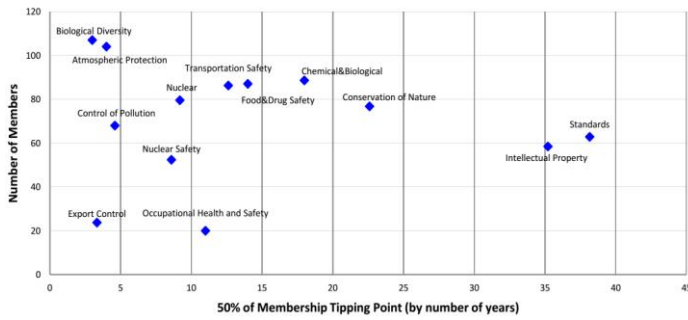


Fig. 6 Cycle Time of Policy Making towards Different S&T Issues

Nuclear technology related topics, including the control of nuclear technology and nuclear safety are also ranked among the hot topics of the world affairs. While 50% members committed to nuclear test regulations during first 9 year period, it takes only 8 years for that of nuclear safety. It is interesting that the other safety issues, including transportation safety, food and drug safety, occupational health and safety, all converged to the international consensus of 50% membership around 10 to 15 years after their adoptions. Another key topic, the controls of chemical and biological weapons takes 18 years to gain nearly 90 member countries committing in the relevant regulatory regime. Nature conservation takes more than that period of time, about 23 years to gaining the jointly work from nearly 80 states. It is most surprising to find that the regulations related to the issue of technological competitiveness in the global trade system take the longest period of time (from 35 to 40 years) compared with others, to extend the consensus to 50% of their membership. It can reflect how slow the states' policy making process take to commit with the issues of trade competitiveness, including the regulations of standards and intellectual property. As can be recognized that the cycle time of policy making can also be used to describe the nature of difficulty in consolidating the international cooperation in different issue-areas of S&T. While environmental protection actions receives the high attention from international community, the other critical issues such as occupational health and safety or intellectual property protection still gain the limited results in the way countries cooperation universally. It suggests more considerations in national policies to be emphasized towards these issues.

**4.2 S&T Policy Making by HDI grouping**

As the world's interdependence expands and deepens, real progress on human development is not only the matter within national circumstances and policy space of any particular state, it is also the issue at the global level of how secure these achievements are and whether conditions are sufficient for sustained human development. Environmental changes can lead to natural disasters such as floods and droughts. Economic shocks can lead to lost jobs through recession or worsening term of trade. Health shocks can lead to reduces incomes—as well as rising medical expense—for household [5]. All such kinds of global challenges which are trans-border in nature can have pervasive negative impact on every state's human development. Therefore, a global cooperation effort is needed to ensure the global advances in human development. This part of paper takes a broader approach, emphasizing the links of the state's readiness in policy making towards these cross-border challenges in comparative with its level of national human development. By looking at national policy

decision making through human development lens, we draw attention to national policies of different groups of countries to prepare against global challenges and make human development progress more robust going forward. Moreover, the relationship between state's readiness in policy making towards these cross-border challenges and its level of national human development can be highlighted. Human development levels of states are represented by using the human development index (HDI) collected from the latest report of United Nations Development Programme (UNDP)—the 2014 Human Development Report [5]. HDI is the quantitative metric which measures the average national achievement in three basic dimensions of human development: a long and healthy life, knowledge and a decent standard of living. Thenceforth, all countries are divided in four groups based on the classification of HDI regulated by the UNDP. Very high human development country group has the highest rank of HDI score of more than 0.8. The second group comes from the high human development countries with HDI in the range of from 0.7 to 0.8. The third group is for the medium human development countries with HDI in the range of 0.55 - 0.7. Finally, the countries with the HDI value of lower than 0.55 is form the fourth group. By this way of grouping, the countries are clustered in group with others having the similar level of human development. For each group of countries, we have tried quantitatively measure the state's readiness in policy making towards the cross-border challenges. As the international treaties have no binding legal power unless and until states ratify them, understanding why some states ratify a treaty immediately after it opens for signature while others wait forty or more year to do so is important for understanding the policy attitude of actor negotiated in international regimes. In another words, the ratification year itself has meaning as it reflects the intense desire and the quickness of national policy in response to a global issue. The amount of time needed for a country to ratify a treaty depends on national policy making process within each country to deal with international issues. The faster this process is, the more initiatives that country behaves according to different global key topics. For this theoretical reason, we have measured how quick responses from different group of countries to the global call in solving the new and emerging threats by counting how many years in average it takes for that group to ratify a multilateral treaty after its promulgation. Table 1 shows the results of the number of years in average for groups of countries to commit in the regulations of international treaties dealing with different key topics of current global challenges.

TABLE 1: AVERAGE NUMBER OF YEARS FOR RATIFICATION

Key Topics	Country Group by HDI			
	Very High HDI	High HDI	Medium HDI	Low HDI
Nuclear Technology	12.7	14.3	14.1	14.5
Chemical & Biological Technology	12	17.8	16.7	19
Export Control	6.8	14.6	9.5	-
Nuclear Safety	8	14.8	15.7	22



Occupational Health and Safety	12.9	17.9	19.9	24.3
Food & Drug Safety	13.7	23.3	22.2	23.7
Transportation Safety	11.7	17	19.2	18.7
Atmospheric Protection	3.9	5	5.8	6.7
Conservation of Nature	17.7	19.6	20.4	20.4
Biological Diversity	3.6	3.8	4	3.9
Control of Pollution	5.4	7.8	7.6	7.5
Intellectual Property	29.9	45.5	53.6	48.6
Standards	44.4	61.2	72.8	64.1

It can be seen from table 1 that there is the strong correlation between state's readiness in policy making towards the global S&T governance and its HDI level. Indeed, the countries among the top ranking of HDI are also the ones achieving the shortest time length to comply with international law. It is true for all issue-areas of international S&T cooperation where the group of very high HDI countries have performed superlatively in giving promptly response through their quick ratification of multilateral treaties. For the group of countries with lowest HDI level, it can be found that their action in response to global issues is in slow progress, especially for the key topics related to technological competitiveness, safety and health issues. For the issues of safety and health, it took around 20 years in average for low HDI countries to ratify the related treaties. Nobly, it took around 50 years and even longer for them to ratify the treaties regulated intellectual property and international standards. Consequently, the global efforts towards these issues produced little real progress, mainly because states don't perceive their importance in the same way or with the same urgency.

**TABLE 2: PERCENTAGES OF COUNTRIES HAD RATIFIED**

Key Topics	Country Group by HDI			
	Very High HDI	High HDI	Medium HDI	Low HDI
Nuclear Technology	78.8%	76.6%	66.7%	58.0%
Chemical & Biological Technology	88.2%	86.8%	74.6%	64.4%
Export Control	56.3%	9.4%	4.8%	-
Nuclear Safety	82.1%	54.0%	40.0%	21.4%
Occupational Health and Safety	28.1%	21.3%	12.8%	7.4%
Food & Drug Safety	62.5%	82.5%	76.8%	71.6%

Transportation Safety	85.9%	84.4%	75.6%	63.6%
Atmospheric Protection	83.9%	94.8%	95.2%	86.4%
Conservation of Nature	75.4%	74.0%	65.7%	62.0%
Biological Diversity	83.3%	90.6%	89.3%	79.7%
Control of Pollution	76.3%	66.4%	53.8%	48.1%
Intellectual Property	58.5%	51.8%	37.6%	27.0%
Standards	49.3%	44.3%	32.5%	30.8%

From another view corner, we analyzed how many percentages of countries in each group of HDI had ratified these S&T agreements (table 2). As numbers of members differ among groups of HDI, the percentage numbers depict another dimensions of states' policy making behavior. As compared with table 1, table 2 shows the little disparities between groups of countries' behavior. Almost all of the key topics have received the evenly attendance of representatives from each group of countries, except for occupational health and safety and nuclear safety issue. It illustrates the same fact as table 1 that low HDI group still show an inadequate recognition and attention about these critical issues. To sum up, the noteworthy differences in behavior towards multilateral S&T agreements among groups of countries suggests useful information for policy planners to make international cooperation progress more effectively achieved. It is recommended that more global governance policy should be paid for low HDI countries to promote their recognition of the importance in cooperating and committing in various issues of the world, especially for the issues of occupational health and safety, food and drug safety, intellectual property and standards. More progress in the global governance of S&T can be achieved if and only if states equivalently perceive the necessity of acting collectively and show themselves more willingness in taking part to the international cooperation in solving the current global threats.

## 5 CONCLUSIONS

As the world's interdependence expands and deepens, the cross-border challenges are likely to continue in coming decades. The current global governance architectures yet is claimed to short on capacity to cope with them. Multilateral efforts to facilitate international cooperation, especially in areas of S&T are expected to be the solution in the face of the challenges and vulnerabilities. The paper has provided the closer look at the performance of current global governance in S&T by measuring the degree of global commitment and consensus in solving the emerging threats in general, and the policy attitude and readiness of states in particular. Through the comparative results about the policy readiness of states with their level of human development, the paper can provide the useful information to increase the likelihood that states will act collectively at global level in addressing major crises. Based on that, further recommendations can be made to strengthen and extend widespread coordination and cooperation among states and international institutions to

ensure cohesiveness in global governance of S&T.

## APPENDIX

### List of Multilateral Treaties Covered by the Study

Acronym	Name of Treaty	First ratification
AG	Australia Group	1984
APM	Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction (Mine Ban Treaty)	1997
Basel	Basel Convention on the control of Transboundary Movements of Hazardous Wastes and Their Disposal	1989
Berne	Berne Convention for the Protection of Literary and Artistic Works	1887
BWC	Biological Weapons Convention	1972
C115	Radiation Protection Convention	1961
C119	Guarding of Machinery Convention	1964
C120	Hygiene (Commerce and Offices) Convention	1965
C127	Maximum Weight Convention	1969
C13	White Lead (Painting) Convention	1922
C136	Benzene Convention	1972
C139	Occupational Cancer Convention	1975
C148	Working Environment (Air Pollution, Noise and Vibration) Convention	1978
C155	Occupational Safety and Health Convention	1982
C161	Occupational Health Services Convention	1986
C162	Asbestos Convention	1987
C167	Safety and Health in Construction Convention	1989
C170	Chemicals Convention	1992
C174	Prevention of Major Industrial Accidents Convention	1994
C176	Safety and Health in Mines Convention	1997
C184	Safety and Health in Agriculture Convention	2002
C187	Promotional Framework for Occupational Safety and Health Convention	2007
C45	Underground Work (Women) Convention	1936
C62	Safety Provisions (Building) Convention	1940
CACNARE	Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	1986
Cartagena	Cartagena Protocol on Biosafety to the Convention on Biological Diversity	2000
CBD	Convention for Bio-Diversity	1992
CEENA	Convention on Early Notification of a Nuclear Accident	1986
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora, Ratification	1974
CMS	Convention on the Conservation of Migratory Species of Wild Animals	1983
CNS	Convention on Nuclear Safety	1994
COBA	Convention on Offences and Certain Other Acts Committed On Board Aircraft	1964
COC	Convention on Cybercrime	2002
CODEX	Codex Alimentarius Commission	1963
CPPNM	Convention on the Physical Protection of Nuclear Material	1980
CSTB	International Convention for the Suppression of Terrorist Bombings	1998
CTBT	Comprehensive Nuclear-Test-Ban Treaty	1996
CTBT	Comprehensive Nuclear-Test-Ban Treaty	1996
CWC	Chemical Weapons Convention	1993
FAO	Food and Agriculture Organization of the United States	1945
GATT	General Agreement on Tariffs and Trade	1948
Geneva	Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare	1926
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	and of Bacteriological Methods of Warfare	
Hague	Hague Agreement Concerning the International Deposit of Industrial Designs	1928
IAEA	International Atomic Energy Agency Safe Guard Agreement	1962
IAEA	International Atomic Energy Agency Safe Guard Agreement	1962
ICA	Protocol for the Suppression of Unlawful Acts of Violence at Airports Serving International Civil Aviation	1988
ICAO	International Civil Aviation Organization	1945
ICRW	International Convention For The Regulation Of Whaling	1948
ICSANT	International Convention for the Suppression of Acts of Nuclear Terrorism	2006
ICSANT	International Convention for the Suppression of Acts of Nuclear Terrorism	2006
IEC	International Electrotechnical Commission	1906
IMO	International Maritime Organization	1948
IPPC	International Plant Protection Convention	1951
ISO	International Standardization Organization	1947
ITU	International Telecommunication Union	1866
JCS	Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management	1998
Kyoto	Kyoto Protocol to the United Nations Framework Convention on Climate Change	1998
LC72	Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter	1975
LTAP	Convention on Long-range Transboundary Air Pollution	1980
Madrid	Madrid Agreement Concerning the International Registration of Marks	1892
Metre	Convention de Metre	1875
Montreal	The Montreal Protocol on Substances that Deplete the Ozone Layer	1988
MTCR	Missile Technology Control Regime	1987
NPT	Non-Proliferation of Nuclear Weapons	1968
NPT	Non-Proliferation of Nuclear Weapons	1968
OST	Outer Space Treaty	1967
Paris	Paris Convention for the Protection of Industrial Property	1884
PCT	Patent Cooperation Treaty	1978
PEPD	Convention on the Marking of Plastic Explosives for the Purpose of Detection	1992
Phonograms	Convention for the Protection of Producers of Phonograms Against Unauthorized Duplication of Their Phonograms	1973
PIC	Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides	1998
POPs	Stockholm Convention on Persistent Organic Pollutants	2001
PTBT	Partial Test Ban Treaty	1963
PTBT	Partial Test Ban Treaty	1963
Ramsar	Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat	1975
Rome	Rome Convention for the Protection of Performers, Producers of Phonograms and Broadcasting Organizations	1964
SCA	Convention for the Suppression of Unlawful Acts against the Safety of Civil Aviation	1972
SMN	Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation	1989
SOA	Convention for the Suppression of Unlawful Seizure of Aircraft	1971
SOLAS	International Convention for the Safety of Life at Sea	1974
TBT	Technical Barriers to Trade	1995
TLT	Trademark Law Treaty	1996
TRIPS	Trade Related Aspects of Intellectual Property	1995

	Systems	
UCC	Universal Copyright Convention	1955
UNFCCC	United Nations Framework Convention on Climate Change	1992
UPOV	International Convention for the Protection of New Varieties of Plants	1968
Vienna	The Vienna Convention for the Protection of the Ozone Layer	1986
WA	The Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies	1996
WCT	WIPO Copyright Treaty	2002
WH	Convention concerning the Protection of the World Cultural and Natural Heritage	1973
WHO	World Health Organization	1946
WIPO	World Intellectual Property Organization	1970

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